

## APPLICATION OF THE DOUBLE EXPONENTIAL SMOOTHING BROWN METHOD TO CONSUMER PRICE INDEX FORECASTING IN SORONG CITY BEFORE AND DURING THE COVID-19 PANDEMIC

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### ABSTRACT

The CPI is useful for knowing the increase in income, prices, can also be used as an economic indicator and a benchmark for the amount of production costs. The Consumer Price Index is often used to measure the level of increase or decrease (inflation/deflation) in the prices of goods and services that are the basic needs of the people of an area, as well as a consideration for salary adjustments, retirement wages and others. CPI forecasting in Sorong City is a solution to predict future economic conditions as seen from the increase or decrease in the CPI and choose the right countermeasure or strategy in dealing with the consequences of an increase (inflation) or decrease (deflation) in the CPI that will occur in the future. The Covid-19 Pandemic situation has greatly affected economic and social life, including the CPI in Sorong City. The purpose of this research is to obtain the right model in forecasting the CPI in Sorong City using the Double Exponential Smoothing Brown method, a forecasting method that uses one weighting parameter. The best model of forecasting before the Covid-19 pandemic using optimal weighting parameters with a MAPE value of 0.647%, namely: and the best model during the Covid-19 pandemic using optimal weighting parameters with a MAPE value of 0.633%. The forecasting model obtained, namely:  $F_{t+m} = 107,304 + 0,522(m)$

**Keywords:** Forecasting, Double Exponential Smoothing, Brownian Method, Pandemic, Consumer Price Index.

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### INTRODUCTION

The CPI is an economic indicator that calculates the average price change of a package of goods and services consumed by households within a certain period of time (Purba, 2023); (Murphy & Garvey, 2004). Changes in the CPI over time illustrate the level of increase (inflation) and decrease (deflation) in the prices of goods and services for daily household needs (2018b, n.d.). CPI and inflation are one of the indicators used for development planning in a region (Yolanda, 2017). These indicators can provide a picture of the economy in Sorong City as much as possible ([BPS] Pusat, n.d.). As the only city in West Papua Province, Sorong City has an important role in the economic development of West Papua Province and Eastern Indonesia (Handayani & Mahmud, 2020). The government of Sorong City requires a variety of accurate and relevant data that support development planning, policy making, monitoring and evaluation, so that planning is carried out more carefully (2018b, n.d.).

The average monthly CPI of Sorong City from 2015 to 2018 is (120.07; 125.38; 128.53 and 133.18) respectively, this provides an overview of the increase in CPI from year to year (Sari, 2023). The trend of increasing the average monthly CPI shows that there is a trend pattern in the data (CHANG & Soonhui, 2023). The increase in CPI from year to year also occurred in 2020 to July 2022, respectively (102.79; 105.94 and 108.70). The difference in values from 2015-2019 and 2020 to July 2022 is very far because in early January 2020 the Covid-19 pandemic occurred which affected people's purchasing power weakened and made commodity prices decline, resulting in a drastic decrease in CPI. Forecasting is an activity carried out to predict future events. This forecasting activity can be done by taking existing

historical data and projecting it into the future in the form of a mathematical model (Weron, 2014).

According to (Makridakis et al., 1999), the double exponential smoothing method consists of the Holt method and the Brown method. Holt's exponential smoothing method (Nyoni, S. P., & Nyoni, 2023); (Otiva, et al, 2024); (Gustriansyah et al., 2023); (Satyahadewi et al., 2023) can smooth trends using two different parameters for each smoothing constant and trend, while Brown's exponential smoothing method is preferred because it can smooth trends using only one parameter that is the same for each smoothing constant and trend. So, in this study the authors used Brown's exponential smoothing method.

Research related to Brown's double exponential smoothing method is Andini and Auristandi (2016), in forecasting the number of office stationery stocks at UD Achmad Jaya, getting a MAPE value of 12.36%, which means that the accuracy of the forecasting results obtained is good. In addition, (Syahdan & Aisyah, 2020), who predicted the Tarakan City CPI with a MAPE value of 0.67%, which means that the accuracy of the forecasting results obtained is very good.

Based on the description above, the authors conducted research on "Application of the Brown Double Exponential Smoothing Method to Consumer Price Index Forecasting in Sorong City Before and During the Covid-19 Pandemic".

