

The Power of Bitcoin's Network Effect

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EXECUTIVE SUMMARY

- **Bitcoin's improving network fundamentals**, increased investor holding periods, and reliably diminishing new supply make it a compelling long-term investment.
- **Adoption of Bitcoin is at an all-time high**, with the number of addresses that hold bitcoin now 25.6M.
- **Engagement is rapidly rising**, with the number of unique daily active Bitcoin addresses approaching 900,000.
- **Investors are holding bitcoin for increasingly longer periods**, with 63.2% of total supply currently held for at least 1 year.
- We believe increasing holdings periods will drive future price appreciation given **bitcoin's fixed supply** and **shrinking supply growth** – 88% of all bitcoins ever to exist have already been created, and bitcoin's supply growth, now at only 1.3% annually, is on an automatic and asymptotic journey to zero.
- Our valuation framework is based on **Metcalf's Law**. Supporting our hypothesis that bitcoin's usefulness as a store of value is driven by its monetary network effects, we find that **Bitcoin's valuation can be well explained by the square of its user base**.

OVERVIEW

Increasing fundamental demand combined with a fixed supply and automatically declining supply growth make a compelling case for bitcoin as an alternative investment for institutional investors.

Examining addresses that hold bitcoin balances and daily active addresses, we show that network adoption and network usage are each growing. Regarding supply, average investor holding periods are rising, with the percentage of total bitcoin supply held for at least one year recently hitting an all-time high. We also see record highs in the number of addresses that control large bitcoin balances, which we define as at least 1,000 bitcoins. This development supports our direct, and accelerating, experience at NYDIG: **bitcoin is being increasingly adopted by institutional investors.**

These positive network fundamentals are set against the backdrop of bitcoin's automatically diminishing new supply and its ultimate cap. **There will only ever be 21M bitcoin.** Bitcoin's supply growth, which asymptotically approaches 0% over time, is now down to 1.3% annually, on par with the annual growth in gold supply. While far from perfect, gold is bitcoin's closest real-world analogy. The ultimate supply of bitcoin is fundamentally limited by the design of the system itself and cannot be increased regardless of its value or the level of demand. **Bitcoin is the first store of value in history for which its supply is entirely unaffected by increased demand.**

To value bitcoin, we apply Metcalfe's Law, which states that a network's value is proportional to the square of the number of its users. Applying Metcalfe's Law to Bitcoin's network, we find that bitcoin's historical valuation levels are well explained by the square of its addresses. Applying this relationship to potential future network growth of 15%-25% per year suggests a price level range of \$51,611 – \$118,544 in 5 years.

BITCOIN'S FUNDAMENTAL GROWTH

Bitcoin is both a technology (Bitcoin – uppercase B) and an asset (bitcoin – lowercase b). Bitcoin the technology is an open-source software protocol (akin to HTTP for web browsers or SMTP for email). It allows the tens of thousands of computers that currently, and independently, run the Bitcoin software to hold, send, and receive bitcoin, the native asset of the Bitcoin protocol. Together, these computers form an internet-like network stretching around the world, which neither requires nor permits a centralized coordinating entity and accepts anyone, anywhere to run its open-source software.

Just like certain other durable and time-tested stores of value such as gold and art, bitcoin does not produce income, nor confer to its owners any rights to dividends, voting, or governance. Further, unlike gold, the growth in bitcoin supply reliably diminishes over time and eventually ceases altogether. Someone who "owns bitcoin" more accurately controls a private key, the digital signature which gives them the right to update address balances on Bitcoin's global ledger, thereby transferring bitcoin from one entity to another. To obtain bitcoin, one must either a) "mine" it into existence through a computationally intensive (i.e., expensive) process that forms part of the Bitcoin protocol, b) receive it in exchange for goods and services, or, most commonly, c) purchase it on the secondary market. In short, there is a cost to acquiring every bitcoin.

NEW TECHNOLOGY, ANALOGOUS FUNDAMENTALS

While much of Bitcoin's technology and terminology is unique to the digital asset ecosystem, we can draw analogies to metrics from traditional assets or technologies, such as user growth, engagement, transaction volume, and holding period. Although the identity of each bitcoin holder is pseudonymous, all transactions are public on the blockchain, giving everyone – including us – a clear picture of all underlying network activity.

