RESEARCH NOTE

16 April 2020

CANE ISLAND DIGITAL RESEARCH

There Will Never Be More Than 14 Million Bitcoins

Executive Summary

- **About 4% of available bitcoins are lost each year**. This decline in bitcoin supply confirms prior research on this topic.
- **The maximum number of bitcoins that will ever be in circulation is 14 million.** This maximum value was reached this month, April 2020.
- **The available supply of bitcoins will decrease for the first time ever in May 2020.** After the 2020 halving, the rate at which bitcoins are irretrievably lost will exceed the rate at which new bitcoins are mined.
- **Bitcoin's price elasticity of supply is at or near zero.** We empirically confirmed that changes in bitcoin supply do not arise from changes in price. Because supply is fixed, the implication is that demand-based models are more likely to provide explanations of bitcoin price formation.

Counting Bitcoins

Every day, just under 1,900 new bitcoins are created. That's about 57,000 new bitcoins per month. At today's price of about $7,000, that is $400,000,000 created every month, or $4.8 billion per year.

Coins are created by miners as reward for block validation. On the very first day of economics class you learn that, all other things equal, increases in supply decrease the price of an asset. An increase in bitcoin supply puts downward pressure on bitcoin's price. Even if the production rate is halved, supply is still increased and that puts downward pressure on bitcoin's price. There are only two things that counteract this: an increase in demand, or a decrease in supply.

By all accounts, bitcoin demand has increased over time. Every metric – active addresses, transaction counts, hash rates, etc. has shown increased demand for bitcoin. Since price has also increased over that time, we can conclude that the increase in demand has outpaced the increase in supply.

For the first time ever, bitcoin supply is about to decrease.

Beginning May 2020, number of bitcoins lost in a month will likely exceed the number of new bitcoins generated. The maximum available supply of bitcoin has peaked and will decline from this point forward. The meme about "never more than 21 million bitcoins" is not entirely true. The truth is, there will never be more than 14 million available bitcoins.

Counting Lost Bitcoins

Bitcoins can be irretrievable lost. What does irretrievable lost mean?

- **A user accidentally throws away hardware**. In this extreme case, a man accidentally threw away 7,500 bitcoin, valued today at over $50 million.[1]
- **A user loses their keys.** Perhaps the most high profile case of lost keys is Elon Musk.[2]
- **A user dies without having made arrangements to transfer keys.** A notable case is that of Matthew Mellon, early investor in Ripple. Mellon held almost all his Ripple coins–estimated at $500 million–in cold wallets all around the country, with

[1] "Man accidentally threw away $127 million in bitcoin and officials won't allow a search" https://www.cnbc.com/2017/12/20/man-lost-127-million-worth-of-bitcoins-and-city-wont-let-him-look.html

[2] "Elon Musk Doesn't Know Where He Left His Bitcoin" https://fortune.com/2017/11/28/elon-musk-lost-bitcoin/

no one else knowing the codes to the wallets.[3]

- **A user sends bitcoin to the wrong address, one which is not currently managed, where the keys are lost or the address is otherwise defunct.** Sometimes users may intentionally send bitcoin to an inert address in a process known as *burning*.[4] In an extreme case, a (probably) defunct address holds nearly 80,000 bitcoins worth half a billion dollars. This address gained notoriety in Ratcliff's "Rise of the Zombie Bitcoins".[5] But even before then, people had been "donating" BTC to the address in the hopes the owner would somehow reward them with a payout, like some sort of karmic lottery ticket. Since inception, this address has never sent a single satoshi. Yet to this day, some people continue to throw good bitcoin into this black hole wishing well.

This begs two questions:

1. How much bitcoin has been irretrievable lost?
2. What is the impact on bitcoin's price?

To answer those questions, we provide some definitions.

Irretrievably Lost: this means the bitcoin is gone forever, per the above. Imagine billions in physical cash. It gets put in a vault. The combination is thrown away. The vault is launched into space and his headed toward the nearest black hole. The cost to retrieve it exceeds the value obtained if recovery were successful. This money is gone, it is no longer part of any economy anywhere. It is unable to be transacted. Irretrievably lost bitcoins are like this lost-in-space cash. They are unable to be transacted and the cost of recovery exceeds the value obtained from successful retrieval. This is quite distinct from buy and hold investing (HODL), where the owner maintains control over the bitcoin and is simply unwilling to transact. Those remain part of the *Available Supply* at some future price

Total Supply: total bitcoin mined. None of this supply was initially purchased. All of this supply was created through the mining process.

