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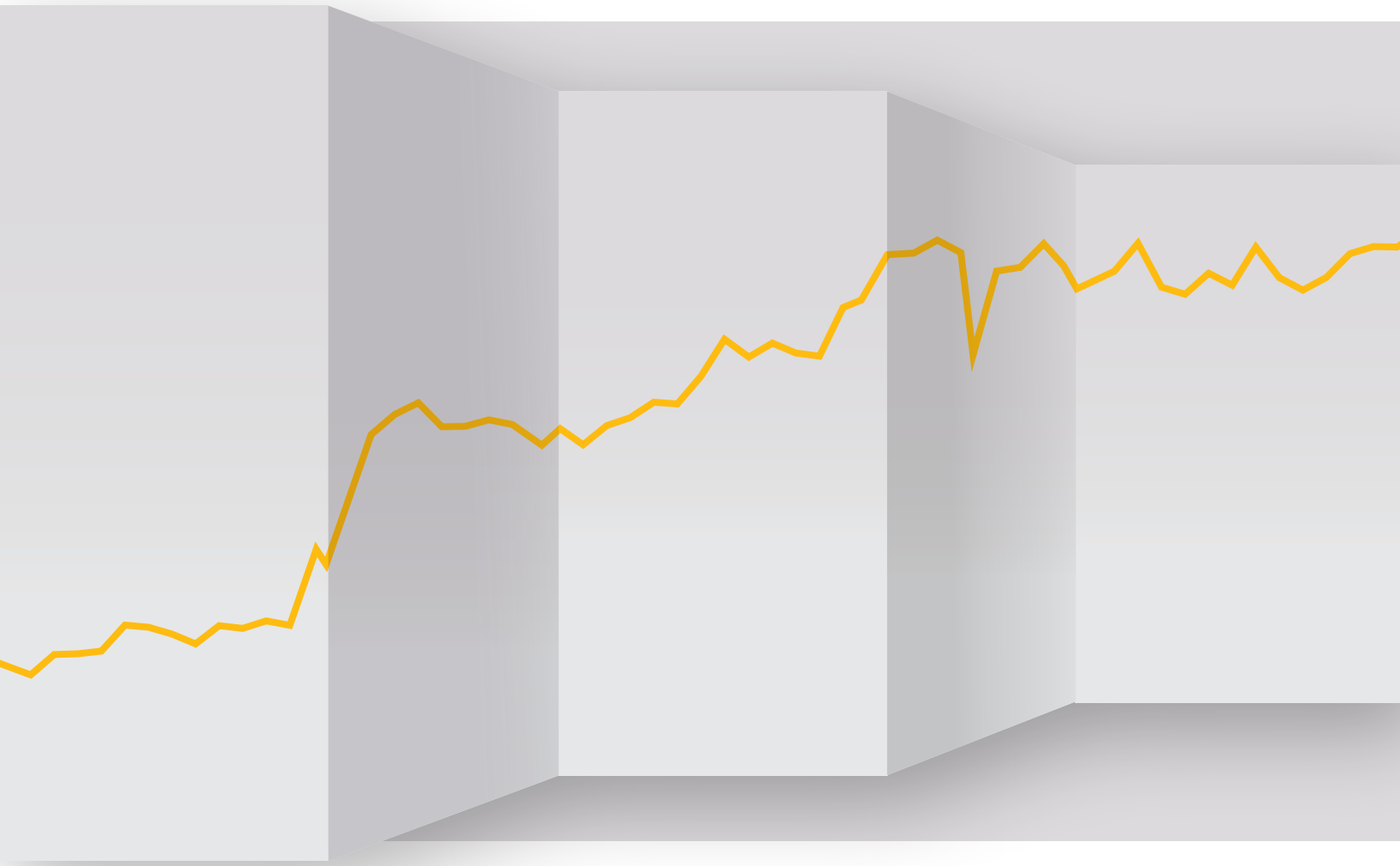

BITCOIN: THE HALVING AND WHY IT MATTERS

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Note: in the following text, "bitcoin" refers to both the cryptocurrency and the network, and $ are U.S. dollars (USD) unless otherwise specified.

INTRODUCTION

It is difficult to overstate just how novel bitcoin's technology is.

It's not just the distributed consensus as to the balances in everyone's wallets, although this is a fascinating validation mechanism.

Nor is it just the pre-programmed monetary policy that cannot be altered by external forces, no matter how powerful.

It's also the intersection of this technology with markets that digest completely new types of information and input new metrics into an untested demand function that then returns prices that move in unpredictable ways.

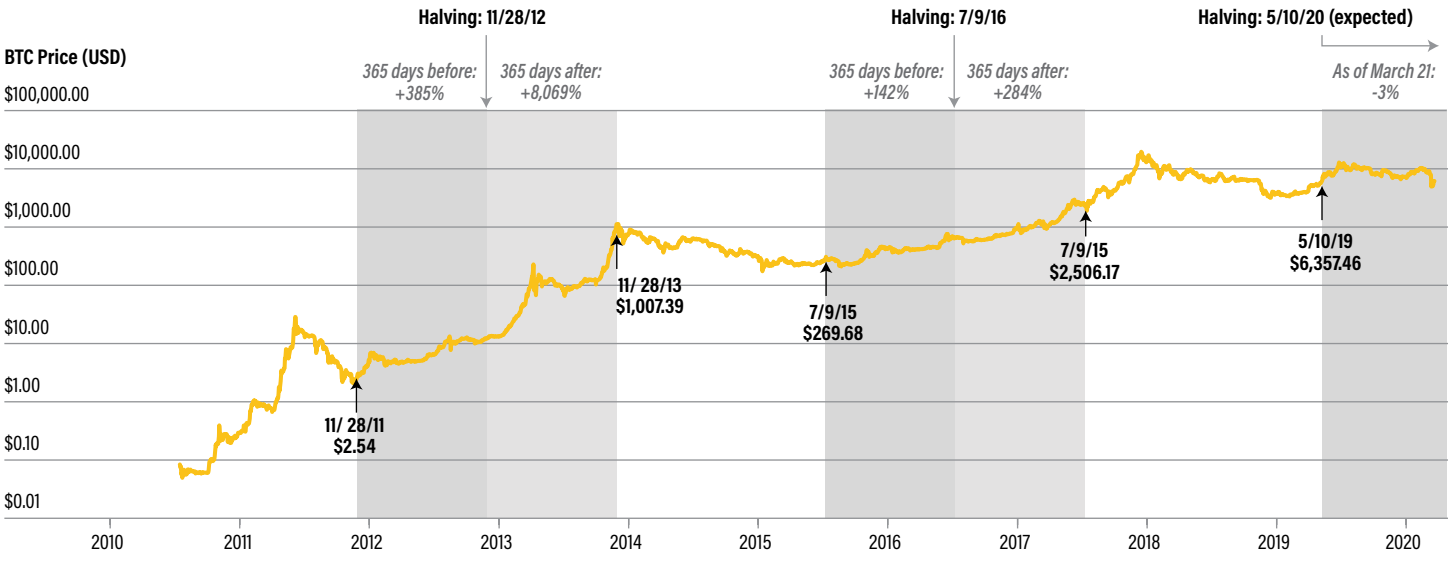
With bitcoin, the technology and the market have a relationship unlike in any other asset class.

In this report, we will look at one feature of the bitcoin protocol—the programmed supply reduction—that has in the past coincided with a strong run-up in the asset's price. Whether it will continue to do so is currently the topic of much conversation and controversy—we will examine both sides of the argument.

The feature that we refer to is known as the "halving" (sometimes also known as the "halvening")—in the next section, we do our best to explain what it is without resorting to a lot of technical terms. We follow with a look at why it matters and why the market is so focused on this event. We attempt to reconcile the various models and theses around the potential bitcoin price reaction as the adjustment approaches, and look at metrics that will shed light on the technological impact. We finish with some input from miners themselves, who lend insight and perspective to the possible consequences of the protocol change.

Nothing in this report should be considered investment advice—we do not know what the bitcoin price will do over the coming months. This report unpacks the market dynamics and technical underpinnings that could affect fundamentals and sentiment as the next bitcoin network adjustment approaches.

Figure 1: Chart with Halvings as Reference Lines



Source: Coin Metrics

WHAT IS THE HALVING?

The "halving" refers to a pre-programmed 50% reduction in the compensation to nodes that maintain the bitcoin network.

These are called "miners." (See sidebar.) Bitcoin miners group transactions into blocks and add them to the blockchain. This requires considerable computing power, which incurs a cost.

To compensate for this cost, the bitcoin protocol automatically includes a fixed amount of new bitcoins in each transaction block. When a block gets successfully added to the blockchain, the miner that processed that block gets to keep those bitcoins. These are known as the "miners' subsidy" or "block subsidy," and part of the "miners' reward" or "block reward" (along with transaction fees).

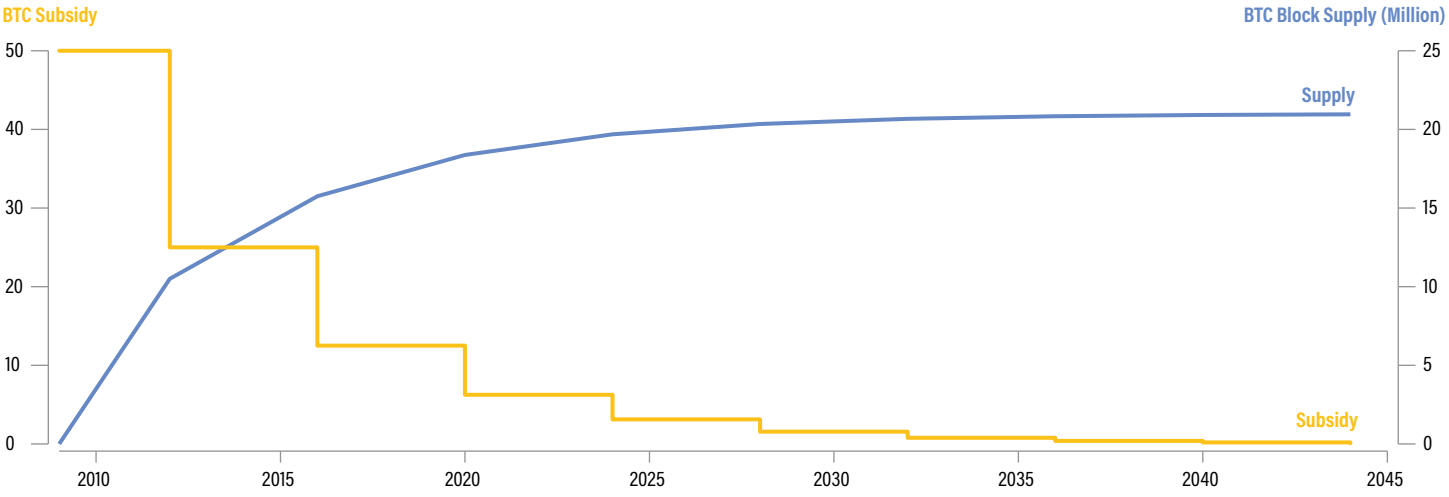
As well as compensating bitcoin miners for their work and expenditure, the reward mechanism controls the issuance of new bitcoins. Miners are the first owners, and can sell those bitcoins into the market via exchanges or OTC desks.

Why do we use the term "miner"?

The term "miner" is used to liken bitcoin to gold. Like gold, bitcoin has a fixed supply limit. And like gold, bitcoin is gradually released into circulation. The work involved in "extracting" bitcoin for circulation is analogous to the work miners do to extract gold from the ground. Hence bitcoin nodes that process transaction blocks came to be known as "miners," and the hardware they use to do so became known as "mining equipment."

Figure 2: Chart of Supply + Subsidy

Bitcoin supply and block subsidy by year



Source: CoinDesk Research

The timing of halvings going forward are estimates based on the state of the bitcoin network and codebase as of March 3, 2020.

Why don't we know exactly when the halving will happen?

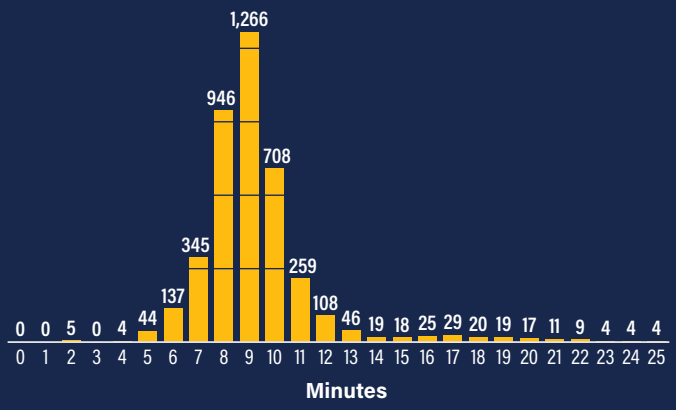
The halving is programmed to occur at certain blockchain lengths—every 210,000 blocks, to be precise. The next one will happen at block 630,000.

Blocks get added to the bitcoin blockchain approximately every 10 minutes—but this is an average figure, and can vary considerably on either side.

Given the compounding nature of even small variations, estimates of the date of the halving range from between early May to mid-June.

The expected addition of mining hash power as the halving approaches means that the event is more likely to occur towards the beginning of that range.

Figure 3: Chart of Block Confirmation Times (No. of blocks)



Data as of March 16, 2020
Block times greater than 25 min are not featured in this chart

Source: Coin Metrics

Bitcoin has a pre-programmed supply limit of 21 million. To taper off the rate of new bitcoin issuance as the circulating supply approaches this limit, the bitcoin protocol self-adjusts the amount of new bitcoin included in each block. It does this by reducing by 50% the amount of the subsidy every 210,000 blocks, which works out to be approximately every four years.

The initial miner subsidy was 50 bitcoins. On November 28, 2012, the amount dropped to 25, and on July 9, 2016, the amount dropped again to 12.5.

The next halving, in which the subsidy drops to 6.25 bitcoins, is expected to occur in May of this year.

