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# Driving Factors Behind the Price of a Decentralised Cryptocurrency

- An Internal Look at Network Factors Influencing the Price of  
Bitcoin

FEK345 Bachelor's Thesis

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Gothenburg, June 8, 2021

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## Abstract

This paper researches internal influences on the price of Bitcoin. By looking at Satoshi Nakamoto's original whitepaper, as well as employing economic theories such as the *Law of Diminishing Marginal Utility*, *Commodity Theory*, and network valuation theory *Metcalfe's Law*, variables are chosen and run through a multiple regression analysis to determine the variables influence on the price of Bitcoin. This paper uses monthly data spanning 6 years from 2015 to 2020. Regression analysis shows that the variables *Number of Active Addresses*, *Difficulty Rate* and *Hash Rate* all are positively correlated to the price of Bitcoin, whilst the *Relative Availability* is negatively correlated to the price of Bitcoin.

### Keywords:

*Bitcoin, Commodity Theory, Law of Diminishing Marginal Utility, Metcalfe's Law.*

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# 1 Introduction

This paper will take a look at the value of a decentralised cryptocurrency and try find what factors influence and determine its value. This paper will take a primary focus on Bitcoin as it has provided the basis for a multiple of cryptocurrencies that have been created after its introduction, most of which have made use of Satoshi Nakamoto's original paper that describes the theory behind a decentralised digital currency.

By looking at Satoshi Nakamoto's original paper we are able learn and locate what internal factors and processes make up Bitcoin and the network and test these against the price of Bitcoin over a period of six years to determine what factors are influencing the value of Bitcoin. With the use of economic theories such as the *Law of Diminishing Marginal Utility*, *Commodity Theory*, as well as network valuation theory *Metcalfe's Law*, this study is able to locate possible influencing factors and determine their influence through the use of a multiple regression analysis.

## 2 Background

Cryptocurrencies are a digital based assets which are created completely digitally and are secured by cryptography. Cryptocurrencies are often built on decentralised networks based on an open source code.

Decentralised cryptocurrencies have emerged as a fast growing market ever since its inception in 2009. Created by "Satoshi Nakamoto" (assumed to be a pseudonym), "Bitcoin" is the first decentralised cryptocurrency ever created (Bitcoin.org, 2021). Since then there have been many iterations based off of the original Bitcoin source code, these are known as "altcoins". Other cryptocurrencies have also emerged out of the success of Bitcoin on the market, examples of these include "Litecoin" and "Ethereum". Transactions in Bitcoin occur completely online on decentralised networks that use a shared ledger system technology known as the "Blockchain". The blockchain is used as a solution to the double spending problem. It is made up of a "peer-to-peer" network that works to verify transactions hashing them into a chain of "proof-of-work" that cannot be altered. This network works without any central authority or administrator making it thus completely decentralised. Each transaction is secured by a digital signature corresponding to the sending address (Bitcoin.org, 2021).

New Bitcoins are created through a process know as "mining". In order to keep the network running, secure the system and process transactions it requires computing power. "Miners" give up CPU power in order to process and confirm transactions, creating new blocks on the blockchain. Miners use "Mining software" and specialised hardware in order to perform these necessary tasks, and in return they receive Bitcoin (Bitcoin.org, 2021). "Mining" therefore serves as a type of reward system for individuals giving up computing power in order to keep the network running. New Bitcoins are however created at a fixed rate making it a very competitive business for miners, especially as it becomes more popular and more miners enter the market.

New "coins" are being created at a decreasing and completely predictable rate. The number of new Bitcoin created is automatically halved over time. Bitcoin is also designed to stop creating new Bitcoin once it reaches 21 million Bitcoins (Bitcoin.org, 2021).

Many other of the altcoins share similar properties as Bitcoin being based off of the same source code, making changes to particular variables to suit their preferences.

Bitcoin and other altcoins are not only being traded on the currency exchange and over-the-counter markets, but are also emerging on the derivatives market.

Bitcoin currently has a market capitalization of approximately \$750 billion, more than

twice that of the second placed Ethereum at approximately \$327 billion (Coinmarketcap.com, 2021).

This paper will focus on looking at the value of Bitcoin by looking at what factors exert influence on its pricing. With the aim to develop a further understanding of what lays behind Bitcoin, as well as other decentralised cryptocurrencies, and understand what effects the price.

This becomes more relevant as cryptocurrencies move further towards the mainstream for companies and individual investors. This is especially relevant as major corporations begin to invest in as well as offer cryptocurrencies such as Bitcoin as methods for payment.

### 3 Problem analysis

With the popularisation of cryptocurrencies ever increasing, as well as large sums being invested into them, it is becoming ever more relevant and important to understand what gives cryptocurrencies value, as well as what factors are effecting price changes in the value of cryptocurrencies. As presented in the previous section [2], cryptocurrencies are created completely digitally, meaning they are not a physical or tangible asset as most other assets. However they do fulfill a functional value in the same way money does, and cover the necessary characteristics to fulfill that role. They also carry with them a production cost in the creation of "new coins", as discussed briefly in the previous section [2].

The problem with valuing such assets as cryptocurrencies has lead to the two major apposing viewpoints:

- That cryptocurrencies are currently in a bubble with no real tangible assets that will inescapably burst.
- That cryptocurrencies provide a major opportunity for all people to invest and participate in a financial network potentially worth trillions of dollars.

The price volatility of cryptocurrencies has also been a major issue that has many split on whether cryptocurrencies can be used in commerce or as a store of value. This volatility has however been on a decline since 2015, see [7]. It is therefor important to develop an understanding behind what is effecting price changes and the value of such cryptocurrencies.

The aim of this paper will be to look at the internal functions and processes behind decentralised cryptocurrencies and find what factors may influence its pricing. This study will put a primary focus on Bitcoin as it has provided the basis for the following altcoins and stands out as the dominating leader in the cryptocurrency market. In order to research possible factors influencing the price of Bitcoin this study will take a close look at the functions and processes involved behind the creation and processing of Bitcoin and transactions, and see to which degree they exert influence on price by performing a multiple regression analysis including the various possible influencing factors as variables.

#### 3.1 Research Question

The aim of this paper will be to provide a better understanding of the inner working of cryptocurrencies, Bitcoin in particular, and provide an answer to the following question:

- *What internal factors built into Bitcoin exert influence on its value?*



## **3.2 Limitations**

When studying the effect that certain variables may exert on the price of Bitcoin this study will focus primarily on Bitcoin's internal influencing variables. Such as the internal processes and functions behind Bitcoin that make up and maintain the Bitcoin network. Thus this study will exclude external influencing factors and variables such as external market influences and manipulations on the price of Bitcoin. This study will also be looking at the effects over a long-term period spanning 6 years, therefore this will not attempt to provide an explanation for short-term price fluctuations.

## 4 Purpose

Given that a digital currency is not a tangible assets, this has lead to a problem of how you put a value on such an asset. This problem has divided the opinions of many experts, with many believing that cryptocurrencies are in a price bubble with no tangible value that is bound to burst, and others believing that cryptocurrencies provide a major opportunity for a new type of currency to arise that brings with it advantages that is can be equally benefiting to all.

This paper will take a prime look at Bitcoin to determine what value it holds by taking a look at what factors may influence that value. Performing analysis of Bitcoin and its inner workings should provide a better understanding for the current state of Bitcoin and other cryptocurrencies as well as how it may fair further along in the future. Bitcoin like most cryptocurrencies have experienced large fluctuations in their price over the years. However these fluctuations may be short-term, and with the price trending upwards it is important to understand what internal factors are driving the price of cryptocurrencies and why investors and industries may be moving towards cryptocurrencies.

## 5 Theory

Presented in this section are the theories and inner workings behind Bitcoin that make up the network. Also presented here are theories behind what influences the value of an asset. Such theories will provide a further understanding for the factors that influence price, and aid in the choice of variables for analysis.

### 5.1 The Double-Spending Problem

The *Double-Spending* problem is the problem that regards the potential risk that a digital currency gets spent twice. This is a major problem for digital currencies as the file for a digital "coin" can be duplicated and thereby falsified. A centralised solution to this problem has been the use of trusted third-party financial institutions that can verify whether a digital coin has been previously spent. Whereas the centralised solution is a system based on trust, a decentralised solution to this problem relies instead on a system based on cryptography for proof (Nakamoto, 2008).

### 5.2 The Bitcoin Network

Satoshi Nakamoto's original paper "Bitcoin: A Peer-to-Peer Electronic Cash System" was the paper that first introduced Bitcoin from which subsequent cryptocurrencies have emerged. This paper will provide a basis for understanding the internal workings of Bitcoin, the processes behind transactions and verification's as well as the decentralised nature of it all.

#### 5.2.1 Hash Function

A hash function converts and compresses data of any arbitrary size into a bit array of fixed size called the "hash" or the "hash value". The hash value is a deterministic random number, meaning if the same data is inputted into the hash function it will produce the same hash value. The hash cannot be determined prior and the hash function also cannot be reversed (Carter and Wegman, 1979). Bitcoin uses a *SHA-256 Hash Algorithm*.