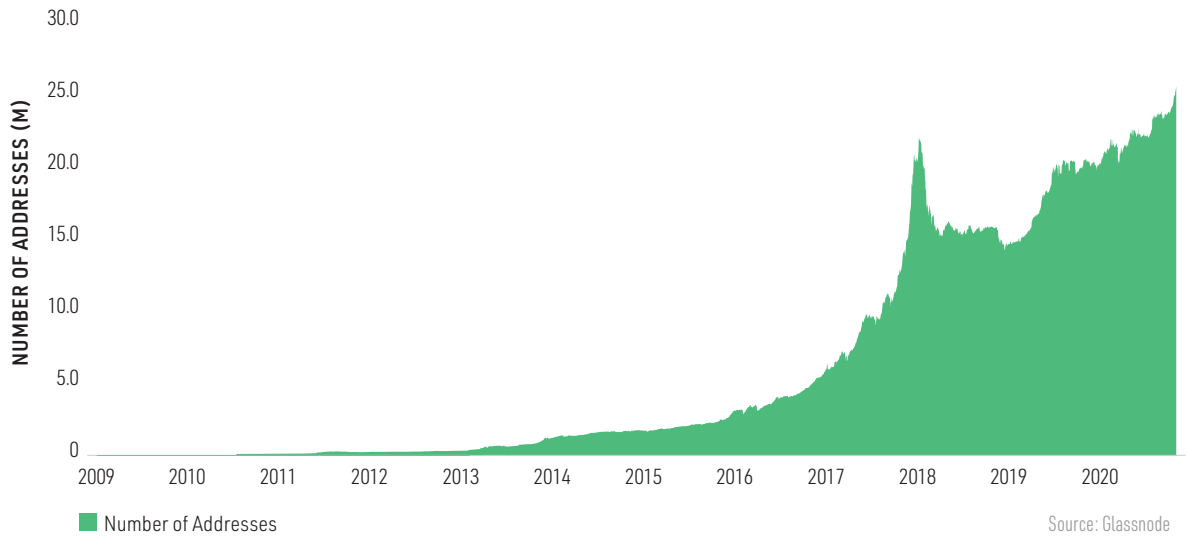
USER BASE AT AN ALL-TIME HIGH AND GROWING

There are currently 25.6M addresses on Bitcoin, an all-time high.

While Bitcoin does not have a precise definition of “users”, a good proxy is public addresses, which are simply (virtual) locations where owners can send or receive bitcoin. Ownership of a public address comes from controlling its private key, which allows users to “spend” bitcoin. While multiple public addresses can be derived from a single private key, we believe that public addresses holding more than \$1 are a reasonable proxy for users.

There are currently 25.6M addresses on Bitcoin, an all-time high. The upward trajectory of public addresses is an important metric for network adoption and market cap.

FIGURE 1
User Proxy:
Addresses

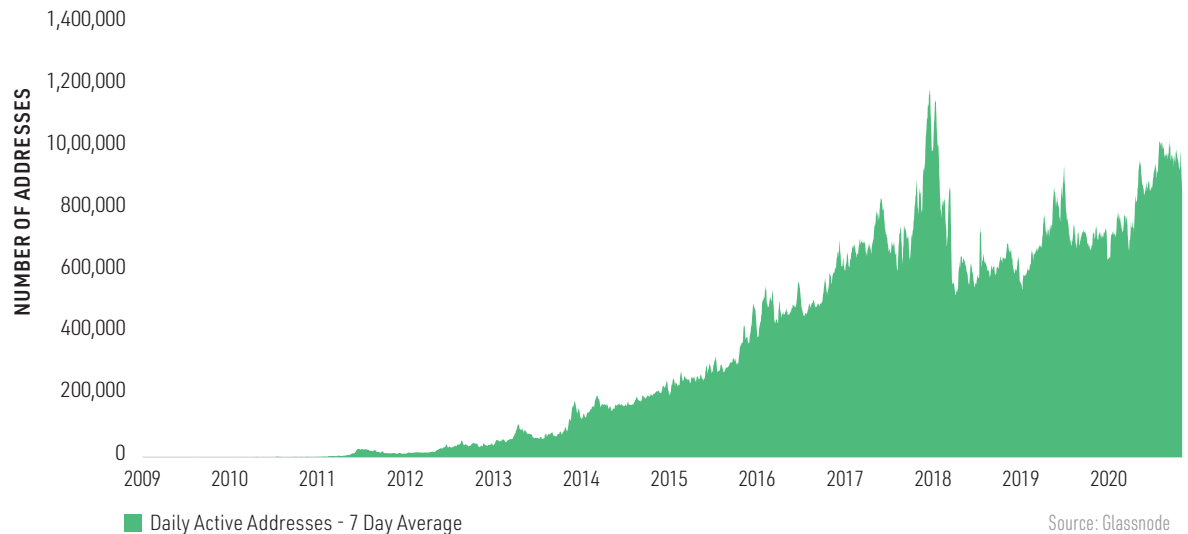


USER ENGAGEMENT TRENDING BACK TO THE HIGHS

Currently, about 900,000 addresses are active on a typical day.

