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Original article

Holt-Winter Forecasting Method for Inflow and Outflow of Bank Indonesia in Riau

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Abstract *- This article discusses the use of the Holt-Winter method numerically in forecasting the circulation of real money in the community carried out by the Regional Representative Office of Bank Indonesia in Riau Province, Indonesia, from 2008 to 2020, which is the inflow and outflow of real money. Inflow and outflow of real money are monthly time-series data that are thought to be influenced by time. In this study, there are several forecasting methods that can be used to forecast inflow and outflow: additive, multiplicative, Holt-Winter additive, and Holt-Winter multiplicative models. Then, the identification of seasonal variations is carried out to choose the right forecasting method. Therefore, the additive Holt-Winter forecasting method for inflow and multiplicative Holt-Winter forecasting for outflow is obtained.*

Keywords *- Forecasting Method, Inflow, Outflow, Additive model, Multiplicative model, Trend, Seasonal, Holt-Winter.*

I. INTRODUCTION

The forecasting method is a way of quantitatively estimating what will happen in the future, based on relevant data in the past, with the hope that we will obtain a small error through this method [2], while time-series data is a series of variable values arranged by time. The most important thing in the forecasting method is to choose a pattern from the data series to be forecasted and the forecasting time span [3]. The data patterns in the time series are divided into 4 types such as horizontal, seasonal, cyclical, and trend data patterns, while the forecasting time span is divided into 3 categories such as short-term, medium-term, and long-term forecasts. Time-series data has two properties, namely stationary and non-stationary time series data. An observation is said to be stationary if the data has an average value and a relatively constant variation from time to time. On the other hand, observational data is said to be non-stationary if the data has an average and variation that is not constant or changes over time [2]. Both of these properties are important in determining forecasting methods that produce small errors, especially non-stationary data.

There are several good forecasting methods used on non-stationary data; one of them is the Holt-Winter method. The Holt-Winter method had been discussed in general by Kalekar [5]. Then the Holt-Winter method was also discussed by Bezerra [6]. In his article, Bezerra evaluated the Holt-Winter model in waste disposal forecasting with the City of Toledo as the case study site. Based on the various applications of forecasting methods previously mentioned, forecasting the flow of real money through the Regional Representative Office of Bank Indonesia in Riau Province is very important to make policies in determining the circulation of real money in Riau in the future.

Real money is rupiah notes issued by Bank Indonesia. As a means of cash payment, real money still plays an important role because there are still many people who choose to use the currency for economic transactions. This is reflected in the improvement in several main indicators of money management, such as the real money in circulation and the flow of real money through Bank Indonesia.

The amount of money circulating in the community will affect the economic conditions in Indonesia, one of which is in the Riau Province. Therefore, as the central bank, Bank Indonesia must develop a plan to meet the needs of rupiah money. The planning can be done by forecasting the inflow and outflow of real money. Inflow is an activity of money that enters Bank Indonesia through deposit activities, while outflow is money that comes out of Bank Indonesia through withdrawal activities. It causes the flow of inflow and outflow in Riau Province to become important to study its development in order to achieve and maintain the stability of the value of the rupiah. To determine the flow of currency from time to time, we use the Holt-Winter method.

II. RESEARCH METHODOLOGY

The Holt-Winter method is a development of the simple exponential smoothing method that uses three smoothing constants such as the constant for smoothing the whole level, trend smoothing (trend), and seasonal smoothing (seasonal). According to Hyndman [4], the Holt-Winter model uses two approaches, such as:

1. Multiplicative Holt-Winter method, which is used for seasonal data variations from time-series data that has increased or decreased (fluctuated).
2. The Holt-Winter Additive method is used for seasonal data variations from constant time series data.

The various smoothing values of the two approaches are given in Table 1 below.

