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Modeling of inflation cases in South Sulawesi Province using single exponential smoothing and double exponential smoothing methods

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Abstract
The inflation rate, particularly in South Sulawesi Province from year to year, is found to be very unstable, so that an effort to overcome the instability of the inflation rate is highly needed. One of the efforts that can be used is to carry out a process of forecasting the inflation rate, so that the government can predict the inflation rate properly in order to realize the sustainable economic growth. The aim of this study was to forecast Inflation Cases in South Sulawesi Province. The forecasting carried out in this study used the Exponential Smoothing method. Exponential Smoothing is a method that will take into account average (smoothing) the data of the past exponentially by repeating calculations continuously using the latest data. In this study, 2 Exponential Smoothing methods were compared, namely: Single Exponential Smoothing (SES) and Double Exponential Smoothing (DES) which were used to obtain prediction results and evaluate the results of predictions using the Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) methods. The smallest MAPE value was obtained when using the Single Exponential Smoothing (SES) method when the value $\alpha = 0.1$ with the MSE value of 0.5567 and MAPE value of 265.7126 and the Double Exponential Smoothing (DES) method when the value $\alpha = 0.3$ and with the MSE value of 4,256 and MAPE value of 574,519. Thus, the Single Exponential Smoothing (SES) method was regarded as the best method in predicting the inflation rate in South Sulawesi Province.

Keywords Inflation · Exponential smoothing · Single exponential smoothing (SES) · Double exponential smoothing (DES) · South Sulawesi

1 Introduction

Inflation is defined as an increase in prices generally and continuously. If prices of just a few types of goods or services are rising, there is not necessarily inflation (Bank Indonesia 2016). Meanwhile, according to Rahardja (1997), inflation is regarded as the sustained

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upward movement in the overall price level of goods and services. The increase that appears in some goods cannot be expressed as inflation, but it can be called inflation if the increase occurs in the majority of the prices of goods or services.

According to the Central Statistics Agency in 2017, the inflation rate in South Sulawesi Province was amounted to 4.44 percent, this condition illustrates that throughout 2017, the price of goods and services generally increased by 4.44 percent. This inflationary condition was much higher than the inflation that occurred in 2016. The inflation rate for goods and services throughout 2016 was amounted to 2.94 percent. This condition generally illustrates that the level of price stability in 2017 was not better than in 2016 (Badan Pusat Statistik Sulawesi Selatan 2018).

Inflation stability is highly regarded as a prerequisite for realizing sustainable economic growth (Hsing et al. 2020), this stability is expected to provide benefits for improving the welfare of the community. The importance of controlling inflation is based on the consideration that high and unstable inflation will have a negative impact on the socio-economic conditions of society. High inflation will cause people's incomes to always decline, so that the standard of living of the community will decrease and ultimately will cause everyone to have a bad income and get poorer. In addition to this, an unstable inflation will create uncertainty for economic actors in the process of making decisions. Several previous studies had shown that unstable inflation will complicate people's decisions in consumption, investment and production, which will subsequently reduce the national economic growth.

Referring to that matter, it is necessary to predict the value of inflation in the coming year to determine the decisions taken by the community in facing inflation. Many things are caused by inflation. To prevent this, forecasting of inflation needs to be conducted.

Forecasting is considered as an important issue which includes many fields including business and industry, government, economics, environmental science, medicine, social science, politics and finance. Forecasting is often classified as short-term, medium-term, and long-term forecasting. Short-term forecasting involves predictive events that are carried out only in a certain period of time (days, weeks, months) in the future. Medium-term forecasting covers a time span of one to two years ahead, and long-term forecasting can extend beyond the next few years (Montgomery et al. 2015).

Forecasting is used to anticipate problems that occur for the future and is widely used in the economic field (Bakri et al. 2019). The method commonly used is the exponential smoothing method (Lestari et al. 2020).

Exponential Smoothing is a method that will take into account average (smoothing) the data of the past exponentially by repeating calculations continuously using the latest data. Exponential smoothing of time series data assigns exponentially decreasing weights for newest to oldest observations. That is the newer value will be given a weight that is relatively greater than the value of the longer observation. Regarding to that matter, a forecasting method to determine the inflation rate for the following year is highly required.