To get a glimpse of why bitcoin investors are excited about this upcoming event, take a look at the price movements around the previous two halvings:

Figure 4: Price Changes Around the Time of Past Halvings

Date	Price	% Change
BTC price one year before, during and after the first halving		
November 28, 2011	2.54	-
November 28, 2012	12.33	385.26
November 28, 2013	1,007.39	8,069.11
BTC price one year before, during and after the second halving		
July 9, 2015	269.68	-
July 9, 2016	651.94	141.75
July 9, 2017	2,506.17	284.42
50 days away from the third halving, expected on May 10, 2020		
May 10, 2019	6,357.26	-
March 21, 2020	6,175.83	-2.85

Source: Coin Metrics

WHY DOES THE HALVING MATTER?

Bitcoin's supply schedule is crucial to the value of the network because of its role in the network's security.

NETWORK SECURITY

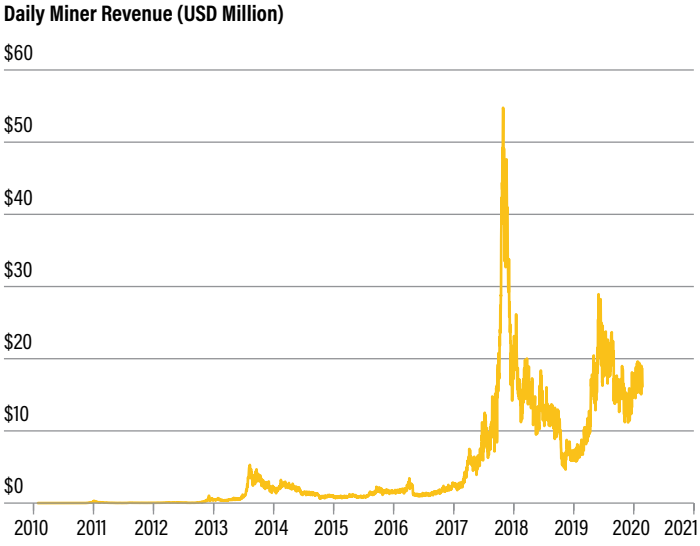
One of the main breakthroughs that bitcoin's pseudonymous creator, Satoshi Nakamoto, achieved with the network's design was an ingenious solution to maintenance incentives. Previous attempts at creating a decentralized currency had stumbled at finding a way around the need to centralize payment to those working to maintain the network.

With one person or entity controlling the compensation to the network maintainers, the network could not be truly decentralized.

Satoshi's solution embeds the compensation in the protocol itself. Bitcoin miners receive their reward from the program—no central authority is involved. The protocol "mints" new coins, following a pre-established schedule, in each block that has been successfully processed. These tokens have value if the network has value.

Herein lies the ingenious incentive mechanism of bitcoin: the miners are incentivized to work towards the network having value, since they are only paid a meaningful amount if the network is a success.

Figure 5: Chart of Bitcoin Revenue (USD Millions)



Source: Coin Metrics

All network creators have to consider the likelihood that bad actors will try to attack the system for personal benefit, either by taking control of the incentives, blocking access for select groups or profiting from the network's collapse.

Since bitcoin does not have a central overseer, there are limited opportunities for sabotage, other than collective action by the miners themselves. In theory, a group of miners could collude to control the transfers that get included in the blockchain, and even undo recent payments.

Yet should this happen, bitcoin would no longer be a trustworthy mechanism to transfer value in a decentralized manner, and it would lose much of its market value.

Since bitcoin miners' rewards depend on bitcoin having value (if their earned bitcoins are worthless, they have no meaningful income), this in theory disincentivizes a network attack.

Furthermore, any attack would require the control of a significant percentage of the network's processing power. If a miner wanted to double spend, for example, or change a transaction that had already been processed, he/she would have to expend considerable computing power just to recalculate subsequent hashes and fight off miners trying to maintain the "honest" chain. Even at reduced energy rates, this would be costly.

Therein lies bitcoin's ingenious incentive mechanism—that it is more costly to attack the system than it is to maintain it.

MINING CONCENTRATION

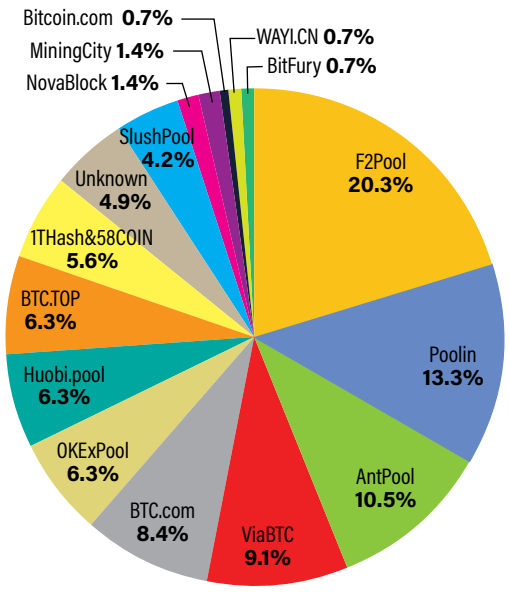
To improve competitiveness and simplify management, miners can choose to join "mining pools." These are groups of miners that elect to pool their resources and share rewards. Economies of scale keep maintenance costs down, and the income spikes from reward allocation are smoothed.

Concerns have been raised that the resulting concentration of mining activity could encourage collusion.[1]

Bitcoin's incentive mechanism, however, makes it costly to attack the system, no matter how concentrated the miners are. Its vulnerability may not change with concentration; it's as easy for 10 or 20 miners to collude as it is for five.[2] Bitcoin works because miners have more to gain from processing blocks impartially than from using their computing power to enrich themselves at the expense of others.

Furthermore, recent developments show that mining power is becoming less concentrated over time as more miners enter the sector and as the activity becomes more diversified geographically. In May of 2016, the four largest mining pools—all based in China (see sidebar on next page)—held almost 75%[3] of the network's hashing power. At time of writing, however, that proportion had declined to just over 57%.

Figure 6: Chart of Mining Pool Concentration



Source: BTC.com

Data from March 6, 2020

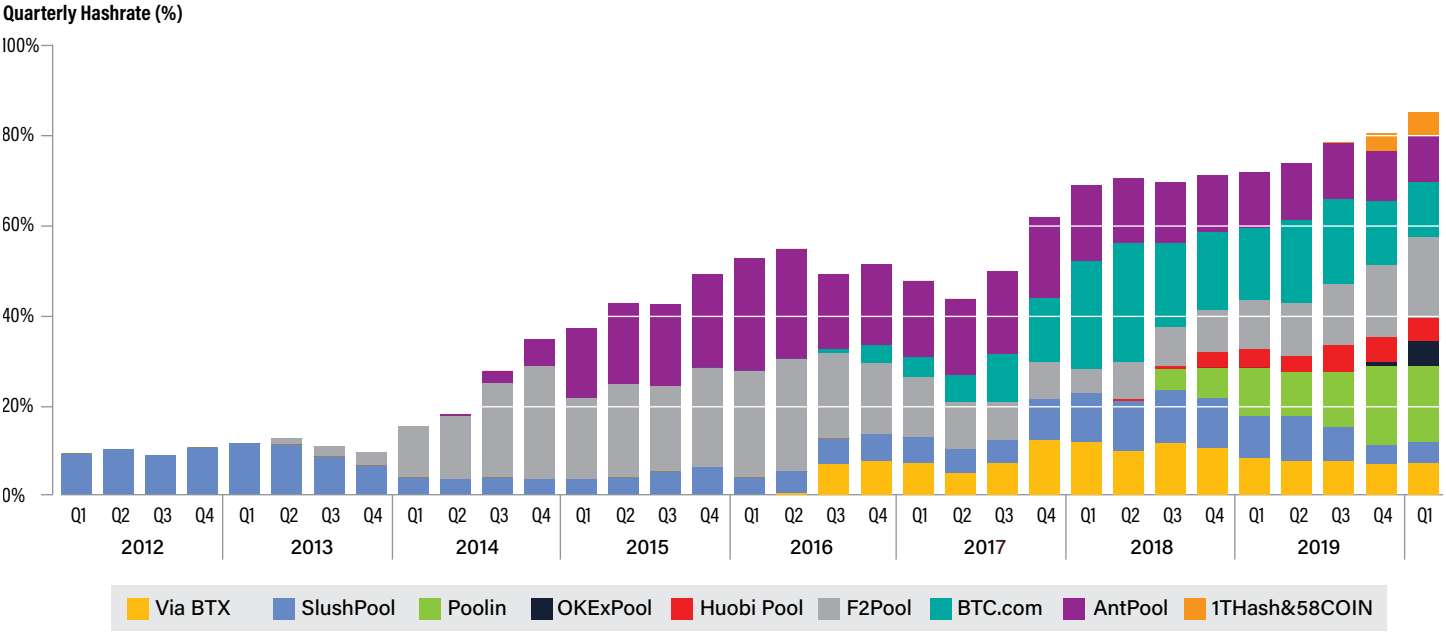
1 Olga Kharif, "Bitcoin's Network Operations Are Controlled by Five Companies," Bloomberg, January 31, 2020

2 Hasu, "No, Concentration Among Miners Isn't Going to Break Bitcoin," CoinDesk, Feb. 20, 2020

3 https://btc.com/stats/pool

Figure 7: Chart on Mining Concentration Evolution

Largest Mining Pools' % of Hashrate, Averaged by Quarter



Largest mining pools by hashrate, as of March 2020

Source: BTC.com

Concerns about mining centralization in China tend to overlook two things:

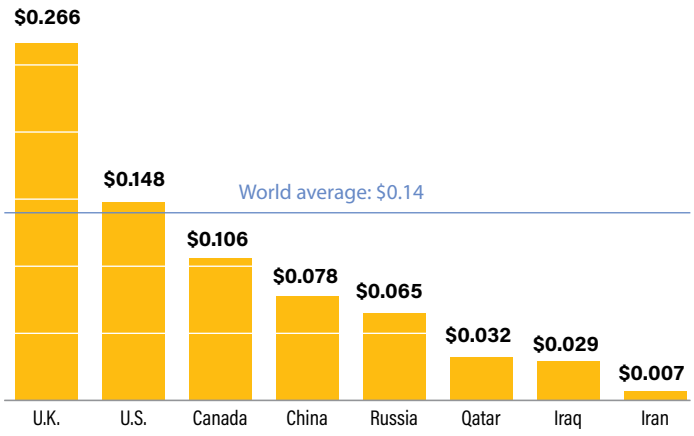
- mining pools are composed of thousands of individual miners or mining groups, who can migrate to other mining pools if they ever suspect theirs of irregular behavior;
- the location of the miners contributing hash power to a pool does not have to coincide with that of the pool operator; most mining pool websites are available in several languages.

The halving could end up having an impact on miner concentration as electricity costs become an even more significant factor in the viability of operations.

Electricity is 40 percent cheaper per household in China than the U.S., according to December 2019 figures from Global Petrol Prices. Costs are even cheaper in Middle Eastern countries such as Iran, Qatar and Iraq. This could imply that mining operations located in the U.S. are more likely to shut down than those in China and the Middle East if bitcoin prices do not rise post-halving. It could also hint at a possible transfer of operations to other jurisdictions with lower electricity costs, although many of these are in high-temperature areas, where the additional costs from keeping the machines cool could offset potential savings.

Figure 8: Chart of Elecricity Prices

Data as of June 2019



Source: Global Petrol Prices

Why China?

Since the early days of the industrialization of bitcoin mining, China has played a prominent role. One likely reason is the relatively low electricity cost, which accounts for the bulk of miners' operating costs. Data from Global Petrol Prices[1] shows that average electricity prices are less than one third those of the U.K., and almost half those of the U.S.

Furthermore, China has made a significant push into hydroelectricity,[2] which is now the second largest power source in the country. Dams are often in remote areas, which offers the attractive combination of cheap land and cheap, clean energy with low transmission costs. Most Chinese miners are concentrated in the Sichuan province,[3] which is the country's largest producer of hydropower,[4] due in part to its long rainy season.

Finally, Bitmain—one of the biggest bitcoin mining equipment manufacturers and pool operators—is based in China. At its peak, from late 2018 to mid 2019, Bitmain controlled over 30 percent of network hash power through operating bitcoin mining pools BTC.com and Antpool. Aside from hash power, bitcoin miners who are closer in proximity to Bitmain hardware factories are able to gain a competitive advantage over other miners by getting their hands on the latest, most efficient machines. As such, part of the centralization of bitcoin mining in China has historically been further focused on one company.

The centralization of bitcoin mining in China does present a small but real security threat to the bitcoin network. Theoretically, the Chinese government could force mass shutdowns of mining pool operators F2Pool, Poolin and Bitmain, all located in the country. These three operators are responsible for about 55 percent of network hash power. The sudden shut-down of their contribution could disrupt the network. It is possible that unforeseen reasons could motivate Beijing to shut down mining.

1 https://www.globalpetrolprices.com/electricity_prices/
2 Wikipedia, "Hydroelectricity in China"
3 Garrick Hileman and Michel Rauchs, "2017 Global Cryptocurrency Benchmarking Study," May 2017
4 Georgina Lee, "Sichuan beckons power-hungry cryptocurrency miners to the home of the pandas with cheap and plentiful hydroelectricity," South China Morning Post, October 31, 2019

MINER ECONOMICS

REVENUE

Revenue from mining activities comes from two main sources: the block subsidy, and transaction fees.

