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FORECASTING THE CONSUMER PRICE INDEX IN YOGYAKARTA BY USING THE DOUBLE EXPONENTIAL SMOOTHING METHOD

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ABSTRACT

The Consumer Price Index (CPI) is an indicator that is often used to measure the inflation rate in an area, or can be interpreted as a comparison between the prices of a commodity package from a group of goods or services consumed by households over a certain period time. The spread of COVID-19 throughout the world affects the economy in Indonesia, especially Yogyakarta. Forecasting CPI data during the COVID-19 pandemic has the benefit of being an illustration of data collection in the CPI of D.I Yogyakarta Province in the predicted period. This is useful as a comparison with the original data at the time of data collection and publication, as well as a consideration in making policies and improving the economy. Researchers use the Double Exponential Smoothing (DES) method to predict the CPI of Yogyakarta D.I Province, which aims to determine the best forecasting model and forecasting results. This method is rarely used in research on CPI data forecasting in Yogyakarta. The data in this study are monthly data from March 2020 to August 2021. The highest CPI in Yogyakarta occurred in August 2021 at 107.21 or 107.2, while the lowest CPI in Yogyakarta occurred in April 2020 at 105.15 or 105.2. The average CPI in Yogyakarta per month is 106.1. The Mean Absolute Percentage Error (MAPE) value obtained from the DES method is 0.1308443%, so that the accuracy of the model is 99.869%. Forecasting with the DES method is quite well used in forecasting the CPI data of Yogyakarta in September 2020 - November 2021. The results of CPI forecasting in Yogyakarta using the DES method were 107.2602, 107.3104, and 107.3606 from September-November.

Keywords: *CPI, DES, Forecasting, MAPE, COVID-19*

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INTRODUCTION

The Consumer Price Index (CPI) is an indicator that is often used as a measure to determine the composition of inflation in a certain area, or other words. It can also be interpreted as a comparison between the prices of a product from a set of goods or services used by households in a certain time interval. The CPI is also defined as an indicator of the price of a set of consumer products, weighted according to the amount of spending by citizens for the commodities involved, including main food, clothing, housing, and various goods and services paid for by the buyers.

Badan Pusat Statistik (BPS) every month, calculates and reports the CPI value. This calculation is very important in everyday life, especially in the economic sector, because it is related to the cost of living used by each person for goods and services consumed, as well as to understand the results of inflation and deflation goods and services. Due to the large effect of the CPI on the inflation rate in the economic sector, this also has a very large effect on whether or not the economy is progressing in a region.

In this COVID-19 pandemic, the values of the expected price index decreased from before the pandemic to the time of the pandemic. According to (detikNews.com), the first positive case in Indonesia occurred on March 2, 2020, when two people were verified as positive for COVID-19 from a Japanese citizen.

During this pandemic, it was found that various sectors in Indonesia experienced a decline, including the economic sector. One of the cities that experienced an increase in the CPI was Yogyakarta. BPS Yogyakarta has recorded that CPI of Yogyakarta in January 2021 reached 106.67 points. The largest percentage of the CPI in Yogyakarta was the increase in the CPI for the beverage, food, and tobacco groups by 0.62% and the health group by 0.43%, the sports, culture, and recreation group by 0.15%, as well as the electricity, water group, housing, and fuel from households amounted to 0.15%. In addition, there was an increase in the footwear and clothing category by 0.05%, in household equipment, supplies, and routine maintenance by 0.01%, in communication, information, and financial services by 0.09, in the education group by 0.5, and 0.01 for food and beverage providers/restaurants.

Based on the explanation, the researcher is interested in analyzing the CPI forecasting for Yogyakarta using the DES method with data taken when COVID-19 first appeared in Indonesia, namely in March 2020. In this forecasting analysis, the method used is the DES method. The advantages of this method can be analyzed with relatively little data, use fewer parameters, and are easy to manage data (it does not require data transformation if the existing data is non-stationary, nor does it need to use autoregression analysis) when forecasting. And this method is more accurate if used in short-term forecasting because this method tends to be flat if for long-term forecasting. It is hoped that this method will produce forecasting data with a high level of accuracy, so that it can be used by the government or other parties to predict the CPI forecasting for the Province of Yogyakarta to anticipate the decline in the CPI in the future (Nofiyanto et al., 2015).

