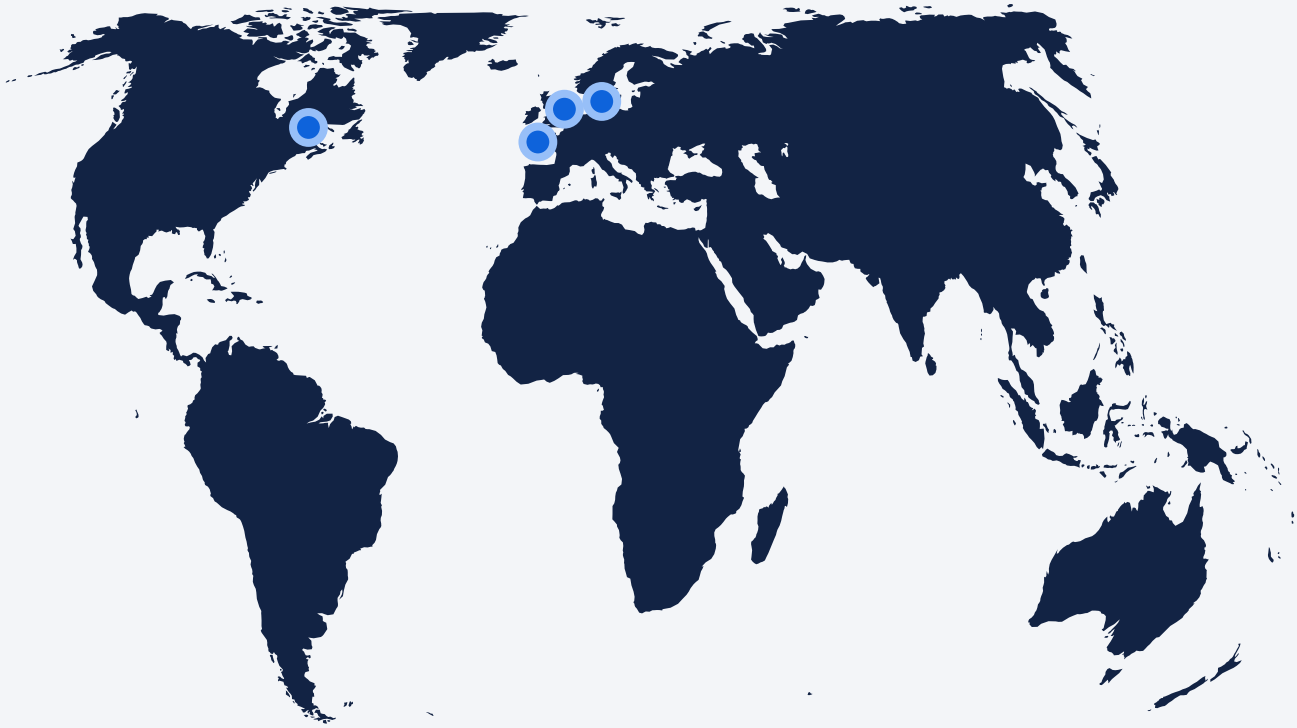
Bitcoin Valuation & Fundamentals

> Part II: Supply

CoinShares®



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We launched the world's first regulated bitcoin investment fund in 2014 and offered the world's first bitcoin-based securities on a regulated exchange in 2015.

Our products & services include Europe's largest exchange-traded product (ETP) digital asset platform with approximately $2.9bn of assets under management as of January 2021.

We believe expertise in both traditional and crypto markets is required to take full advantage of the opportunity that digital assets represent.

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PREFACE

In the first part of our bitcoin valuation series we discussed monetary competition, some of the properties on which this competition is based, and demand for money. Our argument is that bitcoins compete in a global market for use as money and that the totality of current global monetary demand can serve as a model for an upper bound of a future bitcoin exchange value.

Now that we've established a theoretical upper-bound (you can download Part I here), let's talk a bit about the journey to get there.

