

Bitcoin and Ethereum: A Deep Dive into Their Relationship

Rohan Aanegola

Abstract— At the time of writing, there are more than 1000 cryptocurrencies existing, but only 2 of them, Ethereum and Bitcoin, have made news globally. Bitcoin, created in 2009 by Satoshi Nakamoto, and Ethereum, created in 2015 by Vitalik Buterin, have exploded in the past year, having more than a 1000% increase. However, their price movements have not been entirely dissimilar. This paper intends to elucidate these similarities in price movements and formulate a relationship between the 2 cryptocurrencies. For this, three different methods were used. The first method was a graphical approach, in which the prices of the crypto currencies were recorded for 3 hours with 20 second intervals for a week and interpreted. The second method was a statistical approach, in which statistical variables such as standard deviation, correlation, etc. were calculated and conclusions were drawn based on these findings. Lastly, after observing that the relation between the crypto currencies was almost a linear one, a linear model was built to predict the price of 1 cryptocurrency given the price of the other with high accuracy, proving this linear relationship.

Index Terms—Bitcoin, Cryptocurrency, Etheruem, Linear Regression

I. INTRODUCTION

Bitcoin is a cryptocurrency created by Satoshi Nakamoto in 2009. This cryptocurrency was introduced in his paper 'Bitcoin: A peer-to-peer electronic cash system'. The Bitcoin is powered by block chain technology, a distributed database technology that stores information in a very safe and transparent manner. Bitcoin is different from fiat currency as it is decentralized and provides anonymity and transparency.

Etheruem is another cryptocurrency which was created by Vitalik Buterin in 2015. This currency, although based on block chain technology as well, is different from the Bitcoin. While Bitcoin was intended to be an alternative to fiat currency, Ethereum was intended to facilitate smart contracts and applications through its own currency. Like Bitcoin, it is decentralized and provides anonymity and transparency.

In the past year, Bitcoin and Ethereum prices have surged, making it a viable investment in the eyes of several investors. Although Bitcoin and Ethereum are different, both currencies have similar price movements. The objective of this paper is to elucidate this similarity and formulate it.

II. METHODS USED

A. Graphical Approach

The prices of Bitcoin and Ethereum were recorded using a live API called cryptocompare. These were done for 3 hours with 20 second intervals on randomly selected days over 2 weeks. Observations were made using cryptotracker.anvil.app. The observations made were:

1. Min price BTC: The time (UTC) at which Bitcoin reached its minimum value.
2. Max price BTC: The time (UTC) at which Bitcoin reached its maximum value.
3. Min price ETH: The time (UTC) at which Ethereum reached its minimum value.
4. Max price BTC: The time (UTC) at which Ethereum reached its maximum value.
5. Change BTC: The change in price of Bitcoin: End price – Start price
6. Percent change BTC: The percent change in price of Bitcoin = $\text{Change BTC} \times 100 / \text{Start price}$
7. Change ETH: The change in price of Ethereum : End price BTC – Start price ETH
8. Percent change Ethereum: The percent change in price of Ethereum = $\text{Change ETH} \times 100 / \text{Start price}$
9. Max BTC: Maximum price of Bitcoin.
10. Min BTC: Minimum price of Bitcoin.
11. Max ETH: Maximum price of Ethereum.
12. Min ETH: Minimum price of Ethereum.

Results:

The graphs and analysis (next page) show that there is a striking similarity between the price movements of Bitcoin and Ethereum. Majority of the points on the graphs are coinciding or have the same trend i.e. both increasing or both decreasing. From the analyses presented below the graphs, it is clear that the percent changes and time at max/min price are similar. For example, the analysis in figure 1.1 shows that the percentage changes for Bitcoin and Ethereum are 2.35% and 2.16% (0.2% difference) and both currencies reach their min/max roughly at 4:47 and 7:50(UTC) respectively. The analysis in figure 1.5 shows that percentage changes are -0.03% and -0.53% (0.5% difference) respectively. Bitcoin reached its min/max at 13:33/15:07 and Ethereum at 13:34/12:39.



Figure 1.1 02-07-2021



Figure 1.2 02-09-2021



Figure 1.3 02-10-2021



Figure 1.4 2-11-2021



Figure 1.5 2-17-2021

B. Statistical Approach

Prices of Bitcoin and Ethereum over the past year were obtained from investing.com. These values were used to calculate statistical variables such as standard deviation, covariance, correlation, and finally a residual plot was plotted.

