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OPTIMIZING FORECASTING STRATEGIES: EVALUATING HOLT-WINTERS MODELS FOR HOTEL RESERVATION TRENDS

Arjola SINANI[1], Majlinda GODOLJA[2*]

[1] *University of Tirana, Faculty of Economy, Tirana, Albania, arjola_sinani.festudentdr@unitir.edu.al*
[2] *University of Tirana, Faculty of Economy, Tirana, Albania, majlinda.godolja@unitir.edu.al*

Abstract: *This study undertakes the task of forecasting seasonal time series data, employing Holt-Winters' multiplicative and additive forecasting models. The dataset under scrutiny comprises historical records detailing the daily count of reservations alongside corresponding prices across various room categories in a Vlora-based hotel in Albania, spanning the years 2021 to 2023, post the COVID-19 pandemic. The data originates from the hotel's internal records. Through the utilization of Holt-Winters exponential smoothing techniques, this study discerns distinct trend and seasonal patterns within the daily reservation counts for each room category during the aforementioned period. The process involves establishing initial values and smoothing parameters, crucial for unveiling these patterns. The primary aim is to identify the most effective forecasting method for both the reservation counts across room categories and the price fluctuations. Additionally, an analysis is conducted to compare the influx of foreign citizens arriving in Albania with the consequent impact on increased reservations and pricing within the hotel structure. The central focus of this study is to ascertain the optimal approach while determining the superior methodology for handling such forecasts. Through this comparative analysis, the research seeks to delineate the most favorable approach amidst varied methodologies.*

Keywords: *Holt-Winters Models, Dynamic Pricing, Exponential Smoothing*

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1. Introduction

In different countries around the world, the tourism industry holds significant importance as the primary factor in driving local income growth, economic changes, and social transformations. (Roman & Niedziółka, 2020) presents the spatial diversity of tourism in the countries of the European Union (EU). Tourism contributes to the economic development of regions, creates job opportunities, and aids in infrastructure development. Additionally, tourism promotes cultural exchange, fosters community development, and enhances the quality of life in the region.

*Corresponding author
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It is possible to predict changes in the number of tourists if the data from current and previous tourist demand is carefully analyzed. This can facilitate promotion in the tourism sector. In a study by (Goh & Law, 2002) SARIMA (seasonal ARIMA) and MARIMA (multivariable ARIMA) time series models were used to forecast tourism demand in Hong Kong. The application of these models provided a higher level of accuracy compared to othertime-seriess models.

The hotel industry depends on revenue management, which maximizes profits and ensures satisfactory prices for customers. Forecasting is an important element in revenue management. Time series analysis is a statistical technique that involves the periodic collection of data for a certain period, such as hours, days, weeks, months, quarters, etc (Gujarati & Porter, 2009). Forecasting demand is an essential aspect of hotel revenue management, with the goal of optimizing revenue by aligning demand with available capacity. When it comes to short-term forecasting for hotels, advance booking information plays a vital role. Hotel guests often request reservations well in advance, ranging from days to weeks or even months before their intended stay. These reservation profiles are maintained by hotels for each calendar day, providing valuable partial data until the actual stay (Lee, 2018).

Accurate forecasts for available hotel data are the basis of important decisions about hotel structures. A special concern for academics and industry practitioners has been the improvement of the accuracy of tourism demand forecasts. Song and Gang (2021) focuses on forecasting tourist demand during the period of COVID 19. Zhang and Lu (2022) focuses on optimizing the forecasting of demand for hotel rooms in Hong Kong, taking into consideration the impacts of the pandemic. The study by Phumchusri and Suwatanapongched (2023) utilized various prediction models to forecast the daily demand of a hotel in Phuket, Thailand. The models employed include Holt-Winters, Box-Jenkins, Box-Cox Transformations, ARMA Errors, the Multiplicative Seasonal Trend (BATS) model, the Trigonometric BATS (TBATS) model, the Artificial Neural Network (ANN), and Support Vector Regression. In the study, these models were analyzed and compared to determine which one provided the best results for forecasting the hotel's daily demand.