#### 5.2.2 Digital Signatures

A digital "coin" can be defined as a chain of digital signatures. Each owner in a transaction will have two "keys", a "signing key" and a "verification key". The verification key is public and the signing key is private. In a transaction the sender inputs the hash and their private key into a encryption algorithm, this produces a digital signature. The receiver can verify the transaction by inputting the digital signature and the senders public key into a decryption algorithm which then produces the hash, if no altercations have been

made then both hash will be the same. Using digital signatures the chain of ownership can thereby be verified (Nakamoto, 2008), however the problem remains that the receiver cannot verify that a owner hasn't double-spent a coin.

### 5.2.3 Timestamp Server

As part of the solution to the double-spending problem, the *timestamp server* is introduced. The timestamp server takes a hash of a block of items, this is timestamped and then widely distributed. The timestamp proves that the data in the block existed at a point in time. Each timestamp includes the previous in the hash, this forms a chain with each timestamp in the series reinforcing its predecessors (Nakamoto, 2008).

### 5.2.4 Proof-of-Work

With the timestamp server distributed over the peer-to-peer network, a proof-of-work system is implemented. Computers solve a computational puzzle by adjusting the "nonce" (arbitrary number used only once in cryptography) in a block until it gives the required zero bits to the block, this is conducted by a "node" (computer participating in the network). This process requires CPU power, meaning for each block it will require a certain amount of CPU power in order to satisfy the required proof-of-work (Nakamoto, 2008). After the proof-of-work is satisfied, alterations cannot be made to a block without redoing the work for all the subsequent blocks that follow.

### 5.2.5 Miners

"Miners" are the ones who create new blocks on the peer-to-peer network. Miners use specialised hardware and software to create new blocks by performing the proof-of-work required for a block of transactions [5.2.4]. Once the proof-of-work is satisfied, the new block is distributed to the network where nodes either validate or reject the block. Miners are rewarded Bitcoin in return for creating the new block.

### 5.2.6 Nodes

"Nodes" work to verify the blocks on the blockchain, and thereby set the rules for the network. If majority of the CPU power is run by honest nodes the honest chain will grow the fastest outpacing potential forks (deviations) in the chain (Nakamoto, 2008). The implementation of the proof-of-work system is what makes the system decentralised, where anyone in the world can run their own node supporting the network. Each node can independently verify the transactions included in a block and check it against its own copy of the ledger, false transactions are the rejected and potentially boot off the network. There are "full nodes" and there are "light nodes". Full nodes keep a full copy of the

blockchain ledger, and light nodes keep a smaller version of the ledger. Full nodes can also be mining nodes that create new blocks [5.2.5].

### 5.2.7 Network

The network works thus that transactions are distributed over the peer-to-peer network to all the nodes, the transactions are timestamped, miners perform the proof-of-work required and the block is advertised to the network where the nodes either validate or reject the block insuring that transactions have not been double-spent. Once accepted, miners can begin working on the next block using the hash of the previous block.

### 5.2.8 Difficulty Target

The difficulty level is a measure of how difficult it is to mine a new block. The difficulty target is a number that is greater than the hash of the block. In order to create a new block in the chain the miner hashes the header of the block and this hash must be less than the difficulty target. The difficulty target is adjusted every 2016 blocks (approximately every 2 weeks) to maintain an average of ten minutes between each block in the chain (Blockchain, 2021). The lower the difficulty target the harder it is to produce a hash less than the target. The hash is a random number so the miners must rehash over and over till they find a hash that fits the constraints. It serves as a greater than less than operator, as a comparison in order to control the mining speed.

### 5.2.9 Halving

The supply cap for Bitcoin is fixed at *21 Million*. New coins are released gradually to the market through the process of mining [5.2.5]. Miners receive Bitcoin in exchange for creating new blocks and this reward decreases after every 210,000 blocks mined, this occurs roughly every 4 years. The Bitcoin reward started off in 2009 at 50 BTC per block when *Satoshi Nakamoto* mined the first block, this reward was then halved after 210,000 blocks to 25 BTC. After the latest halving that occurred in May 2020 the current block reward stands at 6.25 BTC per block (Coinmarketcap.com, 2021).

## 5.3 Law of Diminishing Marginal Utility

The *Law of Diminishing Marginal Utility* states that for each unit of a product or good consumed by an individual, the value and incremental benefit derived from the consumption decreases (Doyle, 2016). Effectively the more available an item is as well as the rate of which it is available will lower the value of that item. The higher the rate of availability the lower the price.

## 5.4 Commodity Theory

*T.C. Brock's Commodity Theory* continues off of the Law of Diminishing Marginal Utility [5.3] by explaining the psychological effect that scarcity has on peoples perception of value. The theory states that as the scarcity of an object enhances the objects value or desirability for the owner. This may be a product or any other type of commodity that is transferable between persons (Lynn, 1991). With a high demand and scarce supply, this effect causes a incongruity between the supply and demand equilibrium.

## 5.5 Metcalfe's Law

*Metcalfe's Law* is a telecommunications model that describes the value of a network as relating to the number of users connected to the network. Thus larger networks would be deemed to have a higher value than smaller networks. In larger networks users have a higher level of access to information. Metcalfe's Law has also be used to value Ethernet connectivity (Internet, social networks etc.). But instead of users, the variable is number of connected compatible devises to the network. Metcalfe's Law states that the value of a network is proportional to the square of the number of connected users on the network.

$$v = \frac{n(n-1)}{2} \quad (1)$$

Where  $v$  is the value and  $n$  is number of connected users or devices to the network. The law states the number of possible pairings between users (Metcalfe, 2013).

## 6 Methodology

For this study a quantitative approach was taken, collecting and analysing raw data on the price of Bitcoin and variables effect on the price change. Variables are chosen based on established theories as well as the processes and theories behind Bitcoin and the blockchain.

### 6.1 Current Data Collection

Data on the price of Bitcoin and possible variables was collected from publicly available online resources within the time-period from the 1st of January 2015 to the 31st of December 2020 spanning over the 6 years. The Data points were collected over monthly intervals, totaling in 72 data points per variable.

Data on the closing price for Bitcoin was gathered from *Yahoo Finance* (Yahoo Finance, 2021). For data on possible internal influencing variables for analysis was gathered from *Glassnode.com* (Glassnode, 2021) as well as *Blockchain.com* (Blockchain, 2021). These sources have been used in multiple of studies researching price variations and influences [7].

### 6.2 Variables

The choice of variables was based on established economic theories as well as for their relevancy for testing hypotheses. The variables considered for this study were:

- Bitcoin closing price in USD
- Number of Active Addresses
- Circulating Supply of Bitcoin, or the Relative Availability of Bitcoin
- Difficulty Rate
- Hash Rate
- Block Size

### 6.3 Assumptions and Hypotheses

According to the previously mentioned network valuation theory [5.5] the number of users on a network determine and thereby effect the value of the whole network. Therefore the number of users, or for this case the number of active users (or addresses) was included as a variable that effects the pricing of Bitcoin. In order to research the effect of active

addresses on the price of Bitcoin, "number of active addresses" was added as a variable. As the network is positively effected by the number of users on the network, the number of active addresses on the network is expected to have a positive effect on the price of Bitcoin.

*Hypothesis 1: The number of active addresses on the network is positively correlated to the price of Bitcoin*

As the mining difficulty increases this is comparable to an increased CPU power required to mine coins. As the mining difficulty increases, miners have to make the call on whether it is worth the cost of CPU power in order to continue mining. In order for them to do so it would have to be deemed profitable, the marginal profit would have to exceed the marginal cost. Therefor the difficulty would be expected to have a positive effect on the price of Bitcoin.

*Hypothesis 2: The level of mining difficulty is positively correlated to the price of Bitcoin*

The hash-rate would also be expected to have a similar effect on the price of Bitcoin, as the difficulty level is dependent on the hash function.

*Hypothesis 3: The hash-rate is positively correlated to the price of Bitcoin*

As the theory also suggests [5.3 & 5.4], the availability or scarcity of an asset will be reflected in the price of said asset. In order to research the the influence of the availability or scarcity of Bitcoin on the price, the "Relative Availability" is added as a variable. For this variable one takes the current circulating supply of Bitcoin and the total supply of Bitcoin that will ever be available to determine the relative availability. As the supply of Bitcoin increases this would be expected to have a negative influence on the price of Bitcoin according to the theory.

*Hypothesis 4: The relative availability of Bitcoin is negatively correlated to the price of Bitcoin*

The blocks on the blockchain contain the transactions of Bitcoin over the Bitcoin network. As discussed previously [5.2], as the blockchain grows this essentially extends the "ledger" system further securing Bitcoin on the network increasing it's legitimacy. As blocks are created on average every ten minutes, this variable acts as a variable that also represents Bitcoins time in existence. As demand for Bitcoin increases over time, as well as Bitcoin becoming more secure for every block created, it is expected that as the block size increases so may the price of Bitcoin.