User engagement is an important measure of any network’s health. For example, social media networks closely track their daily active users (DAU) as a measure of engagement. For Bitcoin, we have a similar measurement – daily active addresses – which we define as the number of unique addresses that engage in at least one transaction on a given day. Currently, about 900,000 addresses are active on a typical day. While Bitcoin has yet to return to the prior peak of daily active addresses seen in 2017, engagement has been increasing meaningfully in recent years.

FIGURE 2
Engagement
Proxy:
Daily Active
Addresses

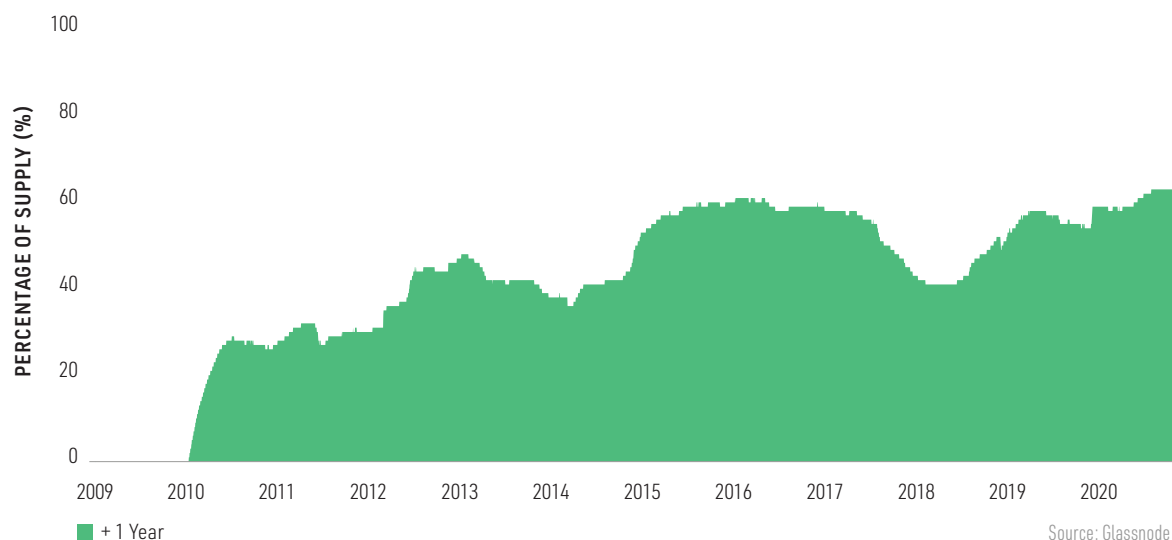


A growing percentage of bitcoin supply is being held for longer.

BITCOINERS ARE INCREASINGLY TURNING INTO LONG-TERM HOLDERS

Examining when any individual bitcoin was last moved on the blockchain, as a percentage of all bitcoin in existence, reveals the behavior of longer-term investors with certainty. Our analysis reveals an important trend: **a larger percentage of total bitcoin supply is being held for longer periods.** Currently, 62.5% of all bitcoin has been held, or more precisely, not moved, for 12 months or longer. Examining even longer holding periods, we see that 44.6% and 32.3% of all bitcoin have been held for at least 2 and 3 years, respectively. This speaks to bitcoin increasingly being used for its primary use case: long-term wealth storage. Should this trend continue, which we believe it will, there will be material implications for future available sell liquidity.

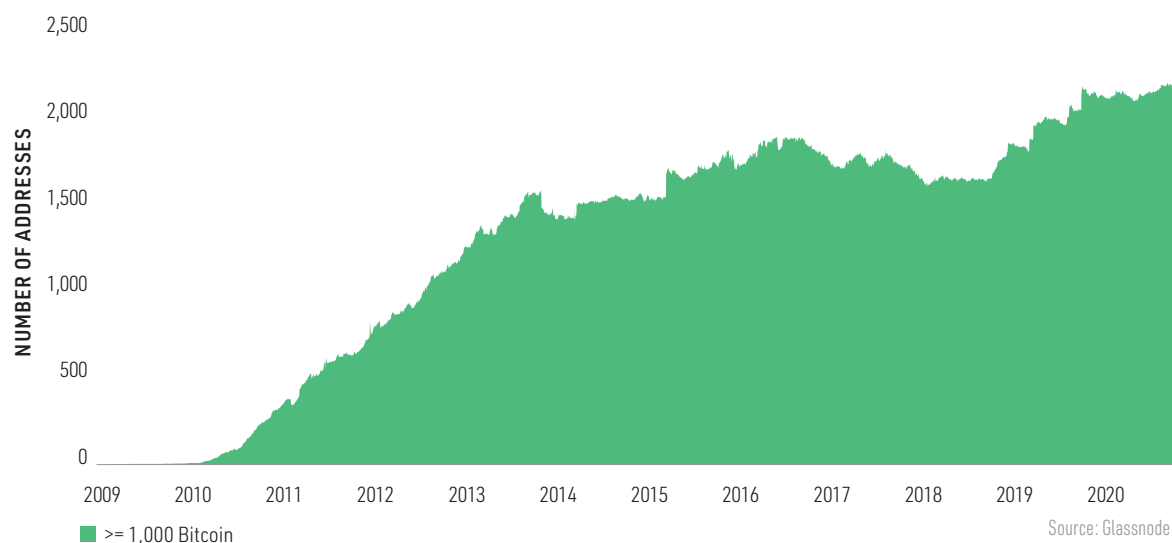
FIGURE 3
Percentage of Supply Held for Greater than 1 Year