Available Supply: *Total Supply* less *Irretrievably Lost* bitcoins. *Total Supply* is known, but *Available Supply* can only be estimated. That is because it is difficult to determine whether an address with idle bitcoin is unable to be transacted (*Irretrievably Lost*), or unwilling to be transacted. If a bitcoin is unwilling to be transacted at a certain price, it is still part of supply, but liquidity may be impacted.

Price: the amount someone is willing to pay per coin to access the bitcoin ledger in order to store or transfer value. *Price* is set by the market. *Price* per coin is the intersection of demand and *Available Supply* of coins.

Calculated Market Capitalization: this is *Price* multiplied by *Total Supply*. This is the number reported in the news and on cryptocurrency monitoring websites. This number is a fiction. Because some bitcoins have been *Irretrievably Lost*, the *Actual Market Capitalization* is significantly lower.

Actual Market Capitalization: this is *Price* multiplied by *Available Supply*. This number is not known with certainty, because *Available Supply* is not known with certainty.

As evidenced in this coinmarketcap.com chart, the difference between bitcoin price and a market cap grows over time.

[3] "Billionaire Mathew Mellon's fortune in Ripple lost" https://cointhud.com/500-million-ripple-lost-billionaire-mathew-mellon-dies/

[4] "How to destroy bitcoins?" https://medium.com/@alcio/how-to-destroy-bitcoins-255bb6f2142e

[5] "Rise of the Zombie Bitcoins" https://letstalkbitcoin.com/blog/post/rise-of-the-zombie-bitcoins

Bitcoin Price and Market Capitalization (coinmarketcap.com)

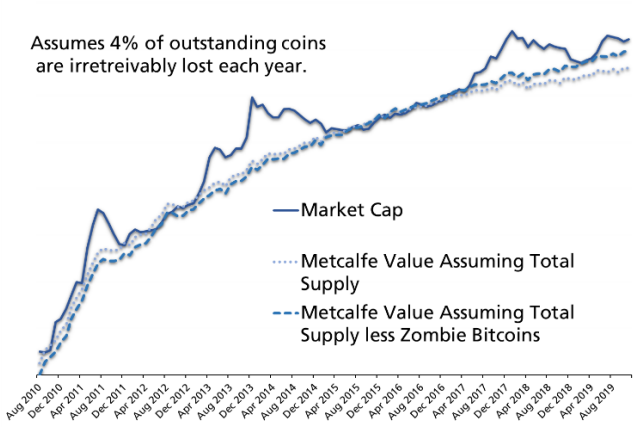
We assume that Adam Smith's invisible hand is at work, and that it is price per unit–not market cap–that reflects actual financial decisions made by people with their money. *Price* is not the same as value, but nonetheless it is usually close to value. While *Total Supply* is the number that is reported, *Price* is determined by *Available Supply* and demand.

For bitcoin, *Total Supply* is fixed, known, and grows at a predetermined rate. It is not necessary to model *Total Supply* because it is a mathematical tautology programmed into the bitcoin mining process.

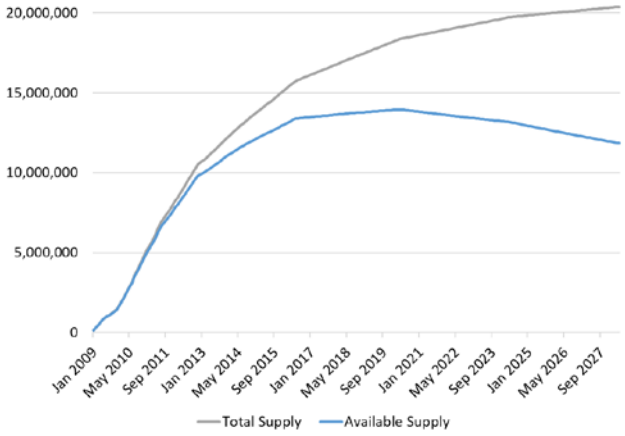
Based on our own methodology used in prior research, we were able to relate the difference in *Calculated Market Capitalization* and *Price* to lost coins. We can estimate that since 2010, about 4% of the *Available Supply* of bitcoin has been lost each year. This puts the current *Available Supply* at about 13.9 million coins, well below the 18.3 million *Total Supply* figure publicized. This means that about 28% of all bitcoins have been *Irretrievably Lost*. This figure is consistent with research conducted by Ratliff in 2014 (n. 5) and Chainalysis in 2017.[6]

Using *Total Supply* and *Available Supply* we can estimate the net number of new bitcoins introduced each day (or month).

