International Journal of Mathematics Trends and Technology
ISSN: 2231-5373/ https://doi.org/10.14445/22315373/IJMTT-V69I10P502

Volume 69 Issue 10, 10-16, October 2023

Original Article

A Comparison of the Decomposition Method and the Holt-Winters Method for Forecasting Tourist Visits in Bali

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Received: 15 August 2023 Revised: 19 September 2023 Accepted: 04 October 2023 Published: 26 October 2023

Abstract *- Bali is a popular destination among domestic and international travellers due to its abundant natural beauty, particularly in tourism. The number of domestic tourists who visited Bali exhibited growth in 2019 but underwent a substantial decrease in 2020 due to the COVID-19 pandemic. Tourism serves as the primary catalyst for economic growth in Bali. This study aims to identify an improved approach to yield precise forecasting outcomes based on available data. The employed techniques encompass the Decomposition and the Holt-Winters methods, which incorporate Additive and Multiplicative models. When comparing the two methods, it is observed that the Holt-Winters Multiplicative method yields the lowest error value for the Mean Absolute Error (MAE), specifically 79866.09, compared to the other ways. The evidence suggests that the Holt-Winters Multiplicative technique outperforms other forecasting methods, as the sample data closely approximates the factual data about the number of trips made by domestic tourists to Bali in 2022. Based on the analysis, it can be inferred that the Holt-Winters Multiplicative method yields more precise outcomes when predicting the volume of domestic tourists in Bali.*

Keywords *- Tourist visits, Decomposition Method, Holt-Winters Method, Forecasting.*

1. Introduction

Indonesia has abundant natural resources throughout various sectors, including agriculture, plantations, manufacturing, mining, and tourism. Salah Wahab asserts that tourism is a nascent business capable of engendering expeditious economic expansion by creating employment opportunities, enhancing living standards, and ameliorating other productive sectors (F. N. Rahma, 2013) [1]. In order to enhance the Indonesian economy, (Yakup in R. Ulfatmi, 2022) [2] asserts that endeavours to augment tourist numbers are undertaken through the implementation of tourism development initiatives.

Bali is a popular destination for local and international tourists, attracting many visitors to Indonesia. Tourism continues to serve as the primary catalyst for Bali's economic growth. The COVID-19 pandemic 2020 has given rise to many worldwide issues, encompassing economic and health service crises. Furthermore, it has exerted an extra influence on other global business sectors, including the tourism industry (J. Abbas, 2021) [3]. The COVID-19 pandemic significantly impacted the tourism and recreation industry in Bali, leading to a decline in domestic tourist numbers—however, the increase in domestic travellers visiting Bali in 2022 shows signs of recovery. Specifically, there was a notable growth of 87.21%, with 8,052,974 domestic tourists recorded. This data demonstrates a notable growth compared to the number of domestic tourists in the year 2021, with an increase of 4,301,592.

The fluctuation in the number of visitors at a tourist site over time is not constant. According to (D. Nurhasanah, 2022) [4], a potential strategy for augmenting domestic tourist visits involves implementing forecasting techniques. Predicting tourist visits involves examining and analyzing patterns in time series data, aiming to estimate future values based on historical and present data (S Herawati and M Latif, 2021) [5]. Forecasting plays a crucial role in the decision-making process. Enhancing the appeal of tourist destinations aligns with predicting outcomes. Forecasting plays a crucial role in the process of decision-making, as the effectiveness of a decision is typically contingent upon several elements (Aswi and Sukarna, 2006, as cited in A. Ramadhani, 2022) [6].

(S. Yuni, 2015) [7] has previously conducted research focusing on using the decomposition method to predict the volume of library patrons at Pattimura University in Ambon. The analysis of seasonal patterns reveals that the expected value for seasonal indications is 100%. The observed results indicate that the number of visitors in the first month is 49% lower than expected. In the second month, visitors were 11% higher than average. The third month shows a 37% increase above the average value. Similarly, the fourth month exhibits a 41% increase above the average value, while the fifth month demonstrates a 60% increase above the average value.