In recent years, forecasting methods within the hospitality sector have undergone significant evolution, moved beyond traditional models and focusing on enhancing accuracy through more advanced approaches. Numerous studies are investigating the comparative effectiveness of various time series models, such as the Holt-Winters model, which continues to have widespread applicability due to its adaptability to seasonal variations and trends. The study (Lima et al., 2019) employed exponential smoothing methods, such as Holt-Winters, to predict demand in boutique hotels, emphasizing the necessity of tailoring smoothing parameters to the specific characteristics of local data.

In the context of advancements in demand forecasting, hybrid models that integrate traditional methodologies with deep learning techniques have shown promising results in capturing complex demand patterns. A study conducted by Wu et al. (2020) has realized this integration by combining the ARIMA model with deep structures such as Long Short-Term Memory (LSTM) for forecasting tourism in various sectors, where seasonality and variations are pronounced. The findings of this study emphasize the potential of hybrid models, but also appreciate that traditional methods like Holt-Winters modeling offer adequate performance in cases where the data exhibit a stable seasonality. This reinforces the relevance of our selected models in scenarios where structured seasonality is evident.

Recent studies have placed a particular emphasis on the practical applications of forecasting models. (Kaya et al., 2021) conducted a study that examined multiplicative and additive models for predicting room demand in luxury hotels, emphasizing the significance of context in choosing the most suitable methodology. Machinetudies suggest that, although advanced machine learning models are gaining popularity, the application of the Holt-Winters model remains valid and effective in scenarios where seasonality and trends are predictable, as demonstrated in our analysis.

The number of tourists in Albania during the last few years shows an increasing trend. In the south of Albania, there is Vlora, a coastal city that lies between the Adriatic and Ionian seas. The city of Vlora is one of the oldest cities in Albania and is known as one of the pearls of the south. Due to its natural beauty and historical elements, this city has had a great development in tourism in recent years. This development has increased the demand for accommodation in hotel structures in the city. The case studied is one of the hotels that operates its activity in one of the most attractive areas of the city, 200 m from the sea. The information being analyzed in this research consists of historical data that documents the number of reservations and prices for various types of rooms on a daily basis. It consisted of 27 rooms in 2021 and increased its capacity to 40 rooms in 2023. This hotel consists of 4 types of rooms: suite, standard suite, junior suite, and deluxe suite. For the prediction of the number of reservations and the prices of the hotel rooms under study within a certain time frame, only the daily data of the previous years is needed, and it is required to determine the appropriate method for this grouping of data. The result of this work could suggest to the hotel manager a reliable method of forecasting the daily demand for hotel rooms in total and in each category.

In the following, this paper is organized as follows: Section 2 summarizes a literature review; Section 3 presents the two forecasting models for the daily demand of the hotel under study; and Section 4 presents the results and discussion about the comparison of the models and identifies the best forecasting model. In the last section, the paper presents the conclusions and suggestions for future research.

2. Research methodology

The methodology used in this study is organized into four main steps, data collection, analysis and data utilization, comparison of prediction results and interpretation of findings and recommendations

This study utilizes historical data from the hotel's internal database to analyze the daily number of reservations and prices for various room types. The data spans from 2021 to 2023, enabling a thorough examination of reservation trends and seasonal patterns. To achieve accurate predictions, widely recognized forecasting models such as Holt Winters exponential smoothing additive and multiplicative methods are applied. In this study, data analysis is done using the statistical software R.

This study aims to compare the accuracy of predictions made by two methods: additive and multiplicative Holt-Winters exponential smoothing methods. The Holt-Winters exponential smoothing method involves a forecast equation and three smoothing equations: one for the level (L), one for the trend (b), and one for the seasonal component (S). These equations utilize smoothing parameters (alpha, beta, and gamma) to adjust the level, trend, and seasonal component, respectively. By examining the errors in the forecasted values by both methods, we can ascertain which technique yields the most dependable predictions (Pisol & Harun, 2023).

