IJDSEA
International Journal of Data Science Engineering, and Analytics

e-ISSN : 2807-1689
p-ISSN : 2798-9208

Hybrid Holt Winter-Prophet method to forecast the number of foreign tourist arrivals through Bali's Ngurah Rai Airport

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Vol. 3, No 2, Page 21-32.
Received: 20 Nov 2023
Accepted: 23 Nov 2023
Published: 23 Nov 2023

Abstract: The Indonesian is an archipelago rich in culture and natural resources. The Government of Indonesia utilizes this wealth by maximizing the tourism potential to earn sizeable foreign exchange. As a major destination, the Indonesian government needs a strategy to ensure foreign tourists continue to increase in terms of health, cleanliness, a sustainable environment and infrastructure. When we can forecast the number of foreign tourists, it is hoped that the government can establish appropriate policies to develop tourism. Based on this, an appropriate forecasting method is needed. This study will use a hybrid model with the Holt-Winter and the Prophet method. The data used is the number of foreign tourists to Bali through Ngurah Rai Airport from January 2009 to December 2019. This study will use stages based on the OSEMN Framework. These stages are Obtain, Scrub, Explore, Model, and Interpret. The result of this study is that the MAPE value for the Hybrid Method is 2.5880%. This result means the Hybrid Holt Winter-Prophet is better than the Holt Winter Method.

Keywords: Forecasting, Hybrid Model, MAPE, OSEMN Framework.

1. Introduction

The Indonesian is an archipelago that is rich in culture and natural resources [1]. The Government of Indonesia utilizes this wealth by maximizing the tourism potential to earn sizeable foreign exchange [2]. The tourism potential in the province or city can be seen from the number of visits by foreign tourists who enter via land, air or sea[3]. In 2019, the government, through the Ministry of Tourism and Creative Economy, targeted the number of foreign tourists at 20 million people [4]. Therefore, tourism is one of the sectors the government prioritizes [5].

The Indonesian government has implemented several policies to help the tourism sector develop. 2011, the Ministry of Tourism issued Government Regulation Number 50 2011 concerning Indonesian tourism development. This policy was created to prioritize tourism development in Bali [5]. As a major destination, the Indonesian government needs a strategy to ensure foreign tourists continue to increase in terms of health, cleanliness, a sustainable environment and infrastructure [6]. In determining these strategies, the government looks at the number of foreign tourists visiting Bali as an indicator of readiness to welcome them [7]. When we can forecast the number of foreign tourists, it is hoped that the government can establish appropriate policies to develop tourism, especially on the island of Bali. Based on this, an appropriate forecasting method is needed.

2. Related Works

In the forecasting concept, if we need the results to be close to the actual data, then we need a method that can capture the time series pattern, which consists of trend, seasonal, and noise [8]. Based on a study from Putu et al. [9], data on the number of foreign tourist visits has a seasonal pattern, which tends to increase in July or August. Therefore, the method used should be able to capture seasonal patterns in the data. One of these methods is the Holt-Winter method[10]. This method was used to forecast the number of foreign tourist visits in Bali using data from January 2015 to April 2018 by Hadiriyanto et al. This study compared the Holt-Winter Method with ARIMA. As a result, the Holt-Winter method can better capture seasonal patterns than the ARIMA method [11].

Although the Holt-Winter method can capture seasonal patterns, it only captures linearity [12]. Linearity is difficult to happen because many influences in the data are unknown [13]. So, we need a method that can not only capture linear patterns but also non-linear ones. One way to do this is to use a hybrid model. This model will combine strategies that can capture the linearity of the data and methods that can capture the non-linearity of the data. A previous study of a hybrid model to predict the number of foreign tourist visits to Bali was carried out by M. Al Haris et al [12] using the Holt Winter-Artificial Neural Network methods. The study results show that the hybrid model produces higher forecasting than the Holt-Winter model.

Based on this, we will use another Hybrid model to forecast the number of foreign tourist visits to Bali via Ngurah Rai Airport. Suppose the previous study combined Holt-Winter and Artificial Neural Network. In that case, this study will combine the Holt-Winter and the Prophet method, which can capture non-linearity patterns in the data. This method was first released by Facebook in 2017 [14]. The use of a hybrid model with the Holt-Winter method and the Prophet method has never been carried out by previous research, so it is hoped that this hybrid model can increase forecasting accuracy compared to Holt-Winter and Artificial Neural Network.