CHAPTER I > BITCOIN HAS A UNIQUE SUPPLY/DEMAND DYNAMIC

Never before in the history of mankind has there existed a strictly fixed supply monetary asset. All other assets used as money — mainly commodities — have some mechanism by which production can be increased. This is not the case for bitcoin. On the surface, bitcoin's supply/demand dynamic is similar to that of hard commodities like gold, yet it differs in crucial ways.

It is similar in that bitcoins can only be created at a cost, and this cost tends towards the market price due to free competition among miners. It is also similar in that hard commodities all have high proportions of existing stockpiles relative to their annual production, causing their price elasticity of supply to be low. This means that whenever prices go up, increased *market supply* can enter the marketplace both from new production and from already existing stockpiles, but out of the two sources of market supply, the existing stock is the largest one.

However, bitcoins are different from all other commodities — including gold — in that increases in price cannot materially increase the rate of production, nor can decreased prices reduce production. There's no extra amount of bitcoin lurking in the ground somewhere, available for production should market prices exceed the costs of production.

The production rate of bitcoins is fixed and pre-set by the protocol. No matter how much or little computing power is pointed towards mining bitcoins, the production rate remains the same. Bitcoin's price elasticity of supply is not just low, it is effectively zero.

This means that the marginal cost curves used to value commodities cannot be used in the same way for bitcoin. The only thing they will tell you is the proportion of the total mining reward each active miner will receive. Production remains the same no matter what the costs of mining may be (keep reading, we'll explain how this works, but if you want to pause and take a step back you can find more in-depth information on this topic here and here).

Section statement: Bitcoin cannot be priced like a commodity. Bitcoin's only comparable relatives in the world of commodities are those where existing stocks are large relative to ongoing production, such as gold and silver.

Key takeaway: Bitcoin's supply/demand dynamic is unique in that the price elasticity of supply is zero and the ongoing new supply has an exponentially diminishing impact on the total supply.

CHAPTER II > BITCOIN'S SUPPLY CURVE IS PREDETERMINED AND FIXED

Bitcoin relies on a simple rule to keep nodes in agreement on the correct transaction history: *The blockchain with the most accumulated cost (proof-of-work) is the correct one.*

Since appending blocks to the blockchain is costly, miners must be incentivised to do so, and this is done via the block reward mechanism. The block reward allows miners who find a valid block to create new bitcoins and award them to themselves. This is referred to as the coinbase transaction (from which the popular but unrelated Coinbase Exchange takes its name) and there can only be one per block. It is a special type of transaction that has no input yet is still valid to spend. Miners also get to keep any transaction fees collected from the transactions they included in the block, but these are all made up of existing bitcoins offered as transaction fees and so they do not add any new supply.

