

Cryptocurrency Correlation Analysis

IEOR 4150: Introduction to Probability and Statistics

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Objectives

The objective of our project is to find answers to the questions mentioned below by performing statistical analysis on the data set.

- 1) Are the cryptocurrency prices normally distributed and can the future prices be predicted by regressing the log returns over time?
- 2) Can the future prices of cryptocurrencies be predicted using the statistical data of daily log returns over a time?
- 3) To find out whether a change in the price of a cryptocurrency is affecting the price of other cryptocurrencies?
- 4) Does high volatility of cryptocurrency prices affect the major stock market indexes around the world and to what extent?
- 5) To determine whether change in the price of a cryptocurrency affects the foreign exchange market (Forex)?

Introduction

The sudden rise in the Bitcoin prices in the last few months has made it the asset giving maximum returns. But, high volatility of the cryptocurrency prices is making it difficult to determine if it is a viable investment option or not. All these factors have made the analysis of cryptocurrency prices very important & interesting. For a very long time, there has been a speculation about the change in price of a cryptocurrency, and its effect on other cryptocurrencies as well as other financial assets like the stock index and the foreign exchange market. Through our statistical analysis (detailed in the sections below) of the financial data involving cryptocurrency, stock index and foreign exchange prices; we wanted to determine if we could put our questions to test and derive meaningful insights from the results that we obtain. The Market stock indexes that we have selected for our analysis are S&P 500 Stock Index (USA), Nikkei 225 Index (Japan), Shanghai SE Composite Index (China), MOEX Russia Index (Russia) as cryptocurrency is considered legal in these countries.

The main purpose was to use statistical tools to analyze the cryptocurrencies and to find their impact on the stock markets and the foreign exchange markets. We used correlation, regression analysis, histograms and scatter plots to derive meaningful results.

Data Set

Our dataset consists of historical data of four cryptocurrencies, four stock indexes and foreign exchange rates with respect to USD of these four countries every trading day from Dec 1, 2016 to December 1, 2017. Crypto currency data was collected from coinmarketcap.com and index price data was collected from Yahoo finance.

The stocks, indexes and Foreign exchange in our dataset are as follows :

Cryptocurrency

- Bitcoin (BTC)
- Litecoin (LTC)
- Ripple (XRP)
- Ethereum (ETC)

Index

- S&P 500 Stock Index (USA)
- Nikkei 225 Index (Japan)
- Shanghai SE Composite Index (China)
- MOEX Russia Index (Russia)

Foreign Exchange Market

- United States Dollar (USD) vs Japanese Yen (JPY)
- United States Dollar (USD) vs Chinese Yuan (CNY)
- United States Dollar (USD) vs Russian Ruble (RUB)

Analysis

Single Cryptocurrency Analysis

For the single cryptocurrency analysis, we wanted to check if the log returns over time are normally distributed. For that purpose, we plotted the histogram of log returns over time and also added the functionality to change the bin size of the histogram. From the histograms, we could see that all the histograms resembled standard normal distribution and to make it more clear, we tried to superimpose a standard normal distribution plot over the histogram.

We also implemented the functionality to estimate mean and variance of the population from the sample data for various confidence intervals.

Dual Cryptocurrency Analysis

To analyze the effect of cryptocurrency prices on each other, we first performed t-test to measure equality of population means for different currencies.

We also performed regression analysis on cryptocurrency pairs to determine whether prices of different cryptocurrencies can be predicted from a single cryptocurrency.

Also, we implemented methodology to perform t-test on cryptocurrency pairs for different confidence intervals. From the t-test, equality of the population mean of the pair was checked.

Cryptocurrency with Stock index and foreign exchange Analysis

We analyzed the correlation between cryptocurrency, stock indexes and foreign exchange.

First, we performed correlation analysis by finding out correlation between different cryptocurrencies, stock indexes and foreign exchange rates.

We obtained a scatter plot for the same and performed regression analysis between a cryptocurrency and a stock index or foreign exchange.

The slope, intercept and R^2 values obtained from the regression analysis were useful in obtaining answers for the questions mentioned above.

Findings

Single Cryptocurrency Findings

After analyzing single cryptocurrency log returns over time, it can be seen from Figure 1.1 that the histogram represents a standard normal distribution plot with mean ~ 0 . As shown in Figure 1.2, the lower range of the mean is 0.0051 and the upper range is 0.019 for Bitcoin (BTC) for a 95% confidence interval. When we take the mean of the lower range and the upper range, we get:

Average Mean for 95% confidence interval for Bitcoin = $(0.0051 + 0.019) / 2 = 0.01205$ which is approximately equal to 0, hence representing a standard normal distribution.