The Additive Holt Winters Exponential Smoothing Method

Level: $L_t = \propto (Y_t - S_{t-k}) + (1 - \propto)(L_{t-1} - T_{t-1})$ (1)

Trend: $T_t = \beta(Y_t - L_t) + (1 - \beta)T_{t-1}$ (2)

Seasonality: $S_t = \gamma(Y_t - L_t) + (1 - \gamma)S_{t-k}$ (3)

Forecast: $F_{t+m} = L_t + mT_t + S_{t-k+m}$ (4)

The Multiplicative Holt Winters Exponential Smoothing Method

Level: $L_t = \propto (Y_t / S_{t-k}) + (1 - \propto)(L_{t-1} + T_{t-1})$ (5)

Trend: $T_t = \beta(Y_t / L_t) + (1 - \beta)T_{t-1}$ (6)

Seasonality: $S_t = \gamma(Y_t - L_t) + (1-\gamma)S_{t-k}$ (7)

Forecast: $F_{t+m} = (L_t + mT_t)S_{t-k+m}$ (8)

In the evaluation of prediction models, smoothing parameters play a crucial role. Trend smoothing involves obtaining smoothed estimates for the level and the change in trend value at time t, while seasonal components are estimated for forecasting in the upcoming period. Model performance evaluation is an inseparable step in the development of prediction models. The prediction error, which shows the difference between predicted and actual values, is a key factor in this assessment. To measure this error, we use RMSE, MAE, and MAPE. RMSE and MAE take into account the magnitude of errors, while MAPE provides a percentage-based evaluation. By utilizing formulas, we can calculate RMSE, MAE, and MAPE for assessing the performance of the model (Andariesta & Wasesa, 2022).

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(F_t - Y_t)^2} \quad (9)$$

$$MAE = \frac{1}{n}\sum_{t=1}^{n}|F_t - Y_t| \quad (10)$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{F_t - Y_t}{F_t}\right| \times 100\% \quad (11)$$

3. Dataset and results

The dataset used in this study consists of daily demand observations for a prominent hotel located in the city of Vlora, situated in the southern region of Albania. The data spans from June 20, 2021, to April 30, 2023. To evaluate the performance of two different forecasting models, we divide the dataset into two segments. One segment was utilized for fitting the models, while the other segment was reserved for testing the models' out-of-sample performance.