Block subsidy

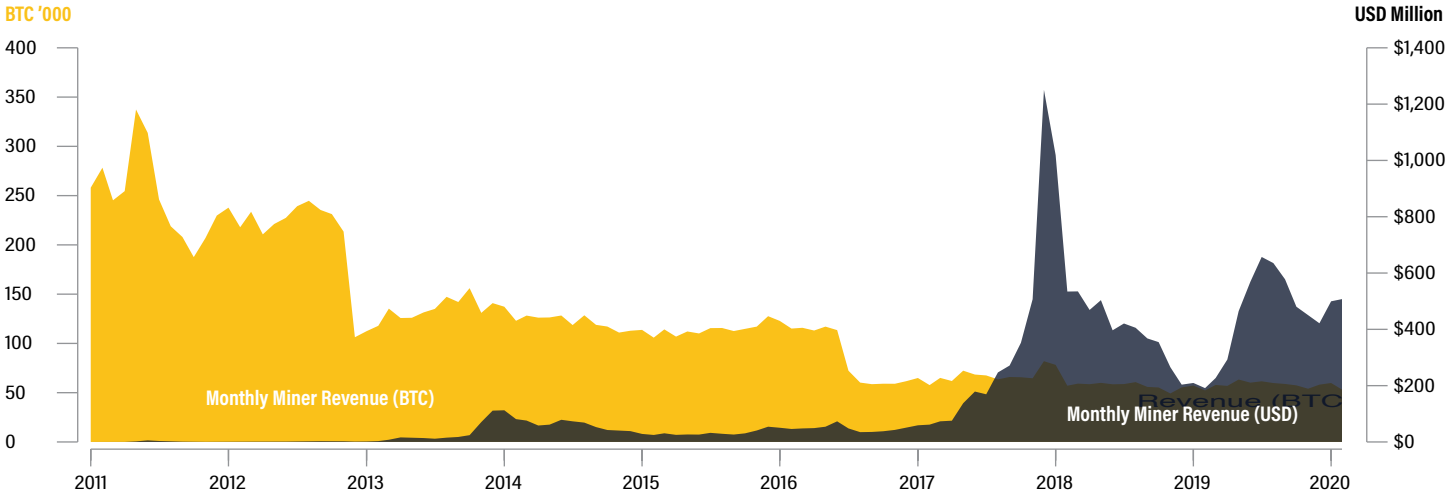
As explained above, bitcoin miners get allocated a fixed number of bitcoins in each block they successfully process and append to the blockchain. Every four years or so, the protocol cuts this number in half.

A 50% reduction in the block subsidy does not necessarily mean that the miners' revenue is slashed by half, however.

The 50% refers to the number of bitcoins allocated—but the value of these bitcoins is measured in fiat currency. If the U.S. dollar price of bitcoin goes up, the value of the reward also goes up. And if the U.S. dollar price of bitcoin goes down, the value falls even further.

In February 2020, the total U.S. dollar value of new bitcoins issued was more than 10x the value of those issued in the month prior to the last halving.

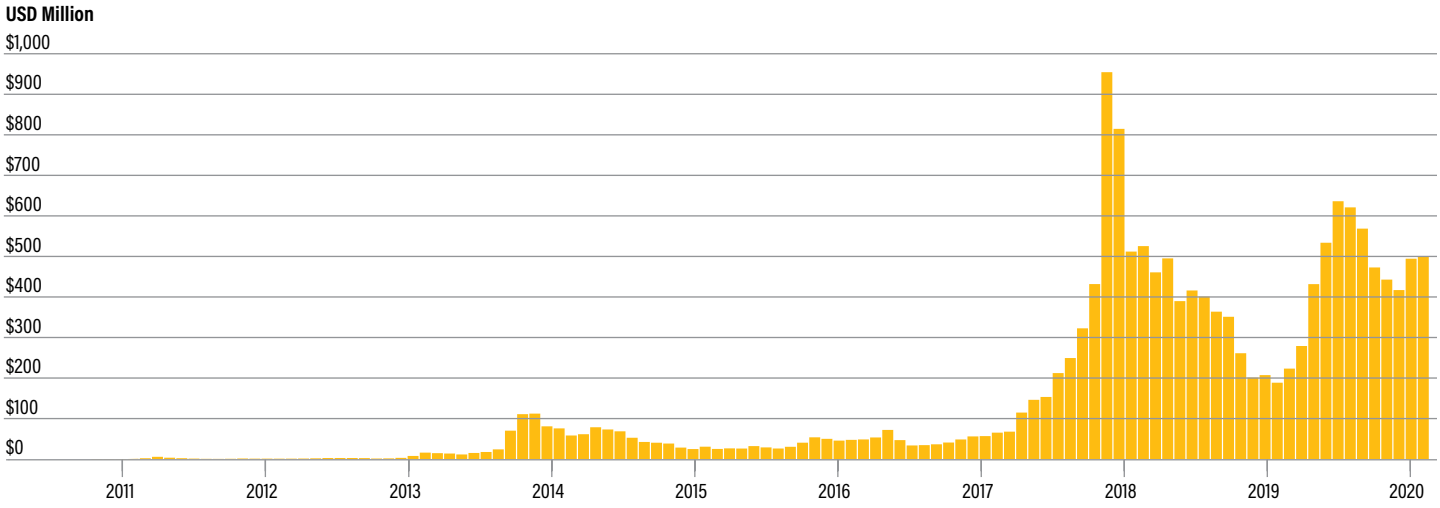
Figure 9: Chart of Monthly Miners' Revenue in Native Units and USD



Source: Coin Metrics

Figure 10: Chart of USD Value of New Bitcoins Monthly

USD value of new bitcoins issued each month



Source: Coin Metrics

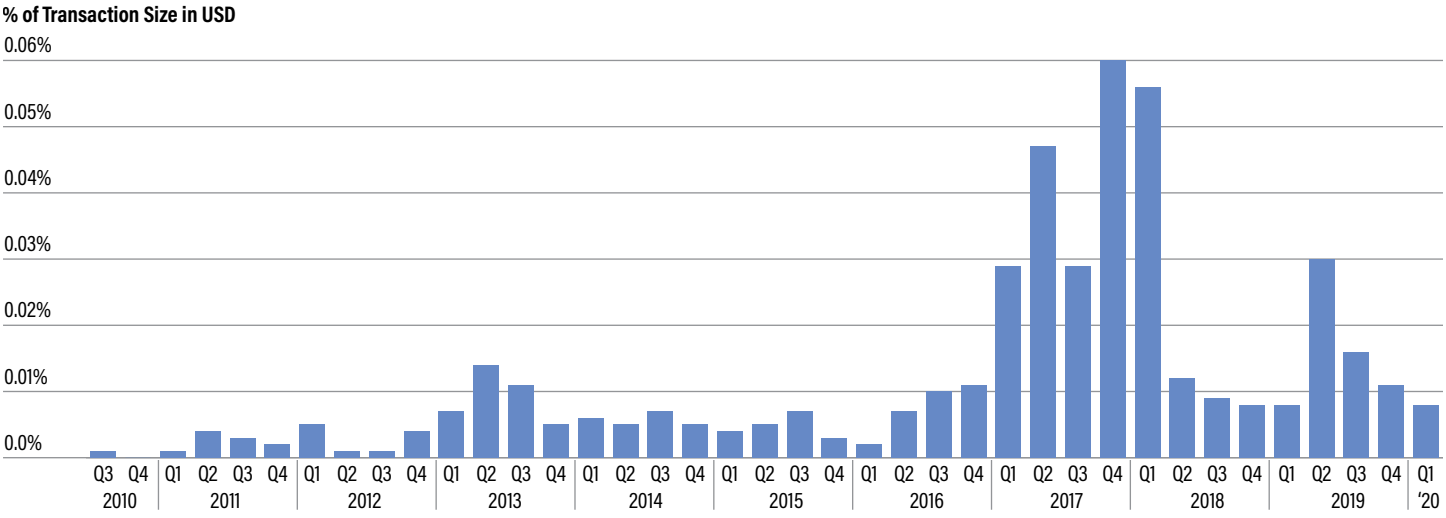
Transaction fees

The block subsidies are not the only compensation bitcoin miners receive. Each transaction included in a block contains transaction fees, which the miners that successfully add the block to the blockchain get to keep.

Since the beginning of 2019, transaction fees have averaged 0.012% of the transaction size in U.S. dollars, although in times of heavy network activity, quarterly averages have spiked to as much as 0.06% (and nearly 0.3% on their peak day in the height of the 2017 bull run).

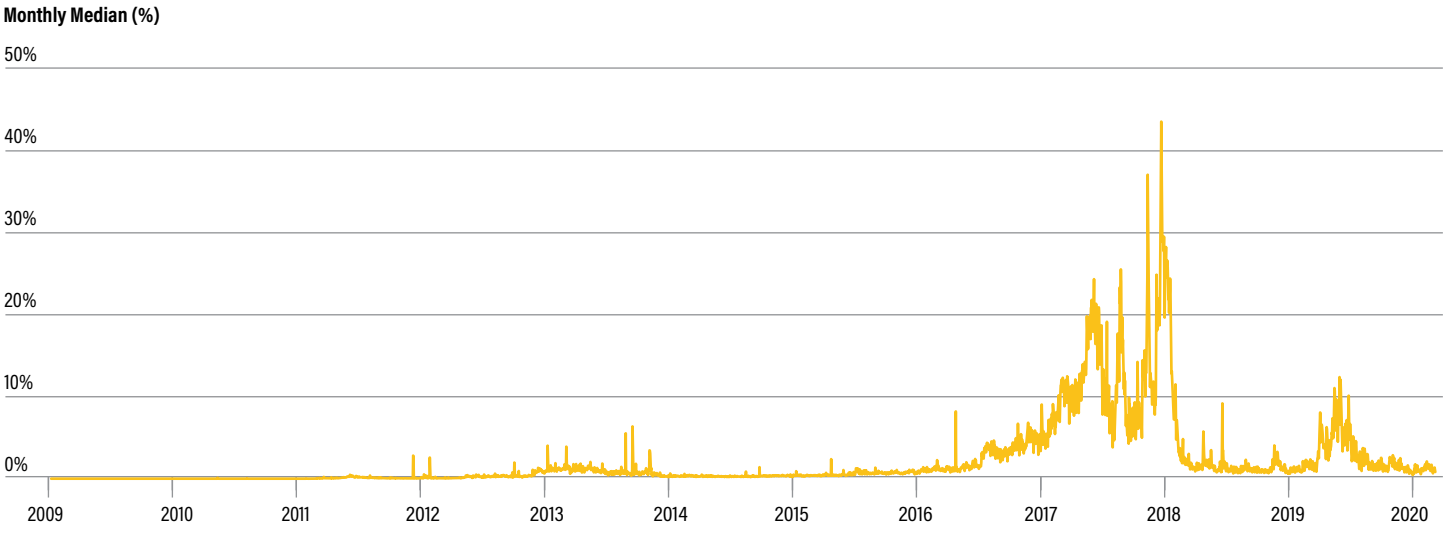
Currently transaction fees are not essential for network security, as the bulk of miners' compensation comes from the block rewards. This will change, however, as block rewards diminish. Given the increasing focus on transaction fees going forward, it is worth spending some time looking at their composition and evolution.

Figure 11: Average Bitcoin Transaction Fee (% of Transaction Size in USD)



Source: Coin Metrics

Figure 12: Chart of Transaction Fees as a % of Miner Revenue



Source: Coin Metrics

Transaction fees are optional, and set by the user, not the miners. Most wallets have a default amount which users can adjust if they wish.

Miners choose which transactions they include in a block, however, and may overlook transactions with zero or low fees. Users who need their transactions processed relatively quickly are likely to include higher transaction fees—those that don't mind waiting a while will probably opt for lower fees.

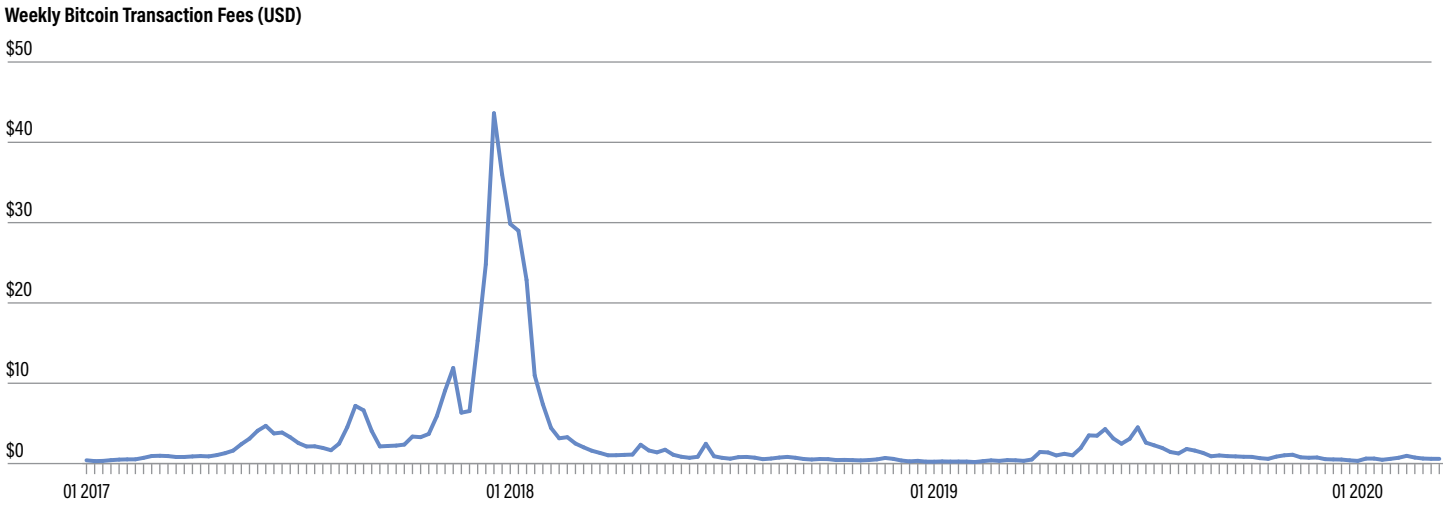
Another factor influencing transaction fees is the average block size. Bitcoin's blocks have a maximum size of 1 million vbytes, which is theoretically equivalent to approximately 4MB.[1] Should transaction volume grow to the extent that block space becomes scarce, fees are likely to increase.

Merged mining

Many miners supplement their bitcoin-based income with the simultaneous production of other cryptocurrencies. Known as "merged mining," this allows miners to use the same resources and power consumption to search for the right hash function to append blocks onto other blockchains that share the same hash algorithm.

