

Original Article

# Comparison among Additive Time Series, Multiplicative Time Series, Holt Winter Additive and Holt Winter Multiplicative Methods in Forecasting the Number of Foreign Tourists Visit to Riau Islands Province

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Received: 10 October 2022

Revised: 15 November 2022

Accepted: 27 November 2022

Published: 10 December 2022

**Abstract** - Tourism plays a pivotal role in the Indonesian economy. As a foreign exchange reserves, the performance of tourism sector is determined by our ability to bring in as many foreign tourists as possible to Indonesia. Riau Islands is the foreign tourism gate which is strategically located as a favorable foreign tourist destination. This journal aims to determine proper forecasting methods for the existing data patterns and to provide more accurate forecasting results. The methods used include Time Series Additive and Multiplicative as well as Holt Winter Additive and Multiplicative. From these four methods, the forecasting is calculated using the Holt Winter Multiplicative method as it has the smallest MAE (Mean Absolute Error) value compared to the other three methods.

**Keywords** - Foreign Tourists, Additive Time Series, Multiplicative Time Series, Holt Winter Additive, Holt Winter Multiplicative, forecasting.

## 1. Introduction

Riau Islands (Kepri) is a province rich with natural, art and cultural resources which entice foreign tourists visiting Indonesia. The area covers 8,201,72 km<sup>2</sup> with 96% of sea and 4% of land. Kepri Province is located on a strategic sea transportation lane and land transportation lane and is the densest lane at an international level. As the region is dominantly surrounded by the sea, no wonder that the magnetic tourist attraction in the region is its vast span of white sand beaches, such as Melur Beach and Nongsa Beach in Batam, Belawan Beach in Karimun Regency, Lagoi Beach, Tanjung Berakit Beach, Batu Kasah Natuna Beach, Trikora Beach and Bintan Leisure Park in Bintan Regency[1].

The efforts to increase the number of tourists is made through tourism development activities in a bid to boost the economy of the Indonesia [2]. Foreign tourists visit to Riau Islands Province had been recorded to experience an increase to 2018. The issue of the number of foreign tourists forecasts has attracted a number of some researchers' attention such as Claveria and Torra (2014). They used the variables of monthly stay and the visit of foreign tourists to Catalonia for several years to analyze tourism demand for performance forecast on several regions [3], Kriti Kumari (2016) [4] Gounoplos, Petmezias, Sanaria, (2012) [5], and the research conducted by Grubb and Mason (2001) used the Holt-Winters method to produce future forecasts and explore past behavior of air passenger traffics for ten years [6].

In 2019 the world suffers from Covid-19 pandemic that forced most countries including Indonesia to limit the entry of foreigners to Indonesia. This lead to the impact of the decline in the number of foreign tourists visits on that period. Not only in Indonesia, Covid-19 also hit tourism sector in other countries Kvirkelia, Tsisagi (2021) [7], Papanikos (2020) [8]. Five elements are interrelated in tourism policy making and planning. Those elements include communities, organizations, facilities and services related to tourism, environment and processes. The government should take these five elements into account in making policies in tourism destinations so as to boost tourists visits. In tourism policy-making and planning, the role of tourism's arrival forecast is indispensable [9][10][11].

According to the study that has been performed by Ferbar Tratar and Strmčnik (2016) [12]. The researcher wants to identify which method was the best method for short and long-term heat load forecasting on the three levels, which were



monthly, weekly, and daily forecasting bases. Forecasting is predicting the future as accurately as possible, given all of the information available, including historical data and knowledge of any future events that might impact the forecasts [13]. Mathematically, forecast is generally produced based on data in the past analyzed using certain methods. In a quantitative forecast, there are several methods that can be used, one of which is the Holt-Winter method. The model considers three smoothing equations: one comprises the level, the tendency, and the other to the seasonality, Ribeibo, Marques, Junior (2019) [14]. Other methods that can be used for forecasting is Time Series Addictive and Multiplicative where each component is identified separately [15]. This method has been widely used by a lot of researchers, including Okoroafor, Otuonye, Chikzie, Akpanta (2021) [16].

The present research employs 4 methods to predict the number of foreign tourists visiting the Riau Islands province. These methods are Time Series Addictive and Multiplicative and Holt-Winter Interactive and Multiplicative. From these four methods, the best method will be selected and recommended (results from the smallest MAE value calculation) that is feasible to be used in forecasting the number of foreign tourists visiting Riau Islands province. MAE was discussed by Weijie Wang, Yanmin Lu (2018) [17].