3. Methods and Methodology

In this section, we will discuss the concepts of the methods used for the study and their formulation

3.1. Holt-Winter Method

The Holt-Winter method was first introduced in 1960 by Winters [10], which consists of three smoothing equations containing Level, Trend and Seasonality parameters. Taylor [15] and Taylor [16] later refined the technique submitted by Winters, resulting in double and triple Seasonal Holt-Winter. The improvement made by Taylor is that the method can divide several seasons with different lengths. Apart from that, it can also adjust forecasts and first autocorrelation errors. The Holt-Winter method has two different types, which can be used to change the time series data pattern. There are two Holt-Winter types: Addictive and Multiplicative [10]. The following is the formula for the Holt-Winter equation of Addictive type at time t [17]:

$$\hat{x}_{t+h|t} = l_t + hT_t + S_{t+h-m(k+1)} \tag{1}$$

In Equation (1) l_t is the smoothing Equation for the level which has the formula $l_t = \alpha(x_t - s_{t-m}) + (1-\alpha)(l_{t-1} + T_{t-1})$. h is the number of steps forward from any arbitrary step t. T_t is the smoothing Equation for the trend, which has the formula $T_t = \beta(l_t - l_{t-1}) + (1-\beta)T_{t-1}$. $S_{t+h-m(k+1)}$ is the smoothing Equation for the trend, which has the formula $S_t = \gamma(x_t - l_{t-1} -$

$T_{t-1}) + (1-\gamma)S_{t-m}$. $\alpha, \beta,$ and γ are parameters for level, trend, and seasonal with $0 \leq \alpha, \beta, \gamma \leq 1$. k is the integer part of $\frac{(h-1)}{m}$, where m is the period in the time series data.

Meanwhile, the formula for the Holt-Winter equation of the Multiplicative type at time t is as follows

$$\hat{x}_{t+h|t} = l_t S_{t+h-m(k+1)} + hT_t S_{t+h-m(k+1)} \tag{2}$$

In Equation (2), l_t is the smoothing Equation for the level which has the formula $l_t = \alpha \frac{x_t}{S_{t-m}} + (1-\alpha)(l_{t-1} + T_{t-1})$. T_t is the smoothing Equation for the trend, which has the formula $T_t = \beta(l_t - l_{t-1}) + (1-\beta)T_{t-1}$. $S_{t+h-m(k+1)}$ is the smoothing equation for trend which has formula $S_t = \gamma \frac{x_t}{(l_{t-1}+T_{t-1})} + (1-\gamma)S_{t-m}$.

3.2. Prophet Method

The Prophet method was first released by Facebook in 2017 [14], where this method can capture the separation of seasonal patterns between holidays and Sundays. This method has three main components, namely upward or downward trend patterns, seasonal patterns, and holiday patterns. The Equation that explains the three components is as follows [13]:

$$Y_t = g_t + S_t + H_t + \varepsilon_t \tag{3}$$

Where g_t describes a non-linear upward or downward trend pattern, S_t describes a seasonal pattern, H_t describes a holiday pattern, and ε_t is an error that describes irregular changes the model may not capture.

3.3. Hybrid Method

The Hybrid method is a combination method of statistics and machine learning that interact with each other. This method was first introduced by Zhang P [18], combining the ARIMA and Neural Network models. This combination makes sense because time series data naturally consists of a linear autocorrelation structure and non-linear components. In general, the Equation for the Hybrid method is

$$Y_t = L_t + n_t \tag{4}$$

Where $L_t$shows a linear and n_t shows a non-linear pattern. In this research, the Holt-Winter method will capture linear patterns. So, the residual from Holt-Winter will establish a non-linear relationship [19]. Then, the Prophet method will use the residual as input, which will be used for forecasting to produce$\hat{n}_t$. The results of the hybrid forecasting method are the sum of the effects of linear forecasting using Holt-Winter with the results of non-linear forecasting using the Prophet method. The final result of the Hybrid method is

$$\hat{Y}_t = \hat{L}_t + \hat{n}_t \tag{5}$$

3.4. Model Evaluation

You can use the best model selection criteria to choose the appropriate method to forecast the number of foreign tourists to Bali. The criteria used in this study is MAPE or Mean Average Percentage Error [20]. The formula for MAPE is

$$MAPE = \left(\frac{1}{n} \sum_{i=1}^{n} \left| \frac{\varepsilon_i}{Y_i} \right| \right) \times 100\% \tag{6}$$

In Equation (6), ε_i the residual value is the difference between the actual and predicted values Y_i is the actual value of the data, and n is the amount of data. According to Trimono et al [21], if it has a MAPE value of less than 10%, it means that the forecasting results are said to be very accurate, while the forecasting results are said to be good if it has a MAPE value of 10% to 20%.