NUMBER OF LARGE OWNERS HITS AN ALL-TIME HIGH

The number of unique addresses that hold over 1,000 bitcoins, a reasonable proxy for institutional investors, recently hit an all-time high. However, this total number, only 2,218, is still strikingly small, which suggests that the ecosystem remains in the very, very earliest stages of institutional adoption. There have been several companies that have adopted bitcoin for treasury reserve investment purposes, starting with Stone Ridge Holdings Group (2017), MicroStrategy (2020), and Square (2020), as well as several well-respected investors who recently came out in support of the asset, such as Paul Tudor Jones, Bill Miller, and Stan Druckenmiller. We believe this trend will continue.

FIGURE 4
Number of Addresses with Large Balances



BILLIONS OF DOLLARS OF INVESTED CAPITAL SECURE BITCOIN'S BLOCKCHAIN

Since 2011,
\$20B has
been paid to
Bitcoin miners.

Miners are paid transaction and block reward fees to find new blocks and permanently record transactions on Bitcoin's blockchain. These fees are sometimes referred to as Bitcoin's "security budget" because they represent the revenue miners receive in return for maintaining the safe functioning of the protocol. Since 2011, \$20B has been paid to miners to secure Bitcoin's blockchain. With mining revenues currently running at about \$11M per day, the annual run rate mining revenue is about \$4B.

Because the security of the Bitcoin network is a necessary and critical driver of its value, mining fees – and miners – are very important. The fact that miners are required to make the network secure is a feature, not a bug, and kicks off a virtuous cycle. The more capital that's invested in bitcoin mining, the safer the Bitcoin network. The safer the Bitcoin network, the more attractive bitcoin is as a store of value. The more attractive bitcoin is as a store of value, the more profitable mining is as a business. As mining becomes more profitable, it attracts more miners. With more miners, computational network security increases. More network security makes bitcoin more valuable. The cycle repeats.

FIGURE 5
Annual Mining Fees, Millions

YEAR	TRANSACTION FEES (\$)	BLOCK REWARDS (\$)	TOTAL (\$)
2011	0	18	18
2012	0	21	21
2013	2	306	308
2014	2	786	788
2015	2	374	377
2016	14	558	571
2017	554	2,832	3,386
2018	291	5,220	5,511
2019	156	5,029	5,184
YTD 2020	203	3,596	3,799
TOTAL	1,224	18,740	19,964

Source: Coin Metrics

BITCOIN CAPEX IS ALREADY NEARLY HALF OF GOLD MINING CAPEX

\$3.9B was spent
on Bitcoin network
capex last year, and
2020 is growing
following the May
reward halving.

Our research shows that bitcoin miners in aggregate already spend 44% of the capex of the 10 largest public gold miners per year. In 2019, the 10 largest gold miners collectively spent \$8.7B on capex. In that same year, bitcoin miners collected revenues of \$5.2B. Bitcoin miners have a capital intensity ratio (capex to revenue) of about 75%. As shown in Figure 6, applying this capital intensity ratio to Bitcoin mining revenue suggests an astonishing \$3.9B was spent on Bitcoin network capex last year, and 2020 is growing following the May reward halving. While Bitcoin network capex vs. gold mining capex is not particularly relevant for anything, and in particular has nothing to do with the efficacy of the bitcoin network, we nevertheless find the framing fascinating and a powerful way to underscore just how mature and scaled the rapidly-growing global bitcoin mining industry already has become.