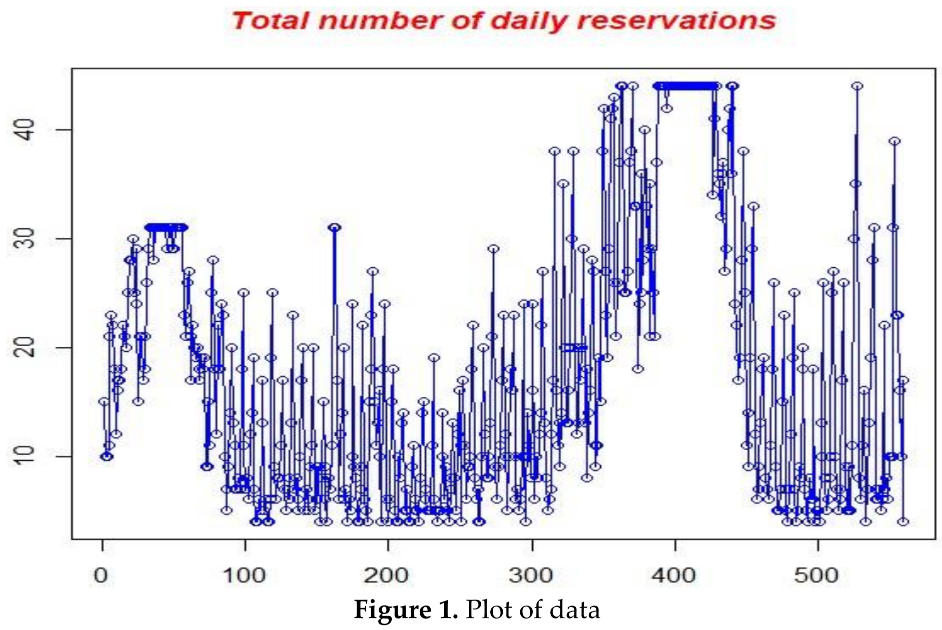
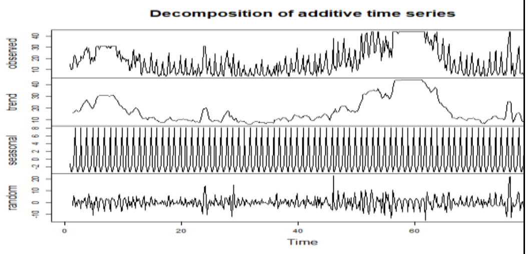
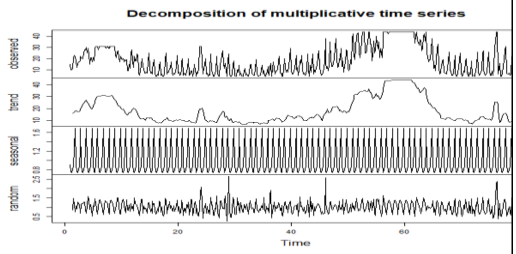
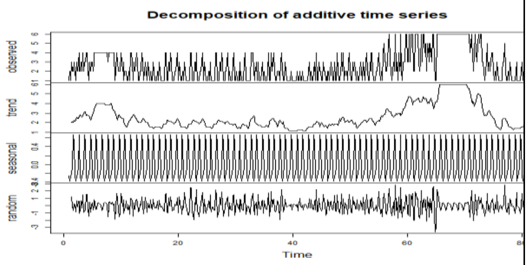
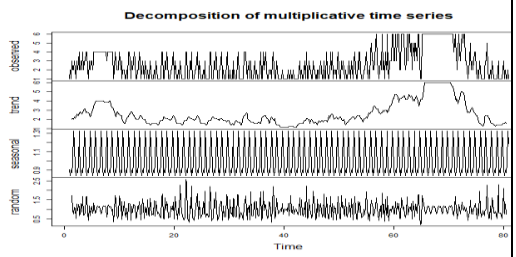
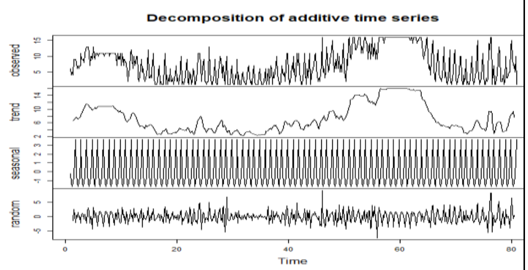
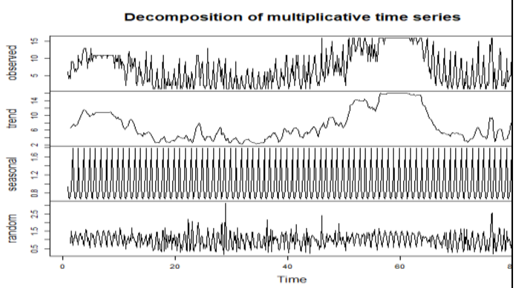
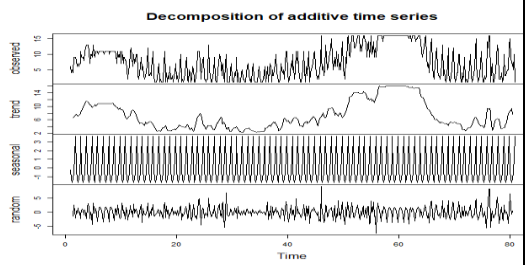
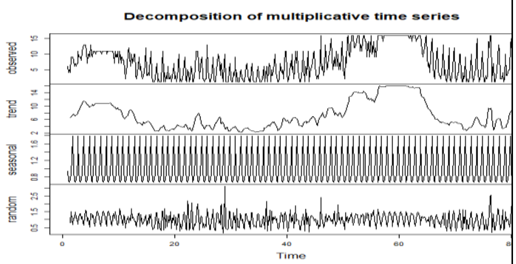
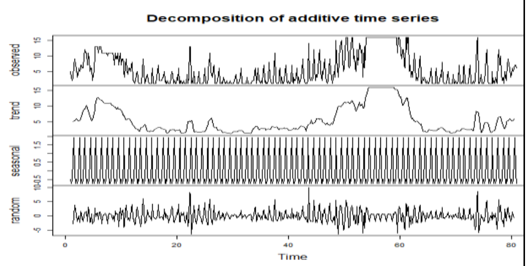
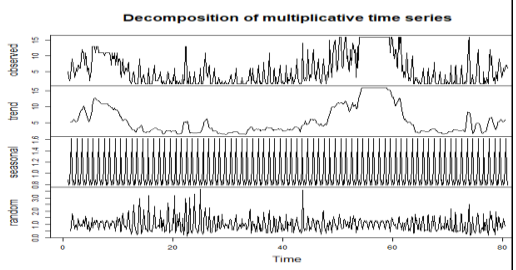


