TIME-SERIES FORECASTING OF BITCOIN PRICES

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Abstract

Since 2008, when the cryptocurrency was first introduced under the name Satoshi Nakamoto, more and more people are interested in the «new money» – Bitcoin. Bitcoin is the first cryptocurrency and although many other cryptocurrencies were created and will be created in the future, Bitcoin remains the most popular cryptocurrency to this day. Naturally, along with the rapid growth of information technologies and their applications, many new «computerized» currencies will emerge. Because anyone can buy and sell cryptocurrency (e.g. bitcoin) and, thus, cryptocurrency is a subject of trade, hence cryptocurrency and in particular bitcoin is a product. Naturally, questions arise about the determinants of cryptocurrency price changes. In particular: Are the changes in the prices of cryptocurrency (and in particular Bitcoin) related to the development trends of the global economy? Are changes in the prices of cryptocurrency (and in particular Bitcoin) related to indicators of the state of the global economy, such as the well-known indices DJII, Nasdaq, S&P 500 and others. Thus it is interesting to see whether it is possible to predict changes in the prices of cryptocurrencies (and in particular Bitcoin) using different methods of time series.

Keywords: *Time Series, Forecasting, Bitcoin prices*

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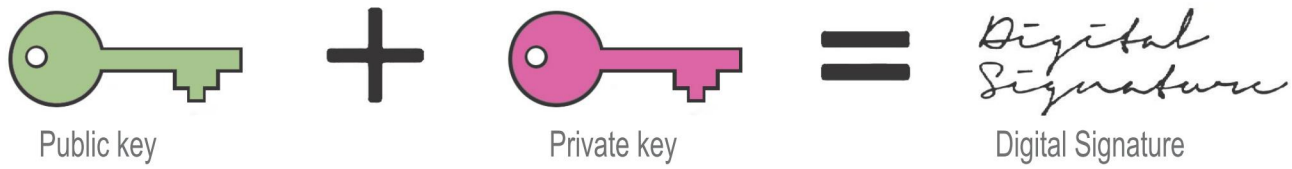
Introduction

Starting from 2008 Cryptocurrency becomes too popular. The first cryptocurrency was created in 2008 by an unknown person, or gang, known as Satoshi Nakamoto (Marr, 2016). 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, 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. 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.

Figure 1

Key Exchange Scheme



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.

So far no one traded in real economy using Bitcoins. That is why it was impossible for anyone to 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. (Chaim, 2019).

The works on cryptocurrency mainly describe the process of creating a cryptocurrency. The novelty in this regard is that a blockchain system is used to carry out virtual currency transactions. The novelty was not the system itself, since today the blockchain system is used successfully for various private and public activities. The novelty was to combine the technologies and sort the chains used by this system. It should be noted, this system has opponents in turn, mainly commercial banks. Because cryptocurrency transactions are carried out without intermediaries, banks, which leads to the loss of quite a large amount of revenue for financial institutions. The literature also discusses the dangers of cryptocurrencies, which are related to many different

factors (e.g. key transfer security) (A Gagnidze, 2016). It is expected that these threats will increase significantly after the actual proliferation of quantum computers. (A. Gagnidze, 2017)

It should be noted that in the papers devoted to the cryptocurrency and blockchain system, none of the authors explicitly expresses a positive or negative attitude towards cryptocurrency. Intensive research and experiments are underway on this issue, as there is a risk that cryptocurrency users may suffer large losses due to volatile and volatile prices that respond to small changes and ongoing processes in the states.

Studies show that cryptocurrencies are volatile currencies that are not part of the economy and are built solely on the demand-supply principle. Its price is affected by even a small event, which to some extent creates the circumstance that prices are artificially rising and falling, in which representatives of the illegal business participate and create a very attractive environment for doing illegal business.

Research Question

It is interesting to answer the following question using Time-Series methods: Is it possible to somehow predict the changes in Bitcoin prices?

Data Collection

Data was collected from official site: https://en.bitcoinwiki.org/wiki/Bitcoin_history from December 1, 2019 to February 6, 2020. The data is presented in the table and chart below:

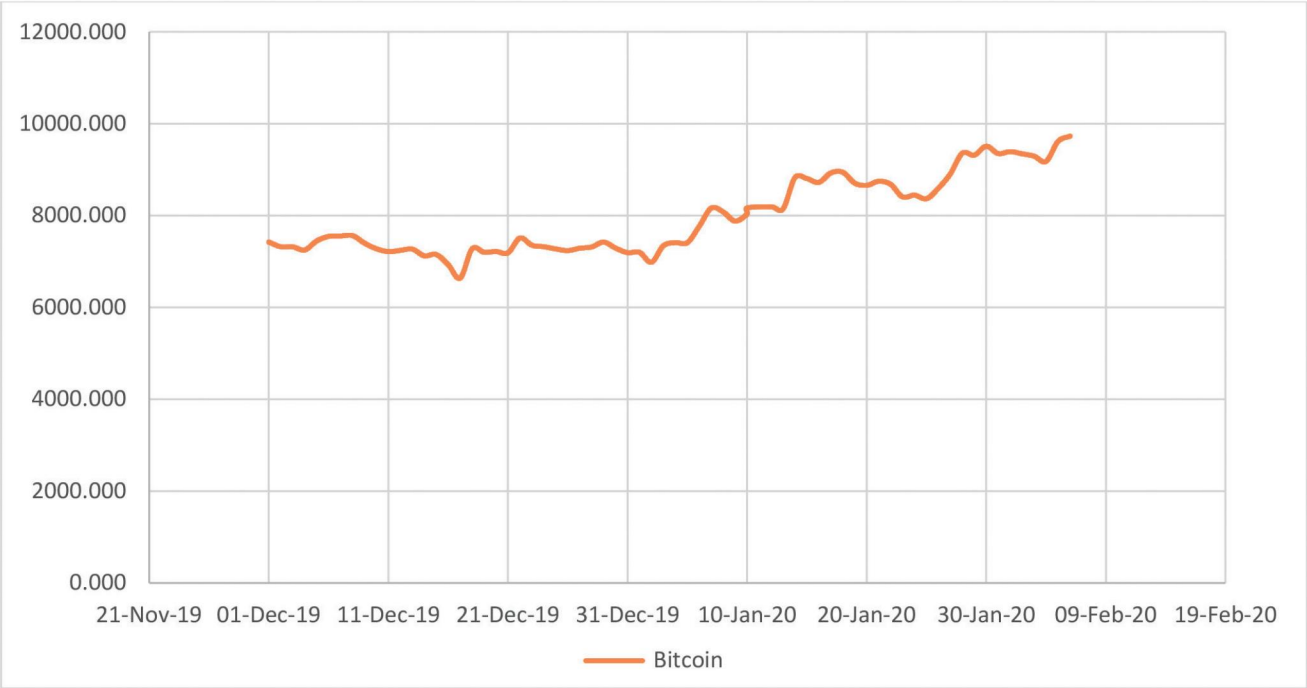
Table 1

Bitcoin Prices in 2019-2020

Date	Bitcoin Close	Date	Bitcoin Close	Date	Bitcoin Close
1-Dec-19	7424.292	24-Dec-19	7322.532	16-Jan-20	8723.786
2-Dec-19	7321.988	25-Dec-19	7275.156	17-Jan-20	8929.038
3-Dec-19	7320.146	26-Dec-19	7238.967	18-Jan-20	8942.809
4-Dec-19	7252.035	**27-Dec-19**	7290.088	**19-Jan-20**	8706.245
5-Dec-19	7448.308	**28-Dec-19**	7317.99	**20-Jan-20**	8657.643
6-Dec-19	7546.997	**29-Dec-19**	7422.653	**21-Jan-20**	8745.895
7-Dec-19	7556.238	**30-Dec-19**	7292.995	**22-Jan-20**	8680.876
8-Dec-19	7564.345	**31-Dec-19**	7193.599	**23-Jan-20**	8406.516
9-Dec-19	7400.899	**1-Jan-20**	7200.174	**24-Jan-20**	8445.435
10-Dec-19	7278.12	**2-Jan-20**	6985.47	**25-Jan-20**	8367.848
11-Dec-19	7217.427	**3-Jan-20**	7344.884	**26-Jan-20**	8596.83
12-Dec-19	7243.134	**4-Jan-20**	7410.657	**27-Jan-20**	8909.819
13-Dec-19	7269.685	**5-Jan-20**	7411.317	**28-Jan-20**	9358.59
14-Dec-19	7124.674	**6-Jan-20**	7769.219	**29-Jan-20**	9316.63
15-Dec-19	7152.302	**7-Jan-20**	8163.692	**30-Jan-20**	9508.993
16-Dec-19	6932.48	**8-Jan-20**	8079.863	**31-Jan-20**	9350.529
17-Dec-19	6640.515	**9-Jan-20**	7879.071	**1-Feb-20**	9392.875
18-Dec-19	7276.803	**10-Jan-20**	8037.538	**2-Feb-20**	9344.365
19-Dec-19	7202.844	**10-Jan-20**	8166.554	**3-Feb-20**	9293.521
20-Dec-19	7218.816	**12-Jan-20**	8192.494	**4-Feb-20**	9180.963
21-Dec-19	7191.159	**13-Jan-20**	8144.194	**5-Feb-20**	9613.424
22-Dec-19	7511.589	**14-Jan-20**	8827.765	**6-Feb-20**	9729.802
23-Dec-19	7355.628	**15-Jan-20**	8807.011		

Figure 2

Bitcoin Prices Dynamics Chart



In order to investigate the future Bitcoin Prices the historical data for December 2019 and January 2020 was used, and data for February 2020 left the data for comparison of the Predicted Prices and the Actual Prices.