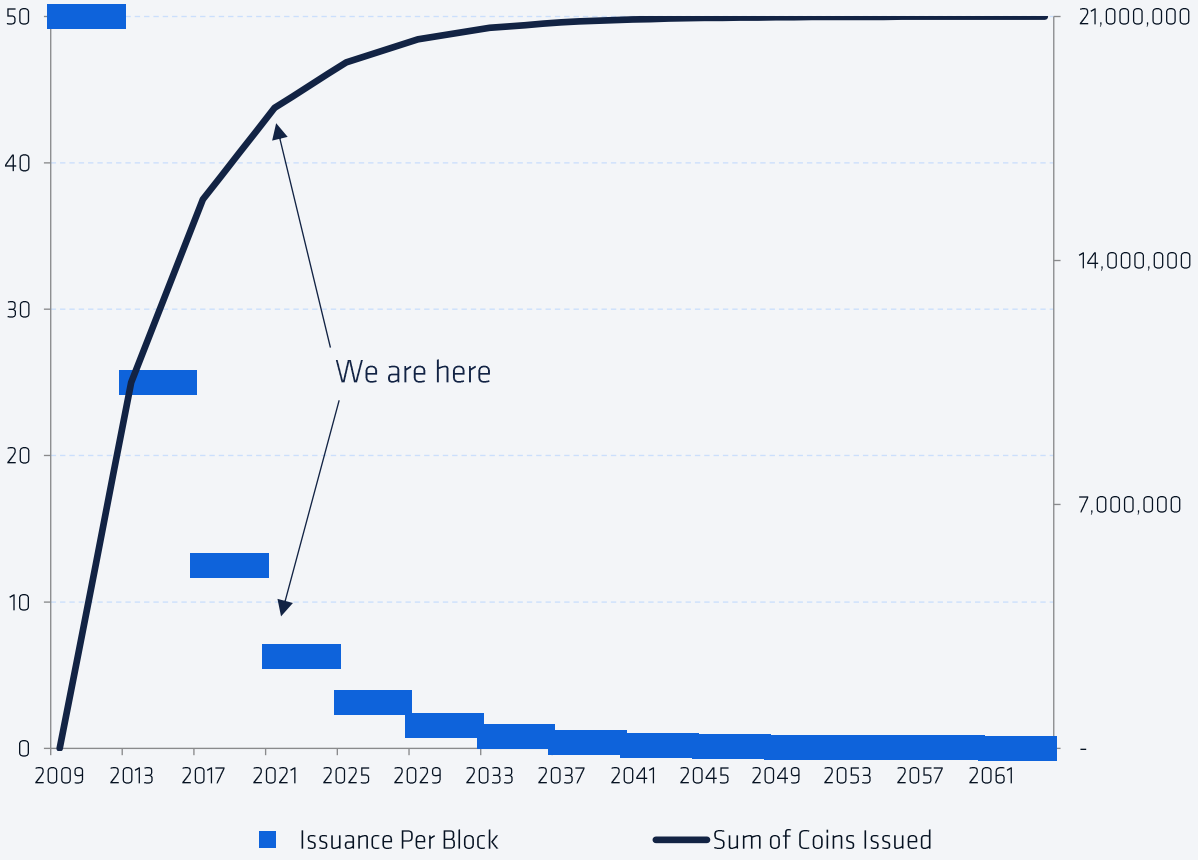
The bitcoin value of the coinbase transaction is fixed for each block. The purchasing power value, on the other hand, varies with the bitcoin exchange rate. Changes in the purchasing power on offer in the block reward will increase or decrease the profitability of computing power pointed towards block creation – higher prices make it more rewarding to mine bitcoins per unit of computational work, lower prices do the opposite.

However, the protocol is designed such that the units of computational work necessary to find blocks adjusts up or down depending on how much computing power is pointed towards finding blocks. Block times are targeted at a 10-minute average frequency: If they are coming in faster because more computational power has been added to the network, the mining difficulty increases, requiring more units of computational work per block; If they come in slower, the difficulty is lowered. This happens automatically approximately every two weeks.

Zooming out, the size of the bitcoin-denominated coinbase transaction is cut in half every 210,000 blocks, or approximately every 4 years. This predictably reduces the flow of newly minted coins by 50% at events known as 'halvings'. Over the next 120 years or so, there will be a new halving every 4 years until the value of the coinbase transaction rounds to zero at the eighth decimal point.

A net result of the dynamic difficulty adjustment and the halvings is that the production rate of bitcoins is fixed within the halving periods. Unlike all other commodities, increased prices do not lead to increased production, nor do decreased prices lower it. Price elasticity of supply is effectively zero. This enables the Bitcoin monetary system to host the first strictly finite asset ever created. No matter how much energy we point towards bitcoin mining there will never be more than 21 million bitcoins and they will not be added to the network any slower or faster than the protocol allows.

Bitcoin's Emission Rules Create a Predetermined Monetary Policy



Source: CoinShares

Section statement: Bitcoin's supply schedule is fixed. This means that unlike the demand component, total and ongoing new supply can be known at all current and future times.

Key takeaway: The Bitcoin protocol is built to self-adjust such that no matter how much or how little computing power is directed at mining, the rate of ongoing supply remains within the predetermined limits set by the protocol. This rebalancing, called the difficulty adjustment, is automatically applied every two weeks or so.