Through various forecasting methods that have developed rapidly with time series data, there are many choices of methods that can be used easily. In predicting time series data as needed, it is very necessary to carry out a comparison process between one method and another so that the forecasting results with high accuracy can be easily obtained.

Based on the previous study of Single Exponential Smoothing method discussed by Fahmi et al. (2013) regarding to the comparison of the Single Exponential Smoothing Method and the Fuzzy Time Series in predicting the Composite Stock Price Index, the smallest forecasting prediction value was obtained after conducting several experiments with the α value that had been used. In addition, previous study on Double Exponential Smoothing conducted by Mahmudi et al. (2018) which predicted the rate of inflation using

the Double Exponential Smoothing Method showed the results of forecasts that gave greater error values every month, so that forecasting by using this method only suitable for short-term forecasting, and this is in line with the results of the study conducted by Muchayan (2019) which examined the Double Exponential Smoothing method in Mutual Funds. In this study, a comparison of forecasting would be carried out using the accuracy measure of a forecast in calculating the inflation rate by means of the Single Exponential Smoothing method which would be compared with the Double Exponential Smoothing method.

2 Method of the study

This study was an applied study with a quantitative approach, specifically by taking the necessary data and analyzing it using the Single Exponential Smoothing and Double Exponential Smoothing methods to predict the inflation rate in South Sulawesi Province.

The data used in this study was the inflation data for South Sulawesi Province. This data was secondary data taken from the Central Statistics Agency of South Sulawesi Province specifically monthly data from January 2013 to June 2018 (66 months).

The stages of data analysis carried out in this study are presented as follows:

(1) Identifying data by plotting data on the Inflation Rate of South Sulawesi Province.
(2) Inputting the parameter value. Parameters are determined by trial and error with a value between 0 and 1.
(3) Performing the forecasting modeling by meabs of the Single Exponential Smoothing method and the Double Exponential Smoothing method.
(4) Determining the resulting smoothing parameters based on the minimum MSE and MAPE from the Exponential Smoothing method (Ahmar 2020).
(5) Determining the form of the forecasting equation that will be used to forecast the future period. Furthermore, forecasting the inflation rate for the period ahead.
(6) Interpreting the inflation rate based on the forecasting model used.

3 Results and discussions

3.1 Descriptive statistics

The inflation that occurs is an indicator of economic movement in a city. This inflation provides information about the increase in prices for goods and services in general, in which these goods and services are the basic needs of society.

Based on Table 1, the average inflation rate from January 2013 to June 2018 was amounted to 0.442%, with a minimum value of − 0.72% in October 2013 and a maximum value of 3.05% in July 2013. The standard deviation of the inflation rate data was amounted to 0.6925 which indicated the low level of difference between the data and the mean value. The data plot is shown in Fig. 1.

Based on Fig. 1, it can be indicated that the data on the Inflation Rate of South Sulawesi Province had a trend pattern (up or down) over a certain period. Therefore, decomposition was carried out with the aim of identifying the three components or basic pattern factors

Table 1 Data on inflation rate in south sulawesi province for the period of january 2013—June 2018

Month/Year	2013	2014	2015	2016	2017	2018
January	1.13	1.11	−0.17	1.22	1.12	0.81
February	0.71	0.30	−0.27	−0.08	0.75	0.23
March	0.26	0.02	0.50	0.08	−0.18	−0.06
April	−0.12	0.36	0.33	−0.39	0.33	0.18
May	−0.26	−0.16	0.31	−0.03	−0.24	0.37
June	0.56	0.30	0.73	0.45	0.97	0.94
July	3.05	1.17	1.19	1.04	0.93	–
Agustus	1.58	0.40	0.37	−0.04	−0.26	–
September	−0.18	0.25	0.54	0.32	−0.07	–
October	−0.72	0.41	−0.08	0	−0.31	–
November	−0.67	1.41	0.26	0.45	0.28	–
Desember	0.77	2.75	0.70	0.30	1.04	–