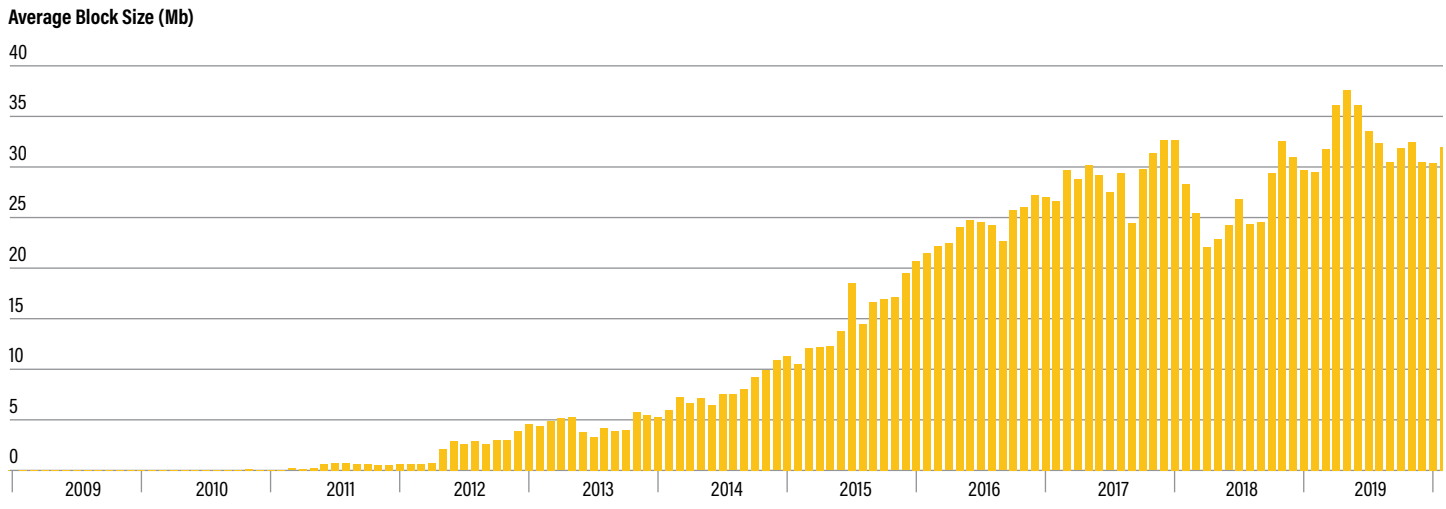
1 Bitcoin Magazine, "What Is The Bitcoin Block Size Limit?"

Figure 13: Average Bitcoin Transaction Fees by Week (USD)



Source: Coin Metrics

Figure 14: Average Block Size (Megabytes) vs. Time



Source: Coin Metrics

For instance, F2Pool and Poolin, the two largest pools at time of writing, both allow merged mining for a cryptocurrency called VCash. F2Pool recently added merged mining options for Namecoin and Elastos.[1] Other pools offer other combinations.

Additional revenue from merged mining could help to insulate miners from movements in the bitcoin price, especially as this practice grows.

COST STRUCTURE

Mining equipment

Processing a transaction block and receiving the miners' reward is a game of luck, which can be influenced by having more powerful and more efficient computing power than competitors. The faster the computations, the more likely it is that the requisite hash will be found; the more efficient the machines, the lower the cost of production and the more profitable each found bitcoin.

A top-end mining machine today (such as the Bitmain Antminer S17+ or the Whatsminer M20S) costs approximately $1,500 to $2,000,[2] and new equipment emerges on average every year. In the run-up to the halving, some miners are repurposing older machines which retail for as little as a few hundred dollars.

As the halving approaches, many miners are upgrading their machines to maximize efficiency in preparation for the reduction in earned bitcoins, in case the shortfall is not compensated by a price increase. The disruption of supply chains[3] triggered by the coronavirus scare may delay some machine upgrades and cause price swings in new equipment, which is likely to affect short-term profitability and cash flow. But miners already heavily invested in the bitcoin ecosystem are likely to have the longer term in mind.

Hashrate

The speed at which a cryptocurrency mining device operates is known as the "hashrate."

The term derives from "hash function," a code script that transforms strings of variable length to strings of fixed, uniform length. Hash functions are used throughout cryptography to facilitate the storage and manipulation of information, and are a key part of cryptocurrency protocols.

Passing a text through a hash function is known as "hashing," and the result is called the "hash."

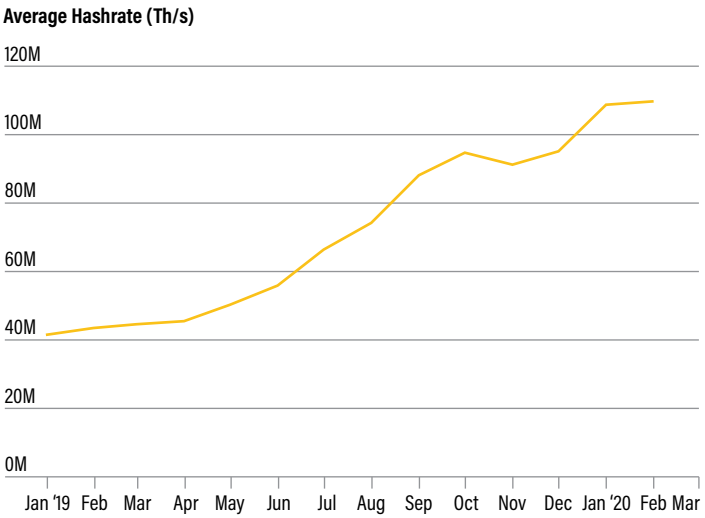
Bitcoin relies on the SHA-256 hash function, created by the U.S. National Security Agency in 2002. The function's name is shorthand for "Secure Hash Algorithm with a 256-bit key." Bitcoin mining involves a stream of hashing attempts, and the speed at which the hash function runs is called the "hashrate."

The hashrate matters in miner economics, because the faster the computer, the greater the number of attempts to produce a hash that satisfies the established criteria, necessary for a block to be added to the blockchain. Each block successfully added includes the miners' reward previously discussed.

The numbers

The hashrate is typically measured in hashes per second (h/s)—for convenience, most data sources track tera-hashes (Th/s, trillion hashes per second), peta-hashes (Ph/s, quadrillion hashes per second) or exa-hashes (Eh/s, quintillion hashes per second). The average hashrate for January 2020 was 109,247,899 Th/s.

Figure 15: Monthly Average Bitcoin Hashrate since 2019



Source: Coin Metrics

1 F2Pool, "Mine BTC with F2Pool and receive ELA, NMC and VCash merged mining rewards!," October 24, 2019

2 https://prominerz.com/shop/bitmain-antminer-s17-73t/?wpam_id=1&v=7516fd43adaa, https://whatsminer.net/shop/

3 Wolfie Zhao, "Bitcoin's Computing Power Is Growing Again After Coronavirus-Related Disruption," CoinDesk, March 4, 2020

The evolution of mining equipment

In the early days, bitcoin enthusiasts could earn 50 bitcoin per processed block by running the software on their desktop computers.

As the market value of bitcoin increased, more people became interested in mining bitcoin. To gain a competitive advantage, miners and equipment manufacturers invested resources into researching and developing new machinery that could run faster and more efficiently than the average household computer. The first bitcoin graphics processing units (GPUs) emerged in late 2010,[1] costing a few hundred U.S. dollars and running five times faster[2] than standard computer processing units (CPUs). In June 2011 field-programmable gate arrays (FPGAs) were specially configured for bitcoin mining, requiring three times less power[3] to run than standard GPUs.

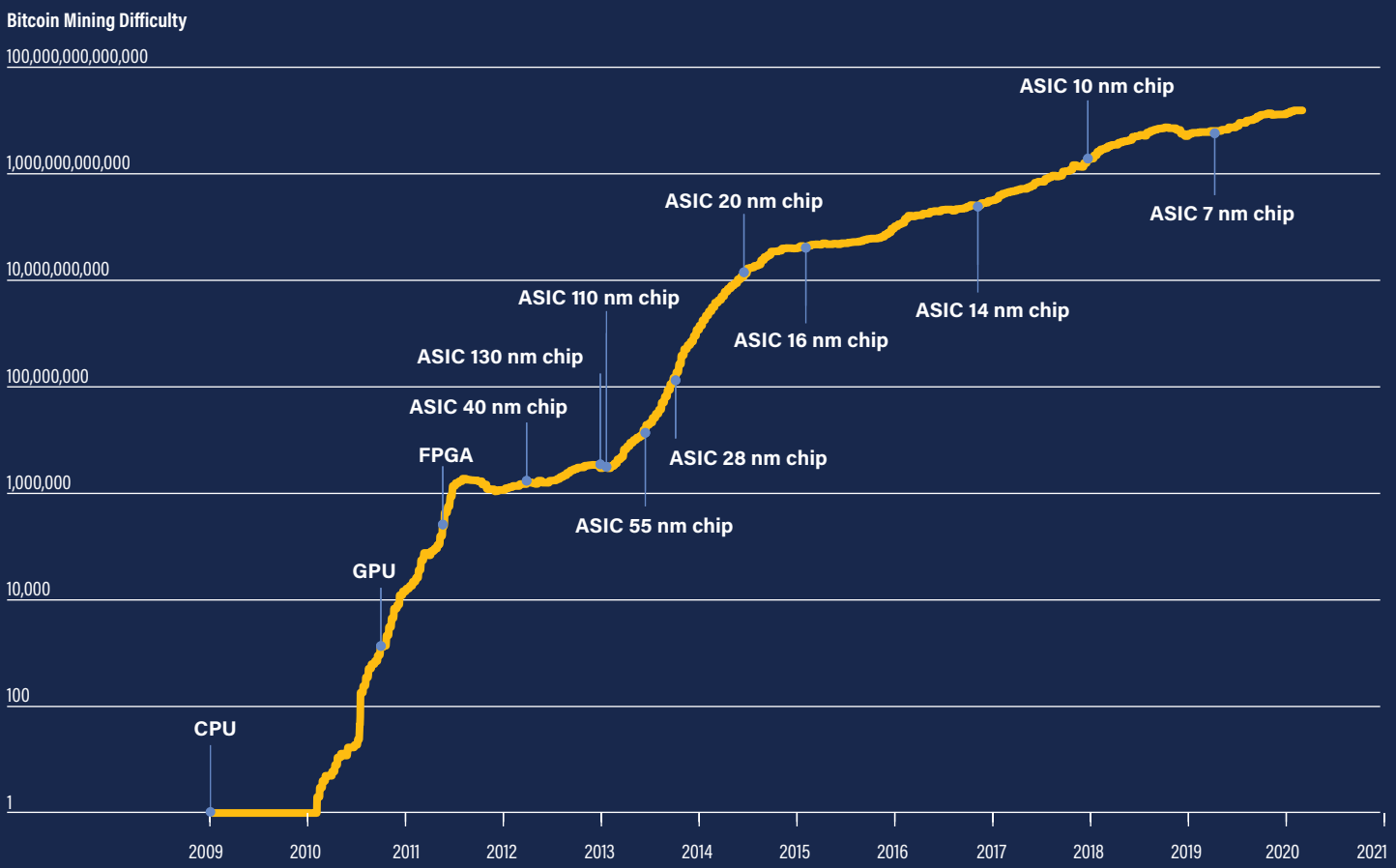
Rather than repurpose existing pieces of CPU, GPU or FPGA hardware, Chinese chip manufacturer Canaan Creative built specialized machines designed from the ground up for miner use only. Called "Avalon", these devices, released in 2013,[4] were the world's first application-specific integrated circuits (ASICs) optimized for bitcoin mining. From this point on, it became increasingly unprofitable for miners with general purpose hardware to compete with ASIC machines.

The evolution did not stop there—bitcoin ASICs have been undergoing rapid upgrades that supersede older models. Every one to two years since the advent of the Avalon chip, smaller ASIC chips improving the efficiency of mining operations have been released.

And it's not just about the chips: the latest innovations to mining technology focus on new methods of machine cooling, such as liquid gels and immersion, which could reduce energy waste and operating costs as well as make machines even more efficient.

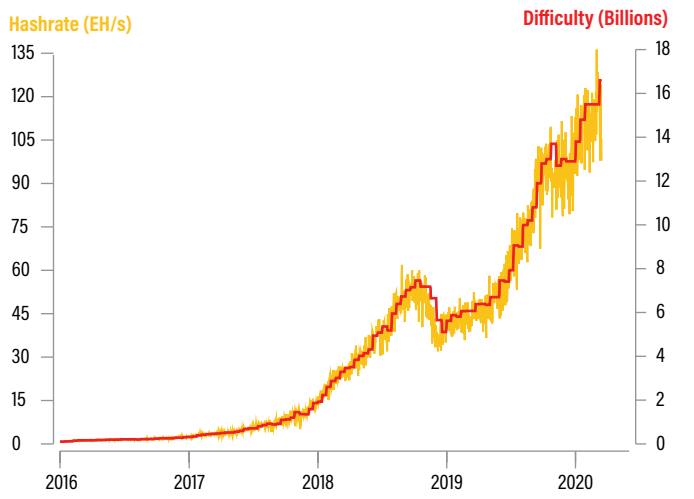
1 Michael Bedford Taylor, "The Evolution of Bitcoin Hardware"
2 Bitcoin Wiki, "Why a GPU mines faster than a CPU"
3 Tristan Greene, "A brief history of bitcoin mining hardware," TNW, February 2, 2018
4 Stan Higgins, "Maker of First Bitcoin Mining ASIC Acquired in What Could Be Industry's Largest Sale," CoinDesk, June 8, 2016

Figure 16: Timeline of Mining Hardware Upgrades



Source: "The Evolution of Bitcoin Hardware" buy Michael Bedford Taylor, University of Washington; CoinDesk Research

Figure 17: Bitcoin Hashrate and Difficulty



Source: Coin Metrics

In the early days, bitcoin's hashrate was around 1] Th/s, which could be easily handled by most personal computers. Now, sophisticated application-specific integrated circuits (ASICs) produce hashrates of as much as 110 Th/s, and technological advances are likely to keep pushing up this rate.

Another factor in the hashrate is the number of machines running the hash function. The more machines applying their hashing power, the greater the hashrate. Higher hashrates increase the likelihood of blocks being processed, which shortens the confirmation time.

To understand why, let's look at coin flips. If you have one person flipping a coin, that person will eventually get a coin heads-side up. If you have 10 people flipping a coin, however, a heads will come up much sooner. The greater the number of machines working on solving a problem, the shorter the likely time between solutions.

To offset this, bitcoin's protocol has a "difficulty rate" which automatically adjusts to make it harder to successfully process blocks, to keep the confirmation time at around 10 minutes (see sidebar).

The hashrate displayed by data providers is not calculated directly from operating mining machines—it is inferred using a ratio of the number of blocks found to the expected number of blocks, multiplied by the difficulty rate.

What is the difficulty rate?

To gradually release new bitcoins into the system, the rate at which transaction blocks are processed and added to the blockchain (which is also the rate at which the block rewards are generated) is modulated to be once every 10 minutes or so. This is controlled through the "difficulty rate." The difficulty rate is the measure of how difficult it is to process a block.