CHAPTER III > SUPPLY-BASED MODELS ATTEMPT TO VALUE BITCOINS BASED ON SUPPLY ONLY

Analysts have attempted to value bitcoins based on supply rates alone. The most famous attempts being the Stock-to-Flow (S2F) and Stock-to-Cross-Asset-Flow (S2FX) models created by the pseudonymous PlanB. The model has amassed a widespread following due to its apparent predictive capabilities and is at this point widely cited.

It is interesting in that its only input variable is bitcoin's supply. This has caused it to be widely criticised on a theoretical basis, yet proponents are steadfast in their support given its continued success as a price predictor.

Let's have a look under the hood.

The S2F Methodology

Stock in this context means the existing stockpile of bitcoins. Flow means the annual rate of change in the stock. Stock-to-Flow is the ratio of the two:

S2F = Stock / Flow

In other words, S2F is the inverse of the annual inflation rate.

The S2F' modelling methodology argues that there is a statistical relationship between bitcoin's S2F ratio and its total market value, leading to the hypothesis:

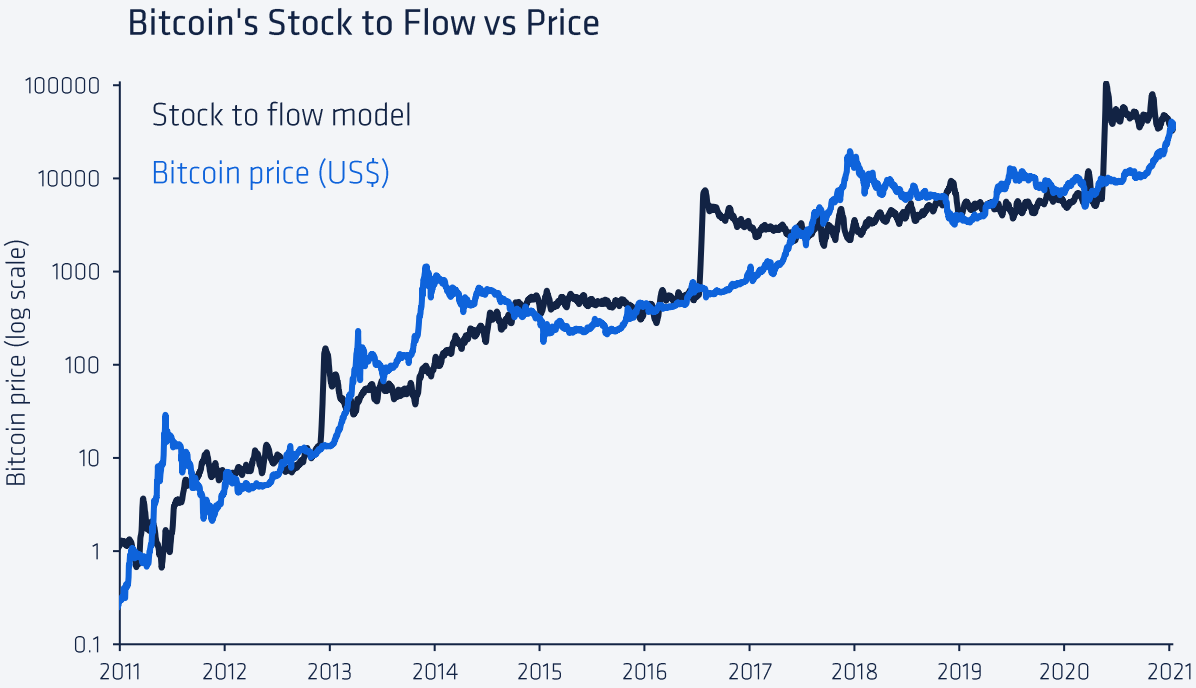
> *"Scarcity, as measured by stock-to-flow ratio, directly drives value".*

PlanB attempts to prove this relationship via regression analysis.

In order to generate the model, both variables (market cap and S2F) are first transformed into their natural logarithms, that is, base e. Ln(market cap) and ln(S2F) are then plotted against each other and fitted with a linear regression. The resulting fit has an R2 of 95% and the subsequent plotting of gold and silver's current estimated S2F ratios on the same scales also reveal relatively close fits to the trendline.