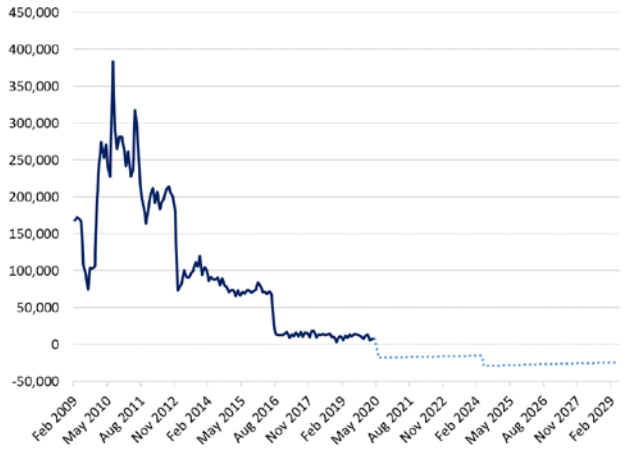
Metcalfe Value Under Different Supply Assumptions



Bitcoin Available Supply



Net New Bitcoins Supplied Each Month



[6] "Exclusive: Nearly 4 Million Bitcoins Lost Forever, New Study Says" https://fortune.com/2017/11/25/lost-bitcoins/

Because new coins are still being generated, the net change in coins is only about -1.4% per year after the 2020 halving.

Understanding the Relationship Between Bitcoin Rate of Production and Price

Suppose we run a magic chicken ranch where chickens lay golden eggs. These eggs are made of solid gold so they can't be consumed. However, sometimes eggs get lost or destroyed. We produce 12.5 eggs every 10 minutes, or 75 eggs per hour. Then half the chickens are attacked and killed by a fox. Now we only produce 6.25 eggs every 10 minutes, or 37.5 eggs ever hour. What will happen to the price of eggs? Well assuming nothing has changed with the demand for eggs, the price will go up. But by how much?

Let's assume there are 18 million such golden eggs in existence and each egg sells for $6,000. If the chickens are laying 684,000 eggs per year, and demand does not change, then there will be no change in price.

The relationship sensitivity of supply to changes in price is:

$$E_s = \%\Delta Q \div \%\Delta P$$

E_s is a number called Price Elasticity of Supply. It turns out that for our magic chicken ranch E_s is close to zero. This condition is called price inelasticity.[7]

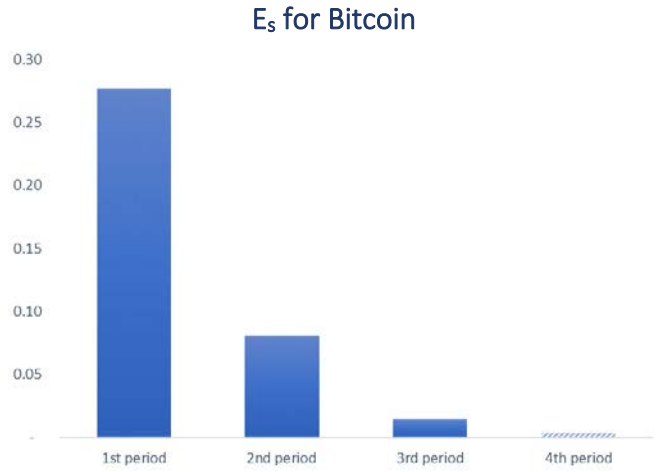
Price inelasticity means supply does not change regardless of what happens to price. And why would it? The chickens lay golden eggs at a rate of 75 eggs per hour. They don't know economics, demand, supply, or price. They just know how to lay golden eggs at a rate of 75 eggs per hour. The supply rate is constant.

Even if we get rid of half the chickens, the supply rate is constant: 37.5 eggs per hour.

We calculated average annual E_s for bitcoin for each of the three halving periods. Not surprisingly, the number is so small it is effectively zero.

The implication is that supply-based and cost-based measures are poor methods for explaining bitcoin price formation.[8]

For a better look at how bitcoin's price is demand-driven, see *Figure 2: Inelastic Expansion and the Slowing Growth of Bitcoin Supply* in "An In-Depth Look at the Economics of Bitcoin" https://www.cmegroup.com/education/featured-reports/an-in-depth-look-at-the-economics-of-bitcoin.html.



Disclosures

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[7] "An In-Depth Look at the Economics of Bitcoin" https://www.cmegroup.com/education/featured-reports/an-in-depth-look-at-the-economics-of-bitcoin.html

[8] "JP Morgan Is Using the Wrong Valuation Technique on Bitcoin" https://medium.com/@omid.malekan/jp-morgan-is-using-the-wrong-valuation-technique-on-bitcoin-65413b287763

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