## **METHOD**

This research was conducted for approximately 6 (six) months at the Laboratory of the Department of Mathematics and Statistics, Faculty of Mathematics and Natural Sciences (FMIPA), University of Papua (UNIPA) Manokwari, by implementing the Covid-19 health protocol. The data used in this study are secondary data, namely Consumer Price Index data using a monthly time period. The monthly data used is 79 months or six years and seven months from January 2015 to December 2018 and January 2020 to July 2022 obtained from the Central Statistics Agency (BPS) of West Papua Province. The data will be divided into two, namely data before the Covid-19 pandemic and during the Covid-19 pandemic. Data division before the Covid-19 pandemic began from January 2015-December 2017 to determine the forecasting model, and the determination of validation began during January-December 2018. While the data during the Covid-19 pandemic starts from January 2020-December 2021 which will be used in determining the forecasting model and to determine its validation starting from January-July 2022. The analysis method in this study uses Brown's double exponential smoothing method. The data processing is done using Microsoft Office Excel 2013 application for input, and data classification. Minitab application to create trend patterns. The R-Studio application is used to simplify the calculations that will be done in this study. Furthermore, the results of forecasting are interpreted descriptively in the form of graphs and tables. The stages of this research procedure are:

1. Create a *time series* plot by inputting actual data to see the trend data pattern.
2. Conduct a trend analysis, to determine the existing trend model using the equation  $Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$ ,  $i = 1, 2, 3, \dots, n$ , while the MAPE value is used for whether the trend model is good or not.

The steps of Brown's double exponential smoothing using data before the Covid-19 pandemic are:

- a. Determining the parameter values used as constants in Brown's double exponential smoothing. The parameter magnitude is between 0 and 1, in this study it is determined by one number behind the comma which is determined by trial and error.
- b. Calculating the first smoothing value (using the equation  $S'_t = \alpha X_t + (1 - \alpha)S'_{t-1}$

- c. Calculating the second smoothing value ( $S_t''$ ) using the equation  $S_t'' = \alpha S_t' + (1 - \alpha)S_{t-1}''$
  - d. Determine the value of the smoothing constant  $a_t$  using the equation  $a_t = S_t' + (S_t' - S_t'') = 2S_t' - S_t''$
  - e. Determining the trend smoothing value  $b_t$  using the equation  $b_t = \frac{\alpha}{1-\alpha}(S_t' - S_t'')$
3. Creating a forecasting model for data before the Covid-19 pandemic (data for 2015-2017) with the one that produces the smallest MAPE value using the MAPE Equation =  $\frac{1}{n}(\sum_{t=1}^n \frac{|X_t - F_t|}{X_t}) \times 100\%$ . Then predict the Sorong City CPI in 2018, with the same steps can make a forecasting model during the Covid-19 pandemic (data for 2020-2021) with the one that produces the smallest MAPE value then predict the Sorong City CPI January-July 2022.
  4. Validate the model before the Covid-19 pandemic (2018 data) and during the Covid-19 pandemic (January-July 2022 data).
  5. Calculating Sorong City CPI forecasting for January-December 2019 and August to December 2022 using Eq.  $F_{t+m} = a_t + b_t(m)$ .

## RESULTS AND DISCUSSION

### Problem Identification

This study uses data on the number of monthly CPI in Sorong City as much as 79 data which are divided into two, namely (before the Covid-19 pandemic) starting from January 2015 to December 2018 and (during the Covid-19 pandemic) January 2020 to July 2021. If the data is plotted, it can be seen that the increase or pattern has an upward trend in the CPI data for 2015-2018 and 2020-2021, but when a trend line is drawn on the overall data, it can be seen that the pattern has a downward trend which will make this pattern unsuitable for describing the trend pattern that occurs, this drastic downward trend pattern is influenced by the Covid-19 Pandemic period. So that in this study the data will be divided into two categories, namely before the Covid-19 pandemic and during the Covid-19 pandemic. Then testing is carried out or to validate each category of data, namely before the pandemic using CPI data in 2018 while for testing the data during the pandemic is the CPI in 2022 for the period January to July.

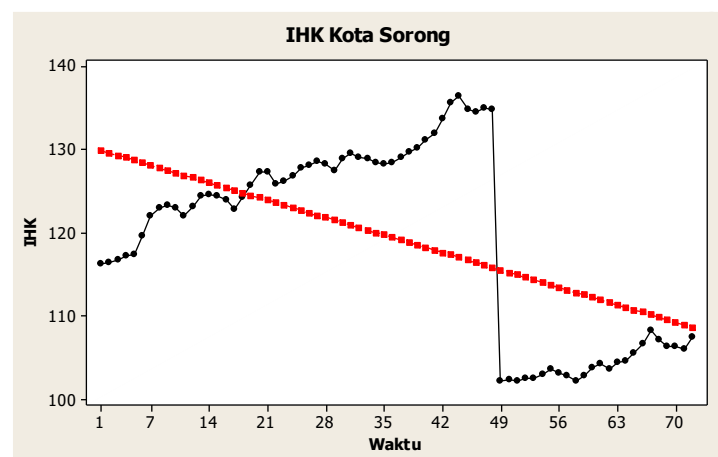


Figure 1. Trend Line of Sorong City CPI Before and During the Pandemic

### Trend Analysis

Trend analysis was conducted to check the trend of the model before and during the Covid-19 Pandemic. Sorong City CPI data for the period January 2020 to December 2021 against the estimated  $\hat{b}_0$  dan  $\hat{b}_1$  so that the linear model equation for Sorong City CPI data before the Covid-19 pandemic is obtained, namely:

$$\hat{Y}_i = 118,099111 + 0,35456756X_i$$

By substituting  $X_i = 1,2,3,4,5, \dots, 24$  then a trend line is obtained as in Figure 2.