*Hypothesis 5: The block size is positively correlated to the price of Bitcoin*



## 6.4 Multiple Regression Analysis

In order to study the effect certain variables have on the price of Bitcoin, a multiple regression analysis is performed in order to determine both their influence as well as to what degree they may influence the price. By performing a multiple regression analysis we can capture the casual relationship between variables, the "explanatory variables" and the "response variable". In this case our response variable is the price of Bitcoin and the other variables the explanatory variables. From the multiple regression analysis one may also determine which variables are statistically significant, and can be included in the model. The multiple linear regression model is defined as:

$$y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k + \epsilon \quad (2)$$

Where  $y$  is the response variable and  $x_1, x_1, \dots, x_k$  are the explanatory variables, with  $\epsilon$  standing for the random error(Jaggia and Kelly, 2015).

## 7 Literature Survey

The study of cryptocurrencies is a relatively new field of research. There are however a few interesting studies surrounding the issue of valuing cryptocurrencies. Studies range from studying the value of cryptocurrencies as a form of money, some studies focusing around the problem of volatility that cryptocurrencies have and factors influencing price changes. A few of these studies will be presented below.

### 7.1 Literature on Cryptocurrencies Value as a Currency

Studies looking at the value Bitcoin has as a currency will tend to vary in their conclusions, but one conclusion tends to remain fairly constant, and that is that volatility presents a barrier for Bitcoin to be used as a mainstream currency.

In studying Bitcoin as a form of currency, *Yermack* claimed that Bitcoin as a currency was too volatile and showed more signs of behaving like a speculative investment rather than a currency (Yermack, 2015). Yermack also highlighted that a problem for Bitcoin was its unusual decimal pricing (Yermack, 2015), claiming it was too confusing to be able to use for the purchase of household products and services. On top of that Yermack also added that Bitcoin, as well as most other decentralised cryptocurrencies, required a high level of computer knowledge creating a high barrier for entry for potential adopters, and therefore could not break into the mainstream as a proper currency (Yermack, 2015). Yermack clearly highlights one side of the major viewpoints mentioned previously [3].

In a piece by *Francois R. Velde* for the *Chicago Fed Letter*, Velde studies Bitcoin in comparison to the already existing currency in order to determine if it could stand to serve as a replacement. Velde determines that while Bitcoin provides interesting features that combat the double-spending problem, it does so at the cost of users anonymity (Velde, 2013). While a user may possess multiple "wallets" in order to increase their anonymity, this is thought to require an extra effort that can be construed as costly for the user. Another cost for the user is the transaction speed, taking approximately 10 minutes for a transaction to be included into the blockchain, with larger amounts requiring more time (Velde, 2013). Velde also argues that while it may generally be thought that creating forks that make up over half of the network is deemed too expensive, the potential growth in value for Bitcoin may be cause for malicious behaviour (Velde, 2013).

In a study by *Kubat Max*, he studies how Bitcoin may fit in with the established definitions of money, as well as how it fits with current legal definitions. Kubat finds that Bitcoin does not settle with most of the current established definitions out there, with some definitions acting to broadly to take into consideration, as well as most legal definitions relying on a

central financial institutions that distribute and verify currency and transactions for their definitions, into which a digital currency like Bitcoin by its making goes against (Kubat, 2015). Kubat finds that Bitcoin from its users may intuitively be considered money, however lacking any legal status Bitcoin cannot explicitly be considered as money. When looking at Bitcoin as a store of value, Kubat compares Bitcoin's volatility to gold, the Euro and the Polish Zloty, with both fiat currencies coming out with the lowest volatility's and Bitcoin with the highest volatility (Kubat, 2015). Kubat determines thereby that Bitcoin incurs too high a risk to be considered a safe store of value.

Presenting in part the other side of the argument (Woo et al., 2013) highlights various advantages to Bitcoin as a currency. In their paper it explains Bitcoin as having major potential for use in e-commerce to even rival fiat currency, highlighting that Bitcoin lowers transaction cost as it does not require financial institutions serving as middlemen, but instead using a peer-to-peer network to verify transactions. In the study, they do however agree in part with Kubat and Yermack's studies in that Bitcoin suffers from high volatility, making it the prime hindrance from it being used for general commerce and gaining mainstream use (Woo et al., 2013).

In an article by *Parker Lewis*, Lewis claims that Bitcoin is not backed by anything, but is in fact backed by the credibility of its own monetary properties. Monetary goods will possess certain properties that make them valuable as a means of exchange. Properties such as scarcity, fungibility, divisibility and durability etc. New monetary goods will emerge fulfilling these properties and improving upon its predecessor and making the predecessor obsolete (Lewis, 2019). Lewis lays out the factors that support his claim by laying out how Bitcoin compares in these monetary properties against gold and fiat currency.

For the property of scarcity, Lewis highlights that Bitcoin has absolute scarcity built in with a limit of 21 Million Bitcoin that will ever be in existence. Regarding divisibility, Bitcoin is divisible to 1 one-hundred millionth. And regarding Bitcoin's fungibility, value can be transferred between parties without use of trusted third party (Lewis, 2019).

For the Dollar its scarcity comes from the size of the debt relative to the amount of dollars in circulation, meaning debt creates the demand for dollars. The amount of dollars is also not fixed, but is manipulated by the Federal Reserve. For Bitcoin's supply to exceed the 21 Million, the vast majority of users would have to agree to debase their own assets (Lewis, 2019).

When compared to gold as a store of value, Lewis highlights that gold's primary value lays in it being relatively scarce and fungible, however it is hard to transport and has become relatively centralised. Bitcoin in comparison improves upon gold's flaws in that

being a digital asset it is highly portable as well as decentralised (Lewis, 2019).

## 7.2 Literature on Influencing Factors

Studies looking at various factors that influence the prices of cryptocurrencies can be quite broad in what variables they choose to take into account. Again here volatility presents itself as a major culprit effecting prices negatively.

Studying primarily the price volatility of Bitcoin, *Bouoiyour and Selmi* looked at the price volatility of Bitcoin between 2010 to 2014 as well as 2015 to 2016. The results of the study was that volatility effected prices negatively overall, however they also found that volatility was in a general decline since 2015 (Bouoiyour and Selmi, 2016). The study also looked at the effect of positive news (positive shocks in prices) and bad news (negative shocks) on price changes, and found that price changes were more responsive to bad news rather than good (Bouoiyour and Selmi, 2016).

When looking at popularity and in a sense the effect of the internet on Bitcoin price, *Kristoufek* studied the relationship between the price of Bitcoin and search frequency on Bitcoin from *Google* and *Wikipedia*. In the study it was believed that due to the decentralised nature of Bitcoin, the price was driven primarily by short-term investors and speculators following the trends. Similarly in a study by *Garcia et al.*, it was also thought that the price was primarily driven by social factors accumulated in the interactions between actors in the market (Garcia et al., 2014). Using the search frequencies, Kristoufek as well as Garcia et al. were able to quantify the interest in Bitcoin and map that against the price. The findings were that the weekly trends on Google and the daily trends on Wikipedia corresponded with the price of Bitcoin (Kristoufek, 2013). As interest in Bitcoin increased on these search-engines as did the Bitcoin price. Another finding was that as the Bitcoin price rose above the tend, the increase in interest pushed the price further up. As was the effect on the opposite when the price fell below the trend, interest would drive the price further below (Kristoufek, 2013). In the study by Garcia et al. they also found that this effect was far more prevalent when the price fell (Garcia et al., 2014).

Studying the multiple factors that influence the prices of cryptocurrencies, *Sovebetov* studied a set of common cryptocurrencies, Bitcoin, Ethereum, Dash, Litecoin, as well as Monero. Sovebetov tested various factors effecting the crypto-market in an attempt to find determining factors of price change. By putting together a "Crypto 50 index", sampling the top 50 "coins" Sovebetov studied possible explanatory factors that correspond to price movements. Sovebetov also studies these influencing factors over a short-run and long-run period. Using historic price data, statistics from various sources as well as *Google* search data, they were able to derive determining factors (Sovebetov, 2018).

Results of this study showed that trading volume positively effected price change in all cryptocurrencies studied, especially in the long-run. Volatility effected prices negatively in both the long-run and short-run, this effect was more severe in the short-run. The "attractiveness" of cryptocurrencies effected all but Dash. This effect was positive but was only statistically significant in the long-run (Sovebetov, 2018).