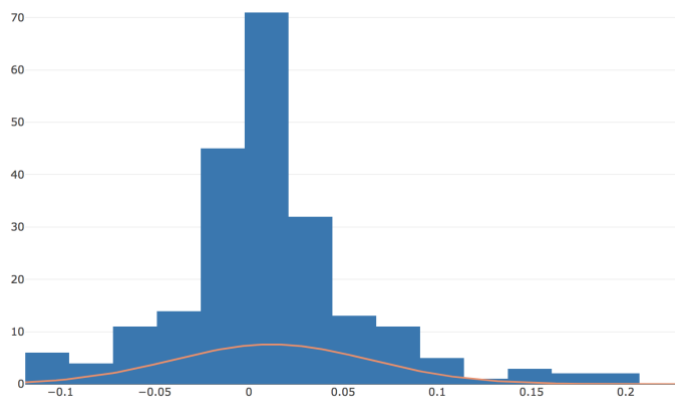


Figure 1.1: Histogram of Log Returns over Time for BTC

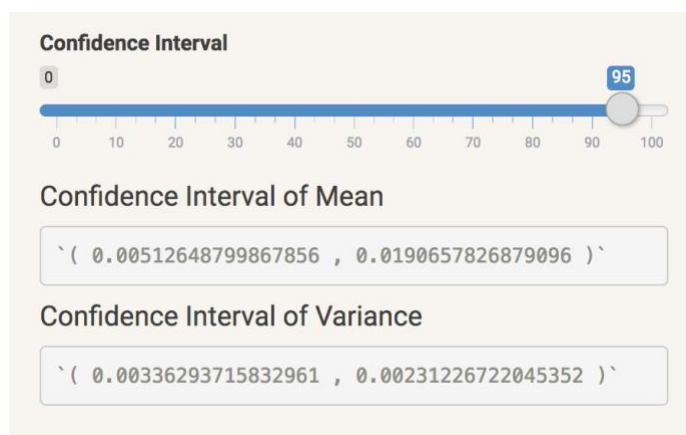


Figure 1.2: 95% confidence interval for mean and variance for BTC

The 95% confidence interval for variance had a very small range which shows that there is not much volatility in the log-returns of cryptocurrencies over time.

Cryptocurrency	β_0	β_1	R^2
BTC	-0.6682396	3.927124e-05	0.005330735
ETH	0.8917754	-5.043018e-05	0.003556779
XRP	0.9785886	-5.553802e-05	0.002257526
LTC	-0.1203548	7.791589e-06	7.791589e-06

Table 1.1: Regression between log returns of individual cryptocurrency

The regression results show that the R^2 values are very small. The presence of many outliers in the scatter plot also confirms this observation. The residual plots also fail to provide any substantial inferences.

Dual Cryptocurrency Findings

	BTC	LTC	XRP	ETH
BTC	1.0000000	0.5040866	0.2139439	0.3634568
LTC	0.5040866	1.0000000	0.2941119	0.4098275
XRP	0.2139439	0.2941119	1.0000000	0.2142618
ETH	0.3634568	0.4098275	0.2142618	1.0000000

Table 1.2: Correlation matrix for cryptocurrency pairs

After correlating the price of one cryptocurrency with the other, we see that there is high positive correlation between Bitcoin (BTC) and Litecoin (LTC) i.e. 0.5040866

Cryptocurrency	β_0	β_1	R^2
ETH	0.007404124	0.2573041	0.1636272
XRP	0.009691398	0.1446083	0.09875802
LTC	0.008089398	0.2725126	0.2468262

Table 1.3: Regression between BTC and other cryptocurrencies

Regression was performed by taking two cryptocurrencies at a time. Consider the example shown in the table above, which shows the results after regressing BTC against the three cryptocurrencies (BTC, XRP and LTC). We can see from the R^2 values that LTC and BTC values are highly correlated.

Cryptocurrency with Stock index and foreign exchange Analysis

	MXClose	SPClose	SHClose	NKClose
BTC.Close	0.01190486	0.8983745	0.7299069	0.8901942
LTC.Close	-0.23752821	0.8922446	0.6585152	0.7478521
XRP.Close	-0.53802558	0.7152065	0.2393428	0.5732739
ETH.Close	-0.38914351	0.8665118	0.5650685	0.7049047

Table 1.4: Correlation matrix between cryptocurrency and stock indexes

After analyzing the cryptocurrencies with stock indexes we have the following observations:

- 1) High positive correlation between all cryptocurrencies and S&P 500 Stock Index (USA Index)
- 2) High positive correlation between Ethereum (ETC) and S&P 500 Stock Index (USA Index)
- 3) There is low or negative correlation between all cryptocurrencies and MOEX Russia Index (Russia)

	USDJPYClose	USDRUBClose	USDCNYClose
BTC	-0.037402404	-0.01835982	-0.06899622
LTC	-0.113153119	-0.10176456	-0.02893347
XRP	-0.042120027	-0.14584199	0.09333040
ETH	0.007257488	-0.08964982	0.12104300

Table 1.5: Correlation matrix between cryptocurrency and foreign exchange market

After analyzing correlation between cryptocurrencies and various currencies, we can observe that there is a very low or negative correlation between them.

