

Testing the relationship between price changes of bitcoin and ethereum and price changes of Coinbase the following day

By Ethan Sirois

1. Abstract

This study tests the relationship between the changes in prices of bitcoin and ethereum at a certain day to the change in the price of Coinbase the following day. The closing prices of bitcoin, ethereum, and Coinbase from the past year were collected and their change compared to their previous day's closing price was calculated, and bitcoin and ethereum were then lagged by one day. At significance level α equals 0.10, we fail to reject the null hypothesis that neither bitcoin nor ethereum's lagged price changes are correlated with the price changes of Coinbase the following day. There is still more research that needs to be done in the field, specifically testing other stocks in the stock market or other lag factors different from one day, especially to draw definite conclusions about the relationship between the price changes in bitcoin and ethereum to the price changes in Coinbase.

2. Background and Significance

Cryptocurrency has increasingly become a widespread concept in society today. Its prevalence is found in many topics ranging from technology and computer science to economics and investing. From the computer science perspective, it provides an interesting challenge for data mining and encryption. From the economic perspective, it is interesting because it lacks any physical value, and thus is highly volatile. This high volatility attracts investment as there is a hope for large returns on investment, similar to the stock market (Kim 2021, as cited in Jeris et al., 2022). Although the crypto market is thought to be more volatile than stocks, it can be observed that certain stocks that are related to the cryptocurrency market trend very similarly to the cryptocurrencies (Figure 1).

This study is an analysis of the relationship between price changes of the cryptocurrencies bitcoin and ethereum and price changes of the stock Coinbase. Coinbase was the stock picked to test due to its relationship to the cryptocurrency market, which is confirmed with its similar trends to bitcoin as seen in Figure 1. Bitcoin and Ethereum were picked to be representative cryptocurrencies as they make up most of the cryptocurrency market (Söderberg, 2018, as cited in Jeris et al., 2022). More specifically, this study tests the relationship between the changes in price of bitcoin and ethereum lagged one day behind and the change in price of Coinbase the following day. The null hypothesis for this study is that neither the changes in the price of bitcoin or ethereum at a certain day are correlated with the changes in Coinbase the following day. The alternative hypothesis is that at least one of bitcoin or ethereum changes lagged by a day is correlated with Coinbase. This is tested at significance level α equal to 0.10.

3. Methods

3.1 Data Collection

The data for Bitcoin and Ethereum is historical price data in USD of bitcoin and ethereum from April 22, 2022 to April 22, 2023, accessed by Yahoo Finance. The data for Coinbase is the historical stock price data of Coinbase from April 25, 2022 to April 21, 2023, also accessed by Yahoo Finance. This was the choice for the data as it is a year from the day that the data was collected on, April 23, 2023, after adjusting for the fact that bitcoin and ethereum would be collected one day behind for the one-day lag. The reason that Coinbase only goes from April 25,

2022 to April 21, 2023 is that Coinbase is part of the stock market, so it does not trade on weekends or holidays. See Figure 2 in the appendix for how the collected historical data chart of bitcoin, ethereum, and Coinbase looked.

3.2 Variable Creation

The two explanatory variables are not just the price of bitcoin or ethereum lagged by one day, but the change in these prices compared to the day before. The prices used are the closing prices, but this is a rather contingent choice, and the opening price could have been used the same way. These change values for bitcoin and ethereum are calculated by the price of the day before minus the price of two days before all over the price of two days before. E.g., the value in the row of 04-28-22 for bitcoin would be calculated by the closing price of bitcoin on 4/27/22 minus the closing price of bitcoin on 4/26/22 all over the price of bitcoin on 4/26/22. If the price of bitcoin was \$1000 on 4/26/22 and \$1100 on 4/27/22, the value for the change column in row 04-28-2022 would be $(1100 - 1000) / 1000 = 0.1$. This can be interpreted as a “10% increase in price from 4/26 to 4/27”. Similarly, if the price of bitcoin was \$900 on 4/27, it would be $(900 - 1000) / 1000 = -0.1$. To avoid negative values, one is added to all these changes. Instead of getting values between -1 and 1, the values are all now between 0 and 2. This can now be interpreted as the percentage that the closing price of bitcoin on 4/27/22 is compared to its closing price on 4/26/22. In the first example from above, bitcoin on 4/27/22 would be 110% of what it was on 4/26/22. This is done to make the graphs easier to view and interpret, and has no effect on the strength of correlation between bitcoin or ethereum with Coinbase because it is performed on all three variables. Bitcoin was used to describe the above procedure, but this is calculated for ethereum and Coinbase analogously, excluding the fact that Coinbase is not lagged by a day.