Because of the halving events, bitcoin's S2F ratio experiences periodic shocks where the ratio conversely doubles. According to the model hypothesis, the halving events are therefore value drivers. Looking at the graphical history of the S2F model versus bitcoin

price, the results seemingly support the hypothesis, with the model repeatedly diverging to the upside before being caught up, and then temporarily overshot, by price in cycles of ever-increasing magnitude.



Source: Bloomberg, CoinShares, data available as of close 14 January 2021

Given that halving events are known in advance and predictable, S2F can be calculated forward which means that prices can be estimated far into the future. According to the model, the most recent halving event suggests prices should rise to ~US$48,200 within approximately one year of the last halving which happened in May 2020.

Over time, the S2F model predicts an exponential increase in bitcoin's exchange rate against the US Dollar, with prices ultimately reaching infinity before (somewhat absurdly) flipping negative when bitcoin's stock inevitably starts shrinking.

Now let's look at its more recent offspring, the Stock-to-Cross-Asset-Flow Model (S2FX).

The S2FX Methodology

At least partly as a response to the litany of statistics-based criticism levied at the original S2F model in early 2020, a new iteration of the stock-to-flow model has been developed,

called Stock-to-Cross-Asset flow. This new model, while similar in concept and theoretical basis to the S2F model, differs from the original model in a few key areas.

The S2FX model uses the same data set as the S2F model but analyses it differently. Instead of looking at the stock-to-flow ratio as a continuous variable, the S2FX model clusters it into four separate groups, each with their own average.

As a justification for grouping the data points, the author claims to have identified four different uses for Bitcoin over time. In order, these are:

1. E-cash proof of concept;
2. Payments system;
3. E-Gold; and finally,
4. Financial asset (its current form).

These groupings are referred to as 'phases' bitcoin keeps transitioning through with reference to the concept of 'phase transitions' known from chemistry whereby a substance can express radically different properties under different external conditions.

The new model measures a stock-to-flow average for each phase and adds the current estimates of both gold and silver's S2F ratios to create a total of six data points. Unlike S2F, S2FX allows interpolation within its existing dataset since Bitcoin's stock-to-flow ratio is still smaller than that of gold.

The resulting regression model results demonstrate a high R2, although we don't believe the results are very meaningful due to the low number of observations (6) and consequent high degrees of freedom. Furthermore, not only does S2FX struggle with the same theoretical shortcomings as S2F in terms of the singular focus on supply and complete omission of demand, but the 'phase transitions' strike us as arbitrary and unlikely to be a consistent perpetual feature (or even real in the first place). For the model to retain its current data structure, Bitcoin would need to experience such phase changes every four years or so until the end of the halving periods, more than a hundred years from now. That doesn't seem very likely.

The S2F Intuition

Both the S2F and S2FX models rest on the theoretical foundation of using stock-to-flow ratios as a measure of scarcity. This idea stems from a historical analysis by economist Saifedean Ammous in his 2018 book *The Bitcoin Standard*. In his book, Ammous argues that

historical evidence proves that when two items compete for market share as monetary assets in a free market, over time, value tends to flow from the softer (where adding supply is cheap) to the harder (where adding supply is expensive/impossible) asset. In other words, whenever a soft money comes into trade contact with a hard money, holders of the soft money will see their purchasing power eroded whilst the holders of the hard money will see theirs grow.

Ammous uses the term hardness as a measure of scarcity or resistance to debasement, and supports his view with a review of historical items used as money. Many traditional monies used throughout the ages of human history remained hard only for as long as a lack of technological and industrial development prevented them from being mass-produced at low costs. Examples include North American wampum (shell money), African copper and glass money, and Pacific rai stones – all of which suffered catastrophic debasement and loss of exchange value when exposed to technologically superior cultures who themselves used harder monies, most often silver or gold, and who could produce the softer monies at drastically lower costs than its original users.