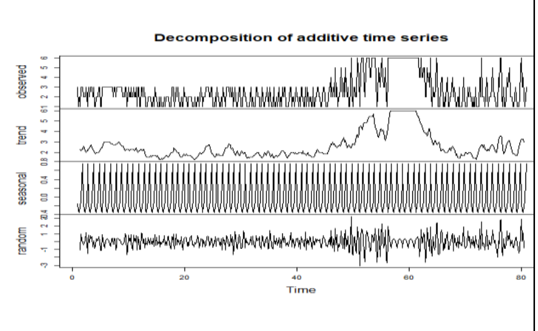
Figure 1. Plot of data
Source: Sinani & Godolja

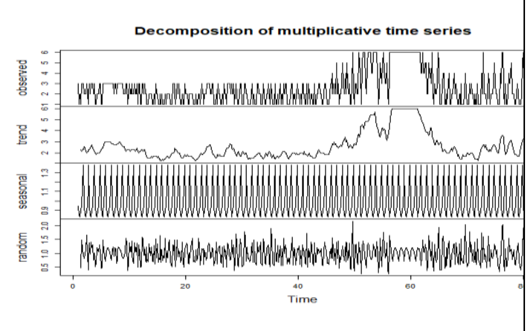
Figure 1 shows the daily demand for reservations for the period June 2021 to December 2022. The plot of daily data shows that the data is influenced by trend patterns as well as seasonal patterns.

Table 1. Decomposition of time series

	ADDITIVE MODELS	MULTIPLICATIVE MODELS
Total data for daily reservation in hotel		
Daily data for Suite Rooms		
Daily data for Standard Suite Rooms		
Daily data for Standard Suite Rooms		
Daily data for Junior Suite Rooms		

Daily data for Deluxe Rooms





Source: Godolja & Sinani

Table 2. Smoothing parameters

		Smoothing parameters		
		Alpha α	***Beta β***	***Gamma γ***
Total Data	*Additive Model*	0.7672143	0	0.2476729
	Multiplicative Model	0.1135852	0.001048864	0.2904538
Suite Rooms	*Additive Model*	0.1351409	0.02806275	0.2698484
	Multiplicative Model	0.1142072	0.01597169	0.321986
Standard Suite Rooms	*Additive Model*	0.3194846	0.003974101	0.132757
	Multiplicative Model	0.06714923	0.005904701	0.248824
Junior Suite Rooms	*Additive Model*	0.4859964	0	0.2468657
	Multiplicative Model	0.6908118	0	0.09132291
Deluxe Rooms	*Additive Model*	0.1975492	0.001923073	0.07850321
	Multiplicative Model	0.1385267	0	0.1515598

Source: Sinani & Godolja

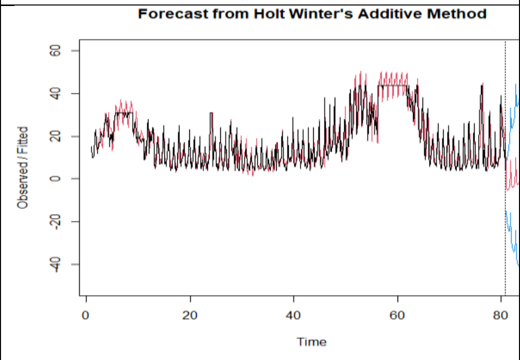
In table 2, we find different values of smoothing parameters that correspond to each type of room and the total daily data. These values have been obtained using both the additive and multiplicative Holt Winters exponential smoothing methods.

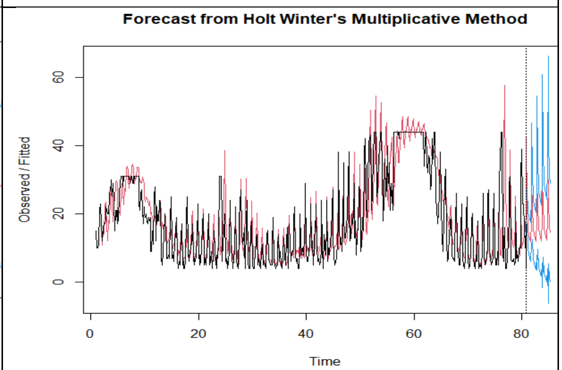
The prediction of the time series with both methods—additive methods and multiplicative methods—is presented. It can be seen that the black color is the test data, and the red color is the prediction.

