FIN6392.0W1
Financial Technology and Blockchain

Group 8

Jessica Chen, Tamo Natarajan, Jane Song,

Kort Suter, and Kristine Wilson

Project 2:

Cryptocurrency Valuation

Introduction

Over the last decade, cryptocurrency has become a financial marvel that seems to be growing in importance at an exponential pace. While the blockchain technology that supports cryptocurrency is revolutionary, many are skeptical about the benefits and needs of digital currency. Banks and governments are worried about the implications of using an unproven currency that cannot be manipulated or regulated by institutions, like the Federal Reserve, to control interest rates and inflation. While the idea of cryptocurrency has now been around for several years, there is still a cloud of mystery around how it works and its viability as a method of payment.

In 2008, a white paper for blockchain was published by Satoshi Nakamoto, highlighting this new groundbreaking blockchain technology and alluded to some of its practical applications in the financial industry. Using Bitcoin cryptocurrency as a method of payment, its purpose was to negate the possibility of double spending by removing the intermediary that processes transactions, like a bank. This is handled through the creation of protocols to facilitate transactions as they occur. Unlike the majority of our financial systems, blockchain is a decentralized network using peer-to-peer validation techniques to form a consensus within the network on whether a transaction has taken place. All of this takes place under the encrypted protection of hash technology, linking each block of transactions to the subsequent block, making it impossible to hack into a block without dismantling the entire system. These blocks of transactions in the chain are nothing more than a ledger of transactions. As cryptocurrency is exchanged, the cryptocurrency's blockchain will record the transaction and will be validated by a majority of nodes within the blockchain network.

Cryptocurrencies have continued to evolve over the last decade and have gained clout through the creation and implementation of smart contracts using blockchain 2.0 technology (Ethereum). The development of Ethereum has spurred on the creation of decentralized applications and smart contracts, which can simplify business and trade between parties with ease and guarantee immutability.

Methods Of Valuation

Cryptocurrencies have consistently proven to be more volatile than fiat currencies like the U.S. dollar or British pound. Since most cryptocurrencies have no financial backing by other physical currencies (besides stablecoins), their price movements fluctuate much more dramatically compared to equities regulated on major stock exchanges. Due to this unpredictability, it is also very difficult to properly

valuate cryptocurrencies. For other securities, valuation methods like the discounted cash flow model (DCF) or capital asset pricing model (CAPM) can be used by analyzing future earnings or expected return relative to risk. Cryptocurrencies behave differently and are modeled better using other valuation techniques.

The first method of valuation was the cost of production method. This scenario assumes that there are no barriers to entry and the market exists in perfect competition. Over the long term, the quantity of currency mined will be where the marginal cost equals the marginal revenue. In this case, marginal revenue will also equal demand and price as well. With this, a producer will eventually receive normal profits, where the cost of the product is the same price it is being sold for. Through these assumptions, by calculating the cost of production in mining each cryptocurrency, we can theoretically predict the price of the coin. To appropriately assess each coin, we used the same mining machine for each analysis, namely a Whatsminer M30S+ with 3,400 W and 100 TH/s hash rate capability. For each currency, our group calculated the total hash required to mine one coin and then used that value to find the time required to mine one coin with the selected mining rig. From there, operating costs (primarily electricity cost) were calculated to determine the cost of production. It should be noted that since electricity cost is the primary operating cost, coins that employ the proof of work (PoW) consensus mechanism like Bitcoin and Dogecoin will have more accurate and potentially meaningful results.

The second method tested uses the macroeconomic Fisher exchange equation of MV=PQ to predict the price of each coin based on the economy that each coin is supporting and its token holders. Using a modified Fisher equation from Vitalik Buterin, MV=PQ becomes MC=TH where M is the total supply of a coin, C is the price of the currency, T is the total value of transaction volume, and H is the time that a user keeps a coin before spending it (Buterin 2017). Since M*C is equivalent to a coin's market capitalization, H = (Market Cap / Volume) = NVT = 1 / Velocity. Using calculated NVT values from public data, we were able to solve for coin velocity at each time period and use these values in the Fisher equation to solve for a predicted coin price.

The third method utilizes Metcalfe's law, which says that Network Value (NV) = C * n^2, where n is number of daily actives addresses on the network and C is a coefficient. This coefficient was solved in R by using regression analysis to fit the historical price of each coin to its active number of addresses. For our analysis, we achieved better results using a factor of 1.5 instead of 2. NV was solved at each time period to evaluate each coin.

The last method focused on relative valuation. A factor model was created for each coin by selecting a variety of fundamental variables and trading data. Each factor model used linear regression to help quantify how much the selected variables can explain the variability in coin price and to determine which factors are significantly correlated to the dependent variable. Some of the selected variables that we analyzed were NVT, transaction count, Sharpe ratio, social media sentiment, transactions per second, average block size, miner revenue and more.

For our cryptocurrency analysis using the methods stated above, we chose four popular coins that have different characteristics or blockchains that make them unique. The coins we chose to analyze and valuate are Bitcoin, Ethereum, Binance, and Dogecoin.

Coin 1 – Bitcoin

UNIQUE CHARACTERISTICS

Bitcoin is the world's first Decentralized digital cryptocurrency. Cryptocurrency is a type of digital asset that uses public-key cryptography to record, sign and send transactions over the Bitcoin blockchain - all done without the oversight of a central authority. Bitcoin uses peer-to-peer technology to operate with no central authority or banks or owner; managing transactions and the issuing of bitcoins is carried out collectively by the network. It can be sent over the Internet removing the need for a third party to transfer and therefore, the fee attached to the transactions are much lesser. Several other advantages of Bitcoin are that they can be used worldwide in every country, account cannot be frozen, and there are no arbitrary limits.

A new block is discovered roughly once every 10 minutes. Bitcoin block rewards decrease over time. Every 210,000 blocks, or about once every four years, the number of bitcoins received from each block reward is halved to gradually reduce the number of bitcoins entering the space over time. As of 2021, miners receive 6.25 bitcoins each time they mine a new block. The next bitcoin halving is expected to occur in 2024 and will see bitcoin block rewards drop to 3.125 bitcoins per block.

Total Supply will be 21m by 2140 and currently 19.2m has been mined. Also, 2.25m bitcoin has been lost and 4m has been hacked. Bitcoins are highly volatile starting from $0.00 in 2009 to $1 in 2011 and $30 in next 4 months. By early 2013, it was $100 but again went down and took 4 more years to come back to $1000 again. In 2020, it became high as $64,789 and currently is traded at $20k. However, the overall climb is a staggering 9,000,000% from 2010 to 2020.

Bitcoin's current market cap is $388.98B and the average 7-day transactions are around 270k. There are 460 million bitcoin addresses to ever have a balance greater than 0.0 BTC. Of those, 288 million hold no bitcoin in them at all today. There are between 700,000 and 1,000,000 active addresses per day. This means there are, likely, 300,000 - 500,000 unique users either sending or receiving Bitcoin per day.

One of the constant criticisms about bitcoins are the energy consumption in a climate change era (other than the transaction speed). As of 2021, the Bitcoin network consumes about 93TWh of electricity per year - around the same energy consumed by the 34th-largest country in the world. This is getting worse as the complexity of solving the hash gets tougher. Currently, the hash rate is 263m, but it kept fluctuating from 244m to 316m in October 2022.

1. Cost-Based Method

Bitcoin uses the Proof of Work (PoW) consensus mechanism. Looking at the table for cost-based production, the coin price was predicted to be $20,800. This prediction was very close to the actual price of __ and showed that overall electricity consumption and cost can be used for roughly predicting the price of Bitcoin, as it is the primary operating cost under PoW consensus mechanism.

2. Equation of Exchange

Using the Fisher equation of exchange, our model calculated a coin velocity and predicted price for each time interval available. Bitcoin velocity was seen to steadily increase from 2020 to 2022, reaching about 40-50 at its peak at the end of 2021. Since then, velocity has been decreasing and is now in the range of 10-20. Since predicted price is directly correlated with velocity from the Fisher equation, these two values have trended in the same direction. From fundamental data available online, the calculated velocity and price were extremely close to actual coin price values, in the range of 0.01% deviation, as can be seen in the attached files. This method of valuation is proven accurate for Bitcoin.

3. Metcalfe's Law

The calculated network value was used as a proxy for coin price. Using R programming, the netweork value was found over a time series and plotted against the actual price of Bitcoin through time to visualize the differences. These results can be seen in the appendix. This method is correlated with Bitcoin price but did not show to be as accurate as method 1 and 2.

4. Relative Valuation

Using the relative valuation technique, a linear regression model showed that some of Bitcoin's significant factors include total coin supply, Reddit active users, Bitcoin unique addresses used, and total Bitcoin fees. The correlation coefficient of this model was near 53%, showing that the factors used in this model only explain about half of the volatility in the price of Bitcoin. In our next analysis, we should pick other fundamental factors and technical indicators to further identify what can explain this volitility.

