

Forecasting Bitcoin Using Double Exponential Smoothing Method Based on Mean Absolute Percentage Error

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Abstract— After being introduced in 2008, the rise in the price of bitcoin and the popularity of other cryptocurrencies triggered a growing discussion about how much energy was consumed during the production of this currency. Making cryptocurrency the most expensive and most popular, both the business world and the research community have begun to study the development of bitcoin. In this study bitcoin price predictions are performed using the double exponential smoothing method based on the mean absolute percentage error (MAPE). The MAPE value is used to find the best alpha (α) parameter as the basis for bitcoin price forecasting. The dataset used is the price of bitcoin from 2017 to 2019. The dataset was obtained from www.cryptocompare.com. As for the value of the alpha parameter (α), using a value of 0.1 to 0.9. Based on the test results using the double exponential smoothing method obtained the smallest MAPE value of 2.89%, with the best alpha (α) at 0.9. The prediction is done to see the price of bitcoin on January 1, 2020. The error rate generated on the predicted price of bitcoin uses an amount of 0.0373%. This shows that the system built can be used as a support for decision making when trading bitcoin.

Keywords— Bitcoin, Cryptocurrency, Double Exponential Smoothing, Mean Absolute Percentage Error.

I. INTRODUCTION

Investment is an understanding related to economics and finance. This understanding relates to a form of capital assets in the hope of future profits. Sometimes, investment is also called as capital investment. Examples of investments include land investment, education investment, stock investment, foreign currency investment or forex trading and new investments appear, namely digital currency investment [1]. Bitcoin is a digital currency that is currently in great demand as an alternative investment. Bitcoin is a virtual currency that began operating on January 3, 2009, by Satoshi Nakamoto [2]. In Indonesia, the bitcoin currency is being sought after by many people as an alternative investment. Fluctuating bitcoin prices make a good means to look for profit. Investors benefit from bitcoin by buying it using the rupiah currency when the price of bitcoin is down, and selling it back to the rupiah when the price is rising. To help the process of buying and selling bitcoin, one of them uses price forecasting using technology. One method that can be used for forecasting data is the exponential smoothing method.

Exponential smoothing is the development of moving averages, which are often used to solve time series data problems [3]. Forecasting in exponential smoothing is done

by repeating calculations continuously using the latest data, where newer values are given a relatively greater weight than older observations. In the moving average case study, the weight imposed on the observational values is a by-product of the system taken. But in exponential smoothing, there are one or more smoothing parameters that are clearly defined and the results of this choice determine the weight imposed on the observed value. Exponential smoothing has three types, namely single, double, triple. In previous studies it was known that the double exponential smoothing method had a smaller error value than the single or triple exponential smoothing [4]–[6]. In double exponential smoothing there are two types of settlement, Brown and Holt. In previous studies regarding the comparison of the brown and holt methods, the results of the completion of the brown method gave a smaller forecasting error value than the completion of the holt for all the criteria tested [7], [8]. The last conclusion of exponential smoothing method from brown shows better results compared to the method from Holt.

Research on forecasting bitcoin prices was conducted by Salwa by using the autoregressive integrated moving average method. In this study bitcoin forecasting was obtained for the next 30 days, starting from March 11, 2018 to April 9, 2018, has decreased slowly [9]. Jaen in 2018 also did bitcoin forecasting using double exponential smoothing.

In this study forecasting the rise and fall of the price of bitcoin with the alpha parameter is set at 0.4035 and produces an accuracy rate of 70% [10]. Teguh uses double exponential smoothing to forecast Antam's gold price which was built using PHP programming and MySQL databases. This study resulted in an accuracy of 87.34% [11].

In this research, a double exponential smoothing method from Brown is applied to predict the movement of digital currency bitcoin with open data. The data will be calculated using the double exponential smoothing method then proceed to find the best alpha value based on Mean Absolute Error Error (MAPE). The MAPE value itself is determined by using the Error Error (PE) and Absolute Percentage Error (APE). The bitcoin price forecasting results are chosen based on the smallest MAPE value. From the bitcoin price forecasting information can be used as a basis for making decisions on bitcoin transactions the next day.