There are a different number of days of data for Coinbase than there are for bitcoin and ethereum, as described in section 3.1, due to Coinbase being a part of the stock market and not trading weekends or holidays, while ethereum and bitcoin do. To account for this, the lagged price change data for bitcoin and ethereum was only collected for the days that Coinbase traded on. See Figure 3 for a sample of the final dataset.

3.3 Analytic Methods

The analysis of this study consists of a multiple linear regression model with bitcoin and ethereum price changes lagged by one day as two distinct explanatory variables, referred to as BTC and ETH respectively, and the Coinbase price changes for the following day as the response variable, referred to as COIN. This model is Model 1. Model 1 was tested for non-linearity, and this was tested through creating a new model which used a square root transformation on COIN. The models were created and graphed in R, utilizing the “plot3D” and “ggplot2” packages. The graphs consisted of a scatterplot matrix, a three-dimensional scatter plot, and a linear regression plot. The models were then tested to see if there is a model with similar r-squared but uses only one of bitcoin or ethereum using backward regression.

4. Results

The multiple regression model, Model 1, had an r-squared of 0.008984 with p-value of 0.3295. The residuals vs. fitted plot indicated slight nonlinearity with a slightly quadratic shape (see Figure 4), however using a square root transformation of the response variable, (i.e., COIN) barely increased the r-squared, as it only changed from 0.008984 to 0.009001. This change is insignificant and doesn't make sense in the context, so the multiple regression model will not be transformed. The slopes for BTC and ETH in the multiple regression model were 0.21409 and -0.01249 respectively, with an intercept of 0.7817. The scatterplot matrix and three-dimensional scatterplot for this model can be seen in Figures 5 and 6 respectively.

The p-values for BTC and ETH for Model 1 are 0.461 and 0.955 respectively. Using best subsets, ETH gets removed from the model because it has the higher p-value. This new model only using BTC as an explanatory for COIN, Model 2, has an r-squared of 0.008971 and a p-value of 0.1361. The p-value for this model is significantly lower while maintaining nearly the same r-squared, so it is a better fit than Model 1 and it is the final model choice. See Figure 7 for the linear regression plot of Model 2. At significance level α equals 0.10, we fail to reject the null hypothesis that at least BTC or ETH is not correlated with COIN, as the p-value of the final model, Model 2, is 0.1361, which is greater than 0.10.

To see the correlation between BTC and ETH, a new model is made that uses ETH as the explanatory variable and BTC as the response variable. This is Model 3. The r-squared of this model is 0.7875, with a p-value of $2.2e-16$. The r-squared and p-value of this model demonstrate how strongly correlated BTC and ETH are for this dataset. This can be seen back in the scatterplot matrix (Figure 5), where BTC and ETH are visibly very strongly correlated. This very strong correlation between the explanatory variables is a multicollinearity, meaning the explanatory variables contribute redundant information about the response variable; i.e., COIN. This can be seen by the extremely high p-value for ETH of 0.955 in Model 1.