We can determine the correlation and regression analysis by selecting any cryptocurrency and stock index or foreign exchange rate. For the purpose of report, we have just shown a two examples below.

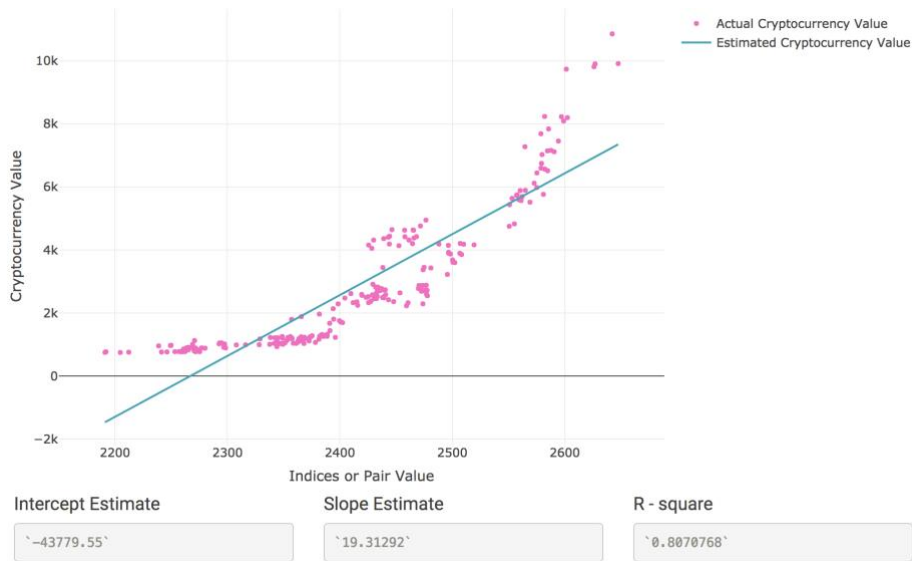


Figure 1.3: Scatterplot and regression results between BTC and S&P 500

The above figure shows the scatterplot and regression between BTC and S&P 500 stock index of the United States. As we can see from the scatter plot, there are a very few outliers. This is also supported by very high R^2 value.



Figure 1.4: Scatterplot and regression results between BTC and MOEX stock index

The above figure shows scatter and regression analysis between BTC and MOEX stock index of Russia. As can be seen from the scatter plot, there are many outliers which is supported by the very low R^2 value.

Conclusions and Final Assessment

From the single cryptocurrency analysis, it is observable that log returns of the cryptocurrencies are normally distributed. Although the residual plot is showing that the regression is fitting the given values appropriately, but from regressing the given high, low and close prices against time it is visible that the R squared value is not substantial enough to predict the chosen values in the future.

From the dual cryptocurrency analysis it is observable that Bitcoin (BTC) and Litecoin (LTC) show a high positive correlation which is a testament to the fact that price changes in one positively affects the price changes in another. This fact is also observable from looking at the regression of BTC v/s LTC which is providing a relatively higher R squared values compared to other possible combinations of cryptocurrencies. Regressing XRP v/s LTC also provides a relatively higher R squared values compared to other possible combination of cryptocurrencies.

From looking at the correlation between cryptocurrencies v/s major stock indices and foreign exchanges of those countries with respect to USD, it is observable that all cryptocurrencies show a negative correlation v/s foreign exchange pairs which is a testament to the fact that the future vision or the long term goal of every cryptocurrency is to be a stable substitute of current fiat currencies in their respective governments. One interesting insight from the correlation values is that in the time-period of our historical data (which is from 1st Dec 2016 to 1st Dec 2017) MOEX Russian Stock Index is not affected by changing prices in cryptocurrency values whereas USA, Japan and China's major stock indices show a relatively high correlation with cryptocurrencies. These insights are also corroborated from looking at the regression results of cryptocurrencies with MOEX Russian major index which show a low R squared value for every regression combination.

Another interesting insight is that while regressing all cryptocurrencies v/s S&P 500, it is observable that the R squared values are comparatively higher when compared to other major stock indices. This is in corroboration with correlation values observed above.

Although we have observed high correlation and R squared values from our analysis, an important caveat to not forget is that correlation does not imply causation. There are various other factors in place apart from historical data which drive price changes in these stocks.

References

Sterlin Lujan. "Research Says Bitcoin Price Booms May Positively Affect Stock Prices"

<https://news.bitcoin.com/bitcoin-booms-may-positively-effect-stock-prices/>

Charles Bovaird. "Follow the Leader: Analyzing Cryptocurrency Price Correlations"

<https://www.coindesk.com/follow-leader-analyzing-bitcoin-cryptocurrency-price-correlations/>