II. THE MATERIAL AND METHOD

This research designed a system that can predict bitcoin price movements one day in the future. This forecasting is useful for traders to support decision making in bitcoin trading transactions to minimize the chance of loss and maximize profits. Data is taken from the website www.cryptocompare.com. The data has two features, namely date and open with a daily time period of 3 years.

A. Bitcoin

Bitcoin (BTC) is a digital currency that is not issued by institutions, organizations or governments in its regulations. Bitcoin utilizes peer to peer networks as a distribution medium by using sophisticated cryptographic protocols [2]. It was first made in 2008 by Satoshi Nakamoto, then began operating in 2009 [2], [12]. Bitcoin was created by going through a process called mining, miners using sophisticated computers to decipher complex mathematics to find new blocks of bitcoin. Computational processes are carried out in a decentralized manner, where transactions are verified and added to a public database known as a blockchain [12]. Bitcoin trading has the advantage and risk of loss, we could lose millions of capital when trading if we take advantage of opportunities or miscalculate when determining prices in bitcoin trading. Bitcoin is not controlled by anyone so it allows everyone to take part in it and even develop bitcoin. Transactions using bitcoin are irreversible (also non-refundable) and also anonymous (without identity) [13]. Figure 1 there is a transaction chain block that is used to store information in the form of bitcoin owner information.

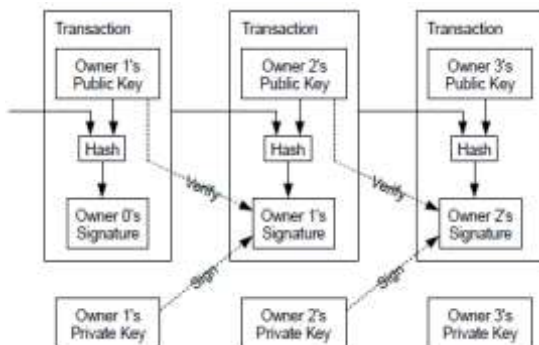


Fig. 1 Bitcoin transactions blocks

Bitcoin Mining is the process of adding transaction records to previous bitcoin transaction log journals [14]. Note the previous bitcoin transactions are known as blockchains. Mining is one way to get bitcoin through a search process on a new block that must be done by a miner. The search time for a block varies, depending on how fast the hardware is, calculated in units of Mhash / s. The growing trend in the number of bitcoins that have been successfully explored as shown in Figure 2.

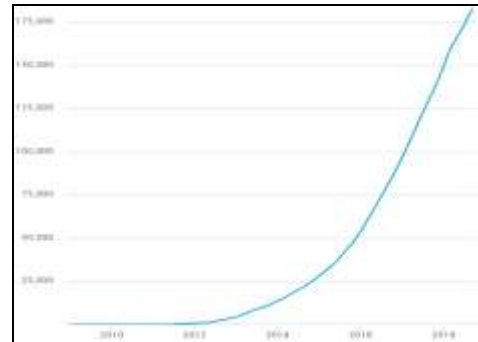


Fig. 2 The amount of bitcoin in circulation (www.cryptocompare.com)

One other way to get a bitcoin is to buy bitcoin through the online buying and selling market. One of the online trading services that provide bitcoin is Mt. Gox Bitcoin which is quite old and reliable [15]. The value of a bitcoin has a selling price that varies greatly depending on current market conditions. Bitcoin selling points as shown in Figure 3

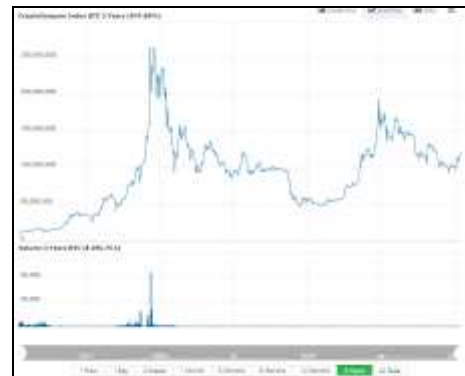


Fig. 3 Bitcoin selling points (www.cryptocompare.com)