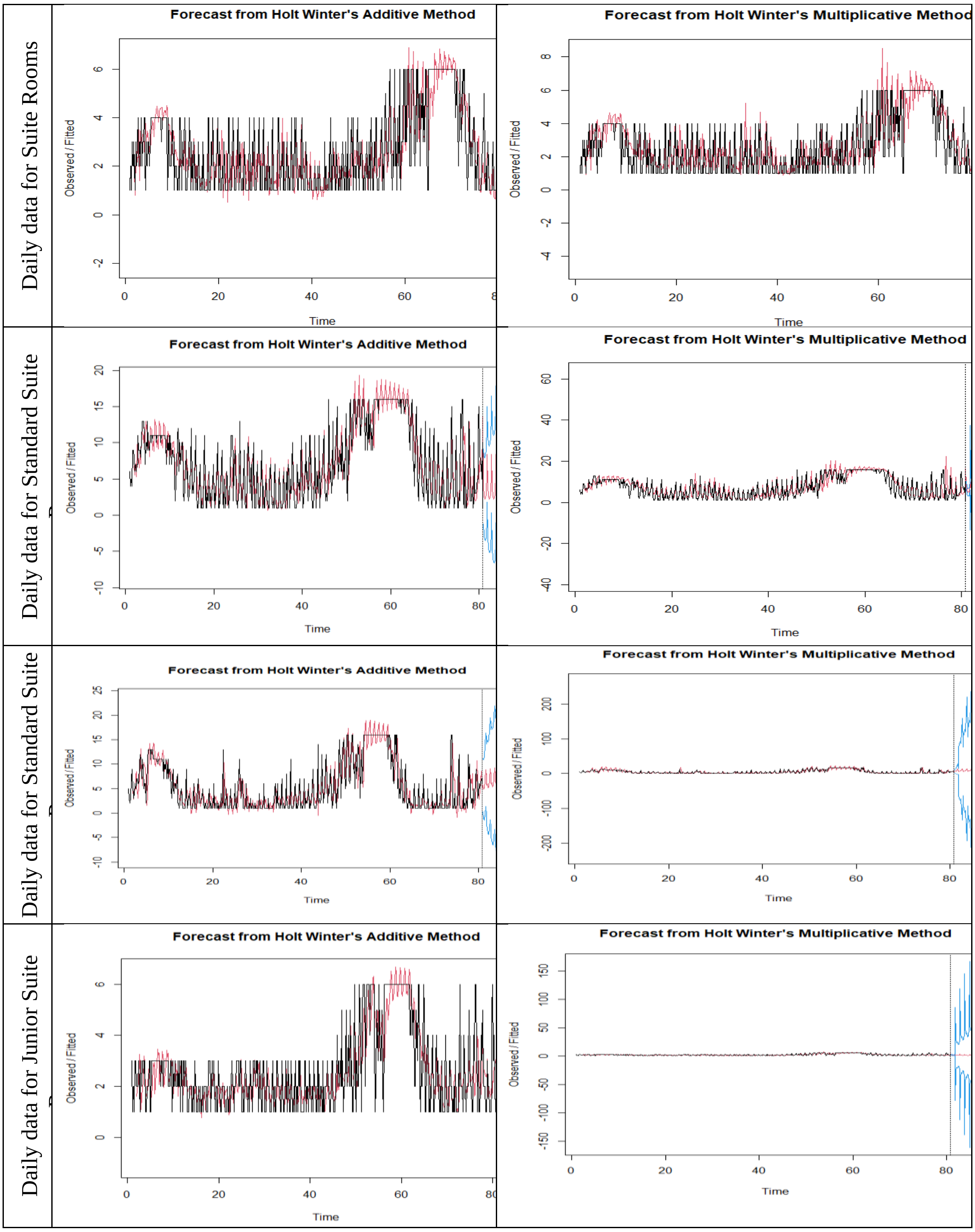
Table 3. Forecast of time series

ADDITIVE MODELS | **MULTIPLICATIVE MODELS**

Total data for daily reservation







Source: Sinani & Godolja

Table 4. The prediction error

		ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Total Data	*Additive Model*	-0.2867036	5.901791	4.154824	-14.12718	33.21703	0.7804408	0.06809905
	Multiplicative Model	-0.9669181	7.155538	4.806295	-23.69774	39.97001	0.9028128	0.5233826
Suite Rooms	*Additive Model*	-0.0491479	1.100297	0.8292624	-20.72043	43.82777	0.977787	0.20053