Source: Central Statistics Agency of South Sulawesi Province

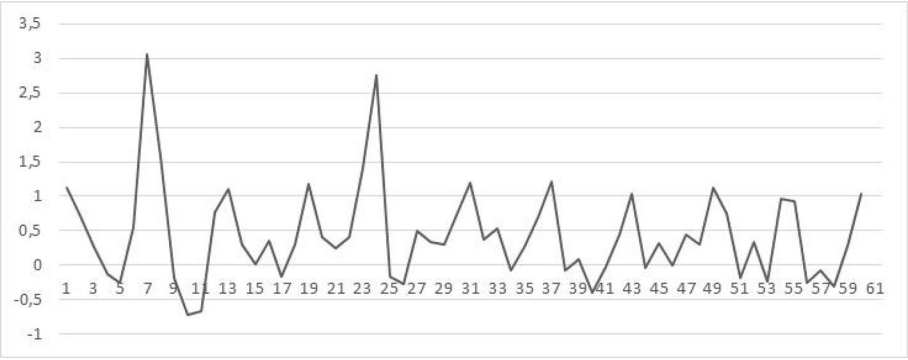

Fig. 1 Plot of Inflation Rate Data in South Sulawesi Province for the Period of January 2013—June 2018

contained in a data series, specifically trend, seasonality and cycle components. The results of the decomposition are shown in Fig. 2.

Based on Fig. 2, the results show that the Inflation Rate data was not markedly trendy or did not have an up and down tendency.

3.2 Single exponential smoothing

The Single Exponential Smoothing model uses 60 time series data on the Inflation Rate and uses one parameter, namely alpha. Alpha values are between 0 and 1. Alpha values can be obtained by trial and error. For the detail information, it can be seen in Table 2.

Table 2 shows the forecasting provisions of the Single Exponential Smoothing method using several experiments with different parameter value of α. The determination of the parameter value was based on the difference in the interval between one parameter and another of 0.3. It can be seen that the smallest MSE value was amounted to 0.5560 with $\alpha = 0.1$ and the smallest MAPE value was amounted to 236.9054 with $\alpha = 0.3$. Several differences in the value of these parameters were markedly found, so it cannot be ascertained that the parameter

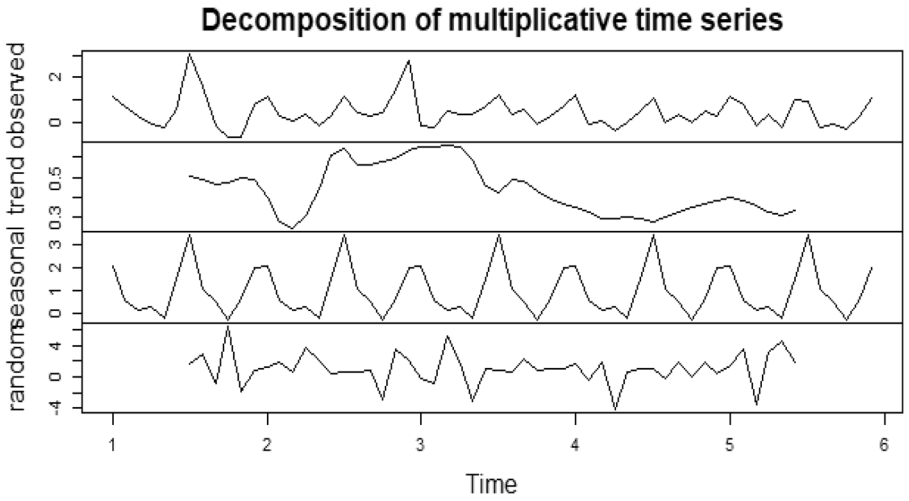

Fig. 2 Plot of Decomposition of Inflation Rate Forecasting Data in South Sulawesi Province for the Period of January 2013—June 2018

Table 2 Provisions for single exponential smoothing forecasting

α	MSE	MAPE
0.1	0.5560	265.7126
0.3	0.6059	236.9054
0.6	0.6729	259.4546
0.9	0.7054	273.3375

values with $\alpha = 0.1$ and $\alpha = 0.3$, could be used in the forecasting method for the movement of inflation data in South Sulawesi Province. The criteria for selecting the best model in the Single Exponential Smoothing method is to have the smallest MSE value, so $\alpha = 0.1$ was used in predicting the Inflation Rate data.