Coin 2 – Ethereum

UNIQUE CHARACTERISTICS

Initially co-founded by Vitalik Buterin and Joseph Lubin in 2015, the Ethereum platform is a decentralized blockchain network that supports smart contracts, decentralized applications (DApps), and decentralized finance (DeFi). Like Bitcoin, the Ethereum platform is built upon blockchain technology and is a distributed peer-to-peer network. However, Ethereum established its own built-in programming language, Solidity, which enables users to create smart contracts that can power applications. To help facilitate the activities of the Ethereum network, a cryptographic token, ether, was created, which can be used to pay transactional fees, transfer funds in real time, and trade for other crypto-assets.

With the second-largest crypto market cap of approximately $192.5 billion, Ethereum has one of the largest communities, as demonstrated by the platform's 329,900 average daily active addresses in the first quarter of 2022. In addition, Ethereum has maintained a lead in the number of Web3 developers who work on its projects—4,000 active per month, compared to other cryptocurrency networks such as Bitcoin, with about 500, and the BNB chain, which has about 300.

In September 2022, Ethereum changed from the proof-of-work (PoW) to proof-of-stake (PoS) consensus method during the Merge upgrade, which will make the network significantly more energy-efficient and environmentally sustainable. There are also plans to introduce sharding in 2023 to improve the platform's scalability and capacity. Under the proof-of-stake consensus method, users can gain interest by staking their ETH to help validate transactions in the network, leading to an issuance of about 1,700 ETH per day. Unlike Bitcoin, there is no limit on Ether's total supply, and since the Merge, it is estimated that new ETH issuance has dropped by about 88%. As of October 2022, ETH has reached approximately

120.52 million coins in circulation.

SERVICES

The Ethereum platform has given rise to a variety of different use-cases from crypto wallets, to Decentralized Autonomous Organizations (DAOs), and NFT marketplaces. For example, MetaMask Swap, a web browser plug-in, was built using the Ethereum protocol and is a cryptocurrency wallet platform that enables users to interact with the Ethereum ecosystem. Another application, MakerDAO, is a DAO that enables users to lend and borrow crypto. Lastly, Rarible, a non-fungible token (NFT) marketplace hosted on Ethereum, enables users to purchase digital assets with their crypto wallets.

COMPETITIVE ADVANTAGE

The Enterprise Ethereum Alliance's (EEA) organizational members include companies such as Microsoft, JPMorgan Chase, and Ernest and Young, demonstrating Ethereum's strong industry partnerships with technology and financial services institutions. Also, as mentioned previously, Ethereum had about eight times the number of developers compared to Bitcoin in 2022, and it has steadily increased its pool of talent, which helps to boost its network effect. Overall, the platform's loyal community, widespread adoption, rich development ecosystem, and potential DeFi applications all make Ethereum stand out from other crypto networks, and it is very likely that as Ethereum continues to grow, ETH's value will rise.

1. Cost-Based Method

Though we calculated the electricity costs for all tokens using this method, method 1 is not considered applicable for Ethereum since the platform has recently transitioned to the proof-of-stake (PoS) consensus method. This is in part because the PoS consensus mechanism is much more energy efficient than the PoW mechanism. This was also concluded since the predicted price of Ethereum was not close to the actual price.

2. Equation of Exchange

Similar to Bitcoin, this was one of the most accurate and highly predictive models used for this analysis, with an average discrepancy from the observed data of 0.01%. The predicted velocity and price actually closely mirror that of Bitcoin, which makes sense as they are the two largest cryptocurrencies in terms of market capitalization and popularity. Not only do the trendlines follow closely to one another, but the

value for velocities are similar as well, nearly peaking at 50 in December of 2021 and currently sitting around 20.

3. Metcalfe's Law

For each coin, different variations of Metcalfe's law were used to determine the best fit. Based on our analysis, formula 2 (NV = C*n*log(n)) has the best precision among all the models with an R^2 of 0.4292. this can be visualized from the graphs in our appendix that compare predicted price with actual price based on the number of daily addresses that are active on the network. This method is correlated with actual price but did not show to be as accurate as model 2.

4. Relative Valuation

Regression analysis using the relative valuation method highlighted that some of significant factors incude market cap, supply on exchanges, network hash rate, and mining difficulty. As the ETH R^2 for method 4 was 0.229, we can conclude it is not a very accurate method, especially when compared to the Metcalfe model and Equation of Exchange method.

Coin 3 – Binance

UNIQUE CHARACTERISTICS

Binance Coin was launched in July 2017 with an ICO, raised a total of $15 million in Bitcoin (BTC) and Ethereum (ETH). During its ICO and early days, BNB was an ERC-20 token built on the Ethereum blockchain. Binance launched its own native blockchain in 2019 calling it Binance Chain (BC). People can hold BNB in compatible wallets off crypto exchanges and send the coin directly to others for payments or otherwise.

SERVICES

On a more technical level, the layer-1 blockchain of Binance is merged to form the BNB Chain (previously the Binance Smart Chain and the Binance Chain). The BNB chain consists of the BNB beacon chain and BNB Smart Chain. The former is focused on BNB Chain governance that allows BNB holders to participate in staking and voting. The latter is a consensus layer, Ethereum Virtual Machine compatible, and has hubs to multi-chains. There are several uses of holding a Binance coin, including investing in stocks, exchange-traded funds (ETFs), and other assets on a variety of platforms. On some platforms, BNB can be used as collateral for loans. Some apps allow users to use Binance Coin to split expenses and

pay friends and relatives. Something unique about Binance compared to other cryptocurrencies like Bitcoin and Ethereum is that Binance spends some of its revenues each quarter to purchase back and burn Binance Coins, totally eliminating them. Binance has continuously performed quarterly burns since 2017. As of October 2022, Binance has $48,725,053,172 market size, and has 1,162,000 active addresses.

Users can use BNB coins to pay for transactions on the Binance Exchange. The BNB coin has historically served as a method of fee reduction on the Binance crypto exchange, with customers of the exchange paying lower fees by holding BNB and paying platform fees in BNB. Binance will extend the option of receiving a 25% reduction on trading fees when paying using BNB until July 13, 2022, at 11:59:59 pm UTC. In addition, BNB has also become a component of other Binance products. Additionally, merchants can accept BNB as a form of payment, giving customers more options in terms of payment methods. Furthermore, BNB is used for various things in the entertainment industry, from paying for virtual gifts to purchasing lottery tickets. While Binance has become popular all around the world, it has faced regulatory action from several regions in 2021 including the Cayman Islands, Japan, Malta, Netherlands, Malaysia, the United Kingdom and Thailand.

1. Cost-Based Method

Since both of Binance's parallel running blockchains in the BNB chain do not operate on the PoW consensus mechanism, this method is not accurate in predicting the price. Since using the proof of staked authority (PoSA) mechanism, the energy consumption used by the network is much more efficient and misleading when solely trying to estimate price based on electricity consumption operation costs.

2. Equation of Exchange

Using the Fisher equation, our predicted velocities for BNB show that it has gradually increased over the time period studied. It has increased from an initial value of 20 back in 2020 all the way up in the range of 60-80 by October of this year. This is different from both Bitcoin and Ethereum, whose velocities have slowed down and decreased after the beginning of 2022. We believe that since the velocity values of Binance have not dropped off like the other coins but has increased in recent history, it has helped the coin keep a higher market price relative to the other two mentioned. From the analysis comparing the actual price to the predicted price, the MSE was 1.77E-28, which means that the result we predicted is very accurate.

3. Metcalfe's Law

Applying Metcalfe's law to the Binance coin, we attempted many variations of the formula as mentioned in previous sections, with the most successful variations being NV = C*n^1.5 and NV = C*n*log(n). Running the regressions for each equation of the law, we found that the coefficient of determination was 0.554 for the original formula, 0.641 for C*n^1.5, and 0.709 for C*n*log(n). Since C*n*log(n) showed to be the most accurate predictor of actual Binance price, this is the formula we used for analysis. The results can be seen in the appendix, showing the difference in predicted values versus actual price over the timeframe studied. The results for this coin seemed to be more accurate than those of Bitcoin and Ethereum, and this method is a better predictor of actual price along with model 2.

4. Relative Valuation

Unlike the other coins studied, all the factors for Binance were not statistically significant. Even further, the coefficient of determination was only 0.004 which is extremely low, meaning that none of the variables we collected and analyzed contributed to the variation in Binance price. For that, we need to further gather more data.