To be able to add a block of transactions to the blockchain (and claim the reward), a miner needs to solve a puzzle: it needs to find the "nonce" (a random number) that, when added to the block of transactions, will generate a hash that meets a certain criteria. The likelihood of any one nonce solving the puzzle is totally random. One nonce proving successful does not mean that the next sequential number will also produce a hash that satisfies the requirement. Hence the need for computers to test as many random numbers as possible, as fast as possible.

The difficulty rate is adjusted every 2016 blocks, or approximately every two weeks. If block confirmation times are averaging less than the desired 10 minutes, the difficulty rate will be adjusted up – that is, a zero will be added to the hash requirements (for instance, instead of five zeroes in front of the string, the hash will need to have six). If the blocks are taking longer than expected to process, a zero will be removed.

Difficulty is usually measured by comparing the difficulty of the current target versus the easiest possible target. Bitcoin has a base difficulty where the hash requirement must have at least seven zeros. For every zero that is added to the requirement, the difficulty increases by 32 times. It is currently 10,000 billion times more difficult to find a block than during the creation of bitcoin when difficulty was at its lowest.

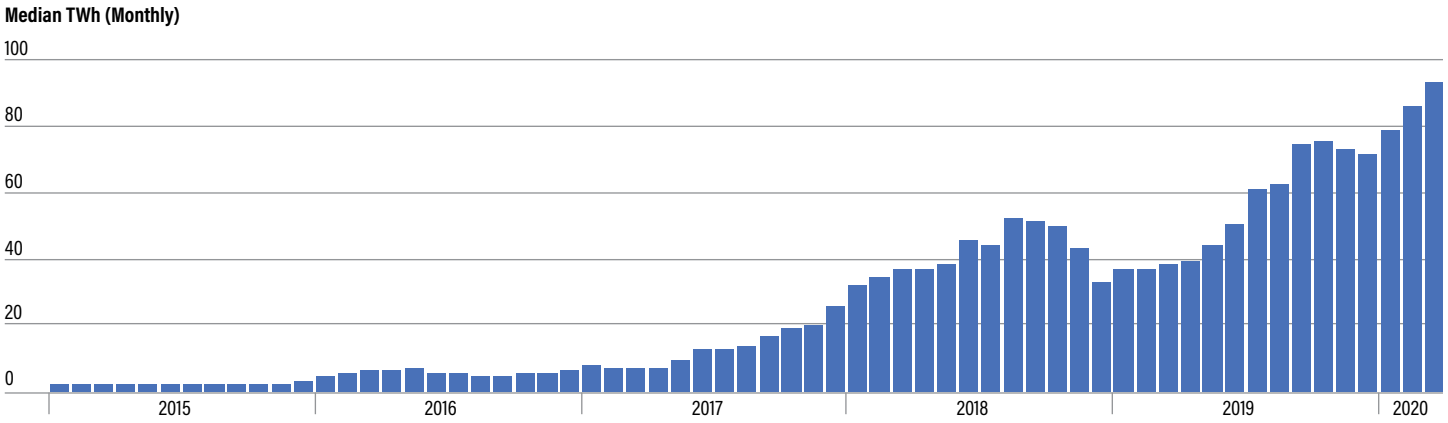
The costs

Given that the hashrate represents the number of machines and computations processing transaction blocks, it is often taken as a proxy for the overall cost of maintaining the bitcoin network.

The Cambridge Centre for Alternative Finance[1] calculated an index of bitcoin electricity consumption by taking into account the hashrate, the average cost of electricity, mining equipment efficiency, data center efficiency and miner revenue (which determines how many miners drop out as the energy cost rises relative to the bitcoin price). At time of writing, its estimated

1 University of Cambridge Judge Business School, "Cambridge Bitcoin Electricity Consumption Index"

Figure 18: Estimated Bitcoin Electricity Consumption (TWh, Monthly)



Source: Cambridge Centre for Alternative Finance

Assumes average electricity cost is $0.05 per kilowatt hour

annualized result has been rising steadily since early December and is currently at an all-time high of over 90 terawatt-hours (TWh).[1, 2]

Multiplying this by an estimated electricity cost gives an approximation of the overall network maintenance cost—although the electricity cost assumption itself influences the model through how many miners are participating. The model above assumes a static cost of $0.05/kWh, which puts the network electricity cost at approximately $4.5 billion per year at current consumption levels and prices.

Further back-of-the-envelope calculations show that, assuming that level of electricity consumption and a constant bitcoin price of $8,500, the network as a whole would not be profitable in 2020.

Note that the above calculations are not realistic estimates in that the price itself will affect the electricity consumption as unprofitable miners switch off their machines. It also does not take into account variations in electricity costs, chip efficiency, cooling requirements, building maintenance and other operating considerations.

For example, in its Q3 2019 report, Hut8—an Alberta-based bitcoin mining company listed on the Toronto Stock Exchange, and the largest of the listed mining companies in terms of capacity and market cap—reported a gross operating cost per bitcoin of $4,250, which on the surface looks very profitable.

Figure 19: Estimated Mining Profits in 2020

No. of blocks in 2020	52,704	52,704
Halving occurs mid-May (# month)	4.5	4.5
New bitcoin @ 12.5 subsidy	247,050	247,050
New bitcoin @ 6.25 subsidy	205,875	205,875
Total new coins	452,925	452,925
Average price	**$8,500**	**$11,000**
Total income	$3,849,862,500	$4,982,175,000
Annualized electricity consumption est. (TWh)*	90.6	90.6
Assumed average cost of electricity ($/kWh)	$0.05	$0.05
Total estimated cost of bitcoin electricity consumption for 2020	$4,530,000,000	$4,530,000,000
Profit	**($680,137,500)**	**$452,175,000**

**Cambridge Centre for Alternative Finance*

Including other operating expenses, however, pushes the cost up to $7,475, and this is without including depreciation.[3]

What's more, mining rigs normally require steep depreciation due to the relatively rapid evolution of the technology. While not an operating cost, this does affect P&L statements which in turn could impact financing ability.

1 https://www.cbeci.org/methodology/
2 https://www.cbeci.org/ (downloadable csv)
3 https://hut8mining.com/wp-content/uploads/2020/01/Hut-8-Investors-Presentation-20200113.pdf

Operating at a loss makes it likely that miners will switch off unprofitable machines, but it's not a given—some miners will be willing to keep the machines running in the expectation of recouping losses later. Those who locked in favorable electricity rates may have penalty clauses if consumption drops below a certain level. And others may choose to mine for the status or even the ideology.

It's also worth bearing in mind that Sichuan—the region with the highest concentration of bitcoin miners—is in southern China, which is typically in the middle of a rainy season around the time of the halving. This should make hydroelectric energy costs cheaper still, and could encourage miners to decide to ride out the revenue cut in the hopes of a bitcoin price appreciation later in the year.

Hashrate and price

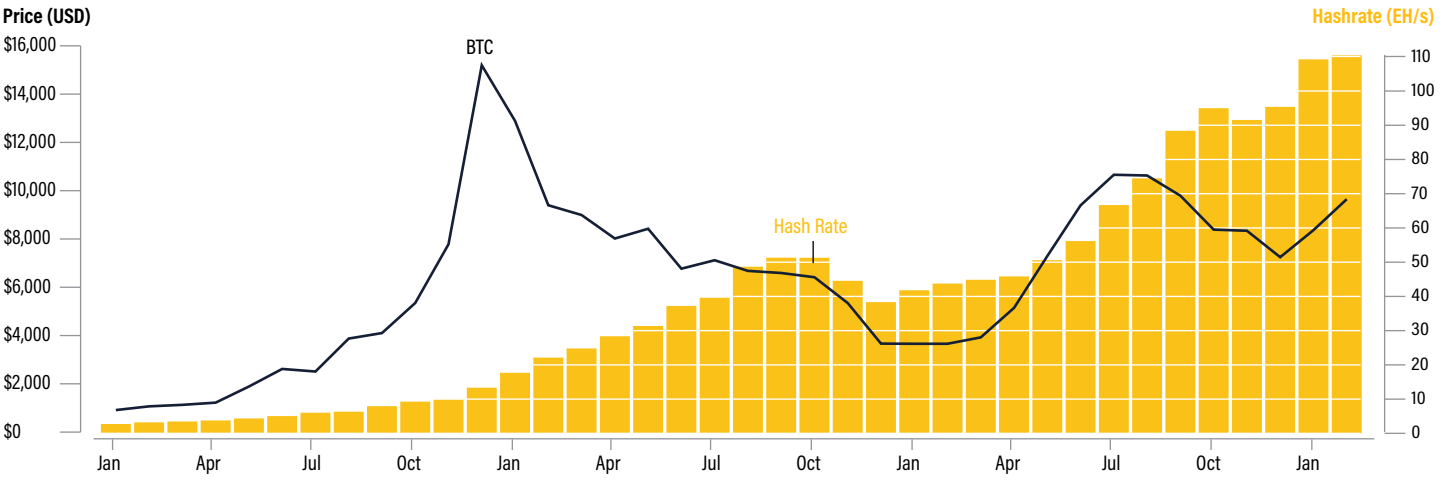
Many insist that a climbing hashrate should lift the bitcoin price, as 1) it means the network is more secure and therefore more valuable, and 2) the growing production costs mean that the price needs to rise for miners to stay in.

Let's examine the reasoning behind the second point, because it's not obvious why a price should rise just because it needs to. A higher hashrate means tougher competition for miners (more miners and faster machines competing for the same bitcoin reward). If a miner's chances of getting the reward drop, his/her income falls and mining may cease to be profitable. This may lead to machines being switched off.

Fewer machines working on solving a problem make it more likely that each of those involved will find the solution and receive the reward. Mining thus becomes more profitable, more miners enter the system, and the hashrate rises.

Recent data confounds these theories, with hashrate increasing even as the price drops. This could be due to miners adding hash power in anticipation of the halving.

Figure 20. Monthly Average Bitcoin Hashrate and Price Between January 2017 and February 2020



Source: Coin Metrics

PRICE IMPACT

While the technology behind the potential security impact and scarcity value is important to understand, most of the broader market's attention is on the impact this event can have on the price of bitcoin. Since the last two halvings coincided with strong bull runs, many assume that the process will be repeated in 2020-21.

History rarely repeats itself, though—in this case, does it at least rhyme? Below we'll look at the price movements in the previous two halvings, and compare them to the macro environments at the time.

We'll also examine two conflicting market theories—the stock-to-flow model and Efficient Markets Theory—and how they apply to bitcoin.

HISTORY

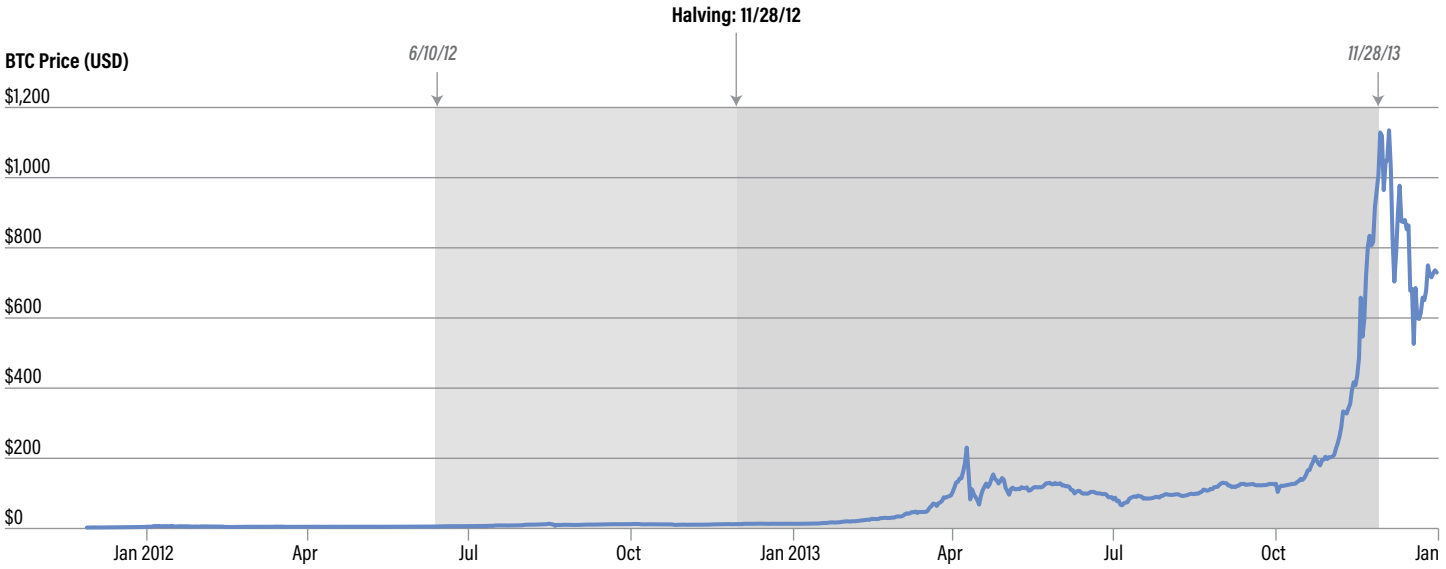
Price

To get a feel for how the bitcoin price might react around the upcoming halving, as well as how this time might be different, it helps to look at the markets around the previous two events.

In the bull run around the first halving in 2012, the bitcoin price increased by over 200x. It started almost six months before the event and continued for another 12 months. The price then fell by 84% over the next 14 months.

