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Time Series Forecasting Of Tourist Overnights In Slovakia, Hungary, And The Czech Republic: Implications For Economic Performance

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Abstract—Tourism is a key economic sector with a positive impact on national economic development, including in countries without direct access to coastal tourism. This study focuses on time series forecasting of tourist overnight stays in Slovakia, Hungary, and the Czech Republic for the period 2001–2025, based on Eurostat monthly data. Using ARIMA-based models, the analysis identifies seasonal and long-term trends in tourism demand and produces short-term forecasts for each country. The selection of overnight stays as the main indicator reflects its strong correlation with tourist spending and broader economic impact. In addition to forecasting, the study explores potential links potential links between tourism development and national economic performance, highlighting tourist overnight stays as a proxy indicator of the tourism sector's contribution to the economy in these Central European countries. By combining statistical modeling with economic interpretation, the study supports informed policymaking and strategic planning in the post-pandemic tourism landscape. The integration of AI-based approaches is suggested as a promising avenue for enhancing future forecasting accuracy and capturing complex patterns.

Keywords— ARIMA, SARIMA, Time Series, Tourism..

I. INTRODUCTION

Tourism is one of the most important service sectors, playing a key role in promoting economic growth, regional development, and job creation [1]. Its importance is particularly evident in Central European countries that lack access to coastal areas but possess rich cultural and natural resources. Slovakia, Hungary, and the Czech Republic are prime examples of such landlocked nations, where tourism demand is largely driven by cultural heritage, spa services, natural attractions, and wellness tourism [2], [3].

Despite the significant contribution of tourism to the economic development of these countries, its quantitative assessment and overall impact on national economic performance remain inconsistently understood in the literature. Several research gaps persist, primarily due to differences in methodologies and limitations in data availability [4]. As some studies suggest, tourist spending can have a positive multiplier effect on gross domestic product, labor productivity, and employment. However, accurately quantifying these effects is challenging due to the absence of harmonized indicators and the heterogeneity of statistical data across countries [5]. Among available metrics, the number of overnight stays is considered one of the key indicators of tourism's economic significance, as it reflects tourist spending, length of stay, and the subsequent multiplier effect on the national economy [1].

Tourism development is highly sensitive to external shocks, as clearly demonstrated by the COVID-19 pandemic. A significant decline in revenues and overnight stays was recorded across virtually all European countries, including those analyzed in this study [2], [6]. In Hungary, for example, the tourism sector's contribution to GDP dropped by more than 5%, highlighting the sector's high vulnerability to crisis events [6].

From a methodological perspective, modeling and predicting tourism development is a complex task, increasingly addressed through the use of time series methods. Some authors employ structural models at the regional level, which enable analysis not only of tourism demand itself but also of the interrelationships between economic variables [4]. Others highlight the importance of applying robust panel models to capture regional disparities, integrate tourism into broader macroeconomic frameworks [7], and analyze the impact of macroeconomic and political factors on tourism activity [8]. In addition to these approaches, the application of univariate and multivariate time series models is gaining importance, as these methods allow for the identification of seasonal patterns, long-term trends, and short-term shocks in tourism demand. The use of Autoregressive Integrated Moving Average (ARIMA) and Seasonal Autoregressive Integrated Moving Average (SARIMA) models has become a well-established methodological strategy in forecasting overnight stays and other tourism indicators, as they effectively capture complex combinations of autoregression, differencing, and moving averages in the presence of seasonality [9]. Furthermore, within the European Union, tourism development is closely linked to processes of economic integration and regional cooperation, which influence the spatial structure of tourist mobility and network connections among member states [9], [10].

At the same time, there is growing interest in the application of index-based approaches that assess the competitiveness of tourism destinations over a longer time horizon [11]. Significant progress has also been made through new concepts of sustainable tourism development, which integrate economic, social, and environmental dimensions into comprehensive evaluation frameworks [12]. In Central European countries, there is an increasing need to systematically assess the impact of tourism on regional development, with particular emphasis on diversifying tourism offerings and enhancing destination competitiveness [13].

Although a growing body of research explores the relationship between tourism and economic growth across various regions, there remains a lack of systematic empirical studies in Central European countries that employ time series modeling to analyze the long-term development of tourist overnight stays as a proxy indicator of tourism activity and its connection to macroeconomic performance. The present study aims to address this research gap.

The aim of this paper is to analyze the development of tourist overnight stays in the Slovak Republic, Hungary, and the Czech Republic over the period 2001–2025 using the Box-Jenkins ARIMA/SARIMA methodology and exponential smoothing applied to monthly time series data. The analysis focuses on identifying long-term trends, seasonal fluctuations, and generating short-term forecasts. Overnight stays are selected as the primary indicator due to their well-established link to tourism revenues, economic performance, and regional development in the countries under study. The results will not only reveal characteristic trends and seasonal patterns but also provide valuable insights for economic policy and tourism development planning amid increasing global uncertainty.