Coin 4 - Dogecoin

UNIQUE CHARACTERISTICS

Although Dogecoin is based on a popular internet meme, the infamous cryptocurrency is now one of the largest coins based on market capitalization. There are four major aspects that make Dogecoin unique including speed and cost, unlimited supply, the enthusiastic community, and its philanthropic nature. Dogecoin offers low transaction costs and quick exchanges. The unlimited supply helps keep the currency stable. The Dogecoin community is active on Reddit, with over 300,000 members (about half the population of Wyoming). Lastly, Dogecoin launched the Doge4Water in Kenya, to aid in the availability of fresh water. Less research was done on this coin, but was looked into out of group interest to see if the coin estimate would be accurate since it has been pumped up substantially over the past year.

1. Cost-Based Method

Although Dogecoin uses the less energy efficient method, the PoW mechanism, it still costs significantly less than the other cryptocurrencies we analyzed. For example, BTC costs over 250 million H (TH/s) while Dogecoin costs a mere 800. While the predicted price is lower than the current price, we think that the current price of dogecoin could be overvalued and overhyped, and this predicted price could be more accurate if the craze dies down in the future.

2. Equation of Exchange

This method for valuating Dogecoin shows a peak in value in May of 2021 with a price of $0.70 and a velocity of over 60. Ever since mid 2021, the value of Dogecoin has been steadily decreasing at a slowing rate. This method is accurate for Dogecoin as we have been seeing the price decline since 2021.

Summary

Overall, from our analysis, the Fisher equation of exchange method and Metcalfe's law method proved to be the most accurate with predicted prices that best correlated to actual historical prices. Using the equation of exchange showed to be very precise but has some limitations. If public data for total transaction volume, market capitalization, and total coin supply are not available then it will be much more difficult to accurately estimate current values and extrapolate to estimate future values. Metcalfe's law proved to be relatively accurate, but depends almost entirely on one variable, namely the number of active addresses in the network. Using the cost-based production method was found to be relatively accurate for those coins that use the proof of work consensus mechanism, but not for those who don't. Lastly, using the method of relative valuation was not as easy as expected, especially when results show a low coefficient of determination and the data does not explain a majority of variation in the dependent variable of price.

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What Is BNB? https://academy.binance.com/en/articles/what-is-bnb

What is Binance Coin (BNB), and how does it work? https://cointelegraph.com/altcoins-for-beginners/what-is-binance-coin-bnb-and-how-does-it-work

Appendix

Method 1 (Cost-Based Method):

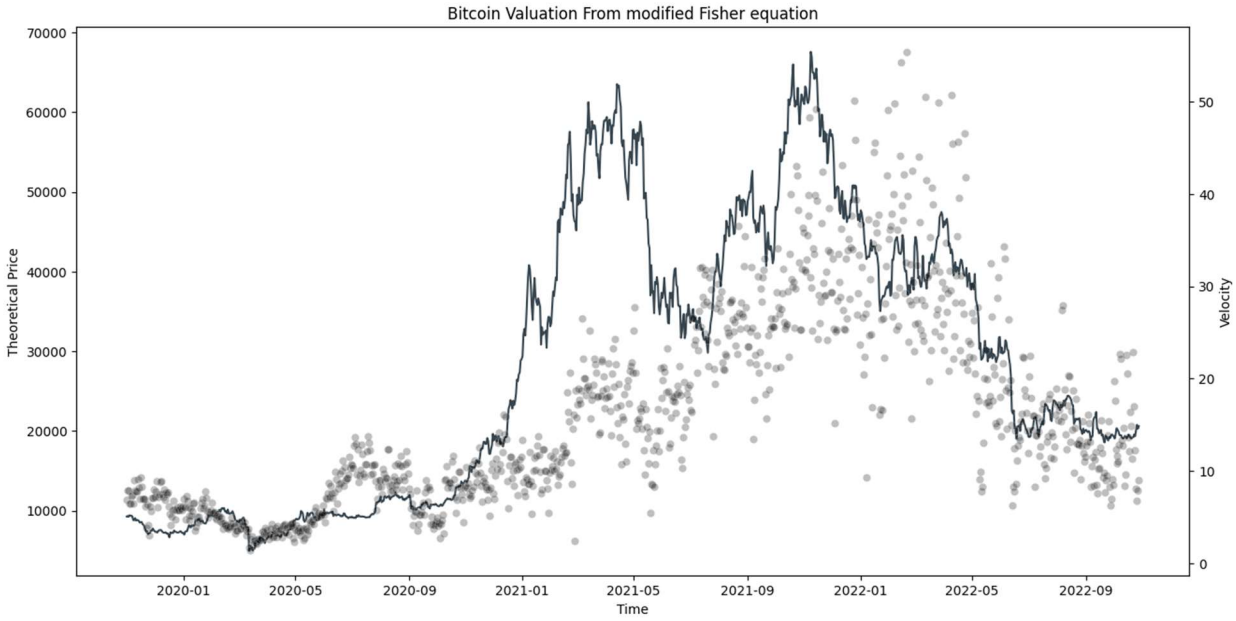
Electricity Cost ($/kWh)	0.136
Electricity Cost Coefficient	0.7
Computer Power Consumption (W)	3400
Computer Hash Rate (TH/s)	100
Computer = Whatsminer M30S+	

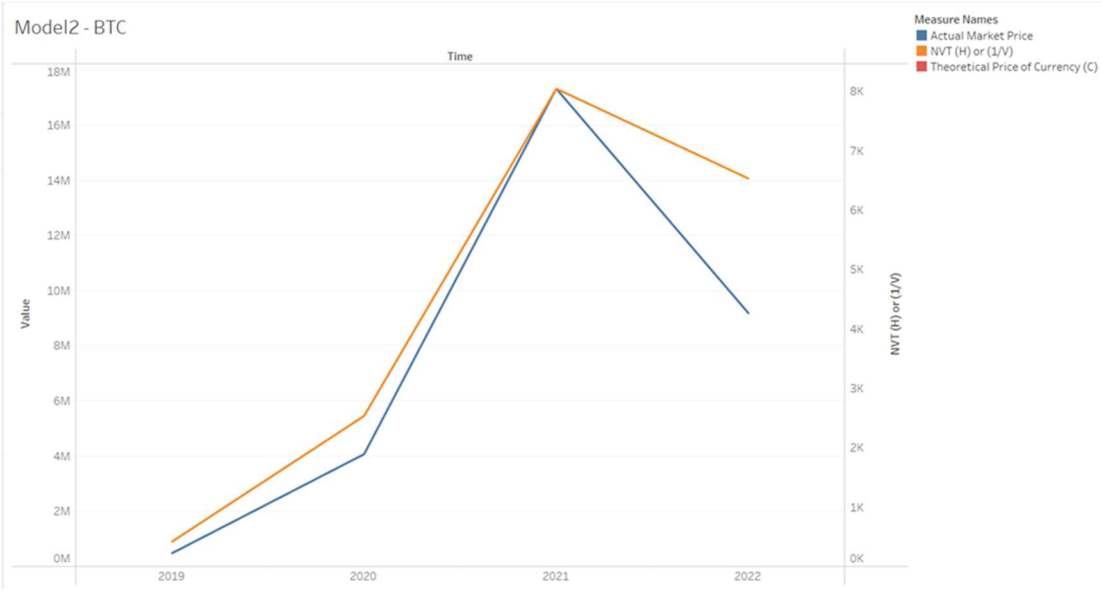
Cost of Power	Bitcoin (BTC)	Ethereum (ETH)	Binance (BNB)	Dogecoin (DOGE)
H (TH/s)	258,550,345	1,029	38,115,000	803
R (coin/day)	918	7,168	1,092,188	14,400,000
Hash required for 1 coin (TH/coin)	24,334,150,095	12,403.13	3,015,172.57	4.82
Time to mine 1 coin (years)	7.72	0.000003933	0.000956105	0.000000002
Electricity cost for 1 coin	$ 21,879.10	$ 0.011152	$ 2.710975	$ 0.000004

Coins in green use PoW consensus mechanism while coins in yellow use PoS or PoSA mechanisms