Figure 21. Bitcoin Price (USD) First Halving

2012—started June 10, 2012 (171 days to halving)— halving Nov 28 2012—ended Nov 28, 2013 (366 days from halving)—537 days total



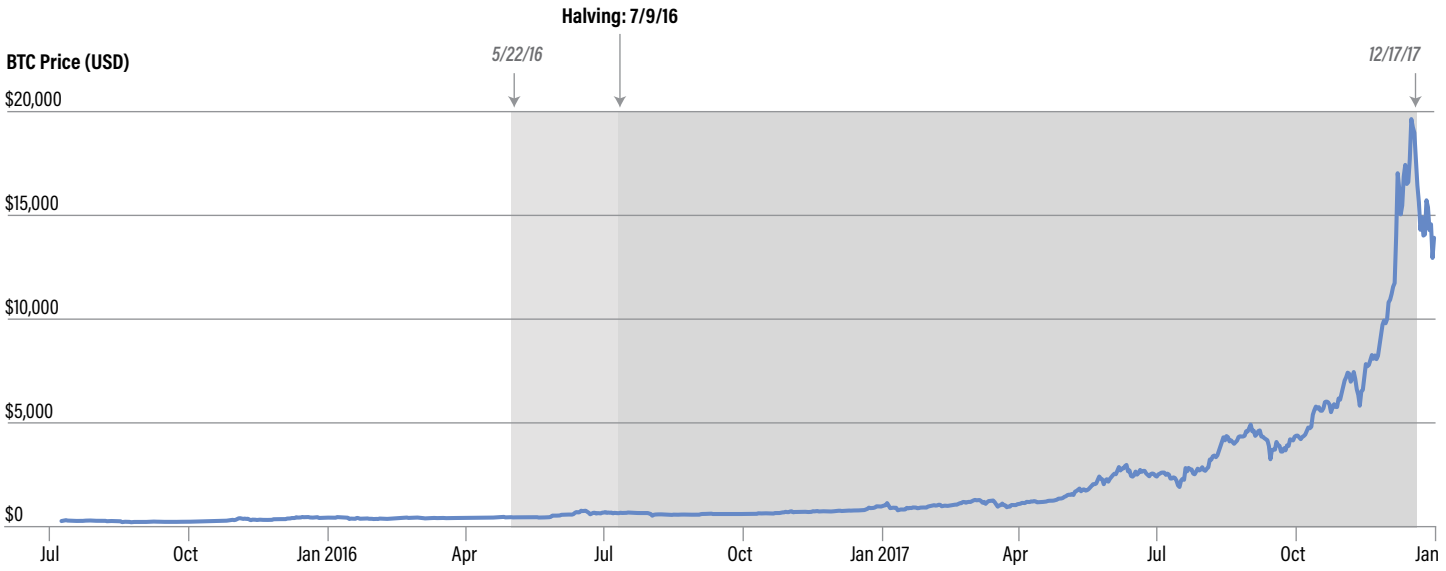
Source: Coin Metrics

The bull run around the second halving started a bit closer to the event, not quite two months, and continued for another 19 months, producing a total price gain of over 4,000%. From the peak in December 2017, the price again fell by 84% over the next 12 months.

At the time of writing, we are approximately two months away from the halving, and there does not yet seem to be any sign of a bull run.

Figure 22. Bitcoin Price (USD) Second Halving

2016—started May 22, 2016 (49 days to halving)—halving July 9—ended Dec 18, 2017 (528 days from halving)—575 days total



Source: Coin Metrics

Volumes

To get a feel for how different the bitcoin market is this time around, let's look at some other metrics.

In 2012, average daily trading volumes increased by 50% over the two months before the first bitcoin halving. They continued to increase until May the following year.

In 2016, average daily trading volumes grew by 150% over the month before the second bitcoin halving. They then fell by 30 percent during the halving month of July and continued to decline for three months.

Figure 23: BTC Average Daily Trade Volume

Month	August 2012	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	March 2013	April 2013	May 2013
Avg. daily trade vol.	28,692.52	21,269.63	31,693.42	33,874.47	38,943.74	85,338.90	218,322.50	951,945.29	4,956,431.47	2,888,115.39
MoM% vol. chg.		-25.87%	49.01%	6.88%	14.96%	119.13%	155.83%	336.03%	420.66%	-41.73%

Month	March 2016	April 2016	May 2016	June 2016	July 2016	August 2016	September 2016	October 2016
Avg. daily trade vol.	55,804,356.23	43,680,644.37	72,426,151.55	181,552,735.93	124,361,905.84	73,182,043.77	59,641,110.13	61,136,131.74
MoM% vol. chg.		-21.73%	65.81%	150.67%	-31.50%	-41.15%	-18.50%	2.51%

Month	November 2019	December 2019	January 2020	February 2020	March 2020
Avg. daily trade vol.	16,386,379,087.97	14,279,023,218.48	20,739,628,449	30,909,031,765.34	36,992,709,855.88
MoM% vol. chg.		-12.86%	45.25%	49.03%	19.68%

Months in which the halving occurred are gray. Positive growths in BTC volume leading up the halving are highlighted in blue.

Source: Nomics; Data as of Mar 3, 2020.

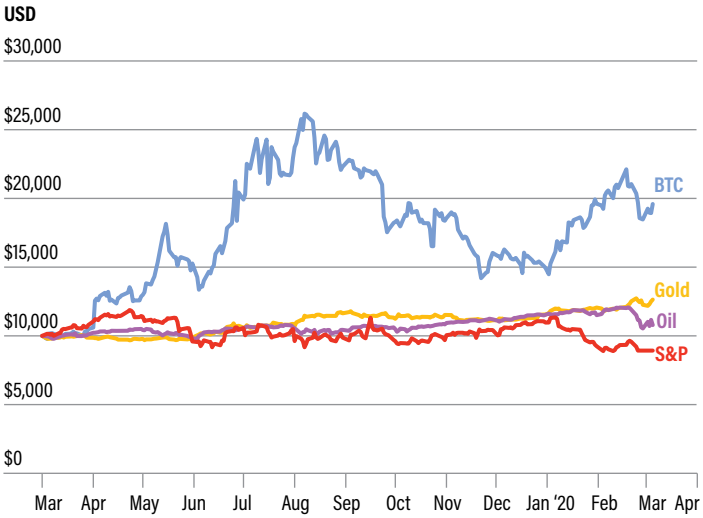
Macro factors

During the bull run around the 2012 halving, the S&P 500 rose almost 35%, while the gold price fell by over 20%.

During the bull run around the second halving, the S&P 500 rose almost 30%, while the gold price was flat.

Figure 24. Performance of $10K invested March 1, 2019

As of March 5, 2020



BTC	Gold	Oil	S&P	Oil
$19,593.00	$12,639	$10,786	$8,928	$10,786

Source: Coin Metrics and the Federal Reserve Bank of St. Louis

Extrapolating

It is not hard to see that this time is different.

Investment decisions are hardly ever taken in isolation—increased investment in cryptocurrencies means less investment in other asset classes, and investors generally have to weigh the attractiveness of one opportunity over others in making allocation decisions.

It is easy to see that, in terms of volumes and general level of interest as well as market structure, the bitcoin market has evolved considerably over the past four years. The macro environment is also fundamentally different, with new factors influencing sentiment and a deeper overall understanding of the limitations of monetary policy.

That does not mean, however, that there will not be a significant bump in the bitcoin price as a result of the halving. Nor does it mean that there will be.

Let's now examine two market theories that argue for each side.

MARKET THEORIES

SUPPLY-BASED PRICING

One of the main rationales for the price bumps before and after previous halvings is the impact on new supply.

The theory rests on a certain level of demand necessary to absorb the new bitcoins entering the market. Assuming that demand remains constant, a drop in new supply means that there will be fewer new bitcoins to absorb that demand. The unmet demand will spill over into the general market and push up prices overall, all else being equal.

However, all else is rarely equal, and prices are generally set by changes in demand, not by expected changes to supply.

True, there are some ways in which the halving could impact demand. The attention paid to the changes in supply may give demand a boost, as mainstream coverage of the halving fuels a greater awareness of bitcoin. Or, investor concern about the impact on miner economics and network security could reduce portfolio holdings.

But, the supply-based pricing theory depends on demand being constant while new supply increases, which is rarely a rational assumption.

And looking at the numbers, the actual impact is not as significant as proponents of this theory make it out to be. The halving will result in the removal of 900 bitcoins per day—just over $7 million at current prices. This is less than 1% of the average daily trading volume for the past three months, using figures taken from Messari.[1]

STOCK-TO-FLOW

Bitcoin has been labelled a "commodity" by the U.S. Commodity Futures Trading Commission, and is often treated as such by investors when it comes to formulating investment theses and asset allocations.

Many have likened bitcoin to "digital gold," in that it is scarce, fungible and not controlled by any one entity. Its process of "extraction" is also similar—in the bitcoin white paper, the network's creator Satoshi Nakamoto explained the system of block subsidies and coin issuance as "analogous to gold miners expending resources to add gold to circulation."[2]

One model often used to value "store of value" commodities (those with limited supply) is a measure of scarcity known as the stock-to-flow model. This tracks the current supply divided by the annual production (the S2F ratio). The higher the number, the lower the dilution of value from new inflows.

In a paper released in March 2019, pseudonymous trader and analyst Plan B[3] showed that this ratio is especially easy to apply to bitcoin given that the current supply and the new inflows are known with precision. For most commodities, current supply is an estimate, and new inflows are influenced by price as production switches on and off according to profitability.

With bitcoin, new inflows are not affected at all by the number of machines working to maintain the system.

Figure 25. Chart of Commodity S2Fs

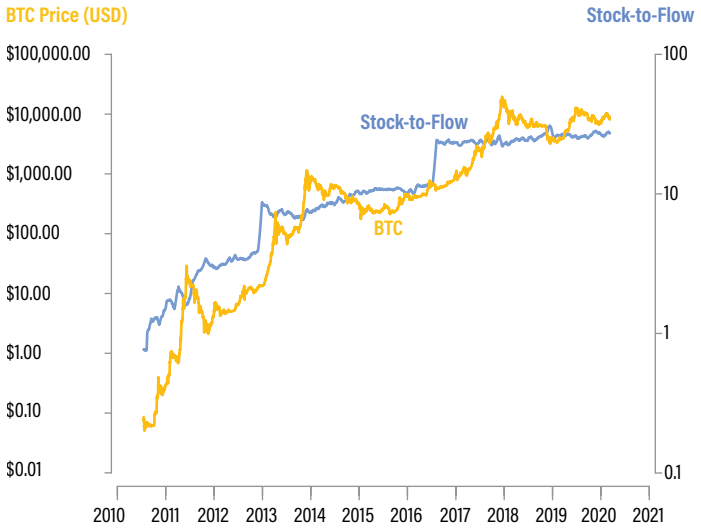
	Stock (tons)	Flow (tons)	S:F	Supply growth
Gold	185,000	3,000	62	1.6%
Silver	550,000	25,000	22	4.5%
Palladium	244	215	1.1	88.1%
Platinum	86	229	0.4	266.7%

Source: Plan B, "Modeling Bitcoin's Value with Scarcity," March 2019

What's more, the bitcoin S2F ratio, at this writing greater than 27, is higher than that of any precious metal other than gold, which is above 60. This ratio is significant in that it shows the susceptibility of a commodity's price to its production schedule. The higher the ratio, the less vulnerable the price is to swings in production. Over 85% of bitcoin's total

1 messari.io
2 Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," October 2018
3 Plan B, "Modeling Bitcoin's Value with Scarcity," March 2019

Figure 26. Bitcoin Stock-to-Flow Ratio and Price vs. Time



Source: Coin Metrics

potential supply has already been mined.

Other valuable metals such as platinum and palladium have a low S2F ratio, as current stocks are roughly equal to or less than production, making production a strong determinant of price.

In his paper,[1] Plan B showed that, as with gold and silver, a strong linear relationship holds between the S2F ratio and the bitcoin price. Since bitcoin's supply and inflows are not price sensitive, the model posits that the S2F drives the price, not the other way around.

Subsequent papers[2] showed that the two series were more than highly correlated, they were cointegrated (see sidebar).

Many market theorists[3] scoff at the idea that past price patterns will be repeated and that relationships will necessarily hold going forward, especially in as new a market as bitcoin.

Others point out[4] that the bitcoin ecosystem has changed so much over the past few years that we cannot rely on past performance to predict future behavior. The use of Twitter and other social media platforms to disseminate market information, the rise of high frequency trading and other algorithmic strategies, the institutionalization of market infrastructure and price discovery as well as the influence of derivatives—these are just some of the fundamental shifts.

Also, markets anticipate future prices—if the price were to follow the S2F model, then the future price would already be discounted in the current price (see also "EMH" below).

However, proponents highlight the cointegration and insist that the model holds in the past, is still holding today and is therefore more than likely to continue doing so.

What is "cointegration"?

Most investors are familiar with the term "correlation," which indicates to what extent two variables move in the same direction.

"Cointegration" reflects the spread between two variables—a high cointegration means the distance between them remains steady. This is especially intriguing for analysts and investors, as true cointegration in markets is rare. It gives a more powerful insight into price movements—if you can plot the path of one series, you can plot the path of the other, and take advantage of any variance from that expected behavior.

EMH

One strong counterpoint to the S2F model is the Efficient Markets Hypothesis (EMH). Developed by economist Friedrich Hayek[5] and others, it is based on the idea that markets process information efficiently, which means that information is rapidly reflected in prices.

On the surface, the EMH theory makes intuitive sense. Applied to bitcoin's supply schedule, if we know the price follows the S2F ratio, and we know this ratio will increase, then we know the bitcoin price will increase and we'll buy it now before it does. This pushes up the price until the future price is reflected in today's price. So why has this not happened?

1 Plan B, "Modeling Bitcoin's Value with Scarcity," March 2019

2 Marcel Burger, "Reviewing "Modelling Bitcoin's Value with Scarcity—Part II: The hunt for cointegration," September 6, 2019 ; Nick, "Falsifying Stock-to-Flow As a Model of Bitcoin Value," August 11, 2019

3 https://twitter.com/nic__carter/status/1166461458818969602, https://twitter.com/ercwl/status/1188974690074873857

4 https://twitter.com/Melt_Dem/status/1209457337393647617

5 Friedrich Hayek, "The Use of Knowledge in Society," 1945

An argument can be made that the S2F effect is already priced in, but so is broad market risk.

Some point out[1] that the S2F model is not yet well known, which shows that markets are not efficient. Also, efficient markets require a common understanding of fundamentals, which are arguably absent in bitcoin.

Countering that is the observation that bitcoin markets are more efficient than ever, with better price discovery, greater liquidity, faster information dissemination and broader familiarity with bitcoin.

DERIVATIVES MARKETS

Bitcoin derivatives have been a feature of the ecosystem since the early days, with unregulated exchanges offering futures and similar products. The sector's largest derivatives exchange by volume, BitMEX, launched in 2014, offering an innovative product called "perpetuals," which mimic futures but automatically roll over. Deribit, the largest crypto options exchange, launched in the Netherlands in 2016, and earlier this year moved its base to Panama.