3.4. Data Source

The data used in this study is the number of foreign tourists to Bali through Ngurah Rai Airport from January 2009 to December 2019. Data from 2020 to 2022 was not taken because, in 2020 and 2021, there were several months when there were no foreign tourists in Bali. This study focuses on finding methods to increase forecasting accuracy under normal conditions. The data comes from "Badan Pusat Statistik" on the BPS Bali website pages.

3.4. Methodological Description

This study will use stages based on the OSEMN Framework [22], which are as follows

1. **Obtaining** is a stage in obtaining data. The way to carry out this stage is to download the .xlsx format data on the number of foreign tourists who visited Bali from 2009 to 2019.
2. **Scrub** is a stage in cleaning, filtering or extracting the forecasting data obtained. The steps to perform Scrub are
   a. Because the data obtained is the number of foreign tourists who visited Bali via Tanjung Benoa Harbor and Ngurah Rai Airport, we first filtered the data for those who only visited Bali via Ngurah Rai Airport.
   b. We are combining separate data for each year into one variable.
   c. Create a date index so that it becomes time series data.
3. **Explore** is the stage for getting to know the data to be researched. At this stage, we will create data visualizations to identify data patterns. This stage aims to give us the intuition to conduct further forecasting analysis.
4. **Model** is the data modelling stage used to forecast. Before doing Hybrid modelling, first, do Holt-Winter modelling with the following steps:
   a. Divide data into training data and testing data. The training data used is from January 2009 to December 2018, while the testing data used is from January 2019 to December 2019.
   b. Create a Holt-Winter model with several types, namely addictive and multiplicative trend types and addictive and multiplicative seasonal types.

   The next step is to use the Hybrid method using the residual values from the best Holt-Winter model. The steps for the Hybrid method are as follows.
   a. Create a Prophet model using residual testing data from the best Holt-Winter model.
   b. Get forecasting results from the prophet model.
   c. Adding up the best Holt-Winter method forecasting results with the residual forecasting results of the Prophet model to become the final forecasting result
5. **Interpret** is a stage in interpreting the model. This stage will be divided into two stages: interpretation of the Holt-Winter model and interpretation of the Hybrid model. In the Holt-Winter model, interpretation is carried out by identifying the best Holt-Winter model that can be used for the Hybrid method by selecting the smallest MAPE in the testing data. Then, after getting the best model, the residuals from the testing data will be searched for modeling in the Hybrid model. Next, at the hybrid model interpretation stage, the final forecasting results are evaluated to find the MAPE value and compared with the Holt-Winter model evaluation results. We will also compare the visualization of forecasting results using the Holt-Winter model alone with the visualization of forecasting results using the Hybrid Holt-Winter-Prophet model.

4. Results

4.1 Obtain and Scrub

The number of foreign tourists visiting Bali via Ngurah Rai Airport was collected from several files from the Bali Province BPS website. The data structure obtained is

Table 1. Data of The Number of Foreign Tourists Via Ngurah Rai Airport

No	Month	Year	The number of foreign tourists
1	January	2009	173867
2	February	2009	146115
3	March	2009	167954
4	April	2009	188189
5	May	2009	190638
⋮	⋮	⋮	⋮
132	December	2019	451708

Before analyzing using the forecasting method, the Month and Year columns in Table 1 are changed to datetime variables, which are then changed again to indexes to be visualized. The following is a new data structure that is ready to be used to perform time series analysis:

Table 2. Data Time Series of The Number of Foreign Tourists

No	Date	The number of foreign tourists
1	2009 – 01 – 01	173867
2	2009 – 02 – 01	146115
3	2009 – 03 – 01	167954
4	2009 – 04– 01	188189
5	2009 – 05– 01	190638
⋮	⋮	⋮
132	2019 – 12 – 01	451708

4.2 Explore

A time series visualization of the number of foreign tourists visiting Bali via Ngurah Rai Airport can be seen in Figure 1.