Similar research on CPI forecasting in Yogyakarta, there are only a few studies, and the last research is research (Danardono & Sarah, 2014) which uses Yogyakarta CPI data in 2014. Therefore, researchers conducted this study using the latest data, namely data in March 2020 – August 2021, which occurred when the COVID-19 pandemic occurred. The difference between this research and previous research is that apart from the data, the researcher also before doing the forecasting, divides the data into training data and testing data. The training data is used to build the model, while the test data is used to test the model that the researcher builds to see how accurate the model that the researcher builds. So that the model obtained is the best model for forecasting.

MATERIALS AND METHODS

1. Data Sources

The data used in this research is secondary data obtained from the publication of BPS 2021, with the research units being observed being districts/cities in Yogyakarta with the URL https://yogyakarta.bps.go.id/. The data starts from March 2020 to August 2021 with a monthly frequency.

2. Consumer Price Index

The variable used in this report is the Consumer Price Index. CPI is the comparison between Current Price and H multiplied by 100 against the Price in the Base Year with the following formula:

$$IHK = \frac{P_n}{P_0} x100 \quad (1)$$

$$IHK_{(n)} = \frac{\sum_{i=1}^{k} \frac{P_{ni}}{P_{(n-i)}} P_{(n-i)}\, Q_{0i}}{\sum_{i=1}^{k} P_{0i}\, Q_{0i}} \times 100 \quad (2)$$

where: P_n= Current Price; P_0= Price in Base Year; $IHK_{(n)}$= Commodity Type; k = Number of types of commodity package goods; P_{ni} = Price type of *I* goods, period *n*; $P_{(n-i)}$ = Price type of *i* goods, period (*n*-1); $P_{0i}Q_{0i}$= Value of consumption of types of *i* goods, in the base year; $P_{(n-i)}Q_{0i}$ = Value of consumption of the type of *i* goods, period (*n*-1).

3. Double Exponential Smoothing (DES) From Brown

According to (Makridakis et al., 2003), Brown's DES method is a linear model proposed by Brown. Brown's DES method is applied when the data prove the emergence of a trend, which is a smoothed estimate of the average growth at the end of each period. Through the comparison used when the time departs from a single moving average (Single Moving Average/SMA) to a single exponential smoothing (Single Exponential Smoothing/SES), it can also depart from a double moving average (Double Moving Average/DMA) towards Double Exponential Smoothing (DES). This is interesting because one of the limitations of SMA (the need to save the final value) is still contained in DMA. DES can be calculated with three data values and one value. It also gives a small amount in past research. Therefore, DES is more widely used than DMA as a forecasting analysis method. The main idea of Brown's DES is similar to that of DMA because the Single Smoothing and Double Smoothing values lag behind the actual data if there is an element of the trend. The dissimilarity between Single Smoothing and Double Smoothing values ($S_t' - S_t''$) is added to the single smoothing value (S_t') and must be right according to the trend. The formula used in the DES implementation of Brown:

1. Set the First Smoothing Value (S_t')
$$S_t' = \alpha X_t + (1 - \alpha) S_{t-1}' \quad (3)$$
2. Set the Second Smoothing Value (S_t'')
$$S_t'' = \alpha S_t' + (1 - \alpha) S_{t-1}'' \quad (4)$$
3. Setting Constant Value (a_t)
$$a_t = 2S_t' - S_t'' \quad (5)$$
4. Set the Slope Value (b_t)
$$b_t = \frac{\alpha}{1-\alpha}(S_t' - S_t'') \quad (6)$$
5. Set Forecasting Value
$$F_{t+m} = a_t + b_t m \quad (7)$$

with; S_t'= SES value *t* period ; α = Exponential smoothing parameter ($0 < \alpha < 1$); X_t = Actual data in the *t* period, S_{t-1}'= SES value of the period; S_t''= DES value *t* period ; S_{t-1}''= DES value *t* - 1 period ; a_t = *t* period constant value; b_t= Value trend *t* period ; *m* = Future period to be forecasted; F_{t+m}= Forecasting value for the next *m* period.

To apply the formula, the values $S_{t-1}'$and S_{t-1}''must exist. However, in *t* = 1, the value is not presented because the value must be determined at the beginning of the period. To solve the problem, you can determine $S_{t-1}'$and S_{t-1}'' equal to the X_1 value (original data).

4. Best Parameter Selection

In various forecasting analyses, accuracy is a rejection requirement when determining the forecasting method. The accuracy of forecasting analysis in the future is so important and can be seen from the errors of forecasting analysis. The inaccuracy of a forecast is an indicator of accuracy and becomes the main thing when comparing performance. In this case, the use of MAPE as the selection of the best method and to understand the value of the right forecast.

$$MAPE = \frac{1}{n}\sum_{t=1}^{M} |PE_t| \quad (8)$$

Where *n* is the number of periods and PE_t is the percentage error rate:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right) 100\% \quad (9)$$

with; *n* = amount of data observed; F_t= value of *t* forecasting; X_t = value in *t* period data.
A method can be said to be the best method if the resulting MAPE value is getting smaller, which means the estimated value is getting closer to the actual value (Makridakis et al., 2003).

5. Analysis Method

The data will be analyzed using R software. The steps in analyzing the CPI data in Yogyakarta are shown in Figure 1.

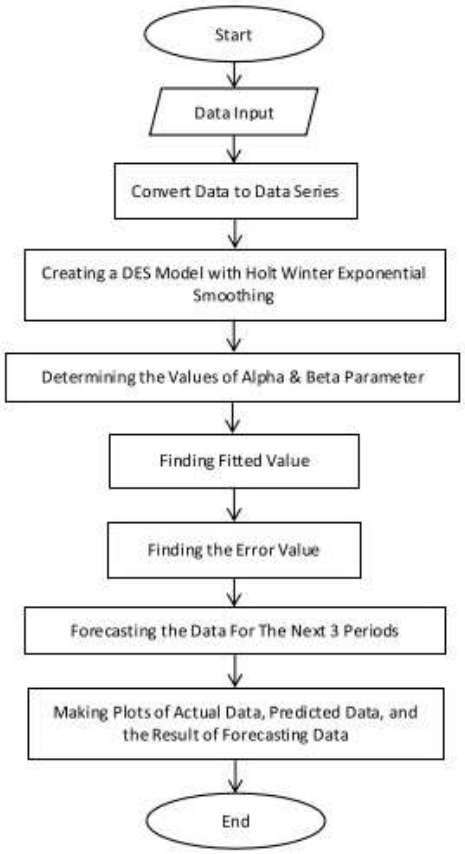

Figure 1. Flowchart of The Research

RESULTS AND DISCUSSION

1. Descriptive Analysis

The first step in data analysis is to explore the data. In this study, data exploration used descriptive analysis. This analysis was carried out to find out the characteristics or general description of the CPI data in Yogyakarta from March 2020 to August 2021. This was done by exploring the CPI data in Yogyakarta.

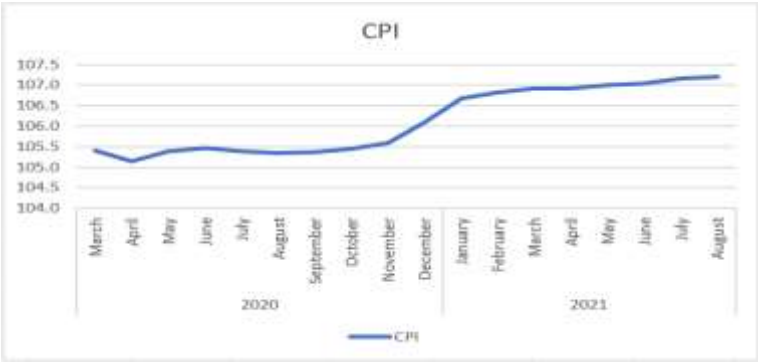

Figure 2. Overview of Actual Data

Based on Figure 2, it can be seen that the Yogyakarta CPI value tends to increase continuously every month, so it can be concluded that the Yogyakarta CPI value tends to have a trend pattern. In Figure 2, we can get a descriptive statistical result of CPI data in Yogyakarta from March 2020 to May 2021, shown in Table 1.

Table 1. Results of Data Exploration

Data Eksploration	Results (Percent)
Minimum	105.2
Maximum	107.2
Mean	106.1
Quartile 1	105.4
Median	105.8
Quartile 3	106.9

Based on Table 1, it is known that the highest CPI in Yogyakarta occurred in May 2021, which was 107.21 or 107.2. Based on (Yogyakarta, 2021), Yogyakarta facing inflation of 0.05% due to the increase in the consumer price index of the food, beverage, and tobacco category by 0.02%; household equipment, equipment and routine maintenance group which increased 0.07 percent; communication, information, and financial services which increased by 0.01%; recreation, sports and culture by 0.17%; the education group was 0.43%; food and beverage providers/restaurants in the amount of 0.08; and personal care and other services by 0.35%; The groups that experienced a decrease were the clothing and footwear group by 0.19%; health group of 0.23%; and transportation group as much as 0.08%. For the relatively stable, namely; electricity, housing, electricity, and household fuel groups. Meanwhile, the lowest CPI in Yogyakarta occurred in April 2020 at 105.15 or 105.2. Based on (Yogyakarta, Consumer Price Index Developments April 2020, 2020) facing deflation of 0.24% due to the decline in CPI for beverages, food, and tobacco by 0.70%; gas, residential electricity, water, and other fuels are amounting to 0.01%; equipment, supplies, and routine household maintenance by 0.03%; health by 0.12 percent; transportation amounted to 0.73%. Then the average CPI in Yogyakarta per month is 105.93 or 105.9. From the graph of the actual data, it can also be seen that the CPI in Yogyakarta has an upward trend, so the next analysis uses the DES analysis.

6. Double Exponential Smoothing (DES)

Before forecasting, the data must be divided into training data and testing data. The data train is used to build the model, while the test data is used to test the model researcher build to see how accurate the model researcher build is. The distribution of training and testing data is up to the researcher. However, the percentage between training and testing data should not be the same, because it will damage the model training process. Always make sure the size of the training must be much larger than the test data. If the training data is too small, we can't evaluate the performance of the model.

The total number of data is 15. Then the researcher divides it into 12 training data and 3 testing data to determine the best mode. If converted into percentage form, it is 83% of training data and 17% of testing data. By using testing data and actual data, the MAPE values are obtained as follows.

Table 2. Comparison of MAPE Value

Data	MAPE
Testing	0.0009328402
Actual	0.06529242

Based on Table 1, the MAPE of testing data is 0.0009328402 and the MAPE of actual data is 0.06529242. From the MAPE value, it can be determined that the error value of the testing data is much smaller than the actual data. Table 2 below is the result of training data analysis with Holt-Winters.

Table 3. Holt-Winters Data Training

Results		
Smoothing parameters	alpha	1
	beta	0.9969327
	gamma	FALSE
Coefficients	a	106.990000
	b	0.06981671

Based on Table 2, it is found that the MAPE value in the testing data is smaller than the MAPE value in the actual data. In other words, the model can already be used for forecasting. Figure 3. obtained the optimal alpha and beta values of $\alpha = 1$ and $\beta = 0.9969327$. By using these alpha and beta values, the next step is to forecast the CPI data. Holt-Winters analysis using alpha and beta modeling results.

Table 3. Best Holt-Winters Model

Results		
Smoothing parameters	alpha	1
	beta	0.9969327
	gamma	FALSE
Coefficients	a	107.210000
	b	0.05021405

Based on Table 3, it is known that the coefficient values are 107.21 and 0.05021405 with values that have been obtained alpha (smoothing average) $\alpha = 1$ and beta (smoothing trend) $\beta = 0.9969327$. Meanwhile, the gamma smoothing parameter used is FALSE, which means that the gamma parameter value is not in optimum condition.

Furthermore, the measurement of the error value is carried out so that the error value is obtained, namely MAPE.

Table 4. Measurement of Error Value

MAPE
0.1308443

Based on Table 4, it is known that the error size value for the average absolute error percentage (MAPE) is 0.1308443, which means that the accuracy of the model is 99.869%.

From the value of the smoothing parameter and the level of accuracy of the model above, the predicted values of the CPI in Yogyakarta will then be obtained. Predictive value is a structured process of estimating something that has the greatest probability of happening in the future based on past and current information so that the error (difference between something that is currently happening with the estimate) can be reduced in number. Furthermore, forecasting will be carried out for the next three periods.

Table 5. DES Prediction

Year	September	October	November
2021	107.2602	107.3104	107.3606

Based on Table 5, it is known that the forecasting values for the next three periods are September to November, with the predicted values of 107.2602 in September, 107.3104 in October, and 107.3606 in November.

Table 6. The Result of Data Forecasting in 2021

Month	Forcasting
September 2021	107.2602
October 2021	107.3104
November 2021	107.3606

Based on Table 6, regarding the results of data forecasting in 2021, it can be seen that the prediction results show a higher value for each period.

The following is a comparison chart between actual data (blue), fitted values (red), and forecast (green).

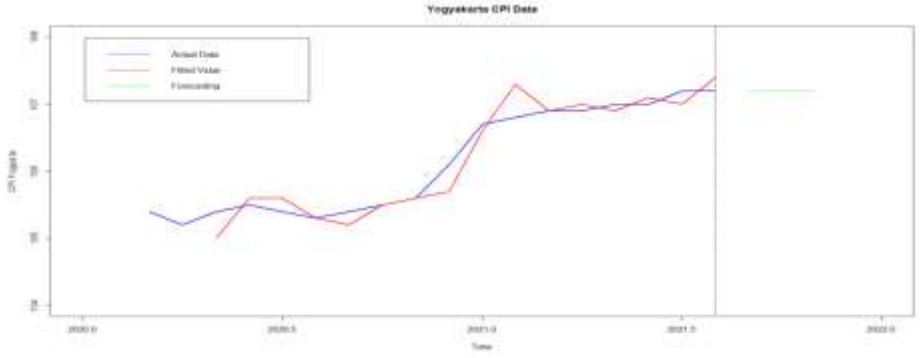

Figure 3. Comparative Graph of DES Analysis

Based on Figure 3, it is known that the predictive data graph symbolized by the red line resembles the actual data graph symbolized by the blue line. Then on the green line is the forecast line for the next 3 periods, on the green line the forecast tends to rise from the actual data. From the forecasting results that have been obtained, it is known that the Yogyakarta CPI for the next 3 months, namely from September, October and November 2021, is increasing every month. This can also be seen in Figure 3. which shows the tendency of the data pattern on the forecasting line to increase for the 3 months forecasted, namely September 2021 by 107.2602, October by 107.3104, and November 2021 by 107.3606.

CONCLUSION

The conclusion of this paper are:

1. The Mean Absolute Percentage Error (MAPE) value obtained from the DES method is 0.1308443%, so that the accuracy of the model is 99.869%. By using the alpha value (smoothing average) $\alpha = 1$ and the beta value (trend smoothing) $\beta = 0.9969327$, we get the best DES model used in forecasting the CPI data for D.I. Yogyakarta Province in September 2020 - November 2021.
2. The results of CPI forecasting in Yogyakarta using the DES method were 107.2602, 107.3104, and 107.3606 form September-November.

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