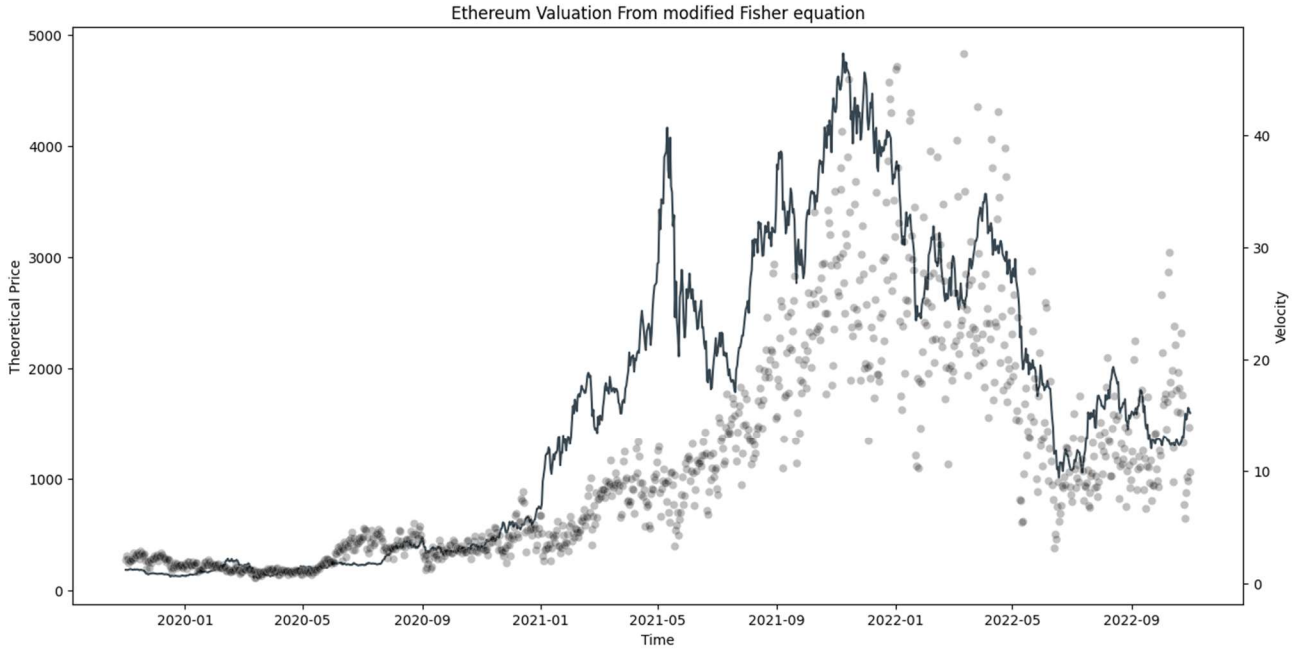
Method 2 (Equation of Exchange Method):

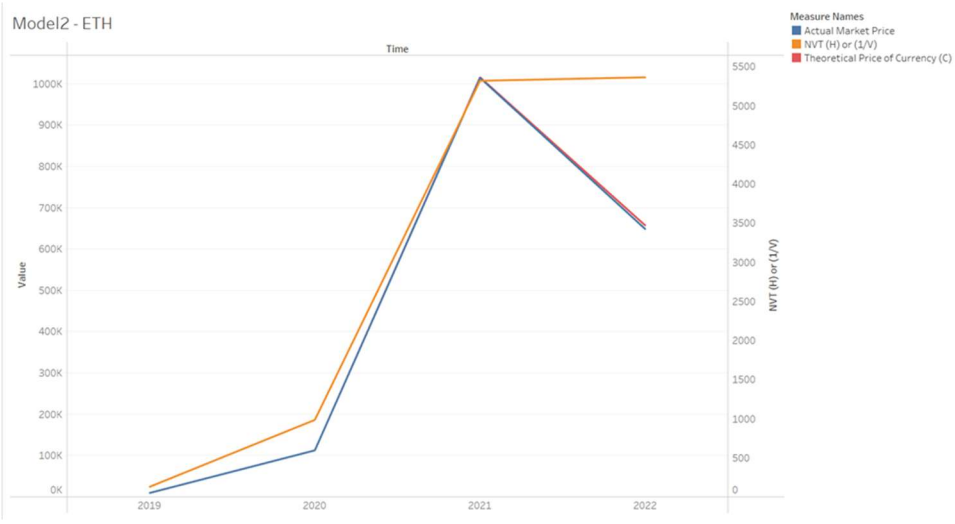
1. Bitcoin



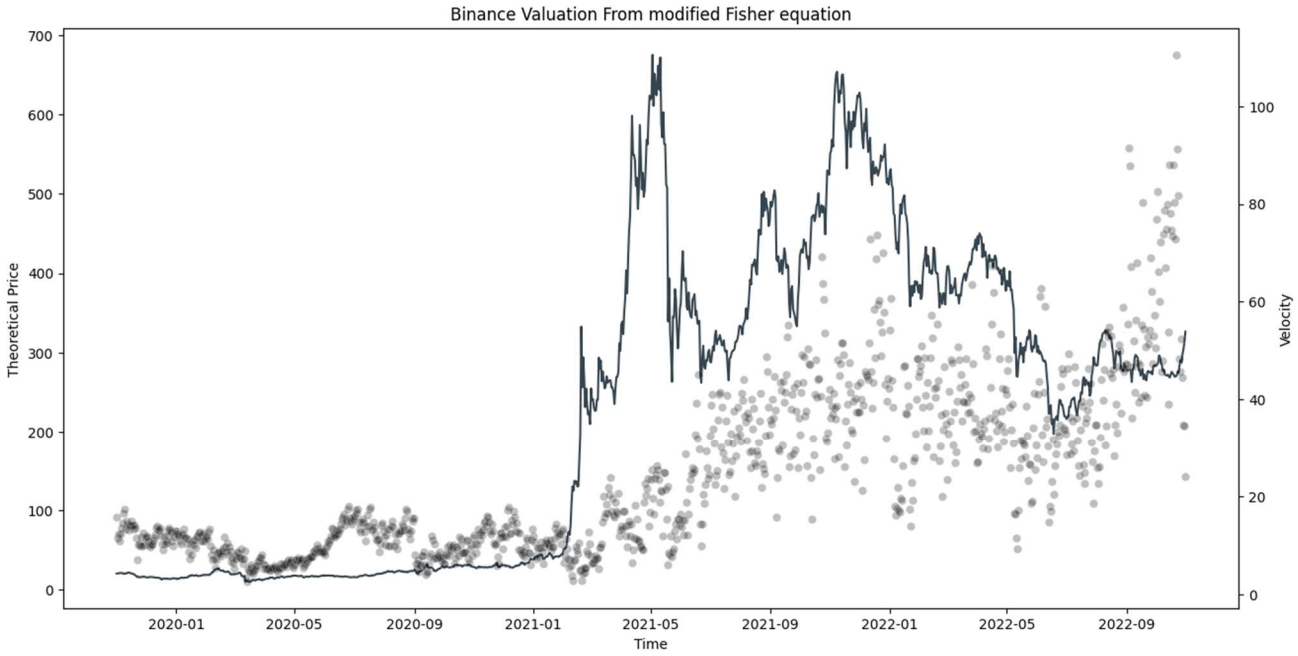


2. Ethereum


Ethereum Valuation From modified Fisher equation
Theoretical Price
Velocity
Time
5000
4000
3000
2000
1000
0
40
30
20
10
0
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
2022-05
2022-09


Model2 - ETH
Time
Value
NVT (H) or (1/V)
Measure Names
Actual Market Price
NVT (H) or (1/V)
Theoretical Price of Currency (C)
1000K
900K
800K
700K
600K
500K
400K
300K
200K
100K
0K
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2019
2020
2021
2022

3. Binance


Binance Valuation From modified Fisher equation
Theoretical Price
Velocity
Time
700
600
500
400
300
200
100
0
100
80
60
40
20
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2020-05
2020-09
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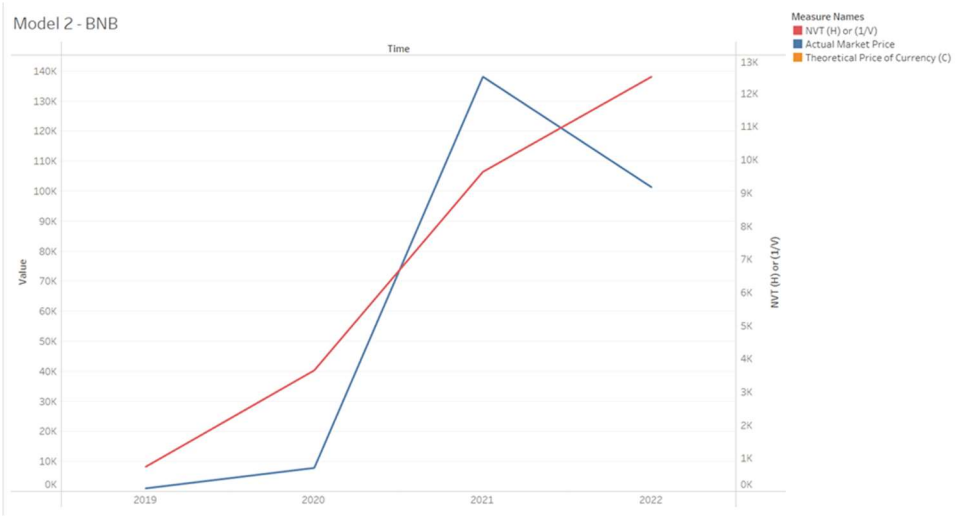
2021-05
2021-09
2022-01
2022-05
2022-09