## 8 Results & Analysis

### 8.1 Data

#### 8.1.1 Bitcoin Price in USD

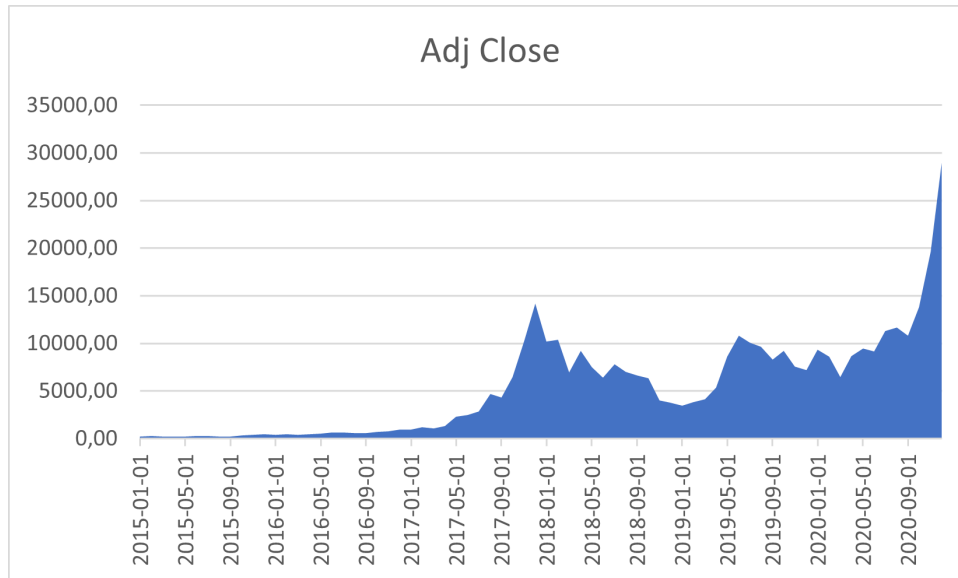


Figure 1: Adjusted Closing Price for Bitcoin (Yahoo Finance, 2021)

In order to study the price of Bitcoin over a long-term period, the adjusted closing price of Bitcoin [fig:1] is transformed into the log-normal values [fig:2]. This is standard practice when studying currency returns over longer periods of time. This helps mitigate heteroskedasticity, where the variance can vary quite comprehensively. This will help when performing the regression analysis of the data.

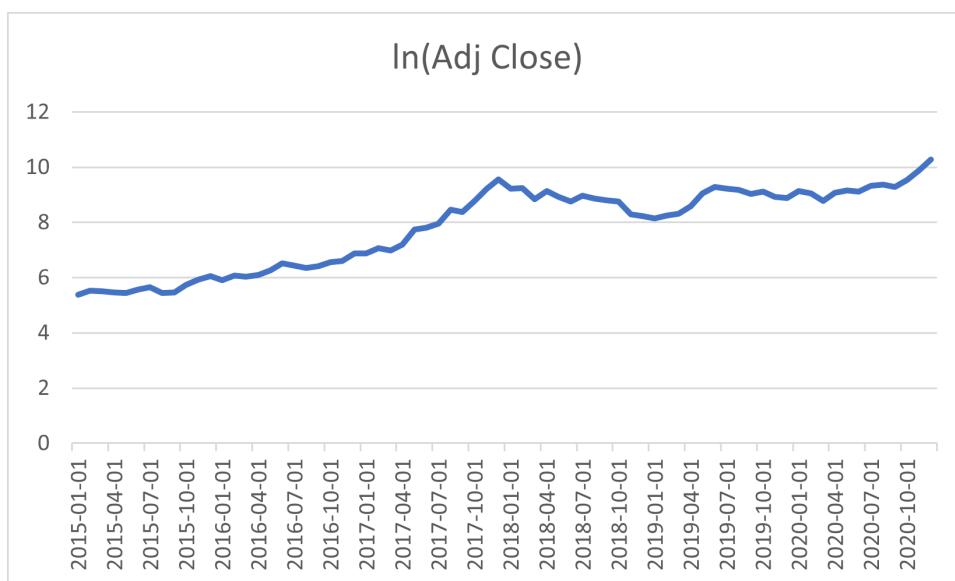


Figure 2: Log-normal Adjusted Closing Price

## 8.1.2 Number of Active Addresses

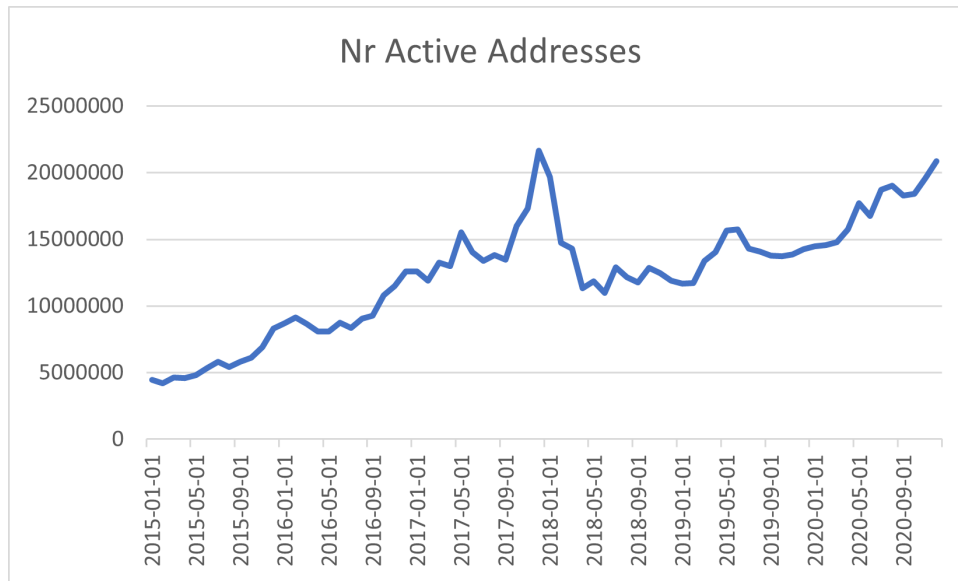


Figure 3: Number of Active Addresses (Glassnode, 2021)

When studying the effect of the number of active addresses on the price of Bitcoin [fig:3], using *metcalfe's law* [eq:1] the values are converted, on top of which the values are then transformed to the log-normal values to produce the following values [fig:4].

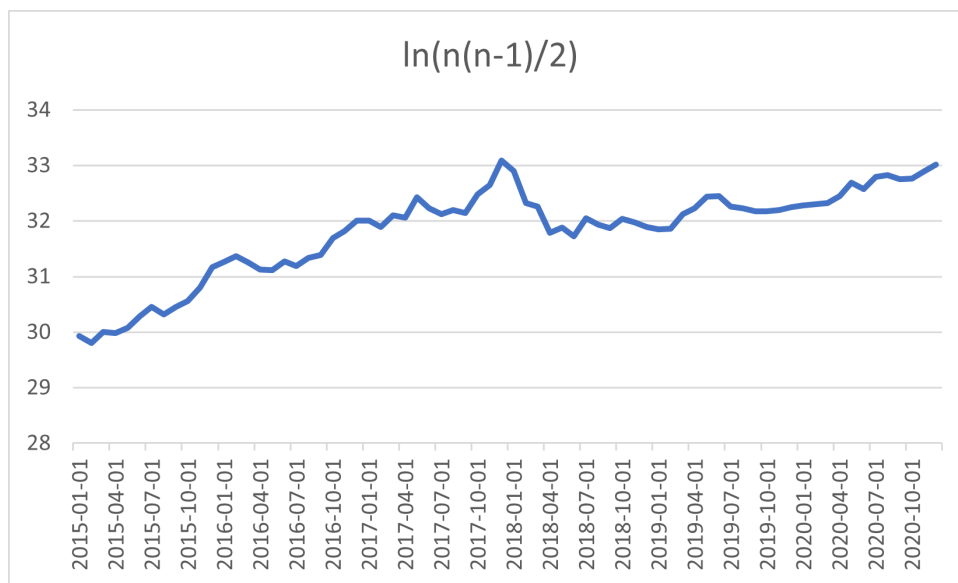


Figure 4: Log-Normal Metcalfe's Active Addresses

### 8.1.3 Level of Difficulty & Hash Rate

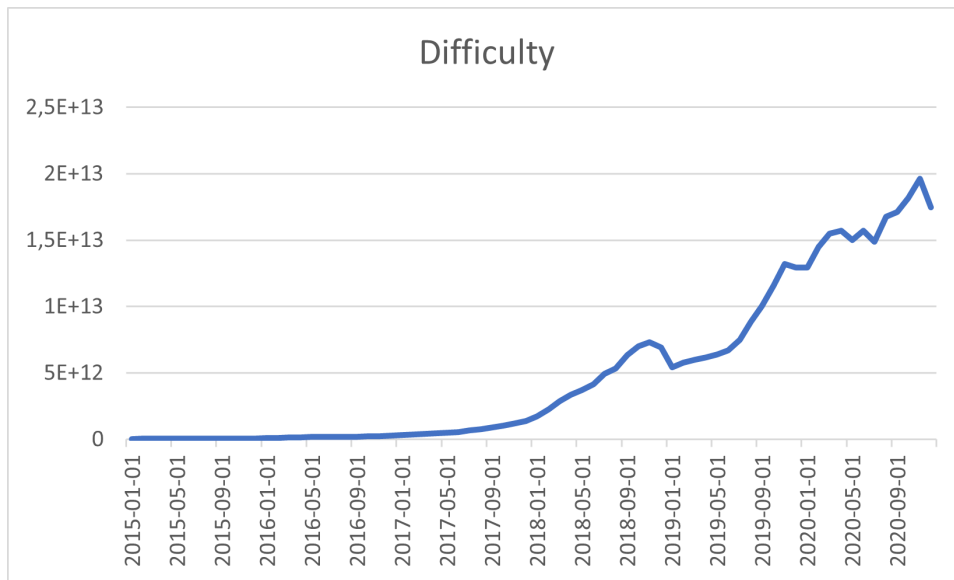


Figure 5: Difficulty (Blockchain, 2021)