	Multiplicative Model	-0.1494132	1.139046	0.8562938	-25.71547	45.72793	1.00966	0.2078221
Standard Suite Rooms	*Additive Model*	-0.1470889	2.632714	1.93983	-35.98695	56.98128	0.8367596	0.2563808
	Multiplicative Model	-0.4981574	3.039408	2.183927	-45.42928	64.5285	0.9420527	0.466549
Junior Suite Rooms	*Additive Model*	-0.06081931	2.73699	1.918731	-38.63844	70.05172	0.8577674	0.2222336
	Multiplicative Model	-0.179013	3.134341	2.217548	-39.98112	71.13844	0.9913535	0.1573095
Deluxe Rooms	*Additive Model*	0.04465817	1.034134	0.7914554	-16.49666	41.1811	0.8632639	0.218293
	Multiplicative Model	0.08281647	1.070934	0.818234	-14.39836	40.99621	0.8924722	0.2686723

Source: Sinani & Godolja

This study assessed the forecasting accuracy of Additive and Multiplicative Holt-Winters models across various room categories in a hotel located in Vlora. The Additive model exhibited better performance in predicting the total daily reservations, with a MAPE of 33.21%, indicating that this model is well-suited for datasets with more stable and linear seasonal trends. Similarly, for Suite Rooms and Standard Suite Rooms, the Additive model achieved MAPE values of 43.83% and 56.98%, respectively, highlighting its ability to handle consistent demand patterns for these room types. On the other hand, the Multiplicative model performed better for Deluxe Rooms, achieving a MAPE of 40.99%, suggesting that the multiplicative approach is more effective for categories where demand fluctuates significantly, likely influenced by external factors such as tourism trends or special events.

However, both models struggled in predicting demand for Junior Suite Rooms, with MAPE values of 70.05% for the Additive model and 71.14% for the Multiplicative model, indicating a high level of prediction error. This suggests that neither model fully captured the complexity or external influences impacting this room category. Additionally, the higher error rates observed in Standard Suite and Junior Suite Rooms indicate the need for incorporating more external variables, such as economic conditions or marketing campaigns, to improve forecasting accuracy for these categories.

Overall, the Additive Holt-Winters model proved more reliable for room types with regular, predictable demand, while the Multiplicative model was more suitable for rooms experiencing greater demand variability, such as Deluxe Rooms. Future improvements could include incorporating external factors to further enhance model accuracy across all room categories.

4. Conclusion

In this study, we evaluated the accuracy of two methods for predicting daily reservations for different room categories in the hotel being investigated. After analyzing the daily data, we found that the additive model was generally more accurate than the multiplicative model in predicting the total number of reservations, as well as reservations for standard, suite, and junior rooms.

However, when it came to predicting reservations specifically for deluxe rooms, the multiplicative model outperformed the additive model in terms of accuracy. This suggests that the multiplicative model may be better suited for forecasting reservations in this particular room category.

To gain a deeper understanding of the relationship between the increase in foreign arrivals and the increase in hotel reservations, further analysis and exploration are recommended. This will help to determine if there is a correlation between these factors and provide more comprehensive insights for hotel management. Additive methods and multiplicative methods for hotel room data performed poorly. The forecast results would be even more accurate if there were more data. Accurate forecasts are essential for hotel managers.

Despite the encouraging results obtained in this study, several limitations still warrant discussion. Firstly, the dataset utilized spans only a two-year period, thereby potentially omitting long-term trends and infrequent occurrences that can have a significant effect on demand forecasting outcomes. Additionally, this research does not account for external influences such as economic fluctuations, marketing strategies, or competitive dynamics, all of which may play a critical role in shaping reservation patterns. Furthermore, the exclusive focus on a single hotel located in Vlora, Albania, constrains the generalizability of these findings to other geographical areas or categories of hotels. To enhance the accuracy and broader applicability of forecasting models, it is imperative for future research to encompass larger datasets and incorporate external variables that may affect hotel demand.

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