It can be seen in Fig. 3 that the forecasting results using Single Exponential Smoothing with α=0.1 were not good enough to predict fluctuating data patterns. This was due to the Single Exponential Smoothing calculation which only used the actual and predicted values of the previous period.

Determination of the forecast value using the Single Exponential Smoothing model with α=0.1 is presented as follows.

$$F_t = \alpha Y_{t-1} + (1 - \alpha) S_{t-1}$$

Let: α=0.1 Than:

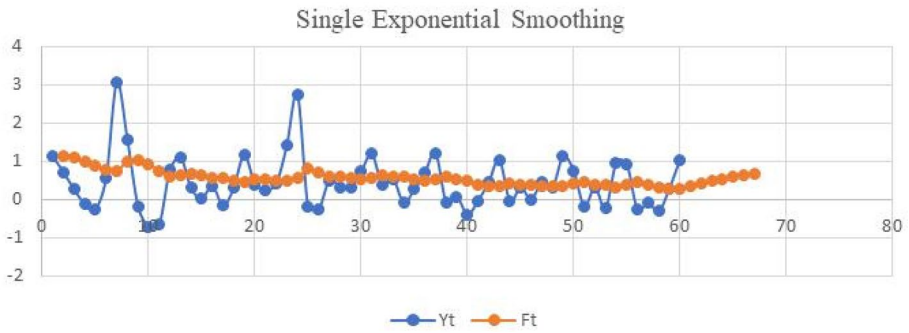

Fig. 3 Plot of Inflation Rate Forecasting Data in South Sulawesi Province for the Period of January 2013—June 2018 using Single Exponential Smoothing

$$
\begin{aligned}
F_2 &= \alpha Y_{2-1} + (1-\alpha) S_{2-1} \\
F_2 &= 0.1(1.13) + (1-0.1)(1.13) \\
F_2 &= 1.13 \\
F_3 &= \alpha Y_{3-1} + (1-\alpha) S_{3-1} \\
F_3 &= 0.1(0.71) + (1-0.1)(1.13) \\
F_3 &= 1.0880 \\
F_4 &= \alpha Y_{4-1} + (1-\alpha) S_{4-1} \\
F_4 &= 0.1(0,26) + (1-0.1)(1.0880) \\
F_4 &= 1.0052 \\
&\vdots \\
F_{61} &= \alpha Y_{61-1} + (1-\alpha) S_{61-1} \\
F_{61} &= 0.1(1.04) + (1-0.1)(0.2649) \\
F_{61} &= 0.3424 \\
F_{62} &= \alpha Y_{61-1} + (1-\alpha) S_{62-1} \\
F_{62} &= 0.1(1.04) + (1-0.1)(0.3424) \\
F_2 &= F_{62} = 0.4122 \\
&\vdots \\
F_{66} &= \alpha Y_{61-1} + (1-\alpha) S_{66-1} \\
F_{66} &= 0.1(1.04) + (1-0.1)(0.5823) \\
F_{66} &= 0.6281
\end{aligned}
$$

So that the results of forecasting data on the inflation rate of South Sulawesi for the period of January 2013 to December 2017 were obtained as in Table 3.

Table 3 shows the results of the overall calculation with $\alpha = 0.1$. This calculation process was carried out in sequence and the final forecasting results for the December 2017 period was amounted to 0.2649. The process of calculating errors using the MSE and MAPE methods was then conducted. After carrying out the forecasting process with $\alpha = 0.1$, then MSE and MAPE calculations were carried out to determine the forecasting results with the lowest error value taken as an accurate forecasting result.

Table 3 Forecasting results (Ft) with actual data (Yt) for parameter of $\alpha = 0.1$

Yt	Ft	Yt-Ft	*Error*	Yt-Ft/Yt
1.13				
0.71	1.1300	0.4200	0.1764	0.5915
0.26	1.0880	0.8280	0.6856	3.1846
−0.12	1.0052	1.1252	1.2661	9.3767
⋮	⋮	⋮	⋮	⋮
0.28	0.2632	0.0168	0.0003	0.0600
1.04	0.2649	0.7751	0.6008	0.7453
Sum			32.8050	159.4276

Table 4 shows the difference between the forecasting results and the actual data for the parameter value of $\alpha = 0.1$. It can be seen that the data in the March 2018 period has the smallest error value of −0.5349. This means that the forecasting results in that period were close to the actual data.