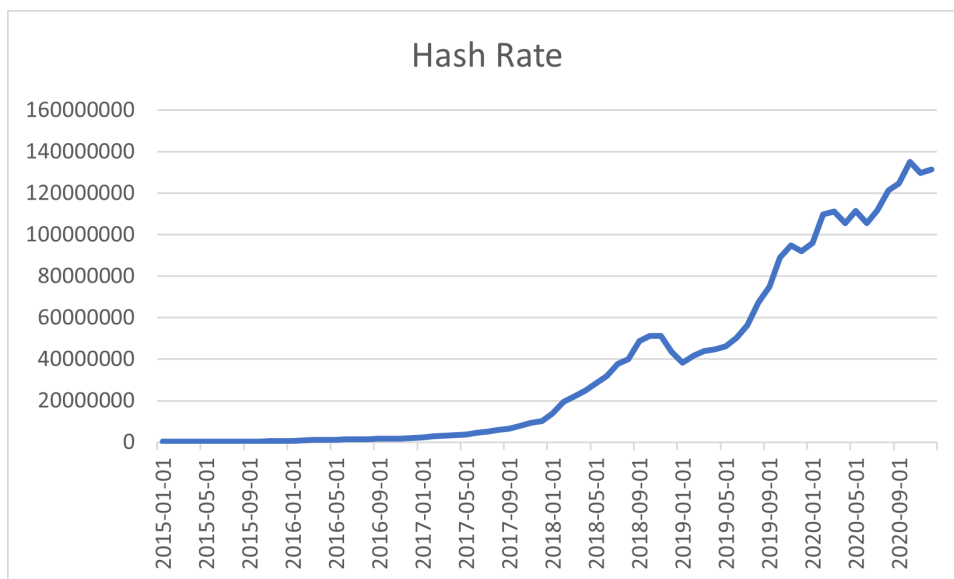


Figure 6: Hash Rate (Blockchain, 2021)

As the level of difficulty and hash rate are both dependent on the other [see 5.2.8], this could present a problem of multicollinearity in the regression analysis. With a correlation of  $Corr = 0.9981$  this is a strong indication of multicollinearity. Therefore when performing the regression analysis only one of these variables will be used at a time. For each of the variables the values were transformed to the log-normal values, producing the following [fig:7] & [fig:8].



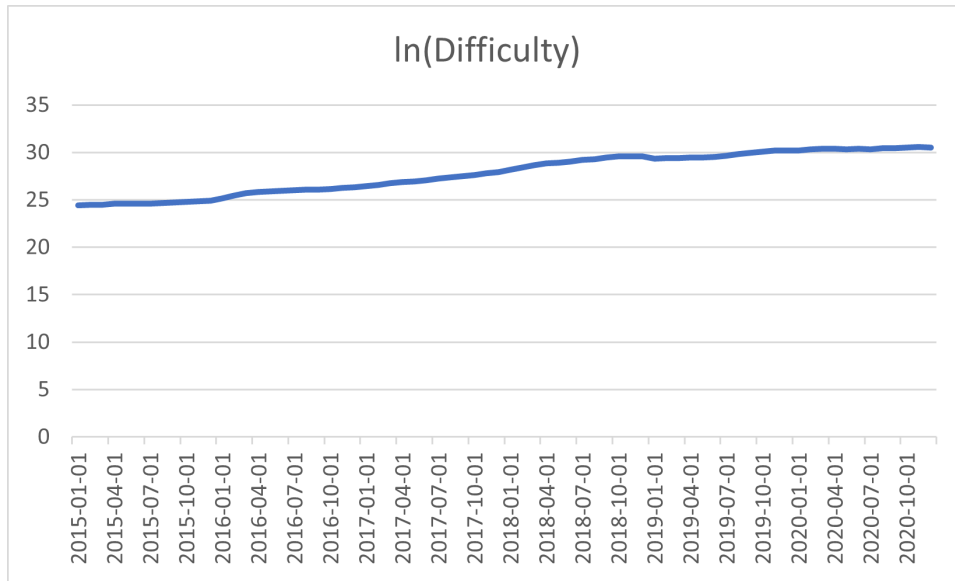


Figure 7: Log-Normal Difficulty

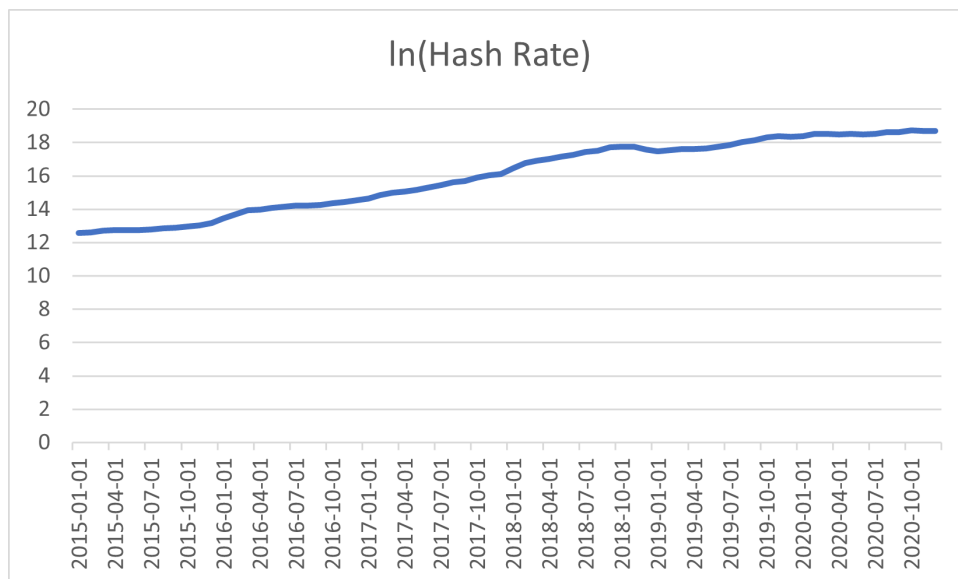


Figure 8: Log-Normal Hash Rate

### 8.1.4 Circulating Supply of Bitcoin

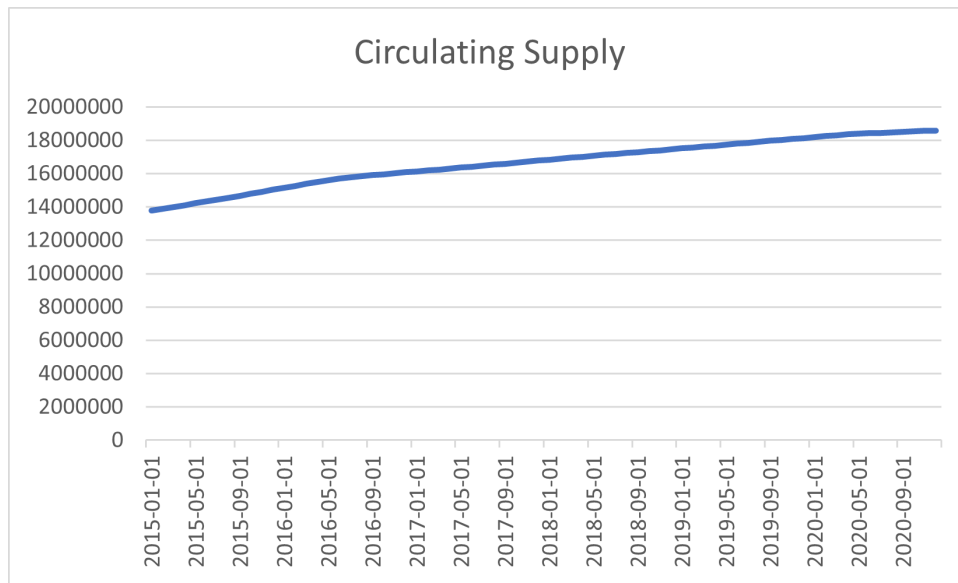


Figure 9: Circulating Supply (Glassnode, 2021)

The circulating supply of Bitcoin values [fig:9] are transformed to a relative variable by taking the values and dividing them by the total supply of Bitcoin that will ever be, 21 million. The following *Relative Availability* variable is produced [fig:10].