Model 2 - BNB
Time
Value
NVT (H) or (1/V)
Measure Names
NVT (H) or (1/V)
Actual Market Price
Theoretical Price of Currency (C)
140K
130K
120K
110K
100K
90K
80K
70K
60K
50K
40K
30K
20K
10K
0K
13K
12K
11K
10K
9K
8K
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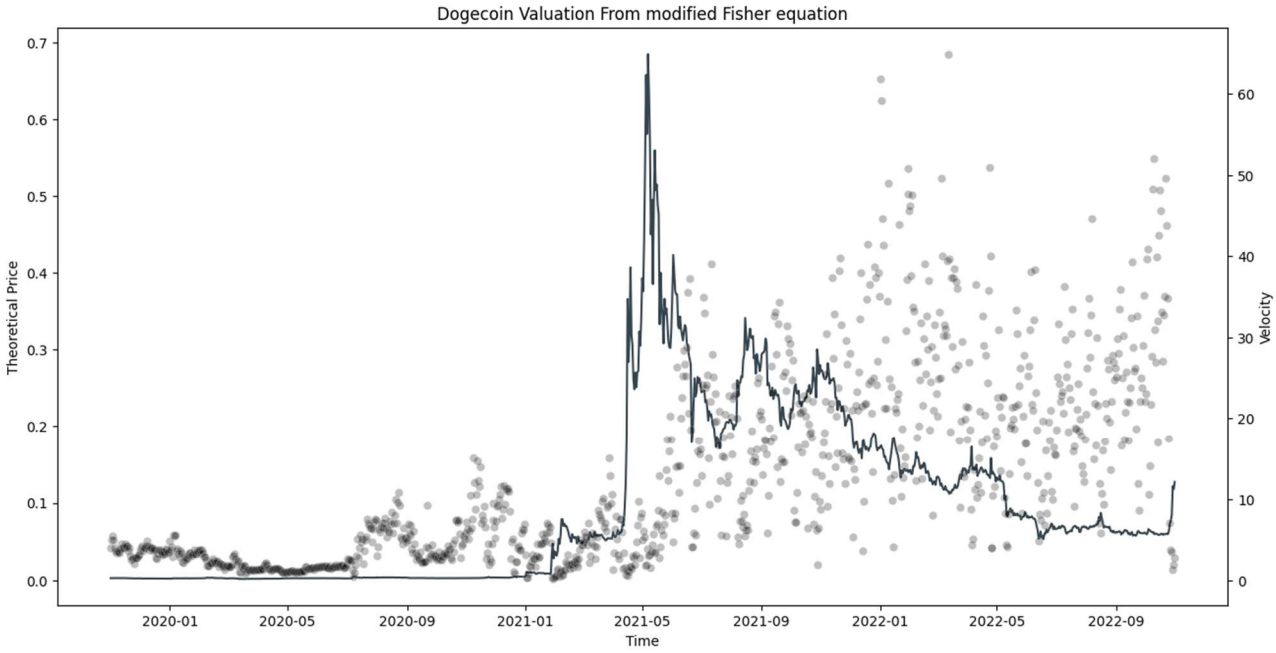
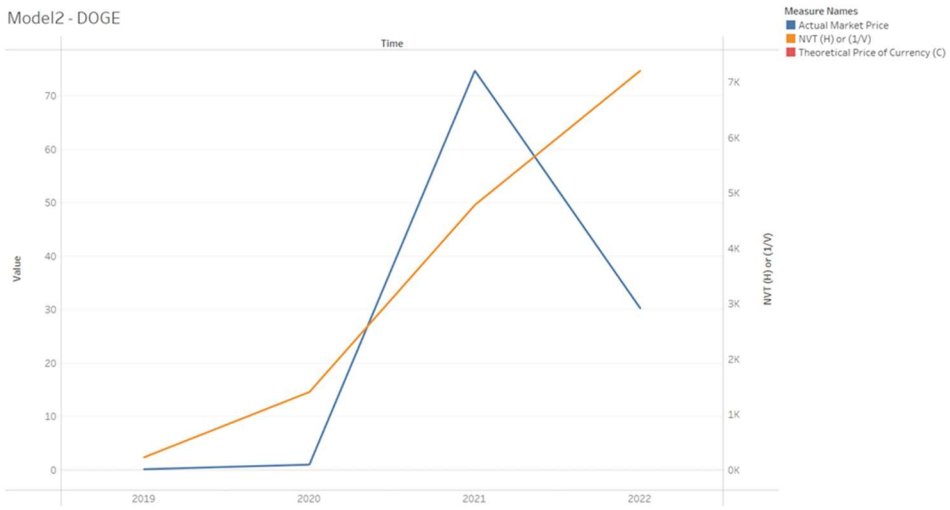
6K
5K
4K
3K
2K
1K
0K
2019
2020
2021
2022

4. Dogecoin


Dogecoin Valuation From modified Fisher equation
Theoretical Price
Velocity
Time
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
2022-05
2022-09


Model2 - DOGE
Time
Value
NVT (H) or (1/V)
Measure Names
Actual Market Price
NVT (H) or (1/V)
Theoretical Price of Currency (C)
0
10
20
30
40
50
60
70
0K
1K
2K
3K
4K
5K
6K
7K
2019
2020
2021
2022

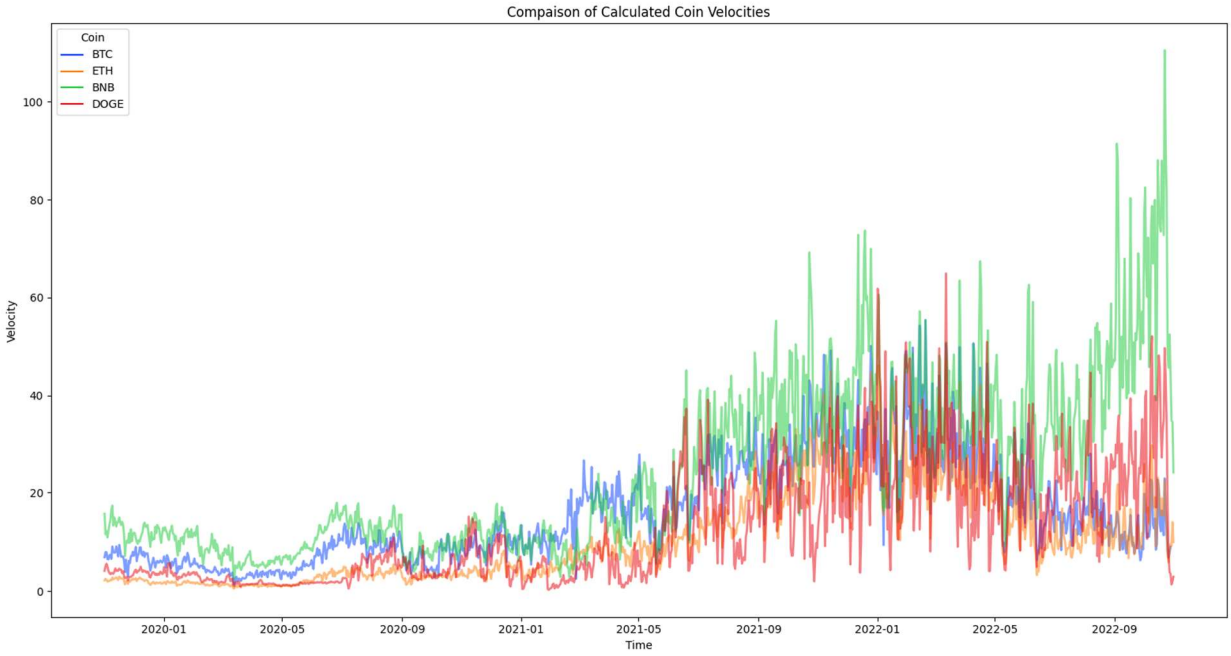


Chart of all coin velocities comparatively to give a general picture of how fast each coin is circulating relative to one another.