Table 1. Comparative equations for the holt-winter multiplicative and additive method

	Holt- Winter Multiplikatif	Holt- Winter Aditif
Level	$\bar{L}_t = \alpha \frac{Y_t}{\hat{S}_{t-s}} + (1-\alpha)(\bar{L}_{t-1} + \hat{B}_{t-1})$	$\bar{L}_t = \alpha(Y_t - \hat{S}_{t-s}) + (1-\alpha)(\bar{L}_{t-1} + \hat{B}_{t-1})$
Trend	$\hat{B}_t = \beta(\bar{L}_t - \bar{L}_{t-1}) + (1-\beta)\hat{B}_{t-1}$	$\hat{B}_t = \beta(\bar{L}_t - \bar{L}_{t-1}) + (1-\beta)\hat{B}_{t-1}$
Seasonal	$\hat{S}_t = \gamma\left(\frac{Y_t}{L_t}\right) + (1-\gamma)\hat{S}_{t-s}$	$\hat{S}_t = \gamma(Y_t - L_t) + (1-\gamma)\hat{S}_{t-s}$
Ramalan	$F_{t+m} = (\bar{L}_t + \hat{B}_t m)\hat{S}_{t-s+m}$	$F_{t+m} = (\bar{L}_t + \hat{B}_t m) + \hat{S}_{t-s+m}$.;

In Table 1, $\hat{S}_t$ is seasonal, $\bar{L}_t$ is level, $\hat{B}_t$ is the trend, S_t is a seasonal component, F_{t+m} is forecast for *m* periods, Y_t is the observed value, and, $\alpha, \beta,$ dan γ are the respective exponential parameters of level, trending, and personal. Furthermore, the parameter values $\alpha, \beta,$ dan γ can be determined through a linear program with the aim of minimizing MAE (Mean Absolute Error). This is done using the R software.

After several forecasting models are obtained, then a comparison is made to choose a better model. The comparison is done by looking at the measurement results of the model error rate. The measurement of model error in this study used MAE, which was expected to be very small and could represent the data. The MAE value is obtained from the following equation:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|e_i|$$

Where $e_i = Y_i - F_i$.

III. RESULTS AND DISCUSSION

A. *Preliminary Data Analysis*

In this article, the data used was the Inflow and Outflow data of the Regional Representative Office of Bank Indonesia (BI) in Riau from 2008 to 2020, which was calculated monthly [1]. The following was a plot of the characteristics of inflow in Riau that had occurred over the last 12 years.

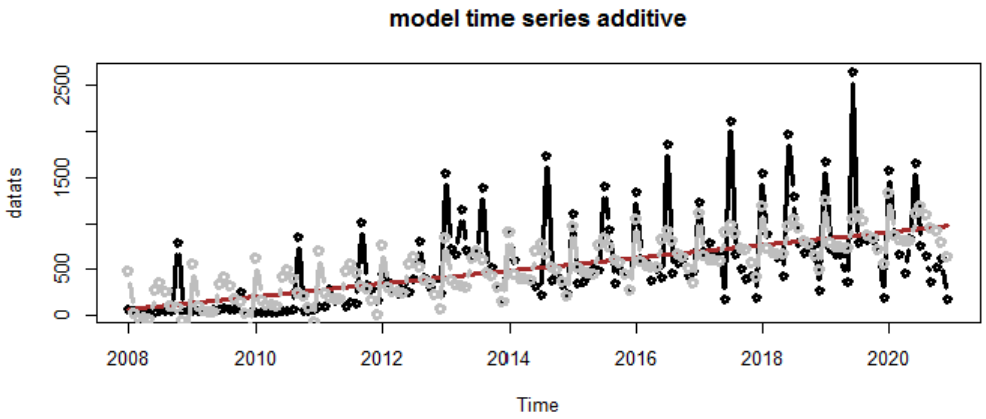

Fig. 1 Inflow characteristics

Based on Figure 1, we can see the inflow conditions in Riau, which was identified seasonal patterns and trends. In the flow of real money that entered Bank Indonesia in Riau from January 2008 to December 2020, there were sharp fluctuations up and

down. This identified the extreme ups and downs of real money entering Bank Indonesia and the effect of calendar variance before and after Eid al-Fitr. The minimum value was IDR 27 billion in November 2009, and the maximum value was IDR 2,633 billion in June 2019. In June 2019, the inflow experienced a sharp increment, and this was due to the effect of calendar variance.