5. Discussion/Conclusion

In conclusion, the price changes in bitcoin or ethereum lagged by one day do not have a statistically significant correlation with the price changes of Coinbase with data from the past year. It seems that there is some correlation in this data between either cryptocurrency and Coinbase, as the p-value of the final model, Model 2, is ~ 0.13 which is close to the statistically significant α level of 0.10. Cryptocurrency is still growing in popularity, and there seems to be a growing interest in using it to predict changes in the stock market, or vice versa (Jeris et al., 2022). This study is limited in drawing conclusions about the relationship between the entire stock market and cryptocurrency market, or other specific members of both, as this study only analyzed bitcoin and ethereum's relationship with Coinbase. This also does not conclude that there is no relationship between bitcoin or ethereum and Coinbase, but rather that there is no significant relationship for the one day lagged price changes in bitcoin and ethereum with the price changes in Coinbase. Using a different amount of lag or no lag at all could yield different

results and demonstrate a correlation between the prices of at least one of bitcoin or ethereum and the prices of Coinbase.

6. Reference list

finance.yahoo.com. (n.d.). *Coinbase Global, Inc. (COIN) Stock Historical Prices & Data - Yahoo Finance*. [online] Available at: <https://finance.yahoo.com/quote/COIN/history?p=COIN> [Accessed 29 Apr. 2023].

finance.yahoo.com. (n.d.). *Ethereum USD (ETH-USD) Stock Historical Prices & Data - Yahoo Finance*. [online] Available at: <https://finance.yahoo.com/quote/ETH-USD/history/> [Accessed 29 Apr. 2023].

Jeris, S.S., Ur Rahman Chowdhury, A.S.M.N., Akter, Mst.T., Frances, S. and Roy, M.H. (2022). Cryptocurrency and stock market: bibliometric and content analysis. *Heliyon*, 8(9), p.e10514. doi:<https://doi.org/10.1016/j.heliyon.2022.e10514>.

Kim, J.-M., Jun, C. and Lee, J. (2021). Forecasting the Volatility of the Cryptocurrency Market by GARCH and Stochastic Volatility. *Mathematics*, 9(14), p.1614. doi:<https://doi.org/10.3390/math9141614>.

Söderberg, G., 2018. Are Bitcoin and other crypto-assets money?. *Economic Commentaries*, 5, p.14. Available at: <https://scholar.google.com/scholar?q=Are%20Bitcoin%20and%20other%20crypto-assets%20money>

www.google.com. (n.d.). *Bitcoin (BTC) Price, Real-time Quote & News - Google Finance*. [online] Available at: <https://www.google.com/finance/quote/BTC-USD?sa=X&ved=2ahUKEwjrkbm2rdL-AhUyEFkFHW2HCa0Q-fUHegQIBhAf&window=1Y> [Accessed 30 Apr. 2023].

www.google.com. (n.d.). *Coinbase Global Inc (COIN : NASDAQ) Stock Price & News - Google Finance*. [online] Available at: <https://www.google.com/finance/quote/COIN:NASDAQ> [Accessed 30 Apr. 2023].

www.sthda.com. (n.d.). *Impressive package for 3D and 4D graph - R software and data visualization - Easy Guides - Wiki - STHDA*. [online] Available at: <http://www.sthda.com/english/wiki/impressive-package-for-3d-and-4d-graph-r-software-and-data-visualization#install-plot3d-package> [Accessed 29 Apr. 2023].

Appendix



Figure 1. From Google Finance. Left: Bitcoin price in the past year. Right: Coinbase stock price in the past year