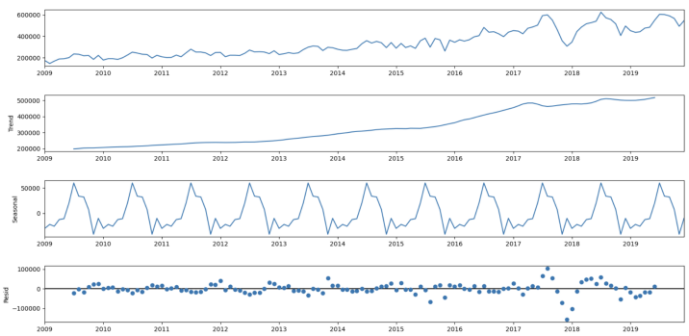

Figure 1. Decomposition of Time Series Plot

The figure shows that the data is increasing yearly, identifying it as having a trend pattern. Apart from that, the seasonal plot shows that each particular period has the same pattern, so it can be said that the data also has a seasonal pattern. Initially, the residual points are around 0 *in the residual plot*, which means that data variability is quite low. However, in the data after 2017, the residuals fluctuate away from 0, which means that the variability in the data is quite high, or it is suspected that the time series data is non-linear. Based on this, a forecasting method is needed to capture trend, seasonal, and non-linear patterns.

Figure 1 is unclear which month has the highest average number of foreign tourists. Therefore, a plot is needed so that the government is alert to the arrival of the largest number of foreign tourists in that month. The following is a plot that can illustrate this:

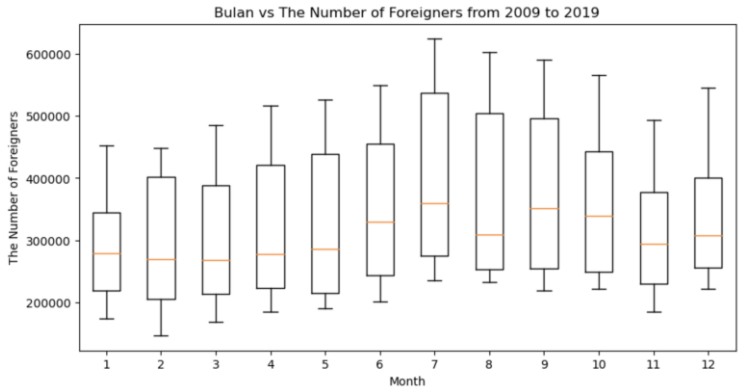

Figure 2. Plot Average of The Number of Foreigners From 2009 to 2019

Figure 2 shows that, on average, throughout the month, the highest number of foreign tourists visiting Bali via Ngurah Rai Airport is in July compared to other months.

4.3. Model and Interpretation

This section will be divided into three stages. The first is modelling and interpreting the Holt-Winter model. The second is modelling and interpreting the Hybrid Holt Winter-Prophet method, and the third is visually comparing the MAPE value. It is from the Holt-Winter model and the Hybrid model.

4.3.1. Modeling and Interpretation of the Holt Winter Model

At this stage, Holt-Winter modelling uses several scenarios to produce parameters and MAPE, as seen in Table 3.

Table 3. Parameters and MAPE of Holt Winter Model

Trend	Seasonal	α	β	γ	MAPE
Addictive	Addictive	0,8889	0,0001	0,0247	7,8126%
Addictive	Multiplicative	0,8182	0,0001	0,0303	246,11%
Multiplicative	Addictive	0,8889	0,0001	0,0247	6,0350%
Multiplicative	Multiplicative	0,8182	0,0001	0,0303	4,7910%

Table 3 shows that the best Holt Winter model for forecasting the number of foreign tourist visits to Bali via Ngurah Rai Airport is the Holt Winter modelling with multiplicative trend and multiplicative seasonality. It is because this modelling has the smallest MAPE value of 4.7910%, which means the forecasting results are said to be very accurate. However, using the Hybrid model, we

will try to reduce the MAPE value from the best Holt Winter forecast results. The following are the results of forecasting testing data for 2019 using the best model:

Table 4. The Results of The Best Holt Winter Forecast

Month	$\hat{L}_t$
January	450946.6779
February	441447.0740
March	445112.3561
April	454479.6582
May	454051.0782
June	507845.4492
July	578727.5951
August	547887.4105
September	540101.7547
October	524554.2338
November	465327.0644
December	531575.2760

Table 4 shows the results of forecasting data on the highest number of foreign tourist visits to Bali via Ngurah Rai Airport in July 2019. The result is 578727.5951 or 579 thousand people. This Forecasting is not yet close to the actual value in July of 604310 or 604 thousand people

4.3.2. Modeling and Interpretation of the Hybrid Model

Hybrid Holt Winter and Prophet modelling used residuals from the best Holt Winter. The residual results are then modelled using the Prophet method to produce a predicted value. The residual results of testing and forecasting data using the Prophet method in 2019 are

Table 5. The Residual and Forecasting using The Prophet Method

Month	Residual	$\hat{n}_t$
January	761.3221	6812.5221
February	−5181.0740	10162.1251
March	−3405.3561	13187.5729
April	21624.3418	16537.1759
May	29876.9218	19778.7271
June	41637.5508	23128.3300
July	25582.2453	26369.8813
August	54569.5895	29719.4843
September	49882.24532	33069.0872
October	41411.7662	36310.6385
November	27576.9356	39660.2414
December	13150.7240	42901.7927