Statistical variables (calculated on sample) used were:

$$\sigma = \sqrt{\frac{\sum_{i=0}^n (x_i - \mu)^2}{N-1}}$$

$$Cov(x, y) = \frac{\sum_{i=0}^n (x_i - \mu_x)(y_i - \mu_y)}{N-1}$$

$$Pearson's \text{ correlation coefficient} = \frac{Cov(x, y)}{\sigma_x \sigma_y}$$

Results:

$$\sigma_{BTC} = 15467$$

$$\sigma_{ETH} = 552$$

$$Cov(BTC, ETH) = 8207635$$

$$Pearson's \text{ correlation coefficient} = 0.96$$

A correlation of 0.96 shows that the prices of Bitcoin and Ethereum are very strongly associated and this association is a positive one. The prices of the 2 currencies over the last year were plotted as in fig 1. The figure shows that there is a strong linear relationship between these currencies. However, this correlation does not necessarily mean causation. It solely refers to a positive association.

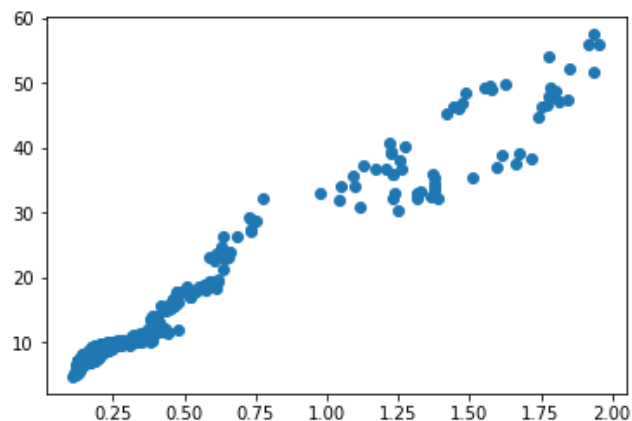


Figure 2.1

X axis: Ethereum, in thousands of dollars.

Y axis: Bitcoin, in thousands of dollars.

Each data point is a value of Bitcoin(Y axis) corresponding to the Ethereum value(X axis) at a particular moment.

Note: The choice of cryptocurrency on the X axis and Y axis was arbitrary.

C. Linear Model

Fig 2.1 and the high Pearson's correlation coefficient validate the relationship to be close to a linear one. Using the same data, a linear model was built to predict the price of Bitcoin given the price of Ethereum. Some of the old data,

when the price of both currencies was relatively low for long periods of time, were removed to avoid over fitting the model.

First, the data was standardized (by taking mean as 0 and measuring number of standard deviations from mean) to ensure that the prices of Bitcoin and Ethereum were on the same scale and to make computations simpler. A linear model was then built and optimized using Gradient descent. Root mean squared error (RMSE) was the cost function used to evaluate the model.

$$\hat{Y}(\text{Predicted standardized value of Bitcoin}) = \theta_0 X_1(\text{Standardized value of Ethereum}) + \theta_1$$

Results:

After running the regression model on the data over 100000 epochs, it was found that

$$\theta_0 = 1.101 \quad \theta_1 = 5E-17 \approx 0$$

However, this value needs to be transformed to represent the original value of Bitcoin. This can be done using:

$$\text{Predicted Value of Bitcoin} = \text{Predicted value of Bitcoin(standardized)} * \sigma_{BTC} + \mu_{BTC}$$

The low RMSE (≈ 0.06 Standard deviations) and random residual plot confirm the linear relationship.

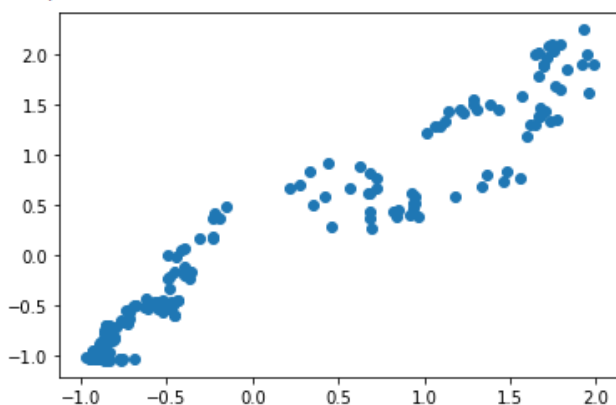


Figure 3.1

X axis: Standardized Ethereum prices

Y axis: Standardized Bitcoin prices

Values on the x and y graphs correspond to number of standard deviations from the mean. As expected, the graph looks identical (apart from data removal to avoid over fitting) to figure 2.1.