| BTC-USDf22-22 | | | | | | |
|---------------|--------------|--------------|--------------|--------------|--------------|-------------|
| Date | Open | High | Low | Close | Adj Close | Volume |
| 2022-04-22 | 40525.863281 | 40777.757813 | 39315.417969 | 39740.320313 | 39740.320313 | 28011716745 |
| 2022-04-23 | 39738.722656 | 39935.859375 | 39352.203125 | 39486.730469 | 39486.730469 | 16138021249 |
| 2022-04-24 | 39478.375000 | 39845.925781 | 39233.539063 | 39469.292969 | 39469.292969 | 17964398167 |
| 2022-04-25 | 39472.605469 | 40491.753906 | 38338.378906 | 40458.308594 | 40458.308594 | 35445730570 |
| 2022-04-26 | 40448.421875 | 40713.890625 | 37884.984375 | 38117.460938 | 38117.460938 | 34569088416 |
| 2022-04-27 | 38120.300781 | 39397.917969 | 37997.312500 | 39241.121094 | 39241.121094 | 30981015184 |
| 2022-04-28 | 39241.429688 | 40269.464844 | 38941.421875 | 39773.828125 | 39773.828125 | 33903704907 |
| 2022-04-29 | 39768.617188 | 39887.269531 | 38235.535156 | 38609.824219 | 38609.824219 | 30882994649 |
| 2022-04-30 | 38605.859375 | 38771.210938 | 37697.941406 | 37714.875000 | 37714.875000 | 23895713731 |
| 2022-05-01 | 37713.265625 | 38627.859375 | 37585.789063 | 38469.093750 | 38469.093750 | 27002760110 |
| 2022-05-02 | 38472.187500 | 39074.972656 | 38156.562500 | 38529.328125 | 38529.328125 | 32922642426 |
| 2022-05-03 | 38528.109375 | 38629.996094 | 37585.621094 | 37750.453125 | 37750.453125 | 27326943244 |
| 2022-05-04 | 37748.011719 | 39000.040000 | 37732.058594 | 39608.371094 | 39608.371094 | 36754404490 |

Figure 2. Historical price information of bitcoin in USD collected from Yahoo Finance. (Note: Coinbase and ethereum had the same information about them collected in the same fashion)

Table 1

| Date | BITL1 | ETHL1 | COIN |
|------------|-------------------|-------------------|-------------------|
| 2022-04-26 | 1.02505785005515 | 1.02965063825649 | 0.940876150221076 |
| 2022-04-27 | 0.942141732134913 | 0.933177495291074 | 0.963822265610346 |
| 2022-04-28 | 1.02947888259996 | 1.02871181699306 | 1.00114238267297 |
| 2022-04-29 | 1.01357522456415 | 1.01661903721625 | 0.918656754117585 |
| 2022-05-02 | 0.970734426106992 | 0.958685205324924 | 1.07656815789698 |
| 2022-05-03 | 1.00156578617088 | 1.01048686481767 | 1.0182957151243 |
| 2022-05-04 | 0.979784879781108 | 0.974125494188724 | 1.05333438092157 |
| 2022-05-05 | 1.05159985663086 | 1.05646480840654 | 0.877833309773337 |
| 2022-05-06 | 0.92132597930518 | 0.934901474116336 | 0.908008735229759 |
| 2022-05-09 | 0.985393938591316 | 0.98027311949388 | 0.804993287160079 |
| 2022-05-10 | 0.889536300006469 | 0.891942853028756 | 0.874027017745731 |
| 2022-05-11 | 1.02396125848051 | 1.04368007359587 | 0.735991265542986 |
| 2022-05-12 | 0.932741608275337 | 0.884189856748553 | 1.08897987548437 |
| 2022-05-13 | 1.00384970678562 | 0.946717511471719 | 1.16017099145299 |
| 2022-05-16 | 1.00810222985176 | 1.02687293351146 | 0.909090883641187 |
| 2022-05-17 | 0.953930998458475 | 0.94268516288195 | 1.13452186167712 |
| 2022-05-18 | 1.01885078523085 | 1.03346139299448 | 0.900428557142857 |
| 2022-05-19 | 0.943942880085715 | 0.916880841481953 | 1.06964935855385 |
| 2022-05-20 | 1.05550304428313 | 1.05305075465264 | 0.981162918456331 |

Figure 3. The values inside each column is how that specific asset did on the date from the row compared to the day before it. The L1 in the BIT and ETH columns indicate that they are lagged by one day compared to the Coinbase information. E.g., for the values in row 2022-04-28, the values in the BIT and ETH columns are how bitcoin and ethereum performed on 2022-04-27 compared to 2022-04-26, and the value in the COIN column is how Coinbase did on the date of the row; i.e., 2022-04-28.