In contrast, the sixth month experienced a 6% decrease below average. The seventh and eighth months show a substantial decline, with visitor numbers 71% and 67% below the average value, respectively. The ninth month also experienced a significant decrease, with visitor numbers being 66% below the average value. However, in the tenth month, there was a notable increase of 47% above the average value. The eleventh month exhibits a similar trend, with visitor numbers being 56% higher than the average value. Finally, in the twelfth month, a marginal increase of 2% is above the average value. The fifth month exhibits the most pronounced seasonal pattern, with a seasonal index of 160%, surpassing the anticipated seasonal index by 60%. In contrast, the seventh, eighth, and ninth months exhibit the lowest seasonal index, registering a value of 29%, which is 71% lower than the anticipated seasonal index.

In addition to employing the decomposition approach, a body of study focuses on forecasting with the Holt-Winters method. The study conducted by (C. T. Noho and R. Fajriyah, 2023) [8], focuses on the analysis of forecasting the number of tourists to the region of DIY with Holt-Winter's Exponential Smoothing technique. The research yielded forecasted results for the upcoming 12 periods from January 2020 to December 2020. The projected figures for each period are as follows: 529923.7, 522733.1, 601414.2, 651816.9, 415661.1, 715964.9, 709304.0, 639275.7, 588622.4, 624689.0, 655746.1, and 800601.8 individuals, respectively. Overall, the forecast findings indicate a rise during multiple time intervals.

This study examines the prediction of domestic tourist trips to Bali by employing the Decomposition and Holt-Winters methods, applying both Additive and Multiplicative models for each method. The most optimal and viable model will be chosen among the four models considered based on calculating the minimum Mean Absolute Error (MAE) value. This selected model will then forecast the number of domestic tourists visiting Bali. Wang Weijie and Lu Minmin [9] examined and analyzed the Mechanical and Aerospace Engineering (MAE) subject in their academic publication 2018. The use of the Decomposition and Holt-Winters methods aims to produce better and optimal forecasting. The forecast results will be serve as a reference for the tourist attractions developement in Bali for the next 5 years.

2. Research Method

2.1. Decomposition Method

The decomposition method, also known as the time series method, is a forecasting technique that relies on the premise that historical patterns tend to repeat themselves. Phenomena that have historically exhibited a consistent pattern of increase will likely continue to do so. Similarly, those phenomena that have typically demonstrated a tendency to decrease would likely continue to exhibit a decreasing trend. Furthermore, phenomena that have traditionally displayed fluctuations are expected to continue fluctuating, while those that have historically shown irregular patterns will likely persist in their irregularity.

The decomposition method is a forecasting technique for predicting time series data that exhibits trend patterns and seasonal impacts (Ibnu Yusuf, 2014) [10]. This methodology is predicated on the premise that events tend to recur or manifest repetitively. Four main factors, namely trend, seasonality, cycle, and unpredictability, impact the decomposition approach and collectively contribute to changes in the data. This projection exclusively employs trend (TC) and seasonality (SN) components. A trend can be identified in a series when a significant upward or downward movement occurs over a significant period. In such cases, the series is said to exhibit both trend and seasonality, wherein the pattern of the series changes periodically at specified intervals. The trend is derived using the regression formula, expressed explicitly as $\widehat{TC_t} = b_0 + b_1 t$ (Elmunim, 2015) [11].