He then goes on to argue that the reason for gold's unprecedented success as a global monetary medium over the aeons lies in its consistently low price elasticity of supply. Because of its chemical properties, gold, unlike almost all other goods, once produced is almost never consumed or destroyed. As such, the majority of all the gold ever produced remains in current stockpiles and these stockpiles keep the ongoing production rate from being a dominant factor in the price-setting mechanism.

Ammous uses stock-to-flow ratio, which is equivalent to the inverse of an asset's inflation rate, as a measure of hardness or scarcity. The higher the asset's stock-to-flow ratio, the lower its price elasticity of supply; the lower the price elasticity of supply, the more suited an item is to store value. PlanB takes the idea one step further and attempts to draw a direct link between the stock-to-flow ratio and the price.

The S2F/S2FX Kernel of Truth

With regards to the S2F/S2FX model, we find ourselves in the same bucket as – we suspect – quite a few other analysts: Whilst the model had us infatuated for a while, it has proven unable to withstand deeper, more rigorous analysis.

In hindsight, the results should not be surprising. It would be almost ridiculously convenient if we could model the current, let alone future, price of assets based on their supply alone.

Under no theoretical framework, however, would that make sense; the fact that prices are set at the cross-point between supply and demand is about as uncontroversial as an economic principle can be.

To the extent that the model touches on some important kernels of truth, we believe that it relates to two separate facts. First, an item's hardness is certainly an important property in monetary competition. Second, an asset's price *sensitivity* to ongoing demand will increase as its ongoing supply decreases. This makes intuitive sense. The fewer new units are available from outside of the system to ease an upward price pressure on an asset, the more of the existing units must instead be enticed out of the stock – at higher prices – to satisfy demand.

And the latter is what we believe the model actually shows. At a *given consistent demand*, an exponential reduction in ongoing bitcoin supply has created an exponential increase in the price response.

But of course demand must play a role. And demand is not, nor will it likely ever be, static. We cannot simply assume that demand will remain consistent and build models around that assumption simply because this has been more or less true in the past.

We would even go as far as to argue the contrary: demand, and specifically changes in demand, is absolutely key to modeling bitcoin prices. It might very well be true that an item's S2F ratio is an important determinant of that item's fitness in monetary competition, but it is not the single determinant.

Deeper Statistical Analysis Reveal Flaws in the S2F Model

In analysing its results we have found that linear regression analysis does have statistical significance, passing both T-Stat and Alpha assessments. This statistical significance is valid on both in-sample and out-of-sample regression analysis, with remarkably similar results. Other analysts have presented further evidence of what they believe(d) show a non-spurious relationship between the two variables, some going as far as claiming that they are cointegrated.

But despite what initially appears to be compelling statistical evidence, there are reasons to be highly cautious of the stock to flow approach.

Deeper analysis by other independent researchers have revealed flaws in the S2F methodology. Of particular interest is the analysis performed by Sebastian Kripfganz of

Exeter University where he clearly rejected previous results and added that there was no way the two variables even *could* be cointegrated. Kripfganz's conclusion is that there is no evidence that the relationship between S2F and price is anything other than random.

In another excellent paper critiquing the S2F model, Nico Cordeiro of Strix Leviathan highlighted that the regression model is doing nothing more than estimating Bitcoin's historical growth rate and then using this rate to extrapolate future prices well outside of its data set.

Cordiero also looks at 115 years of gold S2F and price, both nominal and real, and finds no relationship between the two. He then goes on to make the very salient point that if one takes a step back and thinks a little harder about the theoretical basis of the S2F model, no one in their right mind would believe that the price of bitcoin is *solely* a function of its production rate.

And of course he's right. Monetary competition is a complex phenomenon and cannot be explained by single variables. In reality there are lots of moving parts to this equation and while we do believe that high S2F ratios are helpful properties of items competing as money, they do not tell the full story.

In the next iteration of this series we will have a closer look at demand, and more specifically, ways we can estimate short- to mid-term changes in demand based on existing metrics with which many investors are already familiar.

Stay tuned.

Questions?

Get in touch at research@coinshares.com

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