FIGURE 6
Bitcoin Capex Compared to Gold Miners

GOLD MINING CAPEX IN MILLIONS (\$M)

MINING COMPANY	2019 CAPEX
Barrick Gold	1,701
Newmont Mining	1,463
Kinross Gold	1,105
Agnico Eagle Mines	883
Polyus	822
Newcrest Mining	789
AngloGold Ashanti	703
Gold Fields	613
Polymetal International	436
Harmony Gold	232
TOTAL GOLD MINING CAPEX	8,747

BITCOIN NETWORK CAPEX IN MILLIONS (\$M)

BITCOIN NETWORK	2019 CAPEX
Bitcoin Miner Revenue (\$M)	5,184
Capital Intensity (%)	75
ESTIMATED NETWORK CAPEX (\$M)	3,888
PERCENTAGE OF GOLD MINER CAPEX (%)	44

Source: Bloomberg, Glassnode, NYDIG



FUNDAMENTAL DRIVEN DEMAND COLLIDES WITH DWINDLING SUPPLY

Bitcoin's fixed supply of 21M bitcoin is produced in ever-decreasing amounts, making bitcoin inflation resistant. The protocol produces 144 blocks every day, on average, and rewards the miners of each block with a specific amount of bitcoin. At launch in 2009, this reward amount was 50 bitcoin per block. Every 210,000 blocks, which is predictably and reliably every 4 years, this bitcoin reward is halved. This reward halving is what drives the declining growth rate in bitcoin's supply, which asymptotically approaches 0% between now and the year 2140. Currently running at 1.3% per year, the growth in bitcoin's supply is on par with the historical annual growth in the supply of gold.

Gold has been a reliable store of value primarily because of its scarcity and low annual supply growth – before bitcoin, no form of money has ever had a reliably lower annual supply growth rate than gold. While bitcoin's growth rate is on par with gold today, the next halving in 2024 will put Bitcoin's growth rate below 1%, lower than the lower bound of gold's supply growth over any point during the past 100+ years.

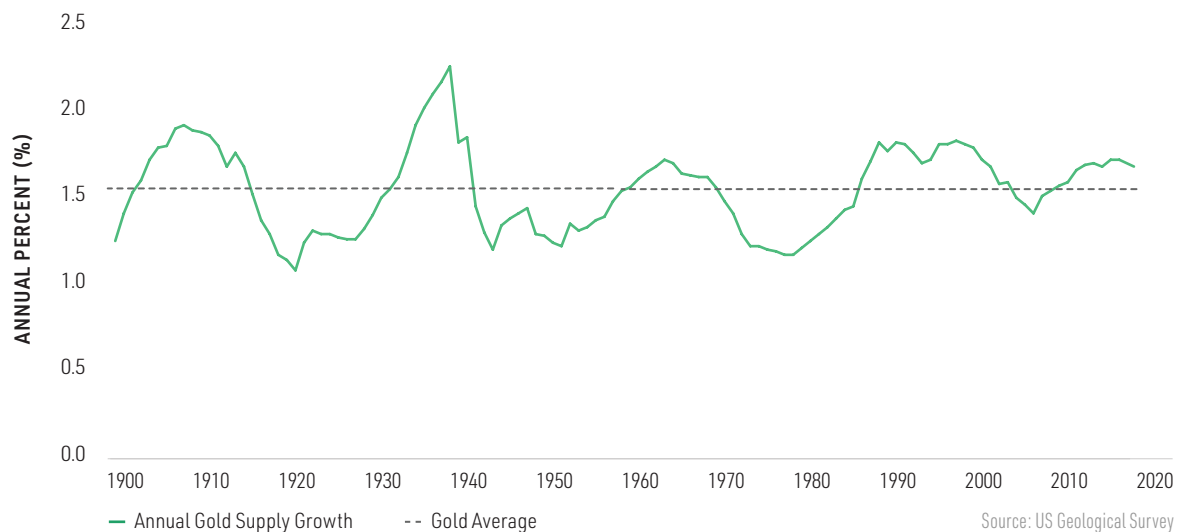
Bitcoin is long past the point of being catchable.

Some observers believe that bitcoin's fixed supply is irrelevant because any other digital asset could copy the Bitcoin code and serve as a replacement. This perspective misses a critical point. While Bitcoin's code is infinitely and inexpensively replicable, its ecosystem is not. Bitcoin's developers, users, miners, merchants, and exchanges, among others, drive the network effect that creates its \$331B moat and unique prominence. Bitcoin-specific mining represents the overwhelming majority of all global energy dedicated to the security of the entire digital asset industry. The bottom line: Bitcoin's code base can be copied, but the credibility, and immutability, of its hard money policies cannot. **Bitcoin is long past the point of being catchable.**

FIGURE 7
Bitcoin's
Annual
Supply
Growth



FIGURE 8
Gold's
Annual
Supply
Growth



VALUING THE BITCOIN NETWORK

Valuing bitcoin, like valuing any asset, is subjective, and we approach this topic with humility. Unlike with stocks or bonds, with bitcoin there are no cash flows to discount. Our approach is to first think of Bitcoin as a network, and then to look at other successful network business models to develop a basic valuation framework.

