Correlation of Bitcoin Price and S&P 500 Company Index

Avtandil Gagnidze[1], Maksim Iavich[2], Giorgi Iashvili[2], Dali Magraqvelidze[3], and Tetiana Okhrimenko[4]

[1] *East European University, 4 Shatili str., Tbilisi, 0178, Georgia*
[2] *Caucasus University, 1 Paata Saakadze str., Tbilisi, 0102, Georgia*
[3] *Georgian Technical University, 77 Kostava str., Tbilisi, 0108, Georgia*
[4] *National Aviation University, 1 Lybomyra Huzara ave., Kyiv, 03058, Ukraine*

Abstract

With the improvement of data technology advances and the sharp addition of web customer numbers since the 90s, we see that numerous computerized monetary standards are presented. The most popular among them is Bitcoin. All transactions are verified and recorded on a block-chain as well and security depends on cryptographic algorithm stability. We have decided to investigate the possible relations between the most popular cryptocurrency Bitcoin price dynamics and global S&P 500 index dynamics using statistical methods.

Keywords

Bitcoin, price, cryptocurrency, S&P 500 index, encryption, accounting, security.

1. Introduction

To begin, we looked at the history of Bitcoin and it was very interesting. While looking at different ideas on how to investigate if Bitcoin is the new kind of currency, we decided that if Bitcoin is "money", then it could be somehow related to the Real Economy and its performance. Computerized cash is virtual cash, it doesn't have a physical structure, it's an unlimited, decentralized system and can displace the cash in any trade. In addition, it is interesting:

1. What is the effect of the cryptographic types of cash on the economy of the country and cash subject to existing monetary techniques?
2. How might we have the option to think about compensation from computerized cash in the country's real economy?

Starting from 2008 Cryptocurrency has become too popular. The first cryptocurrency was created in 2008 by an unknown person, or gang, known as Satoshi Nakamoto. However, there have been times when people have tried to make virtual money that would be cryptographically protected. For example, "Bit-Gold" and "B-Money." They were brought to an early stage, but not fully developed so that anyone could consume them [1].

In 2009, a system was developed to make Bitcoin available to the public. "Mining" was introduced, as one of the ways to generate cryptocurrencies. At this time the user will gain new bitcoins and transactions will be written and verified in the blockchain. The main purpose of blockchain technology is to create a secure and secure digital identity based on the right combination of open and closed cryptographic keys (Fig. 1) [2–4].

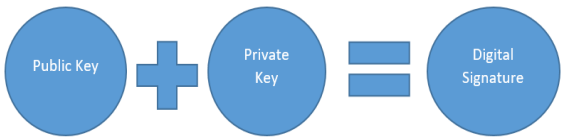

Figure 1: Combination of public and private key

The combination of these keys is treated as consent and represents a digital signature. In turn, this digital signature provides strong ownership control. It seems that the Bitcoin is safe, and this is the advantage. The problem of safety is very important and we investigated the safety in previous works of authors [5–7].

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EMAIL: gagnidze@gmail.com (A. Gagnidze); miavich@cu.edu.ge (M. Iavich); giashvili@gmail.com (G. Iashvili); dmgr@yahoo.com (D. Magraqvelidze); t.okhrimenko@npp.nau.edu.ua (T. Okhrimenko)
ORCID: 0000-0003-4728-3709 (A. Gagnidze); 0000-0002-3109-7971 (M. Iavich); 0000-0002-1855-2669 (G. Iashvili); 0000-0002-3568-6987 (D. Magraqvelidze); 0000-0001-9036-6556 (T. Okhrimenko)

2. Cryptocurrency

The first cryptocurrency was created in 2008 by an unknown person, or gang, known as Satoshi Nakamoto. However, there have been times when people have tried to make virtual money that would be cryptographically protected, for example, “Bit-Gold” and “B-Money.” They were brought to an early stage, but not fully developed so that anyone could consume them.

In 2009, a system was developed to make Bitcoin available to the public. “Mining” was introduced, as one of the ways to generate cryptocurrencies. At this time the user will gain new bitcoins and transactions will be written and verified in blockchain (Fig. 2). The main purpose of blockchain technology is to create a secure and secure digital identity based on the right combination of open and closed cryptographic keys. The combination of these keys is treated as consent and represents a digital signature. In turn, this digital signature provides strong ownership control. It seems that the Bitcoin is safe, and this is the advantage.