3.3 Double exponential smoothing

The Double Exponential Smoothing model uses two parameters, namely alpha and beta. Alpha and beta values are between 0 and 1. Values and β can be obtained by trial and error.

Table 5 shows the provisions of the Double Exponential Smoothing method using several experiments with different parameter values of α and β. Determining the parameter value for the Double Exponential Smoothing method was the same as the Single Exponential Smoothing method, which was based on the difference in the interval between one parameter and another parameter of 0.3. This also applied to the parameter of α and β whose values were combined respectively. It can be seen that the smallest MSE value was amounted to 4.2560 found in $\alpha = 0.3$ and $\beta = 0.3$, while the smallest MAPE value was amounted to 556.7725 found in $\alpha = 0.3$ and $\beta = 0.1$. Several differences in the value of these parameters were markedly found, so it cannot be ascertained that the parameter values by considering at the smallest MSE and MAPE values could be used in the forecasting method for the movement of inflation data in South Sulawesi Province. The criteria for selecting the best model in the Double Exponential Smoothing method is to have the smallest MSE value, so $\alpha = 0.3$ and $\beta = 0.3$ were used in predicting the Inflation Rate data.

Figure 4 shows the actual data plot and the results of forecasting using $\alpha = 0.3$ and $\beta = 0.3$ which showed that the forecasting results were quite able to follow the up

Table 4 Comparison of forecasting results (Ft) with actual data (Yt) for the period of january–june 2018 for parameter of $\alpha = 0.1$

Yt	Ft	*Error*
0.81	0.3424	0.4676
0.23	0.4122	−0.1822
−0.06	0.4749	−0.5349
0.18	0.5314	−0.3514
0.37	0.5823	−0.2123
0.94	0.6281	0.3119

Table 5 Provisions of double exponential smoothing forecasting

α	β	MSE	MAPE
0.1	0.1	8.8523	1024.0534
	0.3	5.2740	573.9277
	0.6	4.3183	643.8474
	0.9	4.8456	697.5286
0.3	0.1	4.7760	556.7725
	0.3	4.2560	574.5199
	0.6	8.4407	893.4035
	0.9	16.8064	1393.1124
0.6	0.1	4.4266	577.2316
	0.3	7.0614	945.1421
	0.6	21.4188	1795.0805
	0.9	49.2067	2667.2221
0.9	0.1	4.7086	712.7013
	0.3	10.4495	1125.1554
	0.6	33.8733	2042.5933
	0.9	73.0569	3189.3431

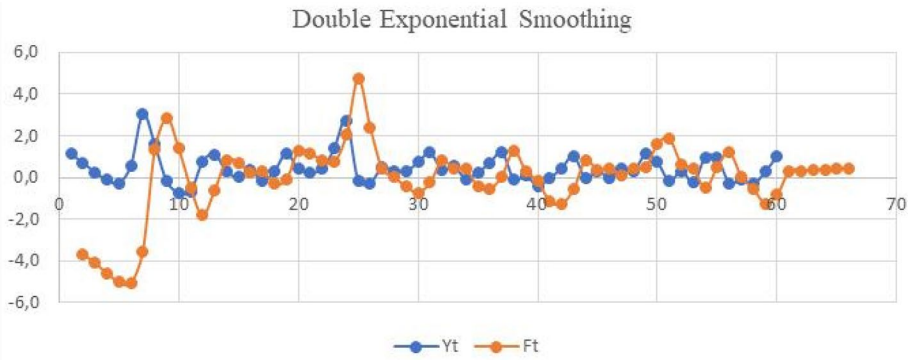

Fig. 4 Plot of Inflation Rate Forecasting Data in South Sulawesi Province for the Period of January 2013—June 2018 using Double Exponential Smoothing

and down pattern of the actual data so that it can be stated that the forecasting results obtained were quite good.