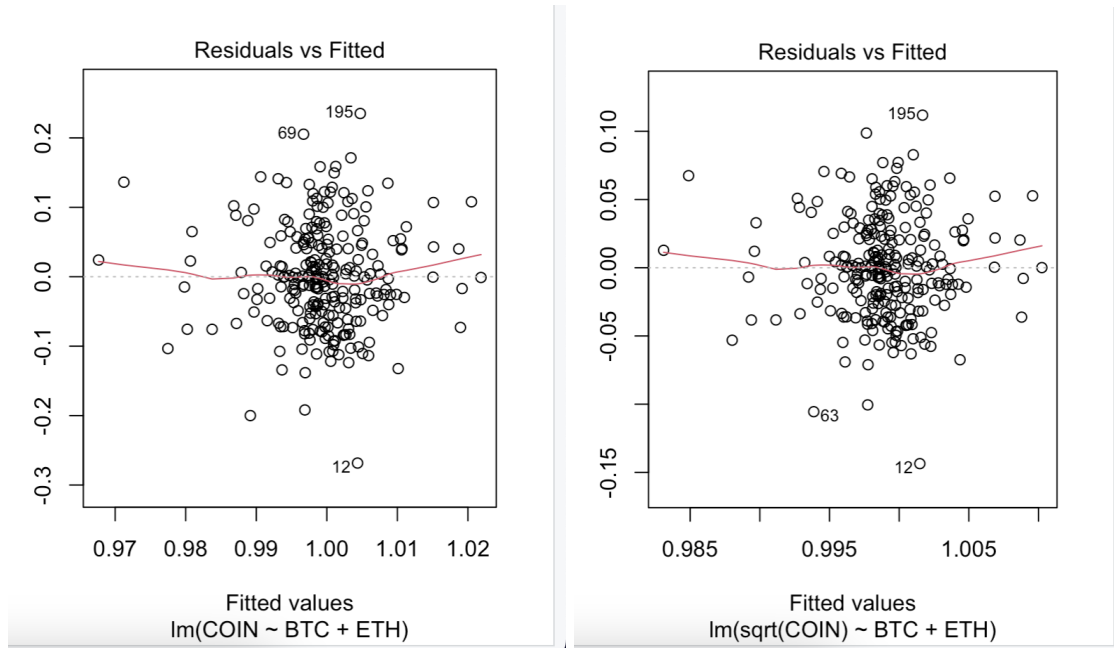


Figure 4. The left is the residuals vs fitted plot for the regular multiple regression model; the right is the residuals vs fitted plot for after the square root transformation.

