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Forecasting COVID-19 Cases in Indonesia using Hybrid Double Exponential Smoothing

Mujiati Dwi Kartikasari

Department of Statistics, Universitas Islam Indonesia, Jalan Kaliurang Km 14.5 Yogyakarta, Indonesia
mujiatikartikasari@uii.ac.id

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ABSTRACT

The COVID-19 epidemic has spread throughout countries around the world. In Indonesia, this case was detected in early March 2020, and recently, there is still an increase in positive cases of COVID-19. The objective of this paper is to predict COVID-19 cases in Indonesia employing a time series approach. The method administered was H-WEMA method because this method captures trend data patterns considering the conditions of COVID-19 cases in Indonesia. Based on the analysis results, H-WEMA was able to predict COVID-19 cases very well. The forecasted results of the COVID-19 cases in Indonesia still possess an upward trend, so it requires the cooperation of all community elements to reduce the spread of COVID-19.

1. Introduction .

Corona Virus Disease 2019 (COVID-19) is a disease caused by the infection of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [1]. The Covid-19 case first occurred in Wuhan, China, in December 2019 with a clinical presentation very similar to the pneumonia [2]. The transmission of the COVID-19 epidemic is tremendously rapid and impacting on death. Currently, 220 countries have been infected with the virus [3], including Indonesia. COVID-19 cases in Indonesia have been detected since March 2, 2020, which started with 2 positive cases remaining to this day with 4,100,138 cases as of September 1, 2021, with a total of 133,676 deaths and 3,776,891 cases recovered [4]. To diminish the spread of the COVID-19 epidemic, the Indonesian government has enacted several policies, encompassing policies associated with health protocols implementing 5M (wearing masks, washing hands, keeping distance, staying away from crowds, and reducing mobility), Large-Scale Social Restrictions (PSBB), Enforcement of Restrictions on Community Activities (PPKM), and acceleration of vaccination.

One of the efforts to corroborate government policies in scaling down the spread of the COVID-19 epidemic is prediction of COVID-19 cases in the future. It is designated to design the herd immunity formation so that the community is able to conduct normal activities. There have been many studies on the prediction of COVID-19 cases, one of which is through the time series method [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15]. It is a method accustomated to determine the pattern in the historical data series obtained in a time sequence and extrapolate that pattern to predict the value of a series in the future [16].

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In this study, we attempted to conduct the time series method in the form of hybrid double exponential smoothing for forecasting cases of COVID-19 in Indonesia. The hybrid double exponential smoothing methods to be administered here is the Holt's Weighted Exponential Moving Average (H-WEMA) [17] methods. H-WEMA is a method that incorporates Weighted Moving Average (WMA) method with Holt's Double Exponential Smoothing (H-DES) method [17]. The H-DES are variants of the exponential smoothing method extensively employed to predict a time series data that possesses a trend pattern [16], which is in accordance with the conditions of the COVID-19 cases in Indonesia.

2. Holt's Weighted Exponential SMoothing

H-WEMA is a hybrid method incorporating Weighted Moving Average (WMA) method with Holt's Double Exponential Smoothing (H-DES) method [17]. H-WEMA procedure is relatively the same as H-DES procedure except in determining the initial value. The initial value for the recursive calculation process in H-WEMA is regulated by calculating the base value, B_t, using the WMA formulation,

$$B_t=\frac{kX_t+(k-1)X_{t-1}+\cdots+X_{t-(k-1)}}{k+(k-1)+\cdots+1}, \quad (1)$$

in which k is the length of the forecasting period and X_t is the value of the time series data for period t.

H-WEMA requires two smoothing constants, α and β, employed as smoothing constant for the data and as smoothing constant for trend estimate, respectively. The α and β values are $0\leq\alpha\leq1$ and $0\leq\beta\leq1$. The mathematical formulation of H-WEMA is as follows [17]:

$$S_t=\alpha X_t+(1-\alpha)(S_{t-1}+T_{t-1}), \quad (2)$$

$$T_t=\beta(S_t-S_{t-1})+(1-\beta)T_{t-1}. \quad (3)$$

The recursive computations in Equation (2) and Equation (3) administered the initial value which depended on the base value in Equation (1), the initial value of $S_{t-1}=B_{t-1}$ and the initial value of $T_{t-1}=B_t-B_{t-1}$. The prediction value for m periods ahead is calculated by

$$\hat{X}_{t+m}=S_t+T_t(m). \quad (4)$$

3. Evaluating Forecast Performance

To evaluate the forecasting performance, we employ the error of the forecast value. Forecasting error can be applied for two things, which are making an option between several alternative forecasting methods and calculating the success or failure of the forecasting method implemented. In this paper, we utilized Mean Absolute Percentage Error (MAPE) to evaluate the performance of H-WEMA. The formulation of MAPE is as follows [18]:

$$MAPE=\frac{1}{n}\sum_{t=1}^{n}\left|\frac{X_t-\hat{X}_t}{X_t}\right|\times100\%. \quad (5)$$

4. Results

The analyzed data is a total of COVID-19 positive cases in Indonesia. The data was accessed through the website of https://kawalcovid19.id/ [19] for the period of March 2, 2020 to September 1, 2021. The data plot is presented in Fig. 1.