Method 3 (Metcalfe Method):

Model_3: ModelMetcalfe

1. **Binance(BNB)**

1. For formula 1: **NV = C*n^1.5,** adjusted R^2 is 0.6408

```
> summary(BNBModelMetcalfe_1)

Call:
lm(formula = BNB$Price..Open. ~ BNB$Active.Addresses.Count1.5)

Residuals:
    Min      1Q  Median      3Q     Max
-579.25  -91.91   -9.45   53.95  420.57

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                    1.326e+02  5.905e+00   22.46   <2e-16 ***
BNB$Active.Addresses.Count1.5 2.127e-07  5.657e-09   37.61   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 104.2 on 791 degrees of freedom
  (1032 observations deleted due to missingness)
Multiple R-squared:  0.6413,    Adjusted R-squared:  0.6408
F-statistic:  1414 on 1 and 791 DF,  p-value: < 2.2e-16
```

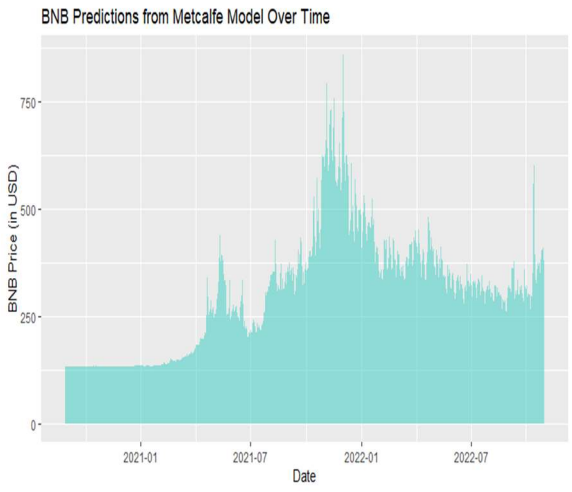
2. For formula 2 : **NV = C*n*log(n),** adjusted R^2 is 0.7091

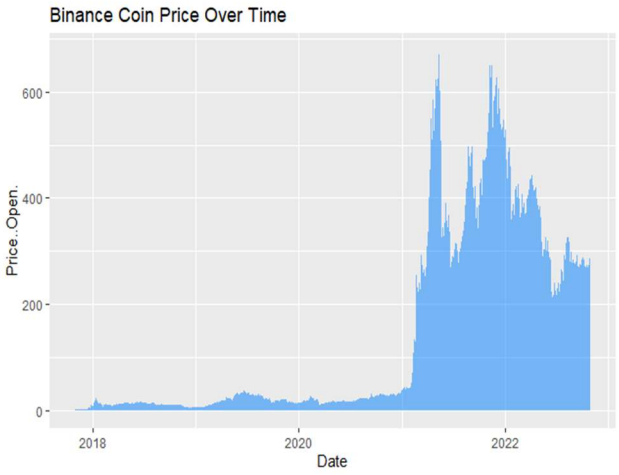
```
> summary(BNBModelMetcalfe_2)

Call:
lm(formula = BNB$Price..Open. ~ BNB$Active.Addresses.Count_log)

Residuals:
    Min      1Q  Median      3Q     Max
-472.29  -64.86  -19.79   48.12  399.74

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   9.141e+01  5.904e+00   15.48   <2e-16 ***
BNB$Active.Addresses.Count_log 1.982e-05  4.509e-07   43.95   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 93.77 on 791 degrees of freedom
  (1032 observations deleted due to missingness)
Multiple R-squared:  0.7095,    Adjusted R-squared:  0.7091
F-statistic:  1932 on 1 and 791 DF,  p-value: < 2.2e-16
```

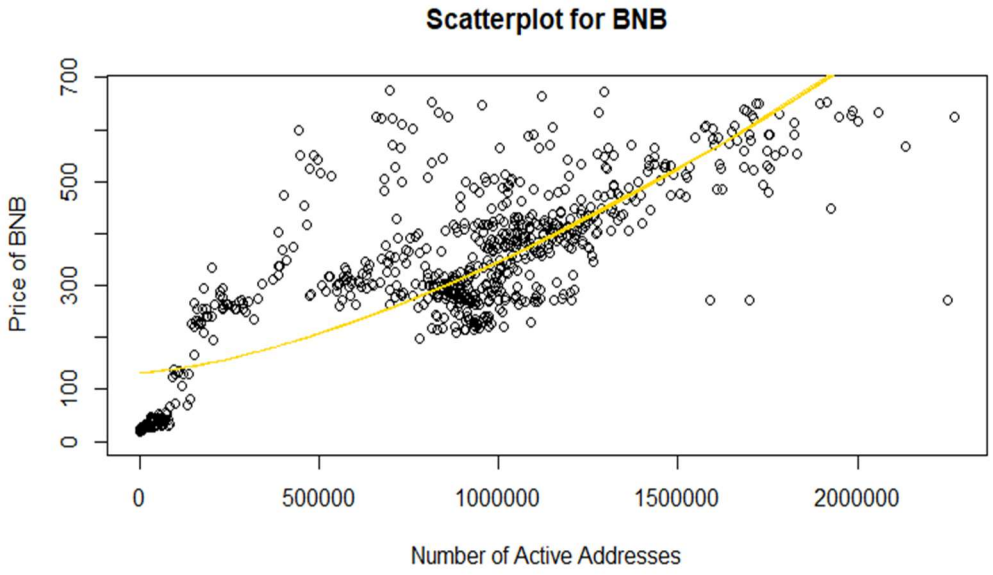
3. For formula 3: **NV = C*(n^2),** adjusted R^2 is 0.5538

```
> summary(BNBModelMetcalfe_3)

Call:
lm(formula = BNB$Price..Open. ~ BNB$Active.Addresses.Count2)

Residuals:
    Min      1Q  Median      3Q     Max
-677.01  -88.41    6.43   62.98  430.97

Coefficients:
                             Estimate Std. Error t value Pr(>|t|)
(Intercept)                 1.713e+02  5.947e+00   28.80   <2e-16 ***
BNB$Active.Addresses.Count2 1.535e-10  4.893e-12   31.37   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 116.1 on 791 degrees of freedom
  (1032 observations deleted due to missingness)
Multiple R-squared:  0.5543,    Adjusted R-squared:  0.5538
F-statistic: 983.9 on 1 and 791 DF,  p-value: < 2.2e-16
```

Compared with all three formula for the Binance, formula 2 has the most precise prediction.







2. Bitcoin(BTC)

1. For formula 1: **NV = C*n^1.5,** adjusted R^2 is 0.1907

```
> summary(BTCModelMetcalfe_1)

Call:
lm(formula = BTC$Price ~ BTC$active_addresses_count1.5)

Residuals:
   Min     1Q Median     3Q    Max
-29484 -12776  -4088  13398  42358

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -4.097e+03  2.076e+03  -1.974   0.0487 *
BTC$active_addresses_count1.5  3.639e-05  2.264e-06  16.078   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15860 on 1092 degrees of freedom
Multiple R-squared:  0.1914,    Adjusted R-squared:  0.1907
F-statistic: 258.5 on 1 and 1092 DF,  p-value: < 2.2e-16
```

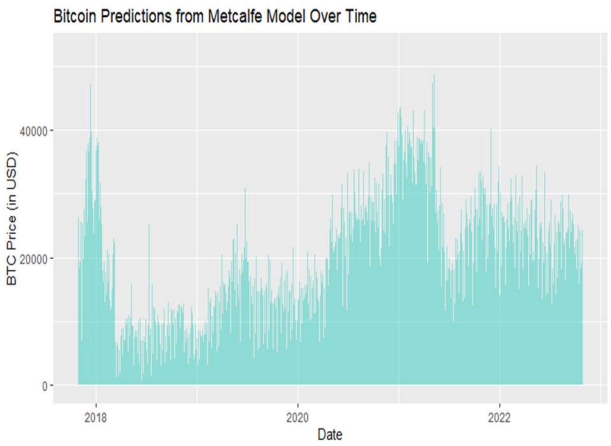
2. For formula 2 : **NV = C*n*log(n),** adjusted R^2 is 0.1905

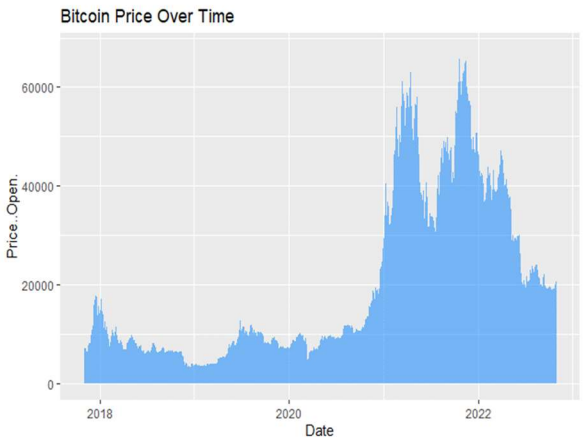
```
> summary(BTCModelMetcalfe_2)

Call:
lm(formula = BTC$Price ~ BTC$active_addresses_count_log)

Residuals:
   Min     1Q Median     3Q    Max
-29177 -12713  -4073  13622  42513

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -1.663e+04  2.841e+03  -5.853 6.38e-09 ***
BTC$active_addresses_count_log  3.555e-03  2.212e-04  16.070  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15860 on 1092 degrees of freedom
Multiple R-squared:  0.1912,    Adjusted R-squared:  0.1905
F-statistic: 258.2 on 1 and 1092 DF,  p-value: < 2.2e-16
```