There are two commonly used types of decomposition methods, namely:

1) The Additive Decomposition method assumes that changes in data may be expressed as the sum of the primary factors (Trend and Seasonal). As mathematically represented using the following formula:

$$\widehat{Y_t} = TC_t + SN_t \quad (1)$$

2) The Multiplicative Decomposition method implies that changes in data may be represented as the product of the main elements (Trend and Seasonal). This can be expressed mathematically using the following formula:

$$\hat{Y}_t = TC_t \; x \; SN_t \quad (2)$$

2.2. Holt-winters

The Holt-Winters approach encompasses two primary variations: additive and multiplicative (Adam Aboode, 2013) [12]. The additive method is appropriate when the seasonal component's magnitude remains constant. However, the multiplicative method is deemed suitable when the magnitude of the seasonal component varies with time.

The Holt-Winters additive method for one-step forecasting is described as follows (Rosy, 2017) [13]:

$$\hat{Y}_{t+1|t} = l_t + hb_t + s_{t-m+1} \quad (3)$$

$$l_t = \alpha(y_t + s_{t-m}) + (1-\alpha)(l_{t-1} + b_{t-1}) \quad (4)$$

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \quad (5)$$

$$s_t = \gamma(y_t - l_{t-1} - b_{t-1}) + (1-\gamma)s_{t-m}) \quad (6)$$

Meanwhile, the Holt Winters multiplicative method for one-step forecasting is stated as follows (N. Sibuea, 2022) [14]:

$$\hat{Y}_{t+1|t} = (l_t + hb_t)s_{t-m+1} \quad (7)$$

$$l_t = \alpha(\frac{y_t}{s_{t-m}}) + (1-\alpha)(l_{t-1} + b_{t-1}) \quad (8)$$

$$b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \quad (9)$$

$$s_t = \gamma(\frac{y_t}{l_{t-1} - b_{t-1}}) + (1-\gamma)s_{t-m}) \quad (10)$$

The forecast equation, denoted as $\hat{Y}_{t+1|t}$, represents the predicted value at time $t+1$ based on the estimated level, l_t, at time t. The parameter α is commonly referred to as a smoothing parameter for levels that are constrained within the range of 0 and 1. The variable " b_t" represents the estimated trend at a specific point in time, denoted as " t ". Likewise, the variables α and β represent smoothing parameters that are constrained within the range of 0 to 1, and are used for modelling trends. The seasonal estimate at time t is denoted as s_t, where γ represents the smoothing parameter for the seasonal component. According to (Sukono , 2014) [15], this parameter is only capable of taking values between 0 and 1.

2.3. Mean Absolute Error

(Cort J and Kenji, 2005) [16] and (Scott and Cort, 2023) [17], have identified the Mean Absolute Error (MAE) as a metric for quantifying error. The MAE is calculated using the following formula:

$$MAE = \frac{1}{n}\sum_{t=1}^{n}\left|Y_t - \hat{Y}_t\right| \quad (11)$$

3. Results and Discussion

3.1 Preliminary Data Analysis

The dataset utilised in this study pertains to quantifying domestic tourist arrivals in Bali from 2004 to 2021. The data presented in this study is sourced from the Bali Province Central Statistics Agency (BPS) [18] and reported monthly.

Figure 1 shows the peak of domestic tourist arrivals in Bali in June 2019, with 1,287,877 visitors. Conversely, the lowest number of domestic tourists in Bali was recorded in May 2020, with 10,1948 visitors. The COVID-19 outbreak resulted in a reduction in domestic tourist arrivals to Bali in the year 2020.