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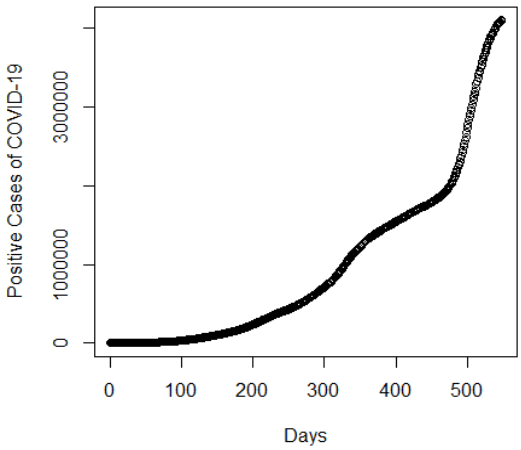

Fig. 1. Cumulative data of COVID-19 positive cases in Indonesia.

Based on Fig. 1, there is an increase in data from the beginning of the plot to the end. Thus, it can be identified that the data possesses a trend pattern. From the exploration illustrating that the data has a trend pattern, we determined to evaluate the data employing H-WEMA with the assistance of R software.

The first step in analyzing COVID-19 cases administering H-WEMA is to determine k as the length of the WMA forecast period. Then, the base value was calculated employing Equation (1) which was used as the initial value for recursive calculations in the H-WEMA procedure. We attempted different k values to identify the best H-WEMA method. Fig. 2 compares the forecasted results of Covid-19 cases using H-WEMA with various k values.

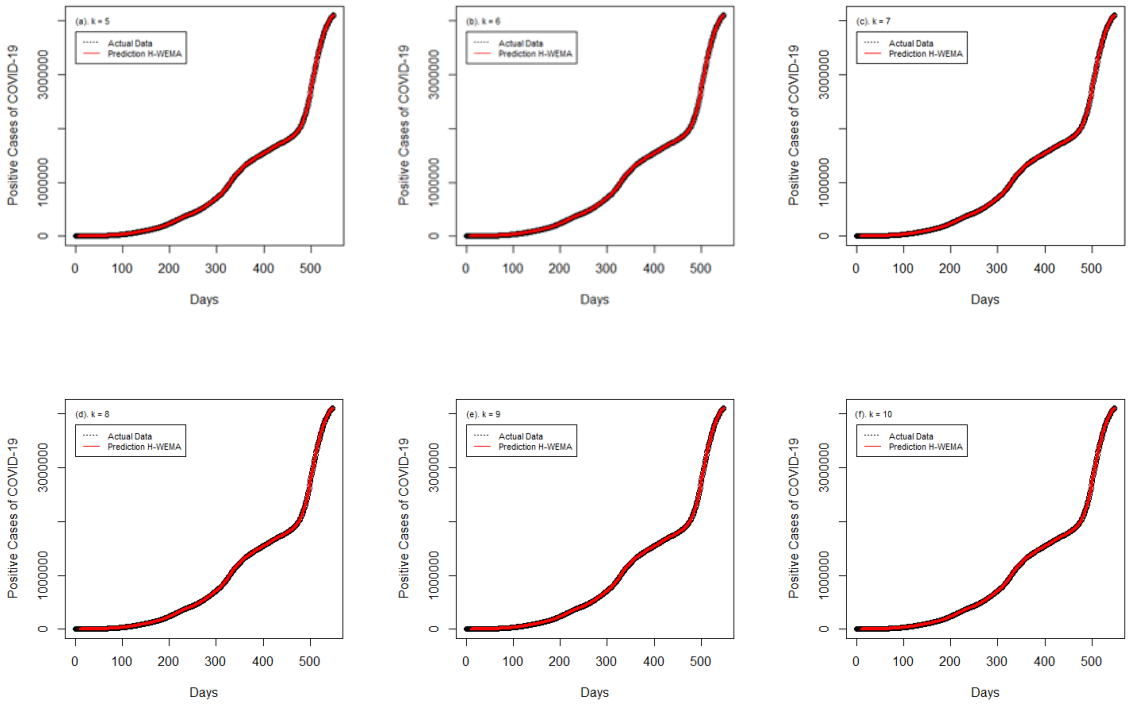

Fig. 2. Forecasted results of COVID-19 cases implementing H-WEMA with six different values for the length of the WMA forecast period: (a). k=5, (b). k=6, (c). k=7, (d). k=8, (e) k=9, and (f). k=10.

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Fig. 2 displays the forecasted and actual curves of COVID-19 cases in Indonesia. From the figure, all the forecasted curves with various k values are significantly close to the actual curve. To identify the best H-WEMA method, we implemented MAPE to evaluate the performance of the H-WEMA method. Table 1 demonstrates the comparison of the MAPE values of the H-WEMA method with various k values.

Table 1. Comparison of MAPE Values

k	**MAPE (%)**
5	0.6839076
6	0.6684196
7	0.6797317
8	0.5396671
9	0.5786570
10	0.5998171

From Table 1, we selected to implement H-WEMA with k=8 that have the smallest MAPE value. According to [20], the H-WEMA method with k = 8 possessing has MAPE value of 0.5396671% is included in highly accurate forecasting.

Based on the prediction results of COVID-19 cases in Indonesia implementing the H-WEMA method, it can be identified that positive cases of COVID-19 are still based on data pattern, in which the increase in the number of positive cases still adhere to an upward trend. Therefore, the decision of the government with the PPKM policy and the acceleration of vaccination is tremendously appropriate. The community must continue to comply with the 5M health protocols (wearing masks, wash hands, keeping distance, staying away from crowds, and reducing mobility) and immediately vaccinate.

5. Conclusion

The conclusion of this study is that H-WEMA is able to predict COVID-19 cases in Indonesia very well. It is indicated by the very small MAPE value generated from the forecasting results. Forecasting results still display an upward trend. The government and community should work together in reducing the spread of COVID-19. We are able to perform it by living a disciplined life according to health protocols, complying government regulations, and immediately vaccinating.

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