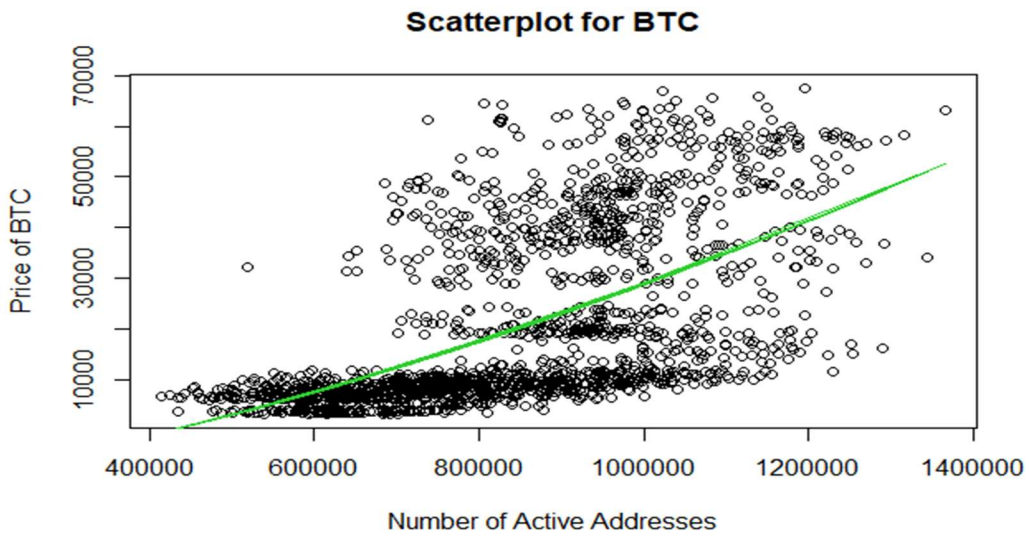
3. For formula 3: **NV = C*(n^2),** adjusted R^2 is 0.19

```
> summary(BTCModelMetcalfe_3)

Call:
lm(formula = BTC$Price ~ BTC$active_addresses_count2)

Residuals:
   Min     1Q Median     3Q    Max
-29762 -12768  -4488  13356  42205

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  3.887e+03  1.600e+03    2.43   0.0153 *
BTC$active_addresses_count2 2.815e-08  1.755e-09   16.04   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15860 on 1092 degrees of freedom
Multiple R-squared:  0.1907,    Adjusted R-squared:   0.19
F-statistic: 257.4 on 1 and 1092 DF,  p-value: < 2.2e-16
```

Based on our result’s Metcalfe’s law is not suitable for predicting the Bitcoin’s price.







3. Ethereum (ETH)

1. For formula 1: **NV = C*n^1.5,** adjusted R^2 is 0.4199

```
> summary(ETHModelMetcalfe)

Call:
lm(formula = ETH$Price ~ ETH$Active.Addresses.Count1.5)

Residuals:
    Min      1Q  Median      3Q     Max
-5125.1  -669.5  -139.2   509.5  2611.4

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -8.467e+02  9.299e+01  -9.105   <2e-16 ***
ETH$Active.Addresses.Count1.5  6.479e-06  2.302e-07  28.147   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1005 on 1092 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.4205,    Adjusted R-squared:  0.4199
F-statistic: 792.3 on 1 and 1092 DF,  p-value: < 2.2e-16
```

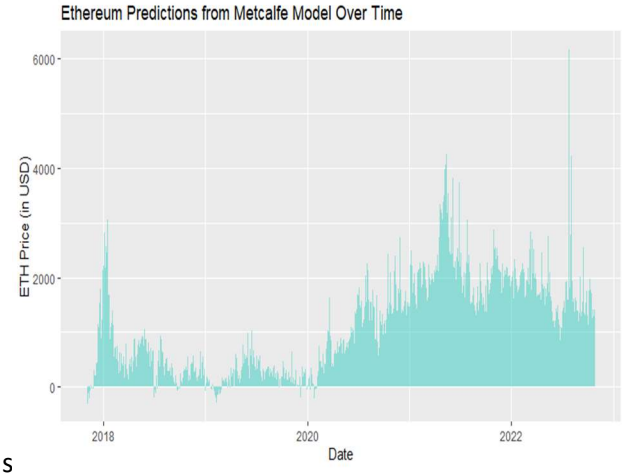
2. For formula 2 : **NV = C*n*log(n),** adjusted R^2 is 0.4292

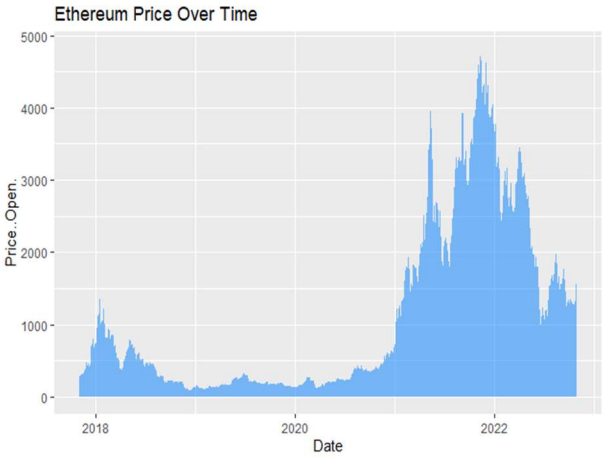
```
> summary(ETHModelMetcalfe_2)

Call:
lm(formula = ETH$Price ~ ETH$Active.Addresses.Count_log)

Residuals:
    Min      1Q  Median      3Q     Max
-4312.8  -680.7  -124.7   524.2  2578.0

Coefficients:
                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -1.746e+03  1.214e+02  -14.38   <2e-16 ***
ETH$Active.Addresses.Count_log  4.930e-04  1.719e-05   28.68   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 997.2 on 1092 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.4297,    Adjusted R-squared:  0.4292
F-statistic: 822.7 on 1 and 1092 DF,  p-value: < 2.2e-16
```

3. For formula 3: **NV = C*(n^2),** adjusted R^2 is 0.3985

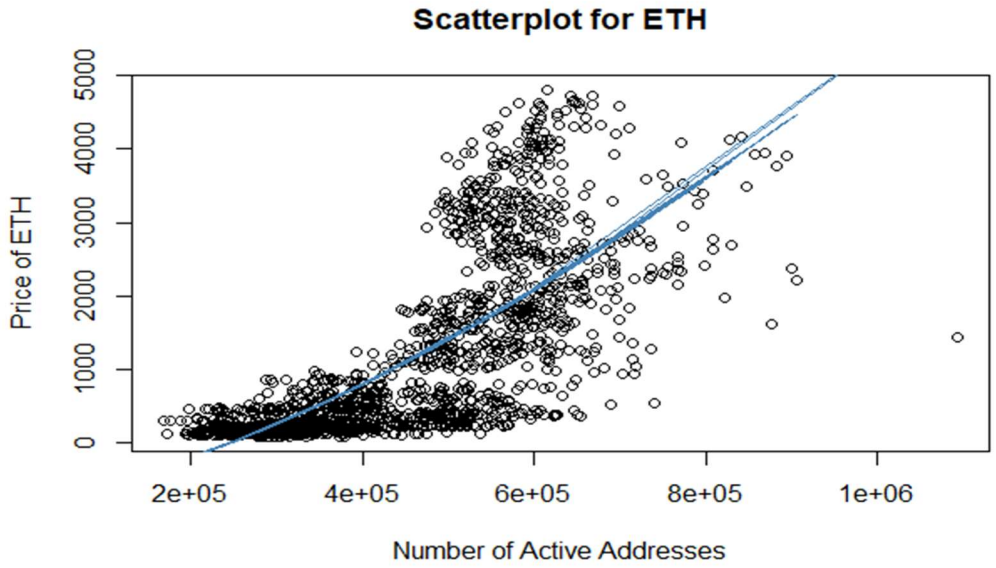
```
> summary(ETHModelMetcalfe_3)

Call:
lm(formula = ETH$Price ~ ETH$Active.Addresses.Count2)

Residuals:
    Min      1Q  Median      3Q     Max
-6121.2  -661.5  -172.7   536.9  2661.9

Coefficients:
                             Estimate Std. Error t value Pr(>|t|)
(Intercept)                -2.244e+02  7.539e+01  -2.976  0.00298 **
ETH$Active.Addresses.Count2  6.507e-09  2.416e-10  26.929  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1024 on 1092 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.3991,    Adjusted R-squared:  0.3985
F-statistic: 725.2 on 1 and 1092 DF,  p-value: < 2.2e-16
```

Based on the results, formula 2 has better precision.