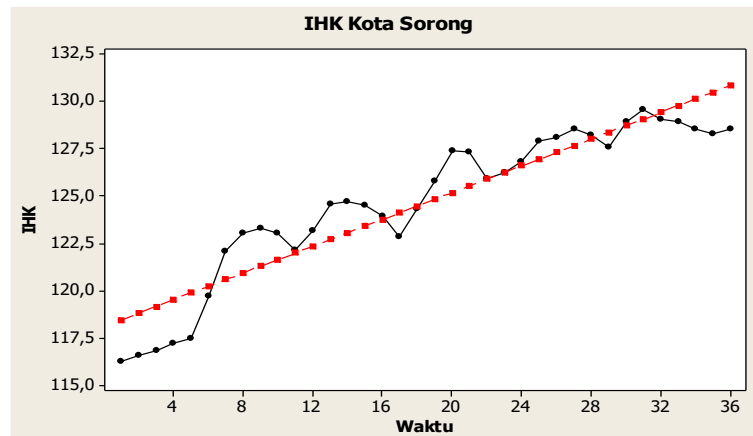


Figure 2. Sorong City CPI data before the Covid-19 pandemic

From Figure 2. above, this pattern appears to be experiencing a positive trend or upward trend in the CPI data for the period January 2015 to December 2017 which appears to be increasing all the time, so that the CPI data before the Covid-19 pandemic meets the requirements for a trend pattern (up or down) in the method. Brown's double exponential smoothing with a MAPE value of 0.97382 is very good. Meanwhile, the linear model equation for Sorong City CPI data during the Covid-19 pandemic is:

$$\hat{Y}_i = 101,296376 + 0,24535652X_i$$

By substituting  $X_i = 1,2,3,4,5, \dots, 24$  then a trend line is obtained as in Figure 3.

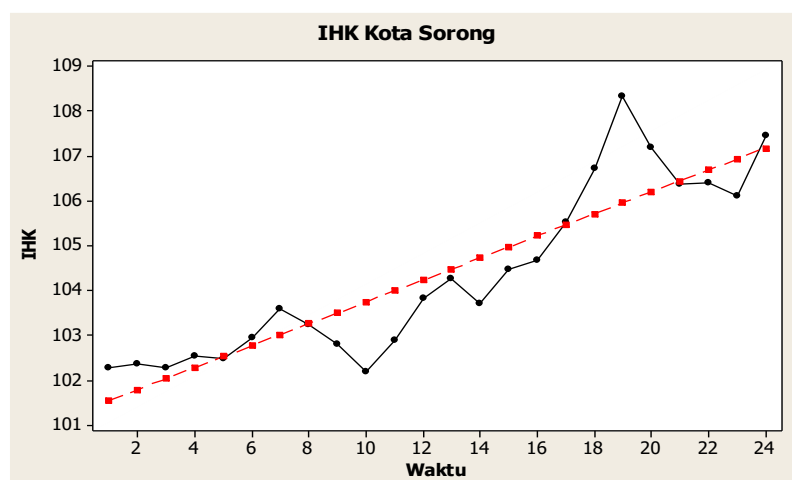


Figure 3. CPI data for Sorong City during the Covid-19 pandemic

In Figure 3 above, it can be seen that the CPI is increasing all the time or experiencing an upward trend, so that the CPI data during the Covid-19 pandemic meets the requirements for a trend pattern (up or down) in the Brown double exponential smoothing method with a MAPE value of 0.58087.