A. Exponential smoothing

Exponential smoothing is a method of forecasting moving averages that weighs historical data in an exponential way so that the most recent data has greater weight or scales in moving averages [3]. The exponential smoothing method is a procedure of continuous improvement in forecasting the latest observed objects. In exponential smoothing, there are one or more smoothing parameters that are explicitly determined, and this result determines the weight that is imposed on its prediction value. In other words, the latest forecast value will be given a higher priority than the older forecast. The exponential smoothing method is further divided into several methods, namely single, double, and triple [3], [4], [6].

B. Double Exponential Smoothing

This method was developed by Brown's to overcome the differences that arise between the actual data and forecast values if there are trend data in the polt [4], [7]. The

rationale for Brown's exponential smoothing is similar to moving averages. This method is used when data shows a trend. Exponential smoothing in the presence of trends such as simple smoothing except that the two components must be updated every period - their levels and trends. The level is an estimate that is derived from the data value at the end of each period. The trend is a smoothed estimate of the average growth at the end of each period [16].

Brown's Double Exponential Smoothing Formula is [3].

- Determine the first smoothing value.

$$S'_t = \alpha X_t + (1 - \alpha)S'_{t-1}$$
 (1)
 - Determine the second smoothing value

$$S''_t = \alpha S'_t + (1 - \alpha)S''_{t-1}$$
 (2)
 - Determine the value of constants.

$$a_t = 2S'_t - S''_t$$
 (3)
 - Determine the slope value.

$$b_t = \frac{\alpha}{1-\alpha}(S'_t - S''_t)$$
 (4)
 - Determining forecasting value

$$F_{t+m} = a_t + b_t m$$
 (5)
- S'_t is a single starting value, S''_t is a double smoothing value, X_t is the actual data value, α is a smoothing constant between 0 and 1, F_{t+m} is the result of forecasting the next period, m is a number of predicted advance periods.

C. Mean Absolute Percentage Error (MAPE)

In forecasting, everything contains a degree of uncertainty. There is always a difference between the forecast value and the actual value, the difference value is called the error value. Even though the error value cannot be avoided, the purpose of forecasting is to minimize the error rate. There are several ways to determine the size of the error in the time series data model, the Mean Absolute Percentage Error (MAPE), can be formulated as follows [17].

$$MAPE = \frac{1}{n} \sum_{t=1}^n |PE_t|$$
 (6)

With details, n is a lot of data and t is a period. While the value of PE_t is produced from the following equation.

$$PE_t = \left(\frac{X_t - F_t}{X_t} \right) \times 100\%$$
 (7)

This MAPE is often used to calculate the average level of absolute error.

III. RESULTS AND DISCUSSION

This research is a reference dataset used from 2017 to 2019. As for the alpha (α) parameter value, it uses 0.1 to 0.9. The process of forecasting bitcoin prices using the double exponential smoothing method is carried out for each subsequent day. Examples of bitcoin data that are used as shown in Figure 4.

No	Date	Open
1065	12/15/19	98535000
1066	12/16/19	100001000
1067	12/17/19	97004000
1068	12/18/19	83480000
1069	12/19/19	88697000
1070	12/20/19	100509000
1071	12/21/19	130007000
1072	12/22/19	100679000
1073	12/23/19	105074000
1074	12/24/19	103048000
1075	12/25/19	102205000
1076	12/26/19	104587000
1077	12/27/19	101396000
1078	12/28/19	101530000
1079	12/29/19	102810000
1080	12/30/19	102902000
1081	12/31/19	101500000

Fig. 4 Dataset

The testing process was carried out with a total of 1081 data bitcoin datasets. In the dataset, there are 2 features, namely date and open. In testing, this system the parameters tested are the opening price (open) of the digital currency bitcoin. The results of the forecasting system that were built and the graphs on the test as shown in Figure 5 and Figure 6.