Ethereum Predictions from Metcalfe Model Over Time
ETH Price (in USD)
6000
4000
2000
0
2018
2020
2022
Date


Ethereum Price Over Time
Price..Open.
5000
4000
3000
2000
1000
0
2018
2020
2022
Date

S


Scatterplot for ETH
Price of ETH
0
1000
2000
3000
4000
5000
2e+05
4e+05
6e+05
8e+05
1e+06
Number of Active Addresses

Method 4 (Relative Evaluation Method):

Bitcoin Analysis:

```
Call:
lm(formula = `Return+1` ~ Volume + Market.Cap + NVT + Volatility +
    Supply.on.Exchanges + Adjusted.Transaction.Volume + Transactions.Count +
    Sharpe.Ratio + Active.Addresses.Count + Reddit.Subscribers +
    Reddit.Active.Users + BTC.sentiment + Total.Fees + Bitcoin.Avg.TPS +
    Bitcoin.Unique.Addresses.Used + Bitcoin.Avg.Block.Size.inMB +
    Bitcoin.Total.Hashrate.inTHperSecond + Bitcoin.Miner.Revenue.inUSD +
    Bitcoin.Avg.Transaction.Fee.inUSD + Difficulty.inTrillions,
    data = BTC)

Residuals:
     Min       1Q   Median       3Q      Max
-0.08723 -0.01576 -0.00104  0.01518  0.09363

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                       -1.12e-01   2.44e-02   -4.60  5.0e-06 ***
Volume                            -2.59e-12   3.98e-13   -6.51  1.5e-10 ***
Market.Cap                        -7.14e-13   3.14e-14  -22.74  < 2e-16 ***
NVT                                3.44e-05   5.53e-05    0.62  0.53355
Volatility                         1.30e-02   6.86e-03    1.90  0.05807 .
Supply.on.Exchanges                8.59e-12   3.65e-13   23.55  < 2e-16 ***
Adjusted.Transaction.Volume        1.38e-12   3.60e-13    3.82  0.00015 ***
Transactions.Count                 3.76e-08   6.94e-08    0.54  0.58819
Sharpe.Ratio                       3.16e-03   3.26e-04    9.68  < 2e-16 ***
Active.Addresses.Count             5.33e-09   2.65e-08    0.20  0.84069
Reddit.Subscribers                -6.61e-09   4.15e-09   -1.59  0.11145
Reddit.Active.Users                1.46e-06   4.05e-07    3.60  0.00034 ***
BTC.sentiment                      1.49e-02   1.05e-02    1.41  0.15761
Total.Fees                         1.73e-08   3.32e-09    5.21  2.6e-07 ***
Bitcoin.Avg.TPS                    3.31e-03   3.42e-03    0.97  0.33362
Bitcoin.Unique.Addresses.Used      9.39e-08   1.58e-08    5.94  4.7e-09 ***
Bitcoin.Avg.Block.Size.inMB       -2.32e-02   1.41e-02   -1.64  0.10114
Bitcoin.Total.Hashrate.inTHperSecond  3.45e-10   1.32e-10    2.62  0.00911 **
Bitcoin.Miner.Revenue.inUSD       -3.55e-10   4.32e-10   -0.82  0.41205
Bitcoin.Avg.Transaction.Fee.inUSD -3.53e-03   8.73e-04   -4.05  5.8e-05 ***
Difficulty.inTrillions             8.65e-04   1.00e-03    0.86  0.38916
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0259 on 658 degrees of freedom
  (416 observations deleted due to missingness)
Multiple R-squared:  0.535,     Adjusted R-squared:  0.521
F-statistic: 37.8 on 20 and 658 DF,  p-value: <2e-16
```

BTC R^2 is 0.521

Ethereum Analysis:

```
Call:
lm(formula = `Return+1` ~ Volume + Market.Cap + NVT + Volatility +
    Supply.on.Exchanges + Adjusted.Transaction.Volume + Transactions.Count +
    Sharpe.Ratio + Active.Addresses.Count + Reddit.Subscribers +
    Reddit.Active.Users + ETH.sentiment + Total.Fees + Ethereum.Avg.TPS +
    Ethereum.Unique.Addresses.Used + Ethereum.Avg.Block.Size.inMB +
    Ethereum.Total.Hashrate.inTHperSecond + Ethereum.Miner.Revenue.inUSD +
    Ethereum.Avg.Transaction.Fee.inUSD + Difficulty, data = ETH)

Residuals:
     Min       1Q   Median       3Q      Max
-0.16536 -0.02660 -0.00275  0.02256  0.22889

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)
(Intercept)                           2.64e-02   3.97e-02    0.67   0.5055
Volume                               -1.52e-12   9.20e-13   -1.66   0.0984 .
Market.Cap                           -9.05e-13   8.85e-14  -10.22  < 2e-16 ***
NVT                                   5.22e-05   1.56e-04    0.33   0.7386
Volatility                           -1.18e-02   9.44e-03   -1.25   0.2106
Supply.on.Exchanges                   1.02e-11   1.04e-12    9.81  < 2e-16 ***
Adjusted.Transaction.Volume           6.36e-13   4.95e-13    1.29   0.1994
Transactions.Count                   -5.61e-06   2.47e-06   -2.27   0.0239 *
Sharpe.Ratio                          2.24e-03   9.02e-04    2.48   0.0135 *
Active.Addresses.Count               -1.85e-08   4.64e-08   -0.40   0.6905
Reddit.Subscribers                    1.27e-07   4.42e-08    2.88   0.0042 **
Reddit.Active.Users                  -3.94e-06   3.73e-06   -1.06   0.2907
ETH.sentiment                        -1.25e-02   1.37e-02   -0.91   0.3630
Total.Fees                           -1.88e-09   1.32e-09   -1.43   0.1546
Ethereum.Avg.TPS                      4.87e-01   2.14e-01    2.28   0.0230 *
Ethereum.Unique.Addresses.Used       -8.29e-10   3.87e-10   -2.14   0.0325 *
Ethereum.Avg.Block.Size.inMB         -9.89e-01   4.28e-01   -2.31   0.0214 *
Ethereum.Total.Hashrate.inTHperSecond -2.24e-06   4.25e-07   -5.27  2.0e-07 ***
Ethereum.Miner.Revenue.inUSD         -1.16e-09   4.55e-10   -2.56   0.0108 *
Ethereum.Avg.Transaction.Fee.inUSD    4.12e-03   1.71e-03    2.40   0.0166 *
Difficulty                            1.76e-04   3.36e-05    5.23  2.6e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0458 on 487 degrees of freedom
  (587 observations deleted due to missingness)
Multiple R-squared:  0.259,     Adjusted R-squared:  0.229
F-statistic: 8.52 on 20 and 487 DF,  p-value: <2e-16
```

ETH R^2 is 0.229

Binance Analysis:

```
Call:
lm(formula = `Return+1` ~ Volume + Market.Cap + NVT + Volatility +
    Circulating.Supply + Sharpe.Ratio + Active.Addresses.Count +
    BNB.sentiment + Binance.Avg.TPS + Reddit.Subscribers + Reddit.Active.Users +
    Binance.Unique.Addresses.Used + Binance.Avg.Block.Size.inBytes,
    data = BNB)

Residuals:
     Min       1Q   Median       3Q      Max
-0.22607 -0.03450  0.00421  0.02982  0.13690

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -3.93e-02   6.01e-01   -0.07     0.95
Volume                         2.15e-12   1.45e-11    0.15     0.88
Market.Cap                    -1.15e-12   1.87e-12   -0.62     0.54
NVT                           -8.93e-04   6.76e-04   -1.32     0.19
Volatility                    -2.51e-02   1.58e-02   -1.59     0.12
Circulating.Supply             1.46e-09   4.00e-09    0.36     0.72
Sharpe.Ratio                   1.27e-03   3.52e-03    0.36     0.72
Active.Addresses.Count        -7.00e-08   5.90e-08   -1.19     0.24
BNB.sentiment                  4.19e-02   5.66e-02    0.74     0.46
Binance.Avg.TPS                2.89e-04   9.65e-04    0.30     0.77
Reddit.Subscribers             4.90e-08   1.44e-07    0.34     0.74
Reddit.Active.Users           -5.66e-06   7.71e-06   -0.73     0.47
Binance.Unique.Addresses.Used  4.19e-10   8.90e-10    0.47     0.64
Binance.Avg.Block.Size.inBytes -8.77e-08   6.60e-07   -0.13     0.90

Residual standard error: 0.0657 on 41 degrees of freedom
  (738 observations deleted due to missingness)
Multiple R-squared:  0.244,     Adjusted R-squared:  0.00422
F-statistic: 1.02 on 13 and 41 DF,  p-value: 0.454
```

BNB R^2 is 0.00422 (not statistically significant, need more data)