The following was a plot of the characteristics of the outflow in Riau that had occurred over the last 12 years.

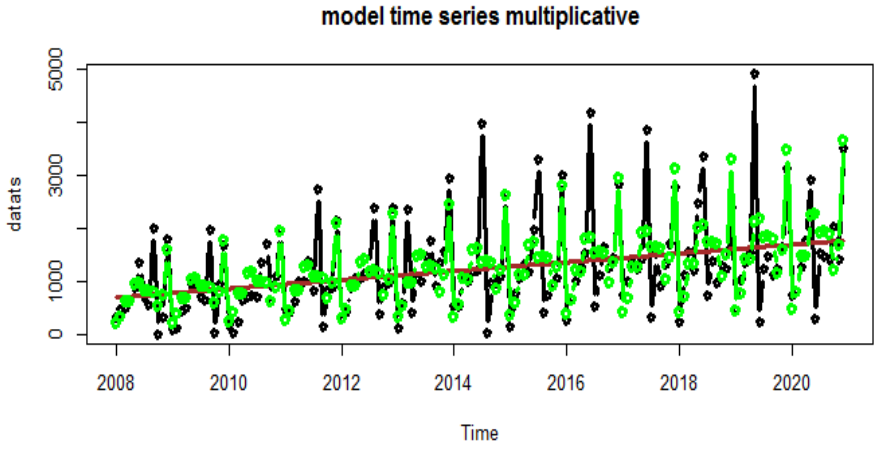

Fig. 2 Outflow characteristics

Based on Figure 2, the outflow condition in Riau province can be seen. In the flow of real money out to Bank Indonesia in Riau from 2008 to December 2020, there were sharp fluctuations up and down. This happened based on the extreme fluctuations in real money that came out and the effect of calendar variance before and after Eid al-Fitr, and the seasonal and trend identification plots. The minimum value was Rp. 5 billion in October 2008, and the maximum value was Rp. 4,903 billion in May 2019. The impact of the calendar variance effect in May 2019 was a sharp increment in the outflow.

From the two pictures above, it can be concluded that the phenomenon between inflow and outflow was almost the same. In 2019, there was a drastic increment between withdrawals and deposits at the Bank.

B. Holt-Winter Method

The first thing to do in forecasting was to analyze the shape of the data pattern through a graph of the data pattern that was plotted. Therefore, it will be easy to choose the forecasting method. The following was a plot of the characteristics of the inflow and outflow data using the Holt-Winter method.