Money and language were the first, and remain the most important, human created networks.

The logic behind viewing Bitcoin as a network rests on our core insight that any successful money must necessarily be powered by a network effect. To see this, first, imagine a world in which no successful money exists (e.g., increasingly Venezuela, Lebanon, and Turkey today, Zimbabwe 10 years ago, etc.). In such a world, people are reduced to bartering; that is, exchanging goods and services directly for other goods and services without an intermediate money. Viewed purely through the lens of a monetary network, such an economy is extraordinarily inefficient, as it requires $(n * (n+1))/2$ prices, where n is the number of specific goods or services. In a simplified example of a modern economy with, say, one billion goods and services throughout a national supply chain, barter would require about 500 quadrillion individual prices. In contrast, with the introduction of a successful money, that same economy needs only one billion prices, one for each good and service. As n gets larger, the network power of a successful money expands. Money and language were the first, and remain the most important, human created networks.

One common critique of bitcoin is that, because it is rarely used as a medium of exchange, it cannot be a money. That critique misses a fundamental point about the nature of money. The fact that bitcoin, like gold, is not widely used in individual transactions today is irrelevant. For bitcoin to be a store of value, the only requirement is that its holders expect to someday use it in a transaction, or else they would not hold it in the first place. The revealed preferences of every person who owns bitcoin, even the fiercest HODLers (i.e., very, very long-term holders) like ourselves, necessarily implies that zero Bitcoiners believe that they (or their descendants) will never exchange bitcoin for something else at some point in the future, even if that transaction is far into the future.

In this overall context, it becomes clear why we believe that bitcoin's fundamental value is best modeled as a network.

METCALFE'S LAW AND BITCOIN

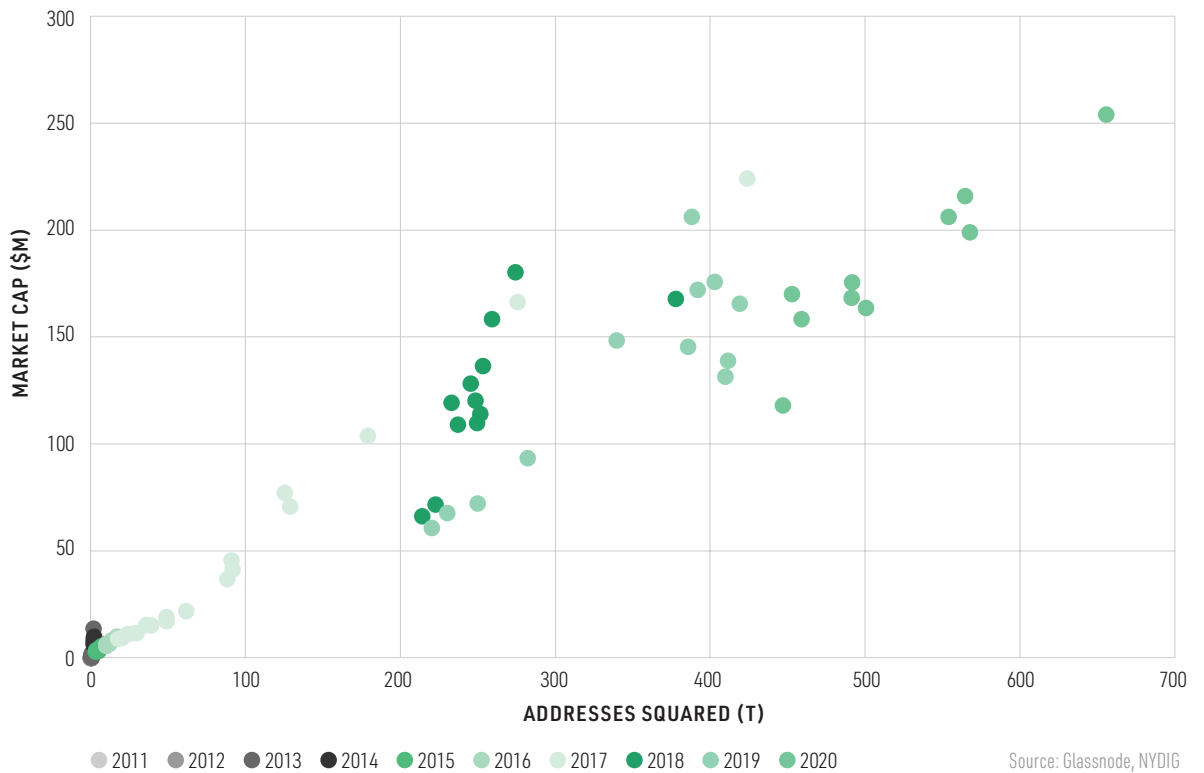
Metcalf's Law, named after the founder of Ethernet technology, Robert Metcalfe, states that the value of a network is proportional to the square of the number of its nodes, n^2 . Metcalfe's conjecture has empirical support from academic research on technology giants Google, Facebook, and Tencent, among others. Given our view that, as an emergent successful money, bitcoin's fundamental value derives from its network effects, bitcoin's value should roughly adhere to Metcalfe's Law. Building on and simplifying prior research in the area, our analysis shows that bitcoin's valuation is well described by the most fundamental factor intrinsic to its network: the number of addresses that hold bitcoin. This may be an important insight for investment professionals who, understandably, require anchoring around a fundamental valuation framework as a necessary component of their allocation diligence and analysis. Next, while acknowledging the statistical challenges of working with price levels rather than changes in price levels, we show that the total value of Bitcoin's network is well explained, with an R squared of 93.8%, simply by the square of its user base, n^2 .