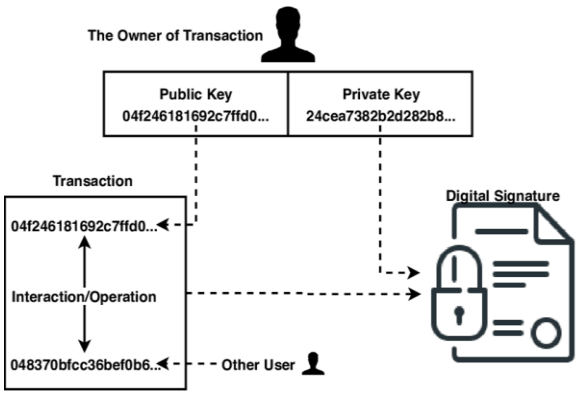

Figure 2: Blockchain scheme

So far no one traded in the real economy using Bitcoins. That is why no one could price their cryptocurrency units. However, the time has come for this and Bitcoin needs to be evaluated. Initially, one customer exchanged 10,000 units of BTC in two pizzas. At today’s prices, it reaches one hundred million dollars. Later, when many had already heard about Bitcoin and reached a certain level of popularity, other cryptocurrencies appeared to offer improved conditions for consumers. For example, more protection, speed, etc. There are more than 1,000 cryptocurrencies in the world today and over time they are being created. Therefore, it is not clear for now if Bitcoin can replace the real currency [8–10].

3. S&P 500 Index

The S&P 500 or Standard & Poor’s 500 Index is a market-capitalization-weighted index of the 500 largest U.S. publicly traded companies. The index is widely regarded as the best gauge of large-cap U.S. equities. Other common U.S. stock market benchmarks include the Dow Jones Industrial Average or Dow 30 and the Russell 2000 Index, which represents the small-cap index. The S&P does not currently provide the total list of all 500 companies on its website, outside of the top 10. Many of the top companies in the S&P 500 include technology firms and financial businesses. The S&P 500 uses a market capitalization weighting method, giving a higher percentage allocation to companies with the largest market capitalizations. Determination of the weighting of each component of the S&P 500 begins with summing the total market cap for the index [11–13].

- Calculate the total market cap for the index by adding all the market caps of the individual companies.
- The weighting of each company in the index is calculated by taking the company's market capitalization and dividing it by the total market cap of the index.
- For review, the market capitalization of a company is calculated by taking the current stock price and multiplying it by the company’s outstanding shares.
- Fortunately, the total market cap for the S&P as well as the market caps of individual companies is published frequently on financial websites saving investors the need to calculate them.

The market capitalization of a company is calculated by taking the current stock price and multiplying it by the outstanding shares. The S&P only uses free-floating shares, meaning the shares that the public can trade. The S&P adjusts each company's market cap to compensate for new share issues or company mergers. The value of the index is calculated by totaling the adjusted market caps of each company and dividing the result by a divisor. Unfortunately, the divisor is proprietary information of the S&P and is not released to the public [14–16].

We are interested in answering the following question using statistical methods: Are the Bitcoin prices somehow related to the S&P 500 Index? It defines the main objective of the work.

3. Data Collection

We collected data from official sources like Yahoo finances and Bitcoin WIKI. The data we decided to use is from June 1 to September 23, 2020. Because Bitcoin prices in this data are given daily (every day), but S&P 500 Index data is given for working days, we decided to use for Weekend and Holiday days S&P 500 Index to equal to the closest preceding working day. The data is presented in the table and chart below.

The correlation coefficient between Bitcoin prices and the S&P 500 index is 0.802 and indicates quite a good correlation. At the same time to investigate the real relations between these two values, more deep analysis is needed. One possible idea is to investigate the relations between rates of change of these variables [17–20].

The data about the corresponding rates of changes is presented in Figs. 3 and 4.

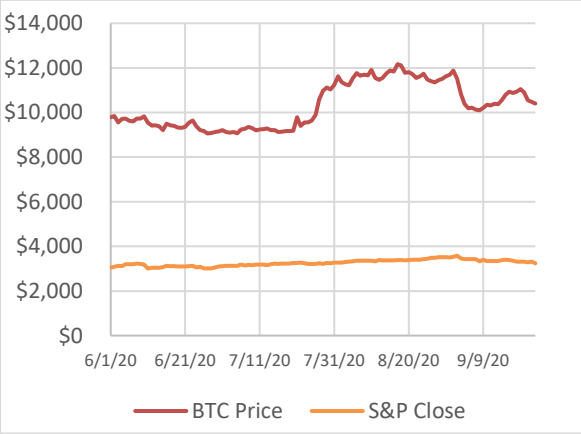

Figure 3: BTC price dynamics at 2020

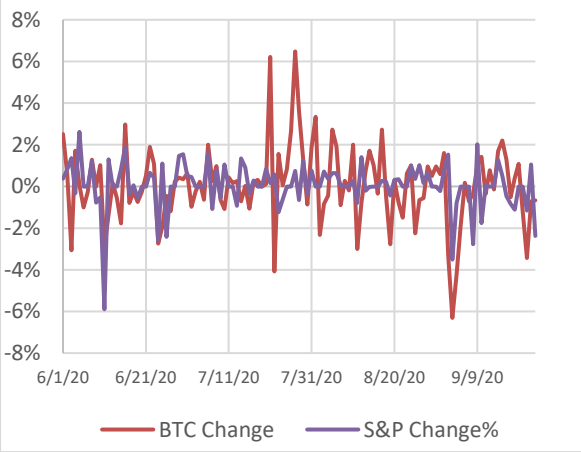

Figure 4: Blockchain scheme

The correlation coefficient between rates of change of Bitcoin prices and the S&P 500 index is 0.290 and indicates quite a weak correlation.