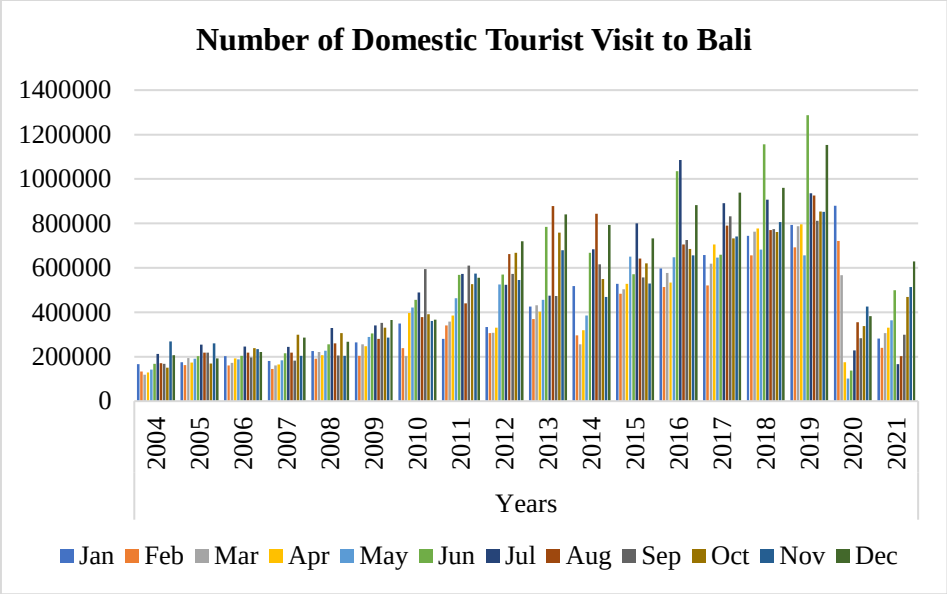

Fig. 1 Number of bali domestic tourist visits

3.2. Decomposition Method

Decomposition methods can be classified into two distinct types, specifically Additive and Multiplicative. Figure 2 illustrates the Additive model and Multiplicative model.

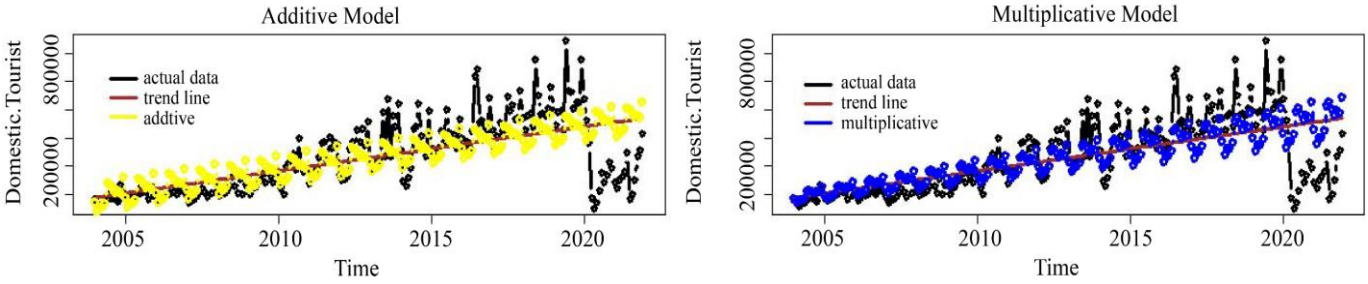

Fig. 2 Additive model and multiplicative model of bali domestic tourist visits

Figure 2 shows the Additive curve in yellow and the Multiplicative curve in blue.

3.3. Holt-Winters Method

The Holt-Winters method comprises two distinct types, specifically Additive and Multiplicative. Figure 3 illustrates the Holt-Winters Additive and Holt-Winters Multiplicative models.