Bitcoin's valuation is well described by the most fundamental factor intrinsic to its network: the number of addresses that hold bitcoin.

BITCOIN MARKET CAP EXPLAINED BY THE SQUARE OF ITS USER BASE

While not precisely equal to the number of people or institutions holding bitcoin, the number of addresses holding bitcoin is an intuitive and parsimonious proxy for Bitcoin's user base. Our expanding monthly regression analysis beginning in 2011 shows that the number of Bitcoin addresses squared explains 93.8% of the variation in the level of Bitcoin's market cap.

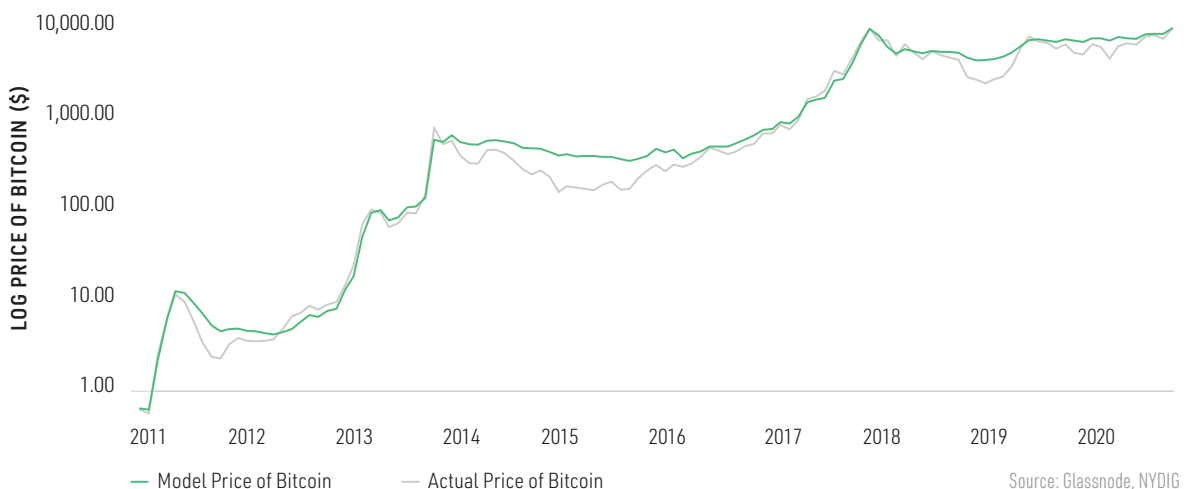
FIGURE 9
Scatter Plot
of Bitcoin's
Market Cap
and Addresses
Squared



CONSTRUCTING A MODEL PRICE

Using the observed number of monthly Bitcoin addresses and the measured factor coefficients with an expanding window, we construct an estimated market cap for Bitcoin and compare that point estimate to its observed market cap. As shown in Figure 10, and both acknowledging and underscoring that this is an entirely in-sample analysis, the estimated and actual price levels follow closely.

FIGURE 10
Bitcoin's
Model Price
vs Actual
Price





FUTURE MARKET CAP LEVELS BASED ON USER GROWTH

The framework we have outlined may be instructive in estimating potential future Bitcoin market cap, and therefore price level. By showing what we believe to be a reasonable range of the annual rate at which Bitcoin addresses will grow over the next 5 years, we can estimate the market cap of bitcoin in the future. To arrive at a price, we divide the future market cap by the predictably known number of coins in the future. We chose a 5-year time horizon to reflect the longer-term investing mindset we strongly suggest investors apply, at a bare minimum, to bitcoin.