From Table 5, you will get the final forecasting results by adding up the best Holt-Winter method forecasting results with the residual forecasting results of the Prophet model. The result is

Table 6. The result of Hybrid Forecasting

Month	$\hat{L}_t$	$\hat{n}_t$	$\hat{Y}_t = \hat{L}_t + \hat{n}_t$
January	450946.6779	6812.5221	457759.2000
February	441447.0740	10162.1251	451609.1991
March	445112.3561	13187.5729	458299.9290
April	454479.6582	16537.1759	471016.8341
May	454051.0782	19778.7271	473829.8053
June	507845.4492	23128.3300	530973.7793
July	578727.5951	26369.8813	605097.4764
August	547887.4105	29719.4843	577606.8948
September	540101.7547	33069.0872	573170.8419
October	524554.2338	36310.6385	560864.8723
November	465327.0644	39660.2414	504987.3058
December	531575.2760	42901.7927	574477.0687

Table 6 shows the results of forecasting data on the number of foreign tourist visits to Bali via Ngurah Rai Airport in 2019 was highest in July. The result is 605097.4764 or 605 thousand people. This forecast is almost close to the actual value in July of 604310 or 604 thousand people.

4.3.3. Comparison of the Holt Winter Method with the Hybrid Method

The Holt-Winter and Hybrid Method can be compared based on MAPE values and visualization between actual and predicted data. The results of the MAPE values obtained by each method are

Table 7. MAPE From Holt Winter and Hybrid Methods

Methods	MAPE
Holt Winter	6,0350%
Hybrid Holt Winter-Prophet	2,5880%

Table 7 shows that the MAPE value for the Hybrid Method is 2.5880%. It means that the MAPE value of this method is smaller than the only Holt Winter method. Therefore, the Hybrid Holt Winter-Prophet method can better forecast the number of foreign tourists visiting Bali via Ngurah Rai Airport than the Holt Winter method. The MAPE results align with the visualization between the actual and predicted values of the Holt-Winter method and the Hybrid Holt Winter-Prophet method, as seen in Figure 3. These figures show that the Hybrid Holt Winter-Prophet (b) method is better because it has an insignificant difference between the actual and predicted data.

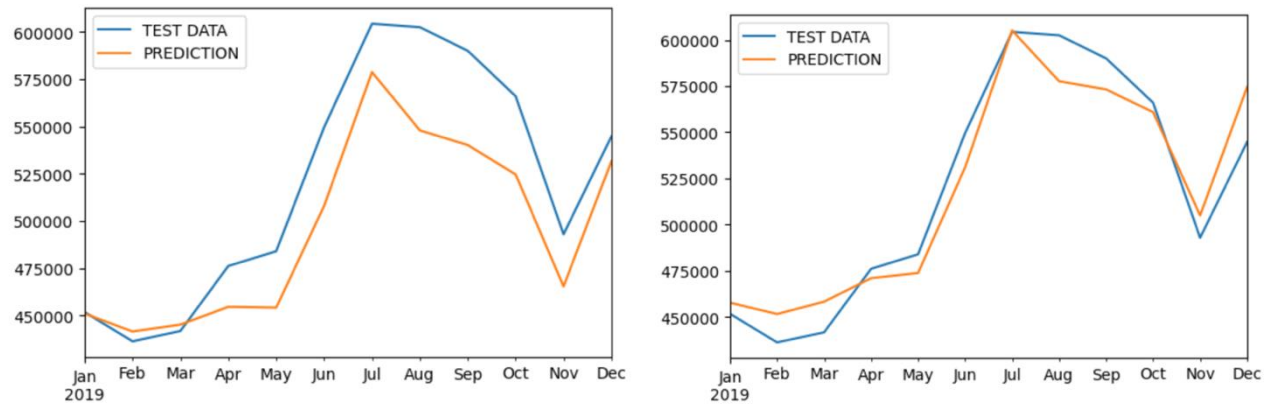

Figure 3. The Visualization of Data Testing and Prediction from (a) the Holt Winter Method and (b) the Hybrid Holt Winter-Prophet Method.

5. Conclusions

The results show that the Hybrid Holt Winter-Prophet method can predict the number of tourists visiting Bali via Ngurah Rai Airport better than the Holt Winter. This method is because it has the smallest MAPE value and a visualization of predicted values closer to the actual values.

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