II. METHODOLOGY

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. This paper adopts a quantitative approach based on modeling and forecasting time series of tourist overnight stays in the Slovak Republic, Hungary, and the Czech Republic. The selection of these countries was intentional, as they represent three geographically proximate Central European nations that share several common characteristics in terms of historical development, economic transformation, and the current structure of their tourism sectors. All three are landlocked countries without direct access to coastal mass tourism, and tourism demand is primarily driven by cultural heritage, historical landmarks, natural attractions, and wellness services. Moreover, their comparable territorial size and population facilitate cross-country comparison while minimizing distortions caused by significant market size differences. Including these countries in a single comparative analysis offers a suitable framework for identifying common regional trends and tourism dynamics with potential implications for national economic performance.

The input data were obtained from the secondary, publicly available source Eurostat, which provides harmonised statistical data on the number of overnight stays in tourist accommodation establishments across EU member states. Due to slight differences in data availability within the Eurostat database, the analyzed monthly time series cover the periods 2001–2025 for Hungary, 2002–2025 for the Czech Republic, and 2003–2025 for the Slovak Republic.

The main objective of the analysis was to identify long-term trends, seasonal patterns, and to generate short-term forecasts for the number of overnight stays, which serves as a proxy indicator of overall tourism activity and its potential economic contribution to national economic performance. Given the nature of the data, a combination of models based on the Box-Jenkins methodology and exponential smoothing was employed.

The modeling was based on the classical structure of ARIMA and SARIMA models. The general form of the SARIMA model is defined by the following equation:

$$\phi_p(B)\Phi_P(B^s)(1-B)^d(1-B^s)^D Y_t = \theta_q(B)\Theta_Q(B^s)\varepsilon_t \qquad (1)$$

where B denotes the backshift or lag operator; s represents the seasonal lag; ε_t indicates the error terms; d and D correspond to the non-seasonal and seasonal differences, respectively; ϕ and Φ are the non-seasonal and seasonal autoregressive parameters; and θ and Θ represent the non-seasonal and seasonal moving average parameters, respectively [14].

Before the actual modeling, the data were tested for stationarity using the KPSS (Kwiatkowski–Phillips–Schmidt–Shin) test. The null hypothesis assumed stationarity around a deterministic trend, and the test statistics were compared with critical values at the 5% significance level. For none of the countries was the null hypothesis of trend stationarity rejected, which eliminated the need for trend differencing (d = 0). However, seasonal differencing was applied where the seasonal pattern indicated its necessity.

IBM SPSS Forecasting software, specifically the Expert Modeler tool, was used to identify a suitable model structure. This tool automatically tested a wide range of possible models, including ARIMA, SARIMA, and exponential smoothing, optimizing the selection based on multiple performance criteria. To ensure the analysis realistically captured natural fluctuations in the time series, including crisis periods such as the COVID-19 pandemic, automatic outlier correction was disabled during model identification.

The quality and performance of the prediction models were evaluated using several standard statistical indicators. The primary measure of prediction accuracy was Mean Absolute Percentage Error (MAPE), calculated according to the following formula:

$$MAPE = \sum_{i=1}^{n} \left| \frac{(Y_i - F_i)/Y_i}{n} \right| \cdot 100$$

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where Y_i denotes the actual data for period i; F_i is the forecast for period i; | | indicates the absolute value; and n represents the number of observations [15]. MAPE values of 10% or less indicate a very accurate forecast; values between 10% and 20% indicate a good estimate; values between 20% and 50% indicate a reasonable forecast; and values above 50% indicate an inaccurate estimate.

Another quality indicator was the Bayesian Information Criterion (BIC), calculated as follows:

$$\mathrm{BIC} = -2\ln(\mathrm{L}) + \mathrm{k}\ln(\mathrm{n}) \qquad (3)$$

where L is the value of the model's likelihood function, k is the number of estimated parameters, and n is the number of observations. Lower BIC values indicate a better balance between model accuracy and complexity.

The explained variability of the analyzed series was assessed using the coefficient of determination R^2 and its stationary version R_S^2. The stationary R_S^2, defined in IBM SPSS software as [16]:

$$R_S^2 = 1 - \frac{\sum_t (Y_t - \hat{Y}_t)^2}{\sum_t (\Delta Y_t - \overline{\Delta Y})^2} \quad (4)$$

provides a measure of the model's quality for the stationary transformation of the series. Both R_S^2 and R^2 can take values within the interval $(-\infty, 1\rangle$. Values closer to 1 indicate higher model accuracy. A negative value means that the model performs worse than the baseline model, while a value of zero indicates that the model's performance is equivalent to the baseline.

An important part of model validation was testing for the presence of autocorrelation in the residuals using the Ljung–Box test, where the test statistic is calculated as:

$$Q = n(n+2)\sum_{k=1}^{h} \frac{\hat{\rho}_k^2}{n-k} \quad (5)$$

where $\hat{\rho}_k^2$ are the estimated autocorrelation coefficients at lag k and h is the number of lags tested. Significant p-values indicate the presence of autocorrelation structures that were not fully captured by the model.

To ensure the comprehensiveness of the analysis, exponential smoothing models—specifically the Holt–Winters additive and multiplicative methods—were also included in the comparative framework and evaluated alongside the ARIMA models. Forecasts were generated for the period extending to the end of 2026. This modeling approach enabled the identification of the most appropriate model structures for