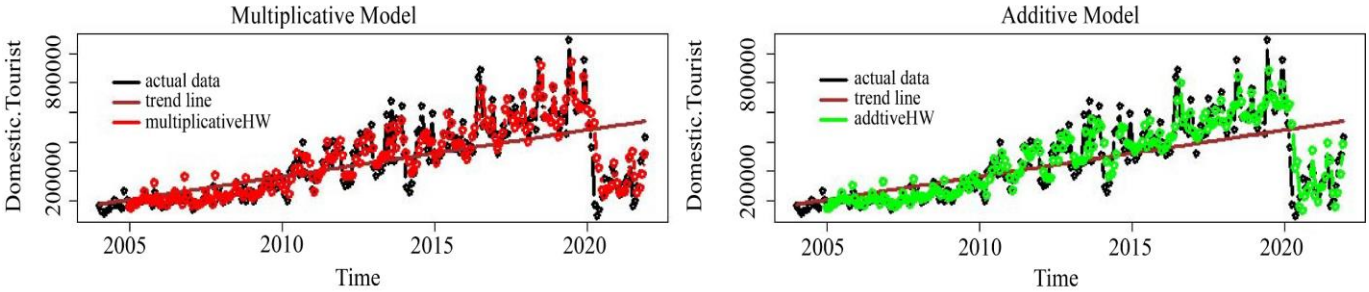

Fig. 3 Additive Holt-Winters model and multiplicative Holt-Winters model of bali domestic tourist visits

Figure 3 shows the Holt-Winters Additive curve in green and the Holt-Winters Multiplicative curve in red.

3.4. Comparison between Decomposition and Holt-Winters

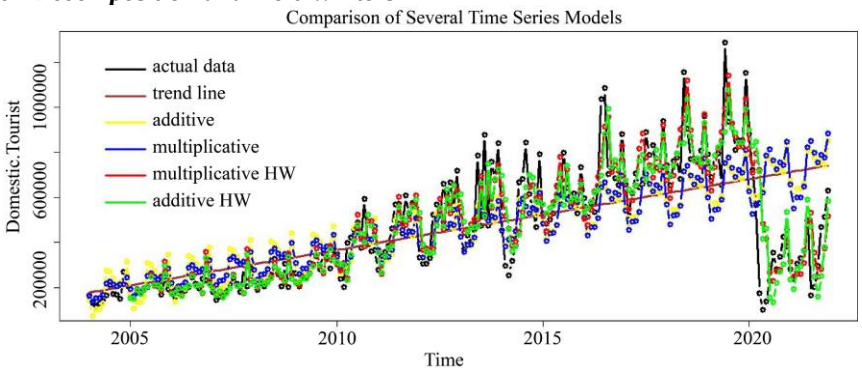

Fig. 4 Comparison of bali domestic tourist visits using the decomposition and Holt-Winters methods

Figure 4 shows the Additive curve represented by the colour yellow, the Multiplicative curve denoted by the colour blue, the Holt-Winters Additive curve depicted in green, and the Holt-Winters Multiplicative curve illustrated in red. Based on the graphical representation, it is evident that the time series data curve generated by applying the Holt-Winters technique exhibits a higher degree of proximity to the actual data curve. Consequently, the Holt-Winters method is more suitable for forecasting domestic tourist trips to Bali. This assertion can be substantiated by examining the juxtaposition of Mean Absolute Error (MAE) values as depicted in Figure 5.

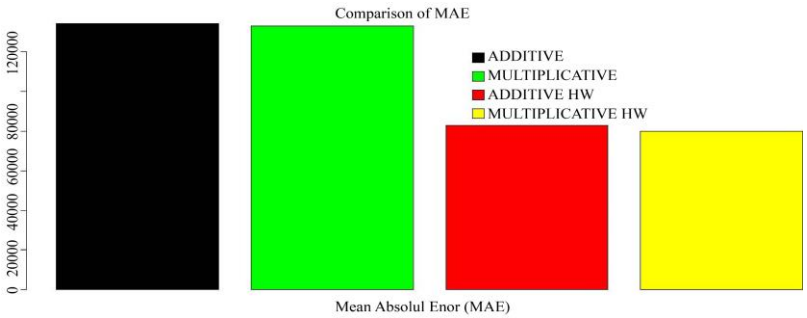

Fig. 5 MAE Comparison

Table 1. Comparison of MAE values

Methods	MAE Value
Additive	134071.58
Multiplicative	132851.28
Holt-Winters Additive	82693.51
Holt-Winters Multiplicative	79866.09

To compare precise MAE values, see Table 1 based on the MAE values that are the minimum for each method. Figure 5 demonstrates that the Holt-Winters method yields the minimum MAE value. Therefore, this procedure will be used for future forecasting.