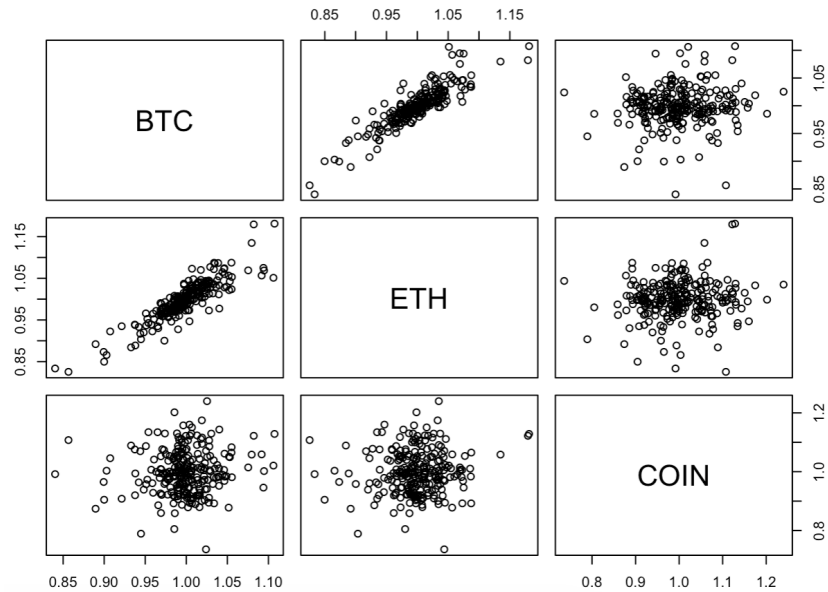


Figure 5. Scatterplot matrix of Model 1.

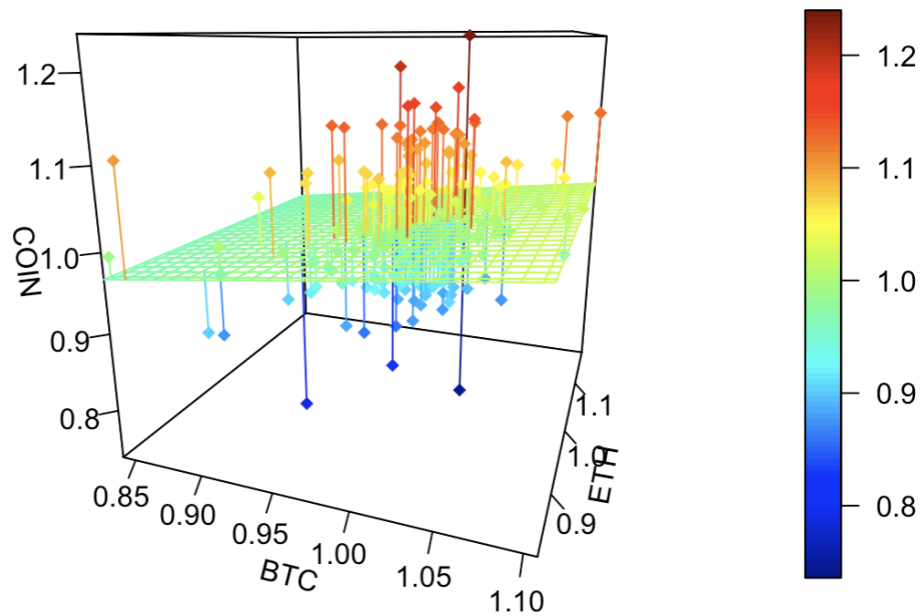


Figure 6. Three-dimensional scatterplot of Model 1. The color represents the Coinbase price change value for that specific point. The plane is a plane of best fit. The vertical lines coming from each point is how far the Coinbase price change at that point is from the predicted Coinbase price change at that point's bitcoin and ethereum price change using the slopes in Model 1.

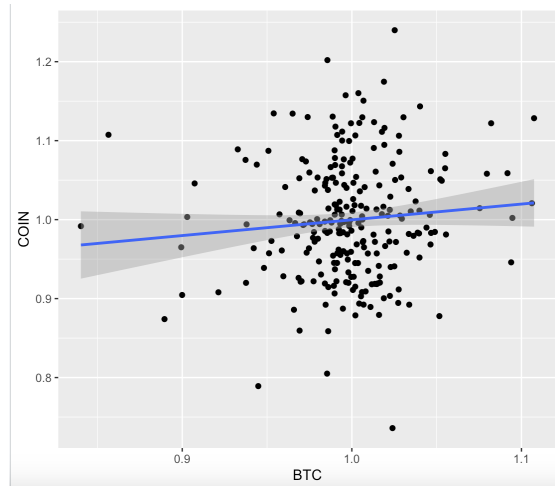


Figure 7. Graph of Model 2, the linear regression model using BTC to predict COIN.