The basic steps for forecasting are as follows: (Render, 2012).

1. Select the items or quantities that are to be forecasted.
2. Determine the time horizon of the forecast – is it 1 to 30 days (short term), 1 month to 1 year (medium term), or more than 1 year (long term)?
3. Select the forecasting model or models.
4. Gather the data or information needed to make the forecast.
5. Make the forecast.
6. Interpret the results.

Time-series models attempt to predict the future by using historical data. These models make the assumption that what happens in the future is a function of what has happened in the past. In other words, time-series models look at what has happened over a period of time and use a series of past data to make a forecast. Thus, if we are forecasting the Bitcoin Prices, we use the past Prices in making the forecast. The time-series models that are commonly used are **moving average and exponential smoothing**.

When making forecasts it is very important to know in what context the prediction is accurate. Three common measures of forecasting error are MAD, MSE, and MAPE. We will focus on these three measures that are calculated as follows:

- Mean absolute deviation (MAD) is computed by taking the sum of the absolute values of the individual forecast errors and dividing by the numbers of errors (n):

$$\text{MAD} = \frac{\Sigma|\text{forecast error}|}{n}$$

- Mean squared error (MSE), is the average of the squared errors:

$$\text{MSE} = \frac{\Sigma\,(\text{error})^2}{n}$$

- Mean absolute percent error (MAPE) is the average of the absolute values of the errors expressed as percentages of the actual values. This is computed as follows:

$$\text{MAPE} = \frac{\Sigma \left| \frac{\text{error}}{\text{actual}} \right|}{n} = 100\%$$

All these measures are important and useful and we can consider all three, but mainly we will focus on MAPE.

Moving Averages

Moving averages method used when the variable is relatively steady over time: The next forecast is the average of the most recent n data values from the time series. (Render, 2012) Mathematically the formula for prediction is:

$$F_{t+1} = \frac{Y_t + Y_{t-1} + \ldots + Y_{t-n+1}}{n}$$

where:

F_{t+1} = forecast for time period $t + 1$

Y_t = actual value in time period t

n = number of periods to average (usually 3 or 4).

It is evident, that in this case calculations not seem to complicated, so Excel was used.

Using moving averages method the results are given below:

Date	Price
28-Jan-20	9358.59
29-Jan-20	9316.63
30-Jan-20	9508.993
31-Jan-20	9350.529

Using moving averages method (3 period) the results are given below:

Date	Price Predicted	Actual Price	% Difference
1-Feb-20	9392.051	9392.875	0.009
2-Feb-20	9414.403	9344.365	0.750
3-Feb-20	9374.725	9293.521	0.874
4-Feb-20	9393.979	9180.963	2.320
5-Feb-20	9393.789	9613.424	2.285
6-Feb-20	9394.224	9729.802	3.449

Mean absolute percentage difference MAPE = 1.614.

Using moving averages method (4 period) the results are given below:

Date	Price Predicted	Actual Price	% Difference
1-Feb-20	9383.686	9392.875	0.098
2-Feb-20	9389.959	9344.365	0.488
3-Feb-20	9408.292	9293.521	1.235
4-Feb-20	9383.116	9180.963	2.202
5-Feb-20	9391.263	9613.424	2.311
6-Feb-20	9393.158	9729.802	3.460

Mean absolute percentage difference MAPE = 1.632

Exponential Smoothing

Exponential Smoothing (or correction) method is very useful. The main idea is to calculate the next forecast using formula:

New forecast = Last period's forecast + α(Last period's actual value – Last period's forecast)

where α is a weight (or smoothing constant) with a value $0 \leq \alpha \leq 1$.