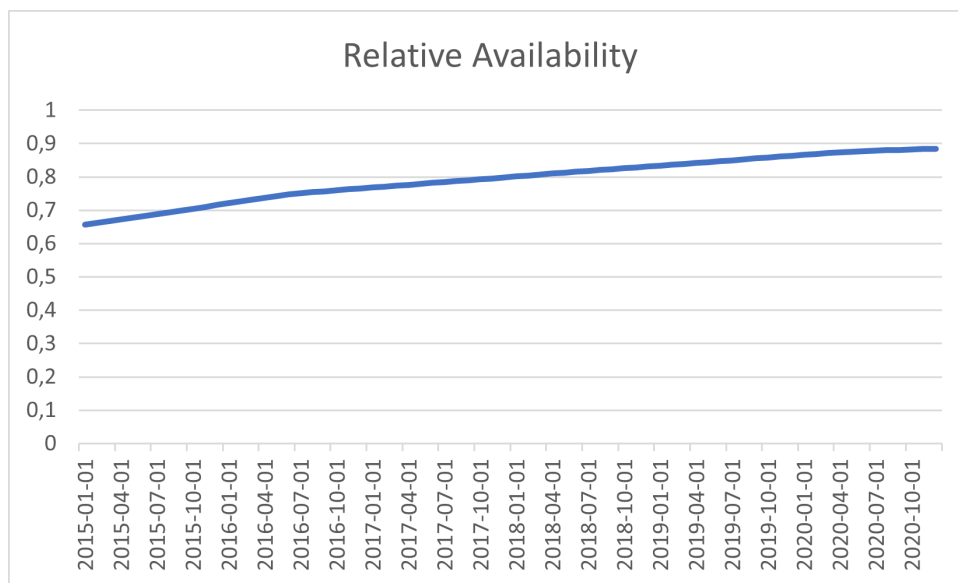


Figure 10: Relative Availability

### 8.1.5 Block Size

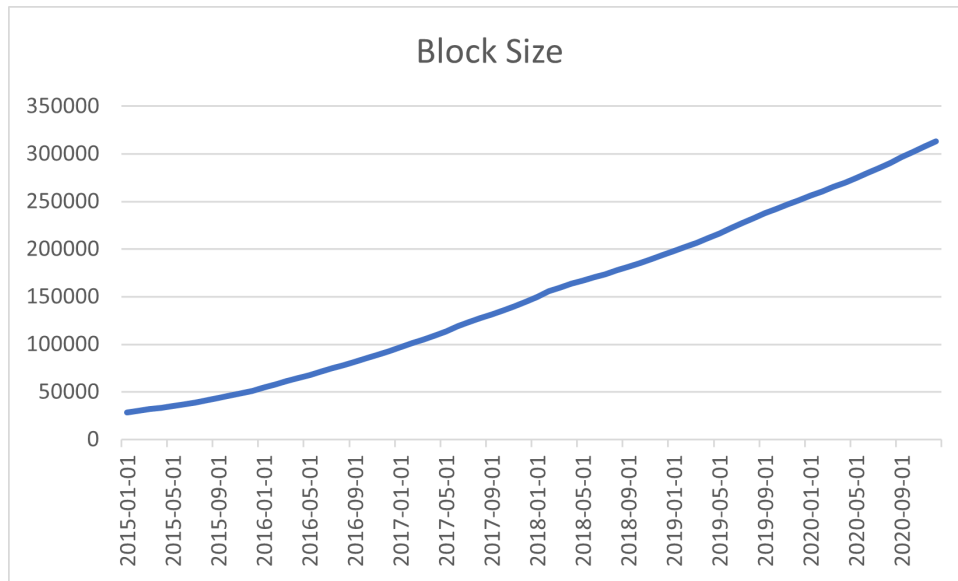


Figure 11: Block Size (Blockchain, 2021)

As discussed previously [5.2], new blocks are created roughly every ten minutes, this provides a linear data set as seen above [fig:11]. This data-set is transformed to the log-normal values to produce the following values [fig:12].

### 8.1.6 Block Size

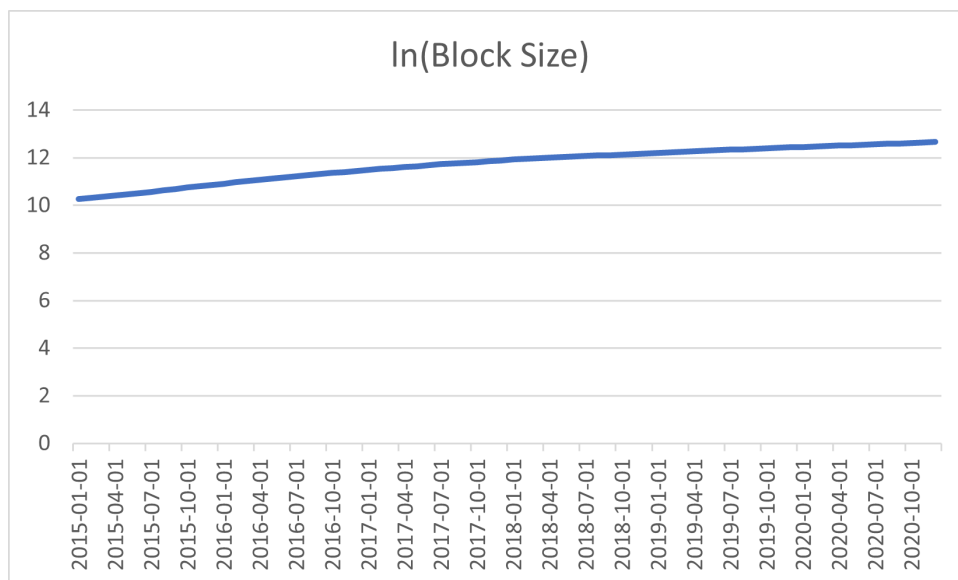


Figure 12: Log-Normal Block Size

## 8.2 Multiple Regression Analysis

Using the above data [8.1] a least-squares (OLS) multiple regression was performed over the 72 data-points per variable in order to determine what variables influence change in the response variable, Bitcoin price. All regressions run on the various data-sets were performed using a 95% confidence level.

### 8.2.1 Model 1A

For the first model to be studied the following model was used:

$$\begin{aligned} \ln(\text{Price}) = & \beta_0 + \beta_1 \ln\left(\frac{n(n-1)}{2}\right) + \beta_2 \ln(\text{Difficulty}) \\ & + \beta_3(\text{Relative Availability}) + \beta_4 \ln(\text{Block Size}) \end{aligned} \quad (3)$$

After running the regression it resulted in the following regression line:

$$\begin{aligned} \ln(\text{Price}) = & -40.307 + 1.039 \times \ln\left(\frac{n(n-1)}{2}\right) + 0.987 \times \ln(\text{Difficulty}) \\ & - 39.152 \times (\text{Relative Availability}) + 1.591 \times \ln(\text{Block Size}) \end{aligned} \quad (4)$$

This model produced an  $R^2 = 0.9632$  and an adjusted  $R^2 = 0.961$ . With an  $R^2$  that high it indicates that over 96% of the variation in Bitcoin's price can be explained by the variables in this model [eq:3].

When comparing the outcome of this regression with the original hypotheses [6.3] the following is confirmed:

- *Hypothesis 1* is confirmed, with a coefficient of 1.039 indicating that the number of active addresses on the network is positively correlated to the price of Bitcoin.
- *Hypothesis 2* is confirmed, with a coefficient of 0.987 indicating that the level of difficulty in the mining process is positively correlated to the price of Bitcoin.
- *Hypothesis 4* is confirmed, with a coefficient of  $-39.152$  strongly indicating the relative availability of Bitcoin is negatively correlated to the price of Bitcoin.
- *Hypothesis 5* is also confirmed, with a coefficient of 1.591 indicating that the block size is positively correlated to the price of Bitcoin.

However the *P-Value* for the coefficient for  $\ln(\text{Block Size})$  comes in at 0.079847, above the required 0.05 to be deemed statistically significant. The remainder of the variables coefficients come in with *P-Values* under 0.05.

### 8.2.2 Model 1B

Given that the *P-Value* for the coefficient for  $\ln(\text{Block Size})$  comes in at  $0.079847 > 0.05$ , a new regression is performed with this variable cancelled out.

For this regression the following model was used,

$$\ln(\text{Price}) = \beta_0 + \beta_1 \ln\left(\frac{n(n-1)}{2}\right) + \beta_2 \ln(\text{Difficulty}) + \beta_3 (\text{Relative Availability}) \quad (5)$$

After running the regression it resulted in the following regression line:

$$\begin{aligned} \ln(\text{Price}) = & -40.382 + 1.249 \times \ln\left(\frac{n(n-1)}{2}\right) + 1.159 \times \ln(\text{Difficulty}) \\ & - 29.963 \times (\text{Relative Availability}) \end{aligned} \quad (6)$$

This model produced an  $R^2 = 0.9614$  and an adjusted  $R^2 = 0.9597$ . With an  $R^2$  that high it indicates that roughly 96% of the variation in Bitcoin's price can be explained by the variables in this model [eq:5]. All *P-Values* in this model are under 0.05 making all the variables in this analysis statistically significant.

When comparing the outcome of this regression with the original hypotheses [6.3], *Hypothesis 1*, *Hypothesis 2*, and *Hypothesis 4* are all confirmed with relevant coefficients indicating how they correlate to the price of Bitcoin.

A closer look at the line fit plots show that the predicted values in this model are fitting in line with the actual values from the data set [fig:13]. A closer look at the residual plots for this model show that the variance in the data is maintained relatively well across values [fig:14]. Reaching the higher values there may be a few outliers in the mix, but otherwise fairly consistent.