## 2. Research Methodology

### 2.1 Additive Time Series and Multiplicative Time Series

Table 1. Comparative equation for the additive and multiplicative method

	Additive Method	Multiplicative Method
Data	$Y_t = T_t + S_t + R_t$	$Y_t = T_t \times S_t \times R_t$
Trend	$\hat{T}_t = a + bt$	$\hat{T}_t = a + bt$
Forecast	$\hat{Y}_t = \hat{T}_t + S_t$	$\hat{Y}_t = \hat{T}_t \times S_t$

In table 1.  $Y_t$  is the observed value,  $T_t$  is the trend,  $S_t$  is the seasonal component,  $R_t$  is irregular random value[18].

### 2.2. Holt-Winters Method

The Holt-Winter method is a method that exhibits the trend and seasonal factors simultaneously present on time series data. According to Suhartono [19], this Holt-Winter model uses two assumptions, namely the assumption of multiplicative effect and the assumption of additive effect. The multiplicative effect means that the measure of seasonal variations increases in par with the increase of data series. The additive effect means that the absolute measure of the variation does not depend on each other. According to N. A. Elmunim, Abdullah, M., Hasbi, A. M., Bahari, S. A., (2015) and (2017), the equatorial Malaysia is more suitable for a multiplicative effect rather than the additive effect [20][21]. This method is based on three elements, i.e. original data, trends and seasonality with three consecutive weights in the forecasts, i.e.  $\alpha$ ,  $\beta$ , and  $\gamma$ . The  $\alpha$ ,  $\beta$ , and  $\gamma$  coefficients are between 0 and 1, which are determined subjectively or by minimizing the error value from the forecast.

Table 2. Comparative equations for the Holt-Winters additive and multiplicative Methods

	Holt Winter Additive	Holt Winter Multiplicative
Level	$L_t = \alpha(Y_t - S_{t-s}) + (1 - \alpha)(L_{t-1} + \beta_{t-1})$	$L_t = \alpha\left(\frac{Y_t}{S_{t-s}}\right) + (1 - \alpha)(L_{t-1} + \beta_{t-1})$
Trend	$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)(T_{t-1})$	$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)(T_{t-1})$
Seasonality	$S_t = \gamma(X_t - L_{t-1}) + (1 - \gamma)(S_{t-s})$	$S_t = \gamma\left(\frac{Y_t}{L_t}\right) + (1 - \gamma)(S_{t-s})$
Forecast	$F_{t+p} = (L_t + T_t p) + S_{t-s+p}$	$F_{t+p} = (L_t + T_t p) + S_{t-s+p}$

In Table 2,  $L_t$  is the seasonality length, is the series level,  $T_t$  is the trend,  $S_t$  is the seasonal component,  $F_{t+p}$  is the forecast for period  $p$ ,  $Y_t$  is the observed value and  $\alpha$ ,  $\beta$  and  $\gamma$  are parameters exponentials of the level, trend, and seasonality respectively[22].

The best model selection could be estimated using error sizes, such as mean absolute errors (MAE). MAE (Mean Absolute Error) is the average deviation of the absolute value (actual) difference with a predicted (forecasting) value. A forecasting model is considered highly accurate only if the model has the least error rate [23][24].

$$MAE = \frac{1}{n} \sum_{t=1}^n |Y_t - \hat{Y}_t|$$

### 3. Results and Discussions

#### 3.1. Data Analysis

The data used in this study are the data of foreign tourists visit to Riau Islands Province taken from the Riau Islands Provincial Statistics Agency, Riau Islands Province from 2010 to 2018 presented in months [25]. The data analyzed using R programming.