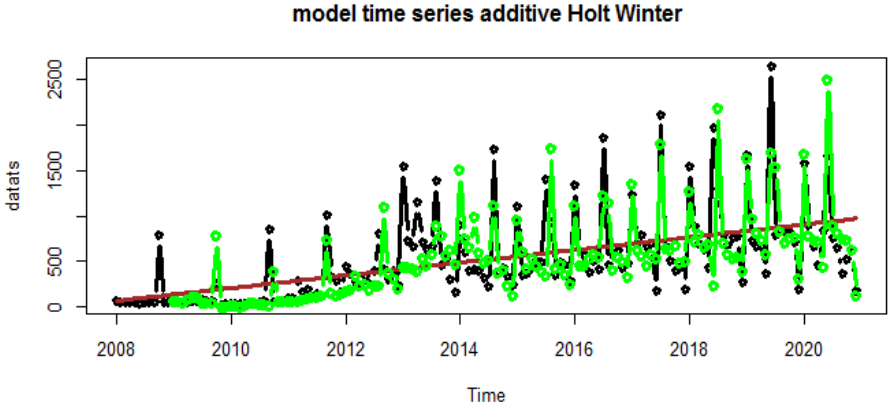

Fig. 3 Inflow characteristics

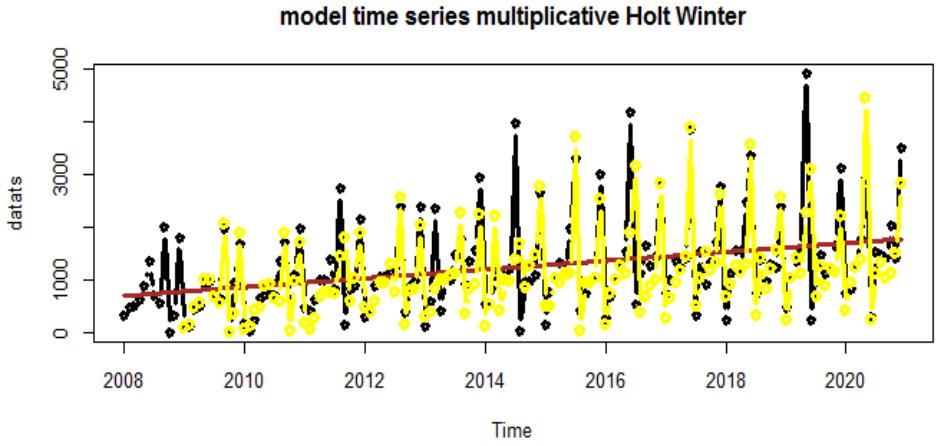

Fig. 4 Outflow characteristics

From Figure 3 and Figure 4, the linear trend line was positive. The positive linear trend line for this data showed that the inflow and outflow data of the Regional Representative Office of Bank Indonesia in Riau were increased time by time until 2020. Seasonal factors were also identified in this inflow and outflow data. The figure showed that there was a pattern of changes that repeated automatically from year to year.

Furthermore, to find out which method was better, the smallest error check was carried out using the MAE formula. So it was obtained for inflow and outflow as follows:

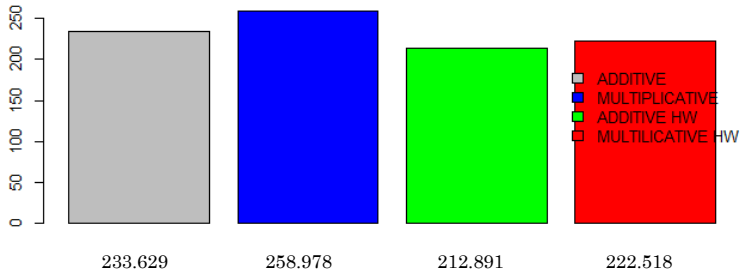

Fig. 5 MAE inflow comparison

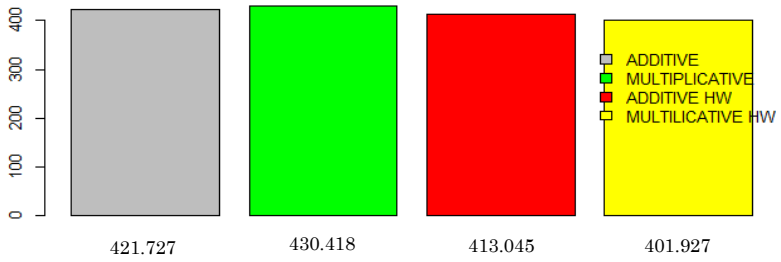

Fig. 6 MAE outflow comparison

Based on the MAE comparison, the appropriate forecasting methods used for Inflow and Outflow data of the Regional Representative Office of Bank Indonesia (BI) in Riau were the additive Holt-Winter method for inflow and the multiplicative Holt-Winter method for outflow. So that forecasting can be done for the next three years in 2021, 2022, and 2023.