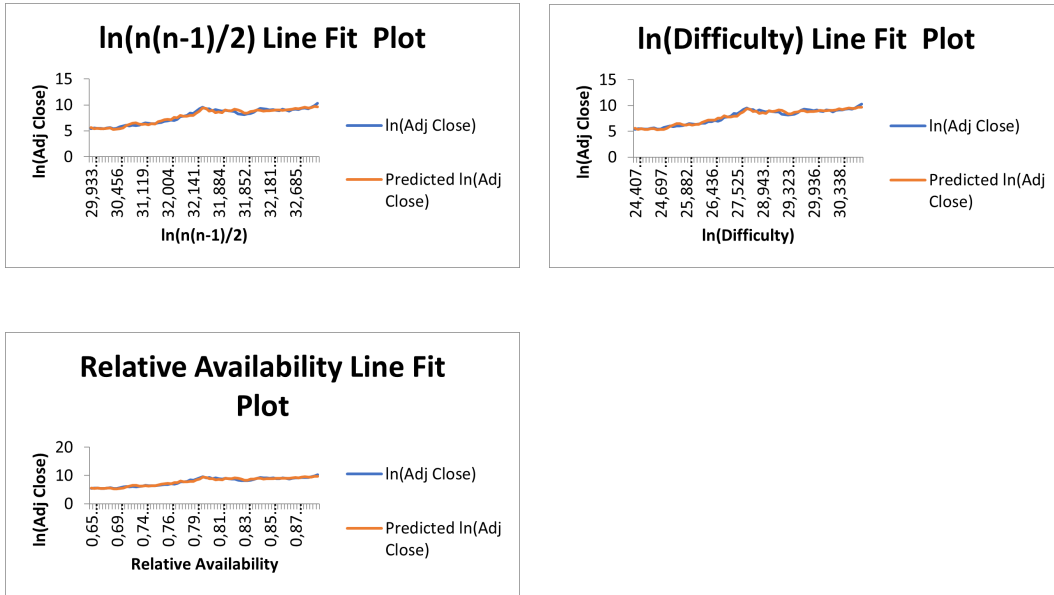


Figure 13: Line Fit Plots Model 1B

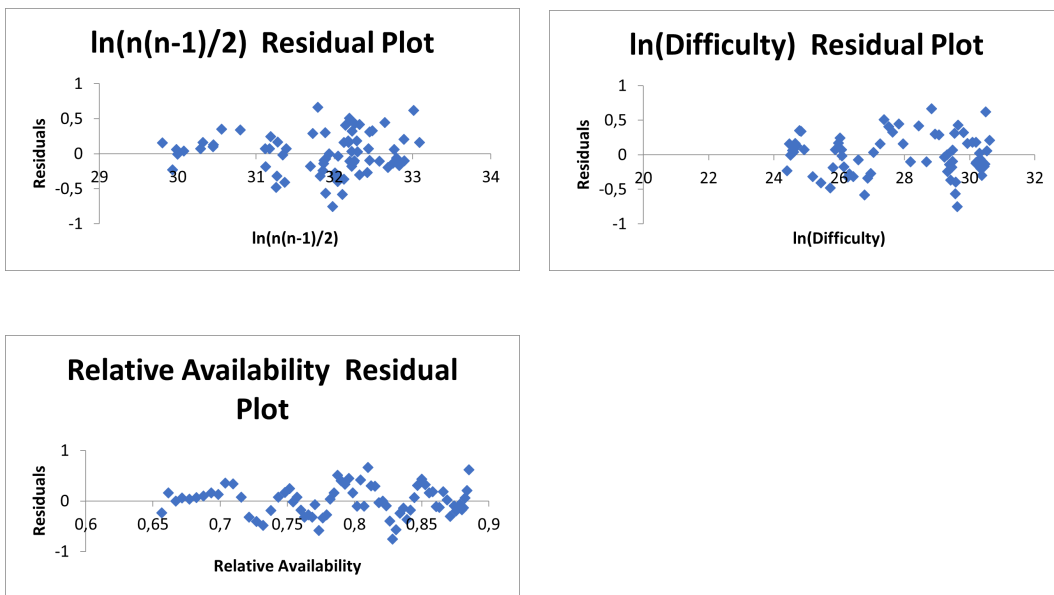


Figure 14: Residual Plots Model 1B

### 8.2.3 Model 2A

Moving forward the difficulty rate variable is replaced with the hash rate variable. For starters the following model was used:

$$\begin{aligned} \ln(\text{Price}) = & \beta_0 + \beta_1 \ln\left(\frac{n(n-1)}{2}\right) + \beta_2 \ln(\text{Hash Rate}) \\ & + \beta_3(\text{Relative Availability}) + \beta_4 \ln(\text{Block Size}) \end{aligned} \quad (7)$$

After running the regression it resulted in the following regression line:

$$\begin{aligned} \ln(\text{Price}) = & -27.182 + 1.022 \times \ln\left(\frac{n(n-1)}{2}\right) + 1.018 \times \ln(\text{Hash Rate}) \\ & - 36.985 \times (\text{Relative Availability}) + 1.324 \times \ln(\text{Block Size}) \end{aligned} \quad (8)$$

This model produced an  $R^2 = 0.9650$  and an adjusted  $R^2 = 0.9629$ . This model provided a slightly higher  $R^2$  value than the previous model [eq:3] including difficulty as a variable instead of the hash rate, however small it may be. With an  $R^2$  that high it indicates that over 96% of the variation in Bitcoin price can be explained by the variables included in this model [eq:7].

When comparing the outcome of this regression with the original hypotheses [6.3] the following is confirmed:

- *Hypothesis 1* is confirmed, with a coefficient of 1.022 indicating that the number of active addresses on the network is positively correlated to the price of Bitcoin.
- *Hypothesis 3* is confirmed, with a coefficient of 1.018 indicating that the hash rate is positively correlated to the price of Bitcoin.
- *Hypothesis 4* is confirmed, with a coefficient of  $-36.985$  strongly indicating the relative availability of Bitcoin is negatively correlated to the price of Bitcoin.
- *Hypothesis 5* is also confirmed, with a coefficient of 1.324 indicating that the block size is positively correlated to the price of Bitcoin.

However the *P-Value* for the coefficient for  $\ln(\text{Block Size})$  once again comes in above the required 0.05 with a value of 0.138527 to be able to deem it statistically significant. The remainder of the variables coefficients come in with *P-Values* under 0.05.

### 8.2.4 Model 2B

Given that the *P-Value* for the coefficient for  $\ln(\text{Block Size})$  comes in at  $0.138527 > 0.05$ , a new regression is performed with this variable cancelled out.

For this regression the following model was used,

$$\ln(\text{Price}) = \beta_0 + \beta_1 \ln\left(\frac{n(n-1)}{2}\right) + \beta_2 \ln(\text{Hash Rate}) + \beta_3 (\text{Relative Availability}) \quad (9)$$

After running the regression it resulted in the following regression line:

$$\begin{aligned} \ln(\text{Price}) = & -25.398 + 1.189 \times \ln\left(\frac{n(n-1)}{2}\right) + 1.160 \times \ln(\text{Hash Rate}) \\ & - 29.236 \times (\text{Relative Availability}) \end{aligned} \quad (10)$$

This model produced an  $R^2 = 0.9639$  and an adjusted  $R^2 = 0.9623$ . With an  $R^2$  that high it again indicates that roughly 96% of the variation in Bitcoin's price can be explained by the variables in this model [eq:9]. All *P-Values* in this model are under 0.05 making all the variables in this analysis statistically significant.

When comparing the outcome of this regression with the original hypotheses [6.3], *Hypothesis 1*, *Hypothesis 3*, and *Hypothesis 4* are all confirmed with relevant coefficients indicating how they correlate to the price of Bitcoin.

Taking a closer look at the line fit plots, they show that the predicted values from the regression are fitting well in line with the actual values in the data set [fig:15]. Also when taking a closer look at the residual plots for this model show that the variance in the data is maintained relatively well across values [fig:16], similarly to the previous model [eq:5]. Reaching the higher values there may be a few outliers in the mix, but otherwise fairly consistent.