Table 3. The number of foreign tourists visiting Riau Islands (people) Province in 2010-2018

Month	Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jan	114,249	113,975	152,155	25,309	164,430	147,641	143,078	180,813	157,025
Feb.	122,332	130,531	121,521	151,999	137,055	165,508	165,385	134,488	205,965
Mar	126,009	133,620	152,045	169,792	167,030	164,541	167,377	173,371	234,156
Apr	115,581	136,571	136,876	130,193	151,982	163,847	164,834	184,866	194,118
May	127,983	138,896	136,794	149,589	154,299	190,186	172,376	156,772	192,553
June	142,090	164,383	171,524	178,399	190,932	175,348	165,849	180,402	228,394
Jul	131,044	158,971	136,522	128,616	146,590	151,972	138,567	171,032	213,521
Aug	116,681	131,169	143,277	161,739	158,977	184,185	142,055	179,479	236,084
Sept.	113,207	131,981	136,165	147,621	151,855	155,397	156,245	172,161	226,980
Oct	117,562	137,920	146,433	142,701	166,931	156,990	150,689	166,965	205,819
Nov	128,108	144,426	143,858	166,361	161,994	160,476	142,045	173,162	220,938
Dec.	165,407	187,068	190,269	206,747	221,350	221,582	211,732	266,451	319,451

#### 3.2. Additive Time Series and Multiplicative Time Series Methods

Figure 1 below are Additive and Multiplicative Time Series models.

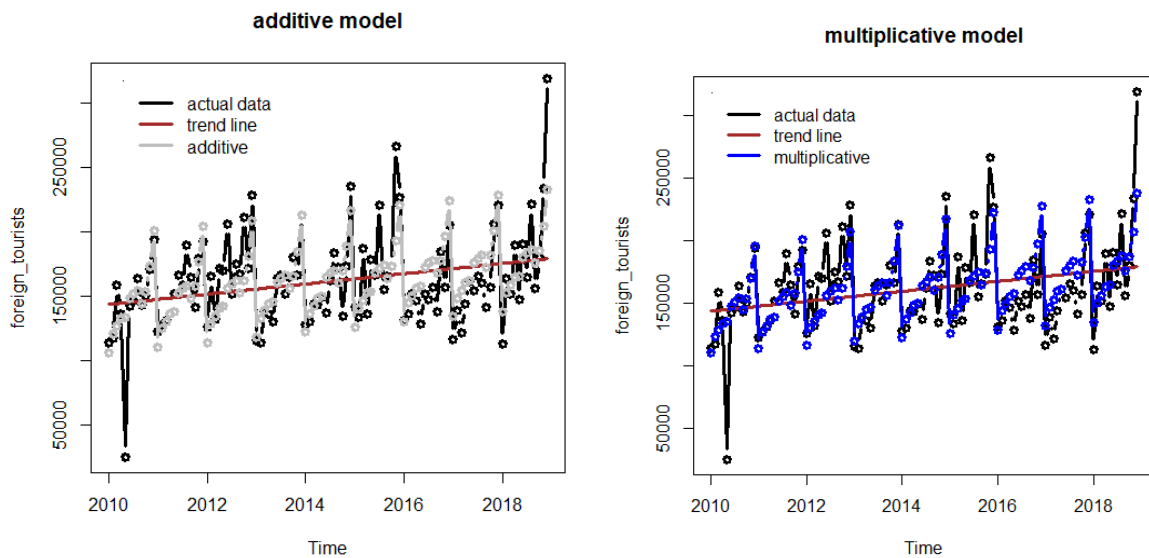


Fig. 1 Additive and multiplicative models fitted to the foreign tourists

#### 3.3. Holt Winters Method

Figure 2 below are the Holt Winter Interactive and Holt Winter Multiplicative models.