Tanggal	I	S'	Nilai	Nilai	Rumus	PE	APE
12/15/2019	105750000	107011200	112771900	102520000	-00000000	101700000	3.19
09-12-2019	105504000	107405900	112180540	102812500	-53290700	101934300	3.38
10-12-2019	103790000	107045270	111883840	102488600	-51540700	102019800	3.66
11-12-2019	102780000	106500240	111172870	101888910	-51036870	101801100	0.48
12-12-2019	101590000	106002110	110664420	101488910	-50914520	101478540	0.12
13-12-2019	101390000	105513800	110150300	101088250	-50506100	100000000	0.4
14-12-2019	101554000	105206820	109664310	100793340	-49006377	100503100	0.89
15-12-2019	10051000	104841040	109161800	100123700	-50232666	100562800	-0.73
16-12-2019	100093000	104177030	108653400	99899000	-49049400	998177700	0.38
17-12-2019	97804000	103459730	108143110	987793570	-52037530	991929850	-2.20
18-12-2019	95489000	102480560	107594800	973482950	-56825520	982556810	-5.12
19-12-2019	99997000	102714200	107038700	97289910	-53000530	987700100	3.22
20-12-2019	100890000	102043380	106590250	975475770	-49954000	986025200	3.63
21-12-2019	100827000	101910740	106077300	97762100	-46100600	970470700	3.73
22-12-2019	101890000	101796070	105548130	974220400	-42810300	970000400	3.38
23-12-2019	102574000	102123500	105206570	968504340	-35265400	975140410	7.19
24-12-2019	103048000	102215750	104806400	96430910	-30800200	969700700	4.32
25-12-2019	102295000	102220070	104711710	96729440	-27070140	961340300	3.66
26-12-2019	101587000	102157310	104482710	968538000	-28844010	964028400	2.1
27-12-2019	101390000	102081170	104218700	969435700	-37150820	96602000	1.77
28-12-2019	101530000	102026860	103898570	100854950	-27019600	967060800	1.8
29-12-2019	102010000	102109170	103810130	100480200	-10943970	968348610	2.88
30-12-2019	102892000	102184800	103647800	100722190	-10222740	100210770	2.62
31-12-2019	101590000	102116370	103494400	100738260	-5312530	100595830	0.93
01-01-2020						100589130	

Fig. 5 Bitcoin price forecasting results on the application

Testing by calculating the MAPE value of each alpha parameter. The test results for the MAPE value and bitcoin price forecasting are shown in Table 1.

TABLE I
MAPE TESTING RESULTS

Alpha (α)	MAPE	Bitcoin Price Forecasting January 1, 2020	Difference
0.1	2.93	100585139.2	120139.18
0.2	5.24	102285586.5	1820586.45
0.3	3.66	102231277.1	1766277.06
0.4	3.55	101997652.4	1532652.41
0.5	3.26	101774408.1	1309408.09
0.6	3.15	101505540.2	1040540.2
0.7	3.05	101170620.6	705620.59
0.8	2.95	100797392.7	332392.69
0.9	2.89	100427483.1	37516.91
0.1	2.93	100585139.2	120139.18

Based on the results of tests conducted obtained the smallest MAPE value is 2.89 at an alpha (α) value of 0.9. From the smallest MAPE value, the forecasting of bitcoin prices is obtained as in Table 2 below.