The first fully regulated derivative exchanges emerged at the peak of the last bull run. CME, the largest derivatives exchange in the world, and Cboe, the largest options exchange in the U.S., started offering bitcoin futures in December 2017 (although Cboe has since withdrawn its offering).

The emergence of a lively crypto derivatives market has changed the conversation around the halving for three main reasons: the shifting nature of bitcoin demand, the increasing ease with which miners can hedge their output to ease the risk of revenue, and the potentially self-reflexive indicators of options pricing.

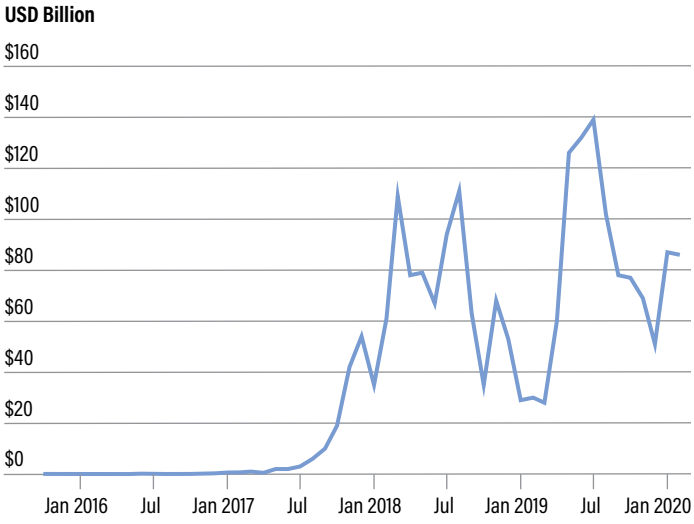
Before bitcoin derivatives became a liquid market, speculators only had one convenient way to express their view on bitcoin: buying in the spot market. Shorting involved finding a willing lender (not as easy as it is today), so the market had a "buy bias," in which only actively positive demand was reflected.

With the development of derivatives offerings, investors could more easily express both positive and negative views, with leverage. This attracted a broader range of professional speculators into the market, which entrenched speculation as the main driver of bitcoin price moves.

Bitcoin derivatives existed four years ago, but volumes were much lower and the market was much less sophisticated than today.

Another potential consequence of the increasing sophistication of the derivatives market is a shift in miners' strategy. Four years ago, miners were generally either holders or sellers (either they would hang on to their block rewards or they would sell them in the spot market).

Figure 27: BitMEX Perpetuals Monthly Volume (USD Billion)



Source: BitMEX

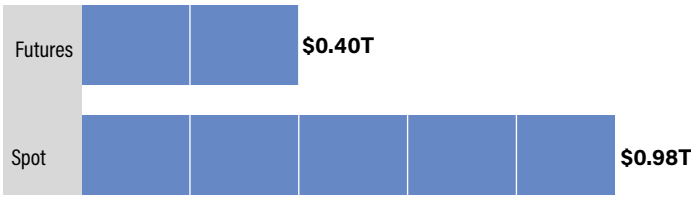
Most needed to sell a large percentage of their mined bitcoins to pay for operating expenses. This constant selling pressure acted as a brake on price appreciation. After the halving, the reasoning goes, miners would have fewer bitcoins to sell—less selling pressure means the price would go up.

With derivatives, however, it is possible to lock in future bitcoin prices in order to cover working capital needs, without actually selling bitcoin. This has been the case for many months now, so it could be argued that selling pressure from miners is less likely to act as a drag on bitcoin prices going forward.

Also, miners could also in theory make additional income by writing options backed by bitcoins they hold. Although there is little evidence they are doing this, the existence of a potential revenue cushion could also affect the supply/demand impact of the

1 https://twitter.com/hhua_/status/1191454680187932672

Figure 28: February 2020 Aggregate Bitcoin Derivatives and Spot Trade Volume



Source: Nomics and Skew

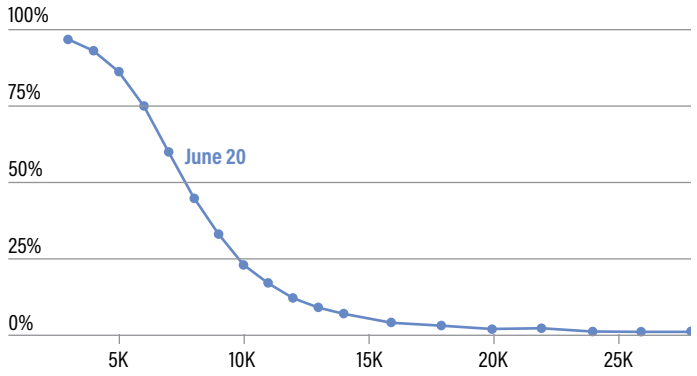
upcoming halving.

The demand side of the equation is also to some extent influenced by the derivatives market. Four years ago, speculation largely involved buying and selling on the spot market. These days, an increasing proportion of trading volume is on the derivatives market. Although futures markets do influence spot prices mainly through the manipulation of arbitrage opportunities, speculative supply and demand is now not as dependent on "physical" supply and demand.

Finally, derivatives markets are rich with information about market expectations. Obviously these indicators are far from perfect, as expectations are often wrong and frictions can distort the information, but they do give a sense of speculative sentiment and consensus estimates. This in turn can influence speculative sentiment, as investors often succumb to pack mentality. Many are likely to believe that if the options market says that the price won't rally, then the price won't rally and they might as well turn their attention elsewhere.

In spite of the conviction of some that the stock-to-flow model will hold and bitcoin will be at $50,000-$100,000[1] shortly after the halving in May, skew analysis at current option prices puts the probability of the bitcoin spot price being above current levels in June 2020 at less than 50%.

Figure 29: Probability of BTC Being above x$ per Maturity



Source: Skew

SOCIAL SIGNALS

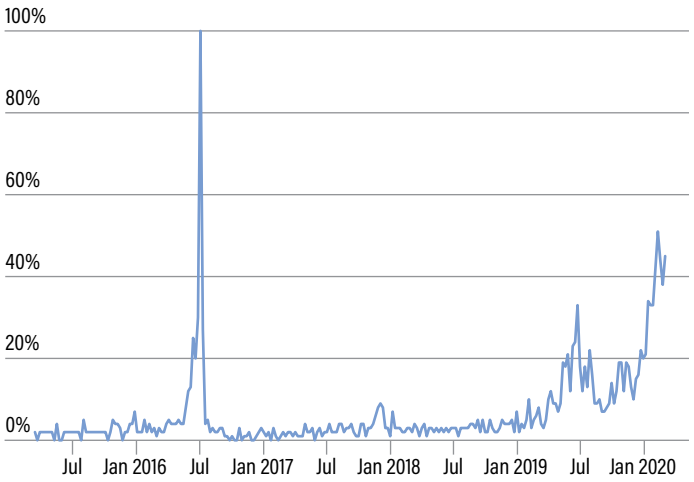
Many market observers believe in the power of search trends on Google to predict price movements.

Given that search trends reflect mainstream interest and are often as a result of overheard conversations or articles in general publications, however, these are often more reactive than proactive.

Studying them can highlight intriguing shifts, however. If we look at Google search trends for "bitcoin halving" during the last halving in July 2016, we see that they didn't jump sharply upwards until the previous month, although—as we saw above—the price started moving up long before.

Figure 30: Chart of Search Trends

For "bitcoin halving"



Source: Google

This time around, the number of searches started trending up much earlier, indicating a more widespread curiosity.

Curiosity does not necessarily lead to buying demand, however, especially in markets as uncertain as these. Yet the increasing attention and greater familiarity with bitcoin and its technology hint at broader mainstream interest, which could support price appreciation once markets stabilize.

1 https://twitter.com/100trillionUSD/status/1212399857605992448

UPCOMING HALVINGS OF BITCOIN CASH + BITCOIN SV

Bitcoin is not the only cryptocurrency that undergoes pre-programmed periodic subsidy changes.

Bitcoin cash (BCH) and bitcoin SV (BSV), both based on the original bitcoin blockchain and both created to solve what their creators saw as deficiencies in the original code, are expected to have halvings in April of 2020.

BCH was spun off from the bitcoin blockchain in 2017 to solve the perceived disadvantage of the limited transaction throughput. Detractors of the original design believed that limiting the block size would favor the speculation and investment use case of bitcoin over that of a medium of exchange. The block size limit of BCH is currently 32MB, vs bitcoin's approximately 4MB.

While greater throughput is arguably an advantage, detractors argue that larger block sizes will make the protocol more costly to store and maintain, which is likely to centralize mining and validation, and thus weaken network security.

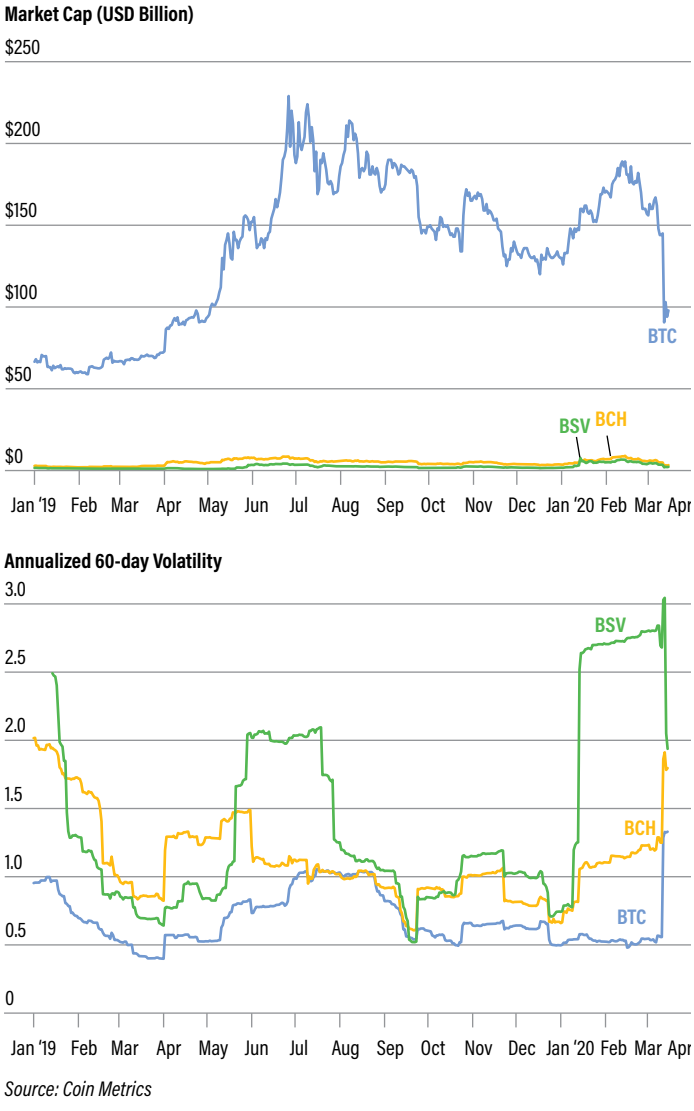
In 2018, BSV spun off from the BCH blockchain to increase the block size even further, to 128MB. This February, the protocol upgraded to remove hard caps on block sizes all together.

Given that they both run on a similar codebase to the bitcoin blockchain, their supply schedule adjustments are alike. Both are expected to have halvings in April of 2020.

While some investors will be watching the price movements for these tokens around their halvings to get a feel for what bitcoin might do, the networks are different enough to make such comparisons of limited value. As you can see from the chart, the overall market weight of bitcoin is much greater than that of BCH or BSV, and both have comparatively higher price volatility.

One aspect to watch as the halvings of the younger siblings approach will be their hashrate—it is possible that it could decline as miners switch to processing BTC blocks, in search of the high reward, even if only temporarily.

Figure 31: Chart of Relative Market Cap + Volatilities



Source: Coin Metrics

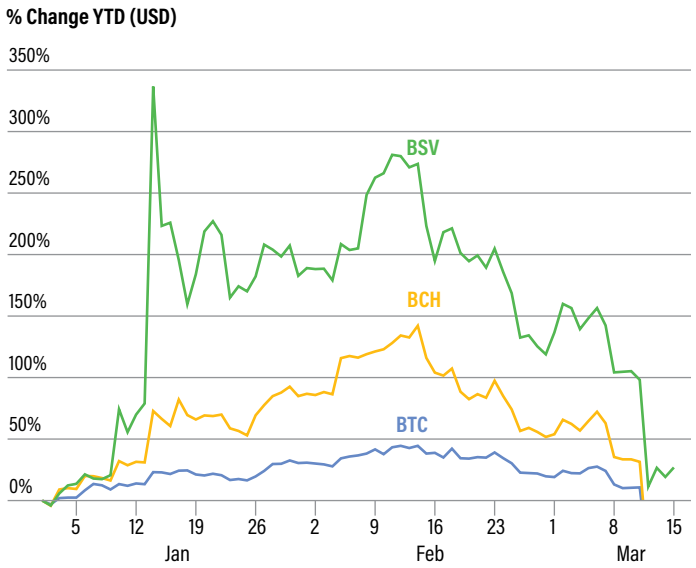
Neither of the bitcoin "alternatives" have a derivatives market of meaningful size. This, combined with the relatively slim volumes and higher volatility, could be contributing to their relative outperformance so far this year as traders price in a supply-led halving impact.

As well as being much younger than bitcoin, both bitcoin cash and bitcoin SV are experiencing internal governance issues. The bitcoin cash community is presently divided on the matter of network

development funding, a battle which could lead to a further fork of the network.[1]

And a proposal to restore the bitcoin SV network to the original design outlined in the bitcoin white paper was implemented in early February, although initially not all miners were on board with the change.[2]

Figure 32: % Change YTD Price USD



Source: Coin Metrics

1 Paddy Baker, "Roger Ver's Mining Pool Pulls Support for Bitcoin Cash Dev Fund Over Chain Split Threat," CoinDesk, January 28, 2020

2 Paddy Baker, "Bitcoin SV Sees Minor Split as Blockchain Shifts to 'Genesis' Upgrade," CoinDesk, February 4, 2020

MINER PERSPECTIVES

EDITED TRANSCRIPTS FROM OUR INTERVIEWS WITH BITCOIN MINERS

To what extent are you involved in mining to hold bitcoin vs to sell bitcoin and earn cash revenue?