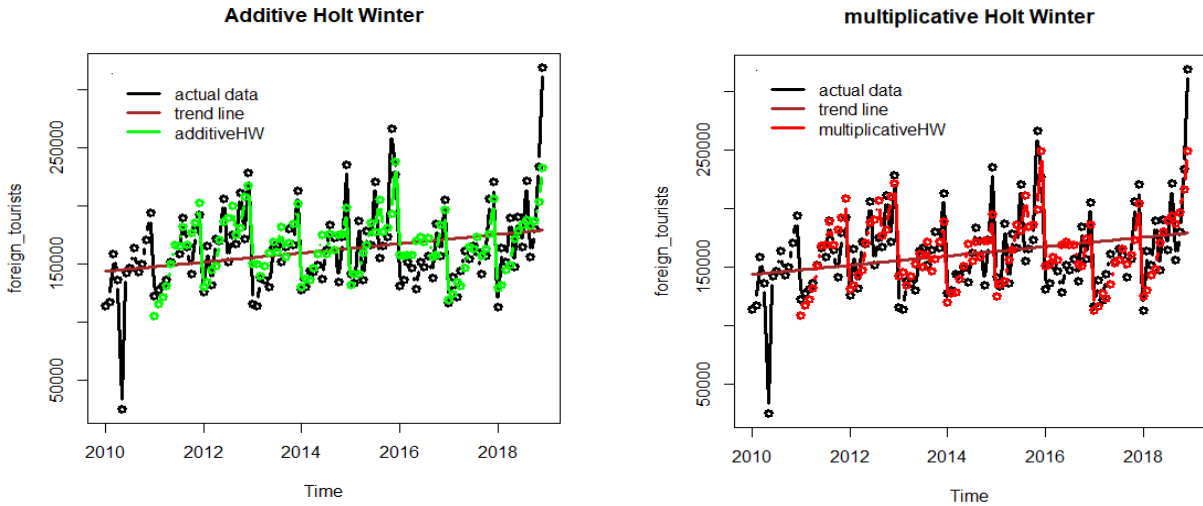


Fig. 2 Holt winter additive and multiplicative models fitted to the foreign tourists

### 3.4. Comparison among Simple Additive, Multiplicative and Holt Winters

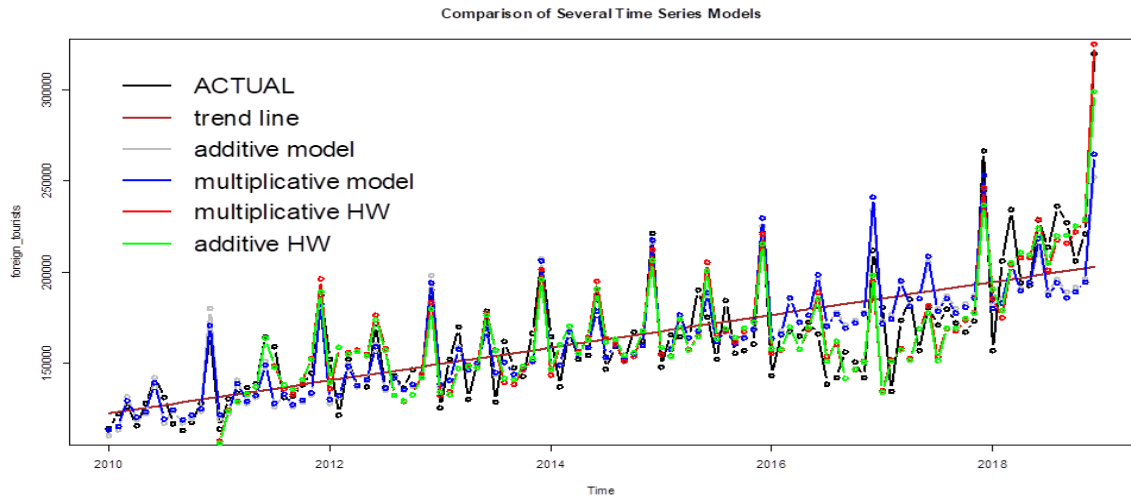


Fig. 3 Comparing the methods

Figures 1 and 2 show that the curve of simple Additive is grey and Simple Multiplicative is blue while that of Holt Winter Additive is green, and Holt Winter Multiplicative model is red. It is clear that the Holt Winter Multiplicative model is closer to the actual data curve.

Moreover, Figure 4 presents that the Holt Winter Multiplicative has the lowest MAE value compared to the other three models.