The idea is simple – the new estimate is the old estimate plus some fraction of the error in the last period. (Render, 2012). Mathematically the formula for prediction is:

$$F_{t+1} = F_t + \alpha(Y_t - F_t)$$

Where:

F_{t+1} = new forecast (for time period t + 1)

Y_t = pervious forecast (for time period t)

α = smoothing constant ($0 \leq \alpha \leq 1$)

Y_t = pervious period's actual value

One of the important questions is: how to select α? I tried to use different values of α, and then choose value that gives the least MAPE. All calculations results are given below:

Table 2

Forecasting Results for Different Adjusting Coefficients

	Date	Price Predicted	Actual Price	% Difference	MAPE
α = 0	1-Feb-20	9508.993	9392.875	1.236	2.041
	2-Feb-20	9508.993	9344.365	1.762	
	3-Feb-20	9508.993	9293.521	2.319	
	4-Feb-20	9508.993	9180.963	3.573	
	5-Feb-20	9508.993	9613.424	1.086	
	6-Feb-20	9508.993	9729.802	2.269	
α = 0.1	**Date**	**Price Predicted**	**Actual Price**	**% Difference**	**MAPE**
	1-Feb-20	9493.147	9392.875	1.068	2.050
	2-Feb-20	9483.12	9344.365	1.485	
	3-Feb-20	9469.244	9293.521	1.891	
	4-Feb-20	9451.672	9180.963	2.949	
	5-Feb-20	9424.601	9613.424	1.964	
	6-Feb-20	9443.483	9729.802	2.943	
α = 0.2	**Date**	**Price Predicted**	**Actual Price**	**% Difference**	**MAPE**
	1-Feb-20	9477.3	9392.875	0.899	2.004
	2-Feb-20	9460.415	9344.365	1.242	
	3-Feb-20	9437.205	9293.521	1.546	
	4-Feb-20	9408.469	9180.963	2.478	
	5-Feb-20	9362.967	9613.424	2.605	
	6-Feb-20	9413.059	9729.802	3.255	
α = 0.4	**Date**	**Price Predicted**	**Actual Price**	**% Difference**	**MAPE**
	1-Feb-20	9445.608	9392.875	0.561	1.835
	2-Feb-20	9424.515	9344.365	0.858	
	3-Feb-20	9392.455	9293.521	1.065	
	4-Feb-20	9352.881	9180.963	1.873	
	5-Feb-20	9284.114	9613.424	3.426	
	6-Feb-20	9415.838	9729.802	3.227	

	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9429.761	9392.875	0.393	
	2-Feb-20	9411.318	9344.365	0.717	
$\alpha = 0.5$	3-Feb-20	9377.842	9293.521	0.907	1.736
	4-Feb-20	9335.682	9180.963	1.685	
	5-Feb-20	9258.322	9613.424	3.694	
	6-Feb-20	9435.873	9729.802	3.021	
	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9413.915	9392.875	0.224	
	2-Feb-20	9401.291	9344.365	0.609	
$\alpha = 0.6$	3-Feb-20	9367.136	9293.521	0.792	1.637
	4-Feb-20	9322.967	9180.963	1.547	
	5-Feb-20	9237.765	9613.424	3.908	
	6-Feb-20	9463.16	9729.802	2.740	
	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9382.222	9392.875	0.113	
	2-Feb-20	9390.744	9344.365	0.496	
$\alpha = 0.8$	3-Feb-20	9353.641	9293.521	0.647	1.481
	4-Feb-20	9305.545	9180.963	1.357	
	5-Feb-20	9205.879	9613.424	4.239	
	6-Feb-20	9531.915	9729.802	2.034	
	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9366.376	9392.875	0.282	
	2-Feb-20	9390.225	9344.365	0.491	
$\alpha = 0.9$	3-Feb-20	9348.951	9293.521	0.596	1.443
	4-Feb-20	9299.064	9180.963	1.286	
	5-Feb-20	9192.773	9613.424	4.376	
	6-Feb-20	9571.359	9729.802	1.628	
	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9358.452	9392.875	0.366	
	2-Feb-20	9391.154	9344.365	0.501	
$\alpha = 0.95$	3-Feb-20	9346.705	9293.521	0.572	1.425
	4-Feb-20	9296.181	9180.963	1.255	
	5-Feb-20	9186.724	9613.424	4.439	
	6-Feb-20	9592.089	9729.802	1.415	
	Date	Price Predicted	Actual Price	% Difference	MAPE
	1-Feb-20	9350.529	9392.875	0.451	
	2-Feb-20	9392.875	9344.365	0.519	
$\alpha = 1$	3-Feb-20	9344.365	9293.521	0.547	1.406
	4-Feb-20	9293.521	9180.963	1.226	
	5-Feb-20	9180.963	9613.424	4.499	
	6-Feb-20	9613.424	9729.802	1.196	

Conclusion

Results are interesting: they tell us that the best forecasting is so called "Naïve" forecasting, when the next forecasted value simple is equal to the previous period actual value. That means: there is no really effective Time-Series model method for prediction of Bitcoin Price changes.

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