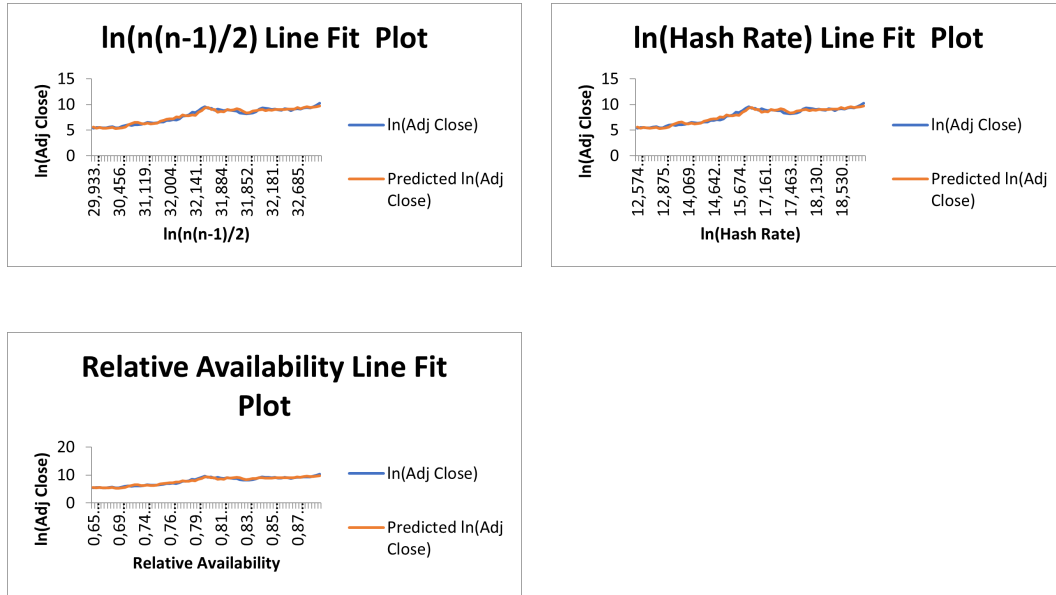


Figure 15: Line Fit Plots Model 2B

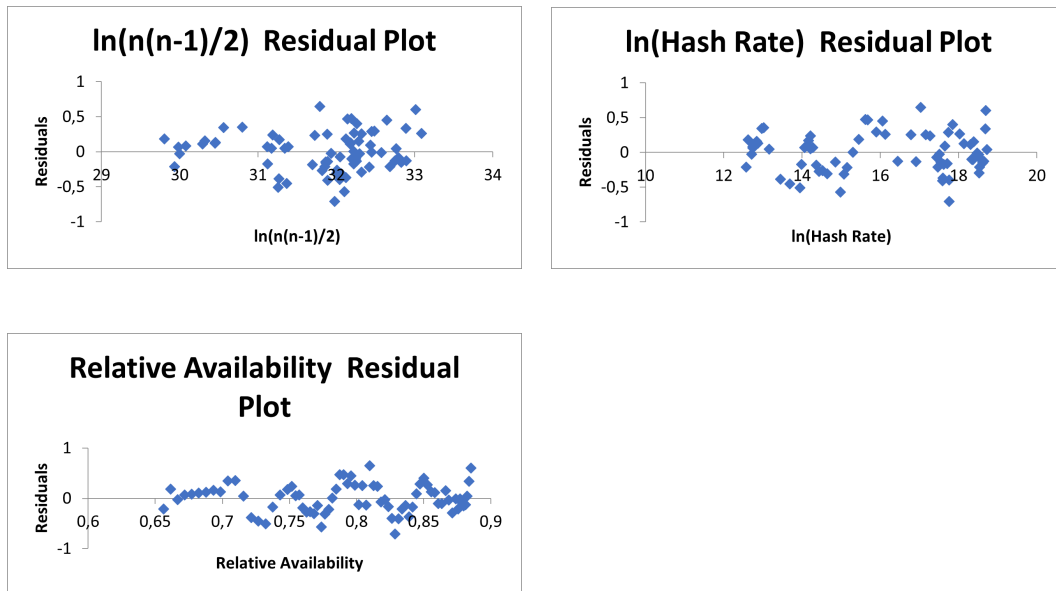


Figure 16: Residual Plots Model 2B

### 8.2.5 Model Metcalfe

As *Metcalfe's Law* is a model used for valuing networks [5.5], and has been used in the previous models [eq:3], [eq:5], [eq:7] and [eq:9], a further regression model is run in order to look at to what degree the number of active addresses on the network have an effect on the price of Bitcoin.

For this regression the following model was used,

$$\ln(\text{Price}) = \beta_0 + \beta_1 \ln\left(\frac{n(n-1)}{2}\right) \tag{11}$$

After running the regression it resulted in the following regression line:

$$\ln(\text{Price}) = -43.198 + 1.604 \times \ln\left(\frac{n(n-1)}{2}\right) \quad (12)$$

This model produced an  $R^2 = 0.8070$  and an adjusted  $R^2 = 0.8042$ , indicating that roughly 80% of the variation in Bitcoin's price can be explained by the variable in this model [eq:11]. The  $P$ -Value in this model also coming under 0.05 making the variable in this analysis statistically significant.

Taking a closer look at the line fit plot for this model, it shows that the predicted values from the regression are fitting fairly well in line with the actual values in the data set. However not as well as with the previous models, [eq:5] and [eq:9].

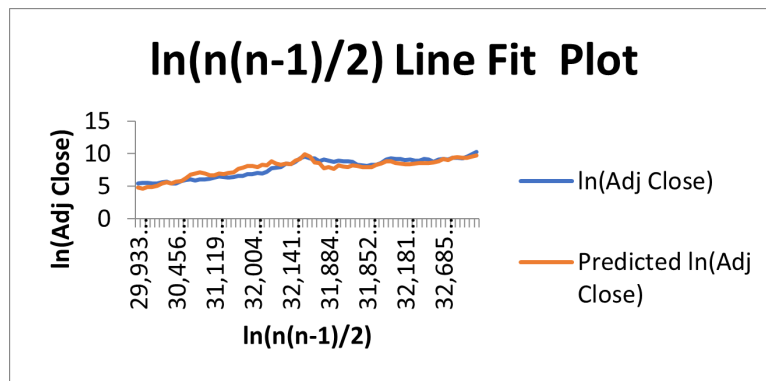


Figure 17: Model Metcalfe's Line Fit Plot

When comparing the outcome of this regression with the original hypotheses [6.3], *Hypothesis 1* is confirmed with relevant coefficient indicating that the number of active addresses on the network is positively correlated to the price of Bitcoin.

## 9 Conclusion

The regressions models researched in this paper were able to determine approximately 96% of the variation in the price of Bitcoin from the chosen variables. This 96% comes across in models: [eq:3], [eq:5], [eq:7] and [eq:9], after performing a multiple regression analysis using up to four explanatory variables to predict the response variable *Bitcoin's price*.

The use of *Metcalfe's Law* in this study has produced a variable for use in all the models, performing consistently in all regressions, producing coefficients ranging between 1.022 and 1.249, always producing *P-Values* in under 0.05 making the variable in this analysis statistically significant. Furthermore when looking primarily at the number of active addresses on the network, based around *Metcalfe's Law*, the regression produced a model able to determine approximately 80% of the variation in the price of Bitcoin [eq:11]. These findings both confirm the original hypothesis and remain consistent with the Metcalfe's Law in valuing networks. However using the number of active addresses alone in valuing the network would be lacking, but instead requires further variables to produce a reliable model to estimate the price.

When looking at the mining difficulty and the hash-rate, these variables could be used interchangeably, both producing necessary *P-Values* to be deemed statistically significant. Modeling the price change using the hash-rate as a variable produced a slightly better model in this study. The use of both the difficulty level as well as the hash-rate both produced models that confirmed the original hypothesis, stating that as the difficulty or hash-rate increases, miners would have to deem it profitable in order to continue mining and would therefor be positively correlated to the price of Bitcoin.

When looking from the perspective of the *Law of Diminishing Marginal Utility* [5.3], as well as *Commodity Theory* [5.4], the researched models did indeed find that the relative availability of Bitcoin has a great effect on its price, with coefficients for the variable in the models ranging from approximately  $-29$  to approximately  $-40$ . As the relative availability increases this has a great negative effect on the price of Bitcoin, which both confirms the original hypothesis and remains consistent with the presented theories.

### 9.1 Answer to Research Questions

When looking at Bitcoin's inner workings this study was able to find certain factors that make up Bitcoin and its network that were influential on the value of Bitcoin. These factors included the *number of active addresses*, *hash-rate*, *difficulty level*, the *relative availability* and the *block size*. All these factors apart from the block size were statistically

significant in the models for this study. This study is therefore able to determine that the following factors that make up Bitcoin and its network are driving factors for the value of Bitcoin:

- *Number of Active Addresses*
- *Hash-Rate*
- *Difficulty Level*
- *Relative Availability*

With most of the models producing  $R^2$  values over 96% it is interesting that despite all the volatility that Bitcoin experiences in short-term price fluctuations, Bitcoin can still in the long-run base its value off of its own internal functions and processes which are fairly basic in nature and fairly predictable, also highly available to all users to observe.

A fault that may exist in the data that is worth of noting is that one cannot know exactly the amount of Bitcoin in circulation. For example people have lost their personal keys, people may have died without transferring their keys etc.

## 9.2 Further Suggested Study

Further study on this topic may be to focus on external market influences on the price of cryptocurrencies, both long-term and short-term. Especially in the short-term as Bitcoin as well as the other cryptocurrencies do experience large fluctuations in price quite regularly.

With more influential actors entering the market of cryptocurrencies, it would also be worth looking at the effect they have on the price of Bitcoin. A question worth researching would be "how decentralised can a cryptocurrency be with highly influential investors influencing its price?".

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