4. Qualitative Research

When thinking about dependence/ independence of two qualitative variables it is usual to consider two Hypothesis:

- The null hypothesis, H_0, states that the variables are independent (there is no relationship between them).
- The alternative hypothesis, Ha, states that there is a relationship between the two variables.

With the hypotheses identified, the next step in the hypothesis test is to examine the data set to see if it supports rejecting or not rejecting the null hypothesis.

We can display the data efficiently with a two-way table (also called a contingency table), so named because it displays two variables [21].

A two-way table shows the relationship between two variables by listing one variable in the rows and the other variable in the columns. The entries in the table's cells are called frequencies.

The basic idea of the hypothesis test is to decide whether the data provide enough evidence to reject the null hypothesis [22–24].

For the case of a test with a two-way table, the specific steps are as follows:

- We start by assuming that the null hypothesis is true, meaning there is no relationship between the two variables. In that case, we would expect the frequencies (the numbers in the individual cells) in the two-way table to be those that would occur by pure chance. Our first step, then, is to find a way to calculate the frequencies we would expect by chance. For each cell in the two-way table, identify *O* as the observed frequency and *E* as the expected frequency if the null hypothesis is true (no relationship between the variables).
- We next compare the frequencies expected by chance to the observed frequencies from the sample, which are the frequencies displayed in the table. We do this by calculating something called the chi-square statistic for the sample data. The larger this value is, the greater the average difference between the observed and expected frequencies in the cells.

Decision rule:

- If the calculated value of χ^2 is less than the critical value, the differences between the observed and expected values are small and there is not enough evidence to reject the null hypothesis.
- If the calculated value of χ^2 is greater than or equal to the critical value, then there is enough evidence in the sample to reject the null hypothesis [24, 25].

5. Qualitative Data Preparation

We decided to use the following criteria for the data:

- If the percentage change is less than minus 1%, then we say that the value went down by a sufficiently large value and denote it as DownDown.
- If the percentage change is between minus 1% and minus 0.2%, then we say that value went down and denote as Down.
- If the percentage change is between minus 0.2% and 0.2%, then we say that the value is almost unchanged Unchanged.
- If the percentage change is between 0.2% and 1%, then we say that value went up and denote as Up.
- If the percentage change is more than 1%, then we say that the value went up by a sufficiently large value and denote it as UpUp.

According to these criteria, the following two-way Table 1 is created.

Table 1

Qualitative data preparation

	Down Down	Down	Unch anged	Up	Up Up
DownDown	4	4	6	3	5
Down	3	5	11	5	4
Unchanged	0	2	6	2	1
Up	2	3	11	6	2
UpUp	2	4	5	12	7

After this compilation, we used Excel Add-in to conduct the χ^2 test for independence with a 5×5 table. As usual, the Null Hypothesis is that S&P 500 Index rates of change and Bitcoin Price rates of change are independent. Testing results are given in Table 2.

Table 2

Bitcoin vs. S&P 500

Observed Frequencies

	DowDown	Down	Unchanged	Up	UpUp	Total
DownDown	4	4	6	3	5	22
Down	3	5	11	5	4	28
Unchanged	0	2	6	2	1	11
Up	2	3	11	6	2	24
UpUp	2	4	5	12	7	30
Total	11	18	39	28	19	115

Expected Frequencies

	DowDown	Down	Unchanged	Up	UpUp	Total
DownDown	2.1043	3.4435	7.4609	5.3565	3.6348	22
Down	2.6783	4.3826	9.4957	6.8174	4.6261	28
Unchanged	1.0522	1.7217	3.7304	2.6783	1.8174	11
Up	2.2957	3.7565	8.1391	5.8435	3.9652	24
UpUp	2.8696	4.6957	10.1739	7.3043	4.9565	30
Total	11	18	39	28	19	115

Data	
Level of Significance	0.05
Number of Rows	5
Number of Columns	5
Degrees of Freedom	16

Results	
Critical Value	26.296228
Chi-Square Test Statistic	16.616684
p-Value	0.4108103

5. Conclusions and Future Research

In this paper have decided to investigate the possible relations between the most popular cryptocurrency Bitcoin price dynamics and global S&P 500 index dynamics using statistical methods. We used Qualitative investigations. Qualitative methods tell us that the rates of change of these two variables are independent.

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