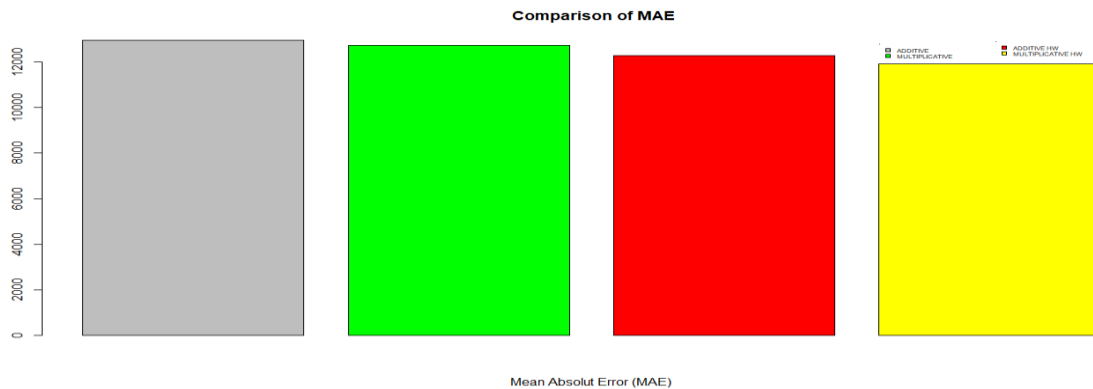


Fig. 4 MAE Comparisons

**Table 4. MAE Comparison**

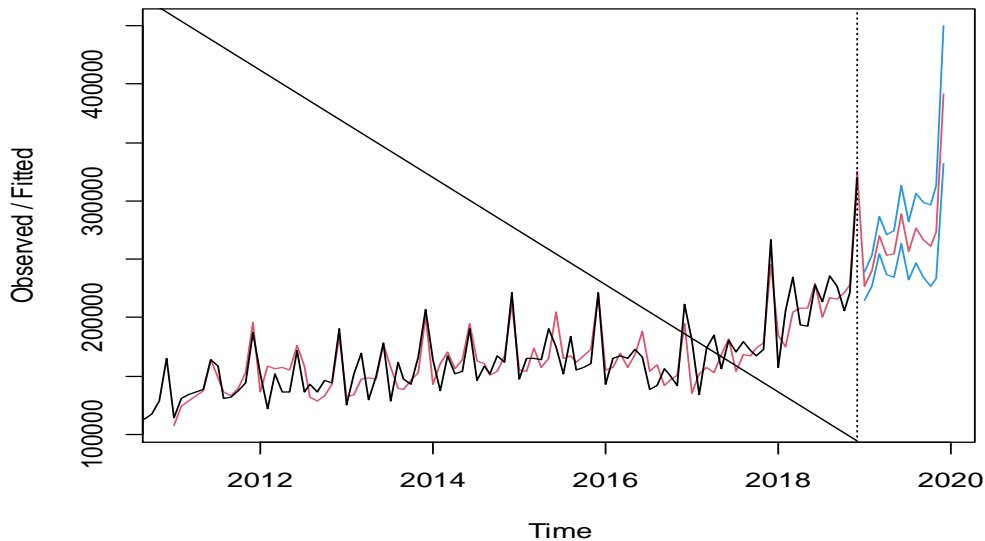
Methods	MAE
Simple Additive	12956.93
Simple Multiplicative	12741.53
Holt Winter Additive	12278.05
Holt Winter Multiplicative	11932.07

Based on the MAE comparisons, the number of incoming foreign tourists to Riau Islands is more properly forecasted by the Holt Winter Multiplicative model. The forecasting results of the Holt Winter Additive model are presented in Table 5.

**Table 5. Prediction result using multiplicative Holt-Winter method**

2019	Actual Data	Forecasting using Holt Winter Multiplicative
<b>January</b>	192856	227073.8
<b>February</b>	233194	239847.9
<b>March</b>	260289	270443.7
<b>April</b>	229250	253900.0
<b>May</b>	225171	254632.3
<b>June</b>	265 904	288427.5
<b>July</b>	217313	257232.0
<b>August</b>	264933	276497.8
<b>September</b>	230576	266843.2
<b>October</b>	227146	261606.4
<b>November</b>	241249	273185.1
<b>December</b>	276914	391162.0

**Forecasting Holt Winters Multiplicative**



**Fig. 5 Forecasting Holt Winter Multiplicative**

#### 4. Conclusion

This paper has analyzed the comparison among additive and multiplicative time Series methods as well as Holt-Winter Interactive and Holt-Winter multiplicative methods and their application to forecasting the total number of foreign tourists visits to Riau Islands Province. The results of the analysis indicated that MAE using the Holt-Winter Multiplicative method has the lowest error value of 11932.07 compared to the other three methods. This indicated that this method is the best forecasting method. The results of the generated sample data using the Holt-Winter Multiplicative method are in line with the actual data of foreign tourists visits during the January 2019 to November 2019 period. However, the actual data on foreign tourist visits to Riau Islands Province experienced a decrease due to Covid-19 pandemic in December 2019.

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