"You can make this general classification that miners at least sell enough to pay their electricity and [operational expenses]. So that can range from 30 to 60 percent of their revenue depending on their operations. They will take that bitcoin, liquidate to USD or CAD and then pay off their bills so they can continue to operate. Then it comes down to preference. The majority of people do hold after they've paid out their costs."
—Ethan Vera, CFO and co-founder, Luxor Technologies

"There's a cycle, I like to call it the "miner pain cycle," which is kind of like a stock market reference. The cycle is not just a psychological cycle, inasmuch as it is embedded in the technology: this halving thing and this ever-rising difficulty thing. "Terribly elegant" is how it can be if you don't plan for the pain cycle as a miner. Here we are a couple of months from the halving and miners are hurting as bad as they can hurt right now.... Miners, because they're inherently speculators, they're not ready to just shut down and clean out the house. To mitigate the fact that they're coming up short, they're coughing up bitcoin that was excess bitcoin they were able to hold at the beginning of the cycle. That's what I call the "terrible elegance" of the system Satoshi Nakamoto designed."
—David Carlson, Founder, Mega Big Power and Giga Watt

"Most miners are cashing the bitcoin immediately. My personal guess it's a 2/3, 1/3 split. 2/3 of the coins would go to an exchange almost immediately and be sold for cash for paying electricity. My expectation is that we are moving towards more miners cashing out immediately than before because the pressure is stronger and the margins are smaller, especially when we are going to face halving. I would expect more selling would be present."
—Pavel Moravec, CEO and Founder, Braiins

"Among the mining farms I manage, for the more conservative, it's 70 percent sell, 30 percent hold. For the farms that are more on the speculative side, they're doing a breakdown of 30 percent sell to 50 percent sell. The rest, they're going even heavier on the hold."
—Kristy-Leigh Minehan, mining operations consultant

Do you use bitcoin derivatives to hedge your operations? If so, futures and/or options?

"A lot of mining companies historically if you look back three years were unprofessional organizations with no governance. They just threw together money from rich angel investors, usually early bitcoiners, and started mining. We never saw hedging historically. Right now, there's a huge turning point in the industry, we started to see it last year, where more sophisticated players are entering the market. You can see it by who runs the mining companies now. They come from traditional backgrounds where they're used to hedging their operations. It hasn't been done historically. It's starting to transition that way."
—Ethan Vera, CFO and co-founder, Luxor Technologies

"It's starting to happen because to be relevant in the market today you probably need to be thinking about building a mine that's in the 50 MW range. You're in the sophisticated money realm. Sophisticated money wants to see risk mitigation. They want to understand the cyclical nature of the business. The miners themselves may not have a lot of that expertise, but I think there are some financial engineers trying to bring products and services to those miners in a way that is hedged and protected."
—David Carlson, Founder, Mega Big Power and Giga Watt

"Braiins doesn't have direct experience with miners using hedging strategies but we know about a few projects working on building these financial tools. We know about people doing it. It's happening. It's talked about a lot but it's not happening on a large scale. The problem is, if you want to hedge yourself

there needs to be a counterparty. The counterparty has to have a lot of money and a pretty precise understanding of what's happening in mining. We can see larger trading desks being interested in looking into the mining space more and more lately but building the understanding is taking some time."
—Pavel Moravec, CEO and Founder, Braiins

How are bitcoin miners getting ready for the third bitcoin halving?

"One of the biggest trends is with old-generation mining hardware is, you are going to see a huge turnover in old-gen ASIC machines. Old gen I would define as anything before May 2018, predominantly S9s, but also some of the earlier Innosilicon and Canaan miner models. Those all will be underwater when it comes time for the halving. They've been changing hands to lower cost regions and operators. A lot are heading to places like Venezuela. Miners have been preparing for that by shifting which type of hardware they have. A lot of mining farms that want to continue operating after the halving have been investing in new-gen machines. A lot are receiving the new Bitmain S17 and the Whatsminer M20S. Those are the two models everyone's trying to load up.
—Ethan Vera, CFO and co-founder, Luxor Technologies

"Preparing for halving is super simple from the point of efficiency. You just have to cut your energy for the same amount of hashrate used. It's so simple. If you're not efficient enough, then the halving or the gradually increasing difficulty will kill you. Halving is roughly the same as doubling the difficulty forever, instantaneously. It's a similar effect. You can buy better hardware or you can do crazy engineering stuff to squeeze more hashes from the hardware you have. People are very creative with how to tweak their hardware or firmware so they can squeeze slightly more than what their machine produced before. You can fine tune configuration of the chips on the machine and squeeze out more hashes with the same power draw which helps you survive slightly longer in the market. There's only so much that you can do with older chips so obviously you'd want to buy as much new hardware as possible, but it depends on if you can get to the machines and price. People try everything. The pressure for being as optimal as possible goes even further to how you treat electricity lines. The pressure is quite strong and people tend to be quite creative."
—Pavel Moravec, CEO and Founder, Braiins

What impact will the halving have on bitcoin hashrate?

"The very first halving we went through, there wasn't enough of a community for it to make a lot of financial impact. The second halving we went through, many of the participants were just understanding that there was such a thing as a halving. This third halving I think everyone's very well educated. I think it's going to affect hashrate more than anything. It's not going to be a cliff. I do think COVID-19 is going to have an impact on machine availability and that stability of hashrate, especially as a majority of the mining infrastructure is still within China. Pressure is still being put on that. But two months after the halving we're going to see hashrate back up to historic levels. The farms that I manage, 20 out of 30 are bitcoin heavy. There's been an upgrade plan in place for at least a year. They've been figuring out, how do we take a portion of our mined rewards and invest that back into equipment. Some have been looking at acquisitions: many believe when the halving hits, some of these higher-cost operations may go out of business. Call it another crypto winter."
—Kristy-Leigh Minehan, mining operations consultant

"Leading up to the halving, bitcoin cash and bitcoin SV halve a month before bitcoin so we'll see some hashrate jump over to the bitcoin network. They'll decrease 30-40 percent and the hashrate will jump over to bitcoin, and then it will jump back after the halving. I don't expect any long-term difference there. You'll see bitcoin network increase in hashrate from those miners then jump back over. The reason they jump over is basically because when bitcoin cash halves, the mining revenue goes down by half. now it's more profitable for those miners to mine bitcoin. so a lot of those miners will just be like, 'I'm not going to take that cut in reward, I'll just jump over to the bitcoin network.' but eventually it balances itself out. Say reward goes down by 50 percent but then 50 percent of miners jump over, then the miners are just as good as before because there's less people competing for

it. It'll happen with the bitcoin halving too where in my opinion 26 percent of network hashrate will drop off so the miners left over will see a bump up in miner revenue and some of that block reward decrease will get offset, due to less people competing for it."
—Ethan Vera, CFO and co-founder, Luxor Technologies

Why is mining centralized in China?

"Proximity to the hardware manufacturers is the biggest thing that has led to an increase in consolidation of hashrate in China. All the manufacturers are in Shenzhen, so it's easy to get your hands on machines and ship them to your facility in Sichuan. The first three weeks of mining are the most profitable because all these new machines are coming online and the difficulty hasn't adjusted yet. Historically, American and Canadian miners have been at a disadvantage because they receive the machines last and usually at a higher cost."
—Ethan Vera, CFO and co-founder, Luxor Technologies

"All the close relationships between miners have historically been built in China because of the hardware manufacturers starting there and being from China. If a new machine goes to the market, you always see hashrate being deployed in China first because the Chinese customers typically have the best relationship with manufacturers. There's a pretty dense web of interactions and relationships there."
—Pavel Moravec, CEO and Founder, Braiins

Can mining make use of surplus electrical energy?

"I've not found anyone trying to put anything together where large hydro facilities that have energy surplus that currently are looking at costly energy storage would instead turn to mining and store it as a stablecoin. For the hydro facilities, volatility is an obstacle. 'I don't want to go from one highly volatile, price-sensitive business and turn to another one.' You're at the whims of bitcoin's price as to whether your energy storage facility gets to turn on. It's still a challenged idea until someone comes up with an opportunity or a model that de-risks for the participants that don't want any more risk."
—David Carlson, Founder, Mega Big Power and Giga Watt

"I know about a few projects placing miners on city electricity grids so they can be paid for consuming excess electricity. It's a dangerous thing to have too much electricity. For miners, the cheaper the electricity the better. So you want to be in a place where chances of electricity cost is zero or minus something. Upstate New York it happens sometimes from hydro plants. It can happen in different places and wherever this happens, bitcoin miners are going to be there for sure. The biggest factor going into the miner profitability calculation is electricity price. This is the most sensitive thing. It is the core of the competition between miners."
—Pavel Moravec, CEO and Founder, Braiins

OUTLOOK

One of the most fundamental and unique aspects of bitcoin is the pre-programmed supply schedule. The "halving" is an integral part of that, as it changes the rate at which new bitcoins enter the system.

This particular halving, however, the third in bitcoin's history, is likely to change much more than that.

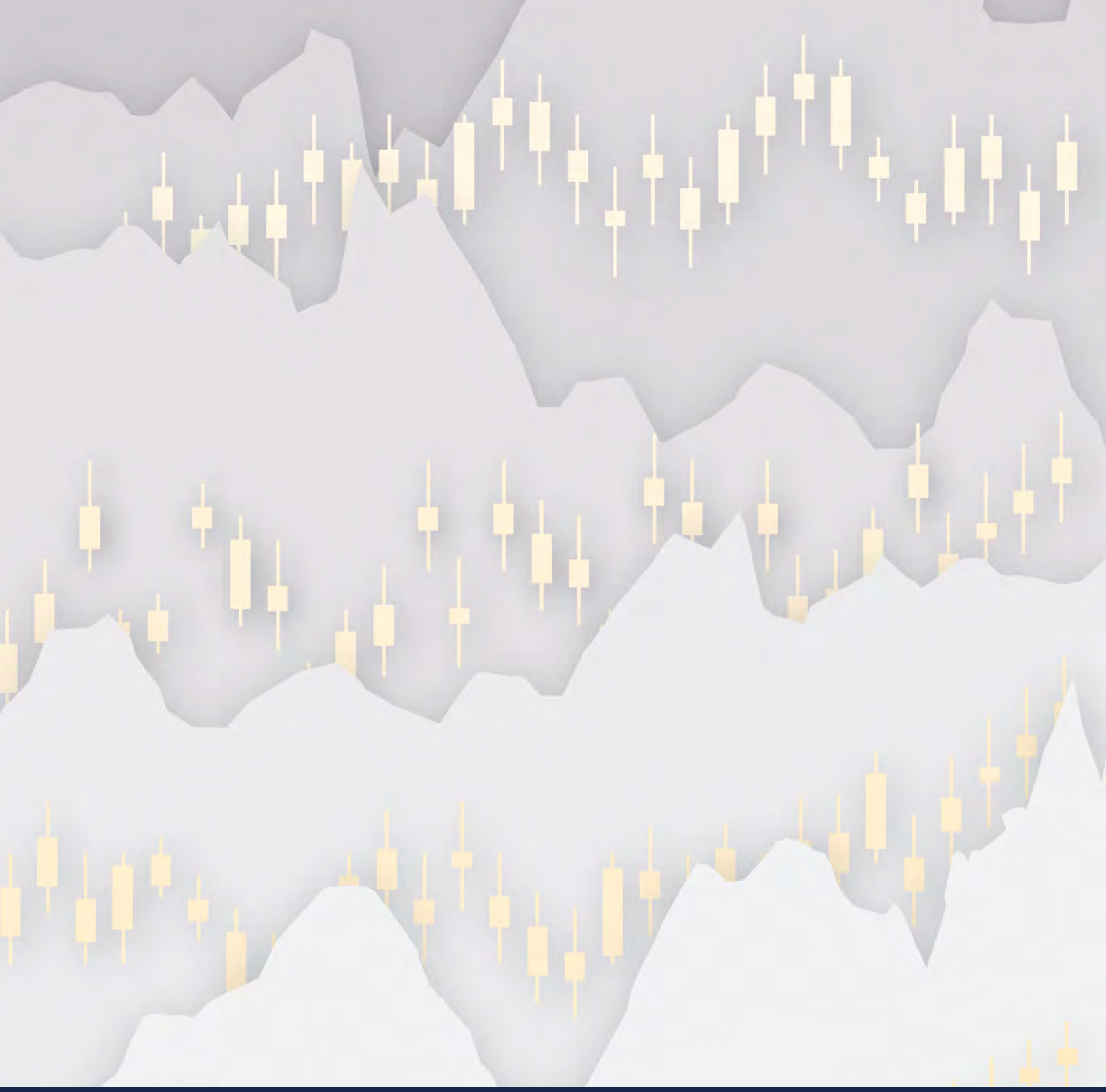
First, it calls into question the role of miners as the backbone of the system. They are the integral component of network maintenance, but the bitcoin ecosystem today is much broader than in previous halvings. The upcoming supply adjustment will have a negative impact on miner economics, as in the other halvings—but the growing sophistication of bitcoin's market infrastructure and the entrance of different types of participants make the production schedule less significant in determining value.

Secondly, it highlights how financialized bitcoin has become. The emergence of crypto derivatives and liquid institutional-grade markets not only shifts attention from supply to demand, as fund managers around the world increasingly treat bitcoin as an investable asset class, and as traders have a broader range of tools with which to express their market views. They also offer miners the opportunity to hedge production and better control cash flows, perhaps ensuring their viability even with lower incentives.

The halving also highlights the sector's dependence on chip technology. The hashrate may drop as miners switch off machines in response to the cut in revenue, but it is likely to soon resume its relentless upward march as chips continue to get faster and more powerful, and as global interest in bitcoin continues to grow. Technological advances in cooling methods, machine maintenance and clean, cheap energy will also boost the hashrate and network security.

And finally, the halving highlights what an innovative creation bitcoin is—the very notion of a pre-programmed supply that is resistant to manipulation, in an asset that has achieved over $145 billion in market capitalization, would have been dismissed as ridiculous fantasy just a few years ago.

The fact that the price of bitcoin so far does not seem to be gearing up for a strong appreciation around the halving reveals a much deeper understanding of crypto markets and economic theory. More than that, though—it shows how far the network has come in just four years.



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