Table 2. Inflow and outflow forecasting for the regional representative offices of bank Indonesian in riau

Tahun / Bulan	2021		2022		2023	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Januari	1498.6544	667.9088	1511.4030	595.9764	1524.1517	524.0439
Febuari	789.1482	752.5186	801.8969	670.7398	814.6455	588.9611
Maret	578.0002	1141.9846	590.7489	1016.7471	603.4975	891.5097
April	429.2636	1599.3816	442.0123	1422.3653	454.7609	1245.3490
Mei	669.6869	2644.8884	682.4355	2349.4324	695.1842	2053.9765
Juni	1726.5320	254.4739	1739.2806	225.7799	1752.0293	197.0860
Juli	737.4214	1374.5026	750.1700	1218.0464	762.9187	1061.5901
Agustus	642.9773	1320.1386	655.7259	1168.4314	668.4746	1016.7243
Oktober	430.6950	1249.1332	443.4436	1104.1978	456.1923	959.2625
September	571.2936	1802.6815	584.0422	1591.4765	596.7908	1380.2715
November	629.7939	1260.7130	642.5425	1111.5495	655.2912	962.3860
Desember	178.3194	3122.0189	191.0680	2748.9534	203.8166	2375.8879

The inflow and outflow forecasting graphs using the Holt-Winters method for the next three years were shown in Figure 7 and Figure 8 below.

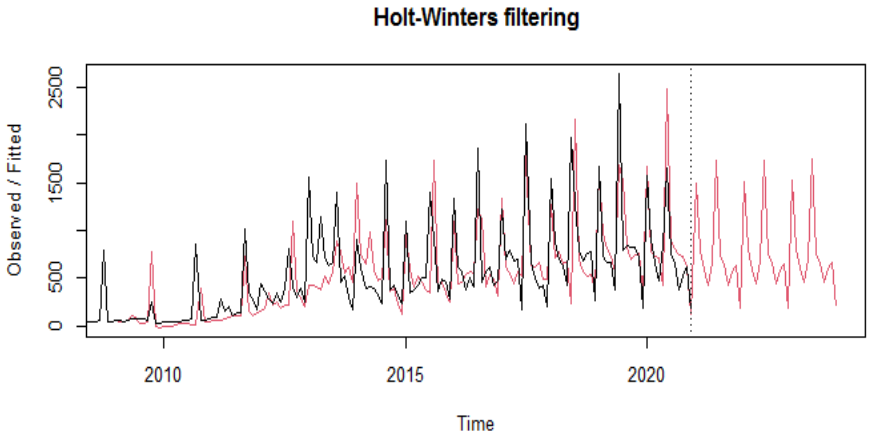

Fig. 7 Inflow forecasting graph

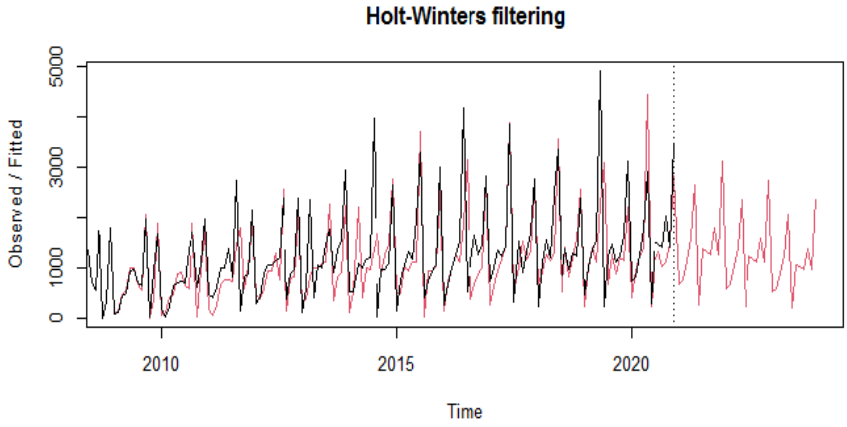

Fig. 8 Outflow forecasting graph

Based on the picture above, it can be seen that there was a decrement in inflow and outflow for the following years.

IV. CONCLUSION

Based on the results of the analysis and discussion that had been carried out in this article, it can be concluded that the forecasting of inflow data for the Regional Representative Office of Bank Indonesia in Riau was done well using the additive Holt-Winter method. This was due to constant seasonal variations. Meanwhile, the forecasting of outflow data for the Regional Representative Office of Bank Indonesia in Riau was done well using the multiplicative Holt-Winter method. This was due to seasonal variations that had increased or decreased.

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