Examples of calculations in the forecasting process for the period of January 2013 to December 2017 using $\alpha = 0.3$ and $\beta = 0.3$ are presented as follows.

$$\text{Let:} \quad \alpha = 0.3$$
$$\beta = 0.3$$

Than:

Table 6 Forecasting results (Ft) with actual data (Yt) for parameters of $\alpha = 0.3$ and $\beta = 0.3$

Yt	St	bt	Ft	Yt-Ft	*Error*	(Yt-Ft)/Yt
1.13	1.1300	−0.4000				
0.71	0.7240	−0.4018	−3.6700	4.3800	19.1844	6.1690
0.26	0.3035	−0.4074	−4.0976	4.3576	18.9887	16.7600
−0.12	−0.1087	−0.4089	−4.5852	4.4652	19.9383	37.2103
⋮	⋮	⋮	⋮	⋮	⋮	⋮
0.28	0.0202	−0.0709	−1.2390	1.5190	2.3073	5.4249
1.04	0.2765	0.0272	−0.8311	1.8711	3.5009	1.7991
Sum					251.1051	344.7119

Table 7 Comparison of forecasting results (Ft) with actual data (Yt) in the period of january–june 2018 for parameters of $\alpha = 0.3$ and $\beta = 0.3$

Yt	Ft	*Error*
0.81	0.3037	0.5063
0.23	0.3309	−0.1009
−0.06	0.3582	−0.4182
0.18	0.3854	−0.2054
0.37	0.4126	−0.0426
0.94	0.4399	0.5001

$$
\begin{aligned}
F_{t+1} &= 0.2765 + (0.0272 * 1)\\
F_{t+1} &= 0.3037\\
F_{t+2} &= 0.2765 + (0.0272 * 2)\\
F_{t+2} &= 0.3309\\
&\vdots\\
F_{t+6} &= 0.2765 + (0.0272 * 6)\\
F_{t+6} &= 0.4399
\end{aligned}
$$

Table 6 shows the results of the overall calculations with $\alpha = 0.3$ and $\beta = 0.3$. This process was carried out in sequence with the final forecasting result for the period of December 2017 was amounted to 0.2765. The next step was to calculate the error using the MSE and MAPE methods. The lowest error value was then taken as an accurate forecasting result.

Table 7 shows the difference between the forecasting results and the actual data for the parameter values of $\alpha = 0.3$ and $\beta = 0.3$. It can be seen that the data in the March 2018 period has the smallest error value of −0.4182. This means that the forecasting results in that period were close to the actual data.

3.4 Comparison of single exponential smoothing and double exponential smoothing methods

From the estimation results of forecasting the Single Exponential Smoothing and Double Exponential Smoothing methods, the value of the forecast error size would be compared by calculating the MSE and MAPE values shown in Table 8.

Table 8 Comparison results of the single exponential smoothing and double exponential smoothing methods

Metode	MSE	MAPE
Single exponential smoothing	0.5560	265.7126
Double exponential smoothing	4.2560	574.5199

Based on the comparison of forecasting results in Table 8, the smallest MSE and MAPE values were obtained in the Single Exponential Smoothing method. Thus, the Single Exponential Smoothing method was regarded as a suitable method for predicting the Inflation Rate of South Sulawesi Province from January 2013 to June 2018.

4 Conclusions

Based on the results of data analysis and discussion, it can be concluded that:

(1) The results of forecasting the rate of inflation in South Sulawesi Province in the period of January to June 2018 using the Single Exponential Smoothing method with $\alpha = 0.1$ experienced an average increase of 0.4952%. Meanwhile, the Double Exponential Smoothing method with $\alpha = 0.3$ and $\beta = 0.3$ experienced an average increase of 0.3718%.
(2) The Single Exponential Smoothing method was regarded as a suitable method for predicting the rate of inflation in South Sulawesi Province based on the smallest MSE value of 0.5567 and MAPE value of 265.7126.

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Author contributions Authors contributed to the manuscript equally.

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Declarations

Conflict of interest The author declares that there is no conflict of interest.

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