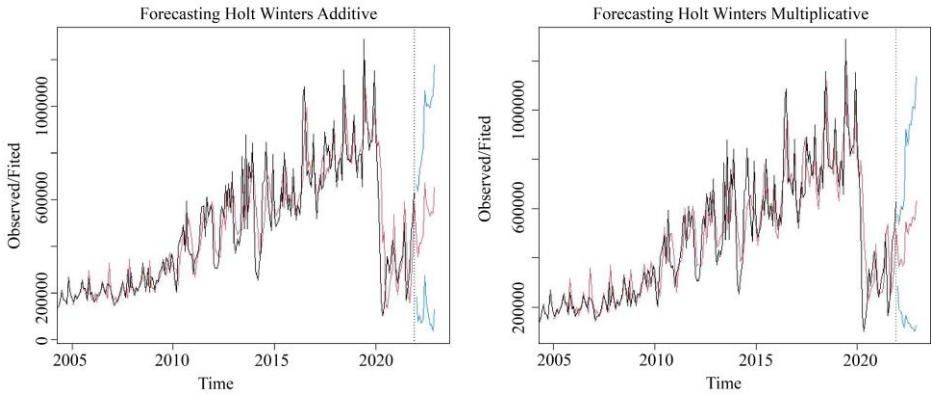

Fig. 6 Holt-Winters method forecasting

Table 2. Comparison of predictions using the Holt-Winters method in 2022

2022	Holt-Winters Additive			Holt-Winters Multiplicative			Actual Data
	Upr	Fit	Lwr	Upr	Fit	Lwr	
Jan	665815.5	425509.1	185202.81	576368.8	430483.9	284598.9	527447
Feb	634343.8	355893.5	77443.27	536314.7	362814.0	189313.2	389690
Mar	725626.7	413662.0	101697.35	609623.2	394535.7	179448.2	547726
Apr	756255.1	414042.6	71830.12	597010.2	366272.2	135534.1	500740
May	825390.2	455394.5	85398.81	641020.4	379377.3	117734.2	960692
Jun	1067084.0	671250.4	275416.83	921886.0	544167.9	166449.8	753907
Jul	999864.6	579779.3	159694.04	859359.5	496720.6	134081.7	784205
Aug	1010253.2	567241.9	124230.57	943021.7	538367.8	133714.0	659567
Sep	993134.9	528326.9	63518.91	940053.3	528886.6	117719.9	622068
Oct	1035396.5	549769.2	64141.94	1014844.0	565213.4	115582.9	718066
Nov	1046249.3	540659.3	35069.26	1005409.8	553296.3	101182.8	657949
Dec	1180290.7	655496.7	130702.77	1138516.8	634389.1	130261.5	930917

The Holt-Winters Multiplicative technique demonstrates superior efficacy in forecasting domestic tourist visits in Bali compared to both the Decomposition and the Holt-Winters Additive methods, as illustrated in Table 2. Table 1 also reveals that the MAE value of the Holt-Winters multiplicative technique is smaller than the Decomposition or Holt-Winters Additive method. Therefore, the multiplicative Holt-Winters method provides more accurate results than other methods.

4. Conclusion

This study compares the Decomposition method and the Holt-Winters approach, employing both Additive and Multiplicative models for each method. The utilization of these two methodologies pertains to predicting domestic tourist arrivals in Bali. When comparing the two ways, it is observed that the Holt-Winters multiplicative method yields the lowest error value for the Mean Absolute Error (MAE), specifically 79866.09, compared to the other methods. The close agreement between the forecasted values and the actual data for domestic tourist visits to Bali in 2022 proves that the Holt-Winters multiplicative method outperforms other forecasting techniques.

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