TABLE III
FORECASTING RESULTS OF BITCOIN PRICE WITH ALPHA 0.9

Date	Open	Bitcoin price forecasting
23-12-19	105074000	100662142
24-12-19	103046000	108580514
25-12-19	102265000	102169021
26-12-19	101587000	101409459
27-12-19	101396000	100874452
28-12-19	101538000	101102466
29-12-19	102810000	101598109
30-12-19	102902000	103843977
31-12-19	101500000	103194514
01-01-20	-	100427483



Fig. 6 The real value of the price of bitcoin on January 1, 2020 (www.cryptocompare.com)

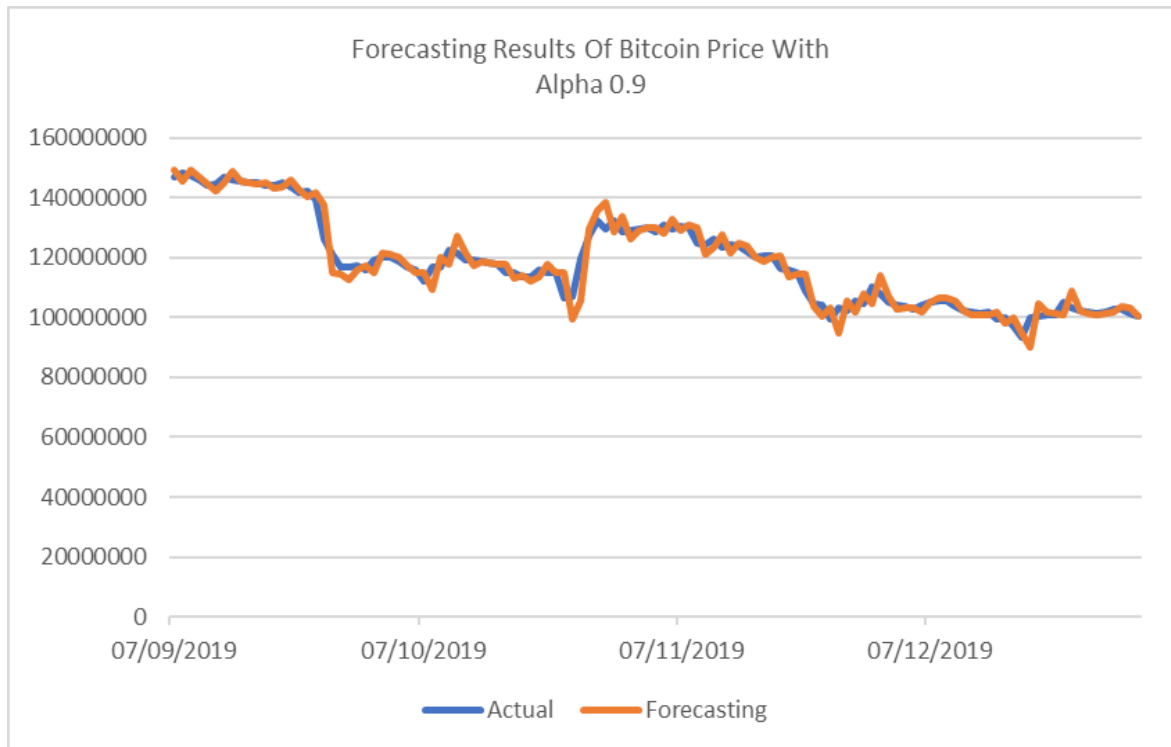


Fig. 7 Forecasting results of bitcoin price with alpha 0.9

Figure 8 shows the price of bitcoin is still volatile but tends to decline in price. Based on the test results of bitcoin price forecasting on January 1, 2020, amounting to 100427483, while the real value of bitcoin prices on January 1, 2020, amounting to 100465000, the difference between forecast results and real bitcoin price is 37516.91 or the resulting error rate is 0.0373% of the real result price bitcoin.

IV. CONCLUSIONS

Based on the results of tests conducted on bitcoin price forecasting using double exponential smoothing, the lowest mean absolute percentage error (MAPE) value is 2.89%, with the best alpha at 0.9. The error rate generated in bitcoin price forecasting uses a double exponential smoothing of 0.0373%. This shows that the system built can be used as a support for decision making when trading bitcoin. The test results also show that the price of bitcoin tends to decrease.

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