We show a purposely wide range of address growth rate, 5% – 25%, to reflect the substantial uncertainty in realized future growth rates. For context, the number of Bitcoin addresses has grown 18% over the past 12 months. While we believe there are good reasons to expect address growth to inflect upward in light of Bitcoin’s improving fundamentals, the reality is that there are many potential future growth rates, and we truly have no idea where growth rates will land. However, even the very top end of the range, 25%, only produces 78.1M addresses in 5 years or about 1% of the world’s population. To us, this suggests that Bitcoin is merely at the very, very beginning of its global adoption. We caveat all below with the reminder that all models are wrong. Some are useful.

FIGURE 11
Potential
5 Year
Price
Levels

ANNUAL ADDRESS GROWTH (%)	NUMBER OF ADDRESSES (M)	PRICE LEVEL (\$)
5	32.7	20,905
10	41.2	33,164
15	51.5	51,611
20	63.7	78,881
25	78.1	118,544

Source: NYDIG

CONCLUSION

Bitcoin has an attractive combination of improving fundamentals and decreasing supply growth which, we believe, supports bitcoin’s price moving materially higher over time. To value bitcoin, we develop a simple model linking bitcoin’s valuation to the size of its user base.

The trillions of dollars currently invested in low or negatively yielding financial instruments will prohibit an enormously large and growing group of individuals from meeting their retirement wants, wishes, and – tragically – even needs. No matter how well-intentioned, unconstrained – and unbacked – global money printing, and the resulting financial repression, is perhaps society’s largest global challenge. Bitcoin is a vitally important tool, and perhaps the most powerful, in the battle. Moreover, from an investment perspective, the ongoing shift out of supposedly safe, no-yielding investments and into bitcoin may have a material impact on bitcoin’s price. For the first time since NYDIG began five years ago, we now see growing, concrete evidence that institutional investment managers and corporate treasurers understand and appreciate the power of Bitcoin’s fundamental factors. This includes the skin in the game of our parent company, Stone Ridge Holdings Group, which recently announced its long-term ownership of more than 10,000 bitcoins as its primary treasury reserve asset, and many others.

For those still on the investing sidelines, we hope that our research represents the first step towards awareness that bitcoin, as an emergent monetary network, has straightforward and observable fundamentals, directly analogous to other network business models and other successful monies throughout history. Further, given Bitcoin’s open-source nature, we can continuously observe the activity on its network, and what we see is quite inspiring.



CLOSING PERSONAL THOUGHTS

Purely from an investment perspective, I can analogize this research piece in six words: **Bitcoin is like Google without antitrust.**

Consider the following thought experiment: imagine 15 years ago that you knew with certainty Google would never be subject to antitrust, ever. How would you have scaled your Google position at the time? Imagine you knew that today. How would you scale Google in your portfolio right now?

Enter Bitcoin. The standard institutional investor approach in evaluating a bitcoin allocation will likely focus on its asymmetric upside potential and lack of correlation. Bitcoin will be run through an industry-standard portfolio optimization framework and, though the optimizer will want an irresponsibly large position, most allocators will end up with an initial 1-5% position.

While I understand the institutional constraints necessitating this approach, it misses the real story and power of Bitcoin, which has everything to do with the nature and importance of sound money.

Money is, and has always been, technology. Specifically, money is technology for making our wealth today available for consumption tomorrow. Sound money – along with language – were the first, and have forever been, the most important human networks responsible for human flourishing. The real Bitcoin story is that Bitcoin is the best technology for money the world has ever seen. Extrapolating the implications of Satoshi's profoundly original insights, I believe Bitcoin's long-term impact on humanity and civilization will be on par with inventions like fire, the wheel, penicillin, the printing press, aqueducts, and the internet.

In future correspondence, NYDIG's research will expand on Bitcoin's long-term, world-changing features – and why they matter – including its:

- **Supply being impervious to its demand**, the first-ever money, or commodity of any kind, for which this is true
- **Guaranteed digital scarcity**, a groundbreaking invention which means, among other things, that when a digital good (i.e., bitcoin) is sent, the sender does not retain a copy (compare that to, say, when an email, or any other digital good, is sent). Guaranteed digital scarcity is what makes bitcoin's fixed supply, its most important feature, actually fixed.
- **Difficulty adjustment**, Bitcoin's most underappreciated breakthrough, a genius application of game theory, and the fundamental reason why its network will always be secure

At the most superficial level, buying bitcoin as a portfolio diversifier, or as a hedge against inflation, makes good sense, and I strongly believe a 0% allocation is the wrong number for every investor.

However, Bitcoin is anything but superficial. In a world replete with unfairness, injustice, the institutionalization of moral hazard, and the State's increasing domestication of our individuality, Bitcoin's incorruptible fairness, justice, truth, and beauty represent a beacon for all optimists who seek personal sovereignty, personal improvement, and peace.

Bitcoin is far more important than a non-zero portfolio allocation.

Ross Stevens, Ph.D.

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