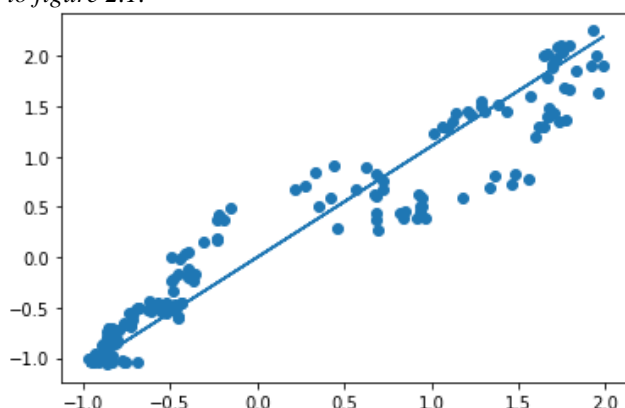


Figure 3.2 The Linear Model

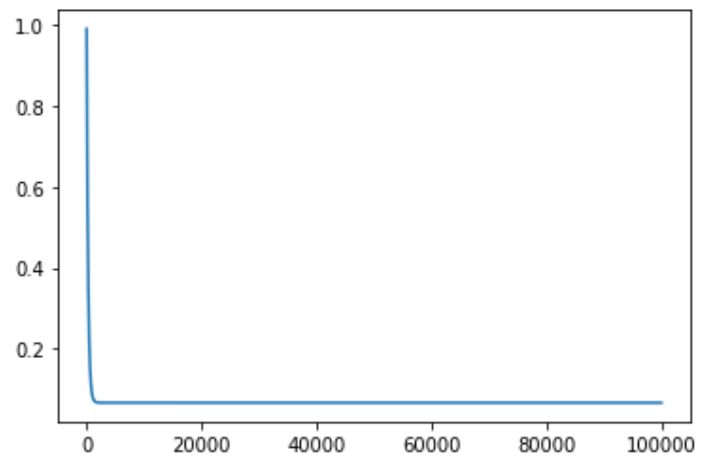


Figure 3.3

RMSE (in terms of standard deviations) over 100000 epochs. Stabilized at ≈ 0.06 Standard Deviations.

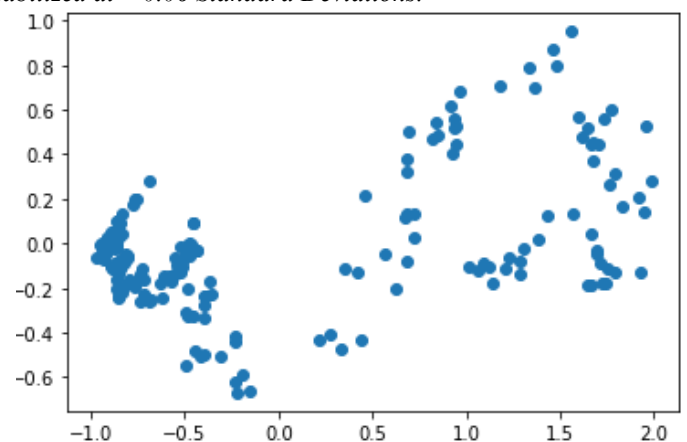


Figure 3.4 Residual Plot

X axis: standardized values of Ethereum prices

Y axis: real values (standardized) - predicted values(standardized)

III. CONCLUSION

After observing the prices graphically, obtaining meaningful conclusions statistically and building a predictive model, it is clear that there is a relationship between the 2 cryptocurrencies. Furthermore, a good estimate can be calculated by modeling the 2 linearly.

IV. LIMITATIONS

One inherent limitation of data driven research is the amount of data available to come to an accurate conclusion. Another drawback is the limited number of free API requests per day, which resulted in only 3 hours of price monitoring a day.

V. IMPLICATIONS AND FUTURE STEPS

Knowledge of the strong correlation between Bitcoin and Ethereum can help while investing in either of the 2 cryptocurrencies. Also, further research may extend this relationship to more than 2 cryptocurrencies and not just Bitcoin and Ethereum.

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Rohan Aanegola, National Public School, HSR, Bangalore