**Double Exponential Smoothing Brown Analysis Before the Covid-19 Pandemic**

The first step in carrying out Brown's double exponential smoothing analysis is to determine the parameter values  $\alpha$  yaitu  $0 < \alpha < 1$  taking into account the MAPE value. Calculations are carried out for each  $\alpha$  (0,1 – 0,9). The results obtained for the best model are  $\alpha = 0,9$  with the smallest MAPE value of 0.647%, the forecasting model is as follows:  $F_{t+m} = 128,525 + 0,137(m)$

Table 1. Comparison of Actual Data and Predicted Data for 2018

<b>Period</b>	<b>Actual</b>	<b>Prediction</b>
January/2018	129,17	128,662
February/2018	129,8	128,799
March/2018	130,31	128,936
April/2018	131,3	129,074
May/2018	132,01	129,211
June/2018	133,8	129,348
July/2018	135,77	129,486
August/2018	136,46	129,623
September/2018	134,91	129,760
October/2018	134,67	129,897
November/2018	135,09	130,035
December/2018	134,89	130,172

The model above was then validated using data for the period January to December 2018 where  $t=37,38,39, \dots, 48$  for the period  $m=1, m=2$  to  $m=12$ , obtained from the R-Studio output results presented in Table 1. From the validation results of the best model, a MAPE of 2.799% was obtained. The results of MAPE calculations from model validation data before the Covid-19 pandemic are presented in Table 2.

This shows that the model is valid and can be used for forecasting. Results CPI forecasting before the Covid-19 Pandemic is presented in Table 3.

Table 3. Sorong City CPI Before the Covid-19 Pandemic

<b>Period</b>	<b>Prediction</b>
January/2019	130,309
February/2019	130,447
March/2019	130,584
April/2019	130,721
May/2019	130,858
June/2019	130,996
July/2019	131,133
August/2019	131,270
September/2019	131,408
October/2019	131,545
November/2019	131,682
December/2019	131,819

Based on Table 3, the results of the Sorong City CPI forecasting above show that for the 12 periods in January-December 2019 before the Covid-19 pandemic, Sorong City's CPI in January was the lowest at 130,309 and in December it was the highest at 131,819.

**During the Covid-19 Pandemic**

The steps taken are the same as solving for data before the Covid-19 Pandemic in Brown's double exponential smoothing analysis by determining parameter values  $\alpha$  yaitu  $0 < \alpha < 1$  and consider the MAPE value. Calculations are carried out for each  $\alpha$  (0,1 – 0,9). The results obtained for the best model are  $\alpha = 0,7$  with the smallest MAPE value of 0.633%, the forecasting model is as follows:

$$F_{t+m} = 107,304 + 0,522(m).$$

The model above was then validated using data for the period January to July 2022 as presented in Table 4.

Table 4. Comparison of Actual Data and Predicted Data for January-July 2022

Period	Actual	Prediction
January/2022	108,51	107,827
February/2022	107,1	108,349
March/2022	107,34	108,871
April/2022	108,43	108,393
May/2022	109,09	109,915
June/2022	109,51	110,438
July/2022	110,89	110,960

In Table 4, the best model validation results are obtained MAPE 0.825%. The results of MAPE calculations for model validation data during the Covid-19 pandemic are presented in Table 5.

Table 5. Model Validation During the Covid-19 Pandemic

Period	Data ( $X_t$ )	Actual Prediction Result ( $F_t$ )	$X_t - F_t$	$ X_t - F_t $	$( X_t - F_t /X_t)*100$
January/2022	108,51	107,827	0,683	0,683	0,630
February/2022	107,1	108,349	-1,249	1,249	1,166
March/2022	107,34	108,871	-1,531	1,531	1,426
April/2022	108,43	108,393	-0,963	0,963	0,888
May/2022	109,09	109,915	-0,825	0,825	0,757
June/2022	109,51	110,438	-0,928	0,928	0,847
July/2022	110,89	110,960	-0,070	0,070	0,063
Amount					5,777
MAPE					0,825%

This shows that the model is valid and can be used for forecasting. Forecasting results during the Covid-19 pandemic are presented in Table 6.

Table 6. Sorong City CPI Forecasting Results During the Covid-19 Pandemic

Period	Prediction
Agustus/2022	111,482
September/2022	112,004
Oktober/2022	112,527
November/2022	113,049
December/2022	113,571

In Table 6, the results of the Sorong City CPI forecasting above show that for the 5 periods from August to December 2022, when the Covid-19 pandemic occurred, Sorong City's CPI was the lowest at 111,482, namely in August, while the highest was in December at 113,571.

## CONCLUSION

The conclusions that can be drawn from the results of the research and discussion regarding the application of the Double Exponential Smoothing Brown method used to predict the CPI in Sorong City are as follows:

1. The best model before the Covid-19 pandemic, namely  $F_{t+m} = 128,525 + 0,137(m)$  with a MAPE of 0,647%. and the best model during the Covid-19 pandemic, namely  $F_{t+m} = 107,304 + 0,522(m)$  with a MAPE of 0,633%.
2. The difference in the rate of change in the Sorong City CPI during the pandemic was greater, namely 0.5, than before the pandemic, namely 0.1, with the CPI forecasting results for the period August to December 2022 respectively as follows: 111,482; 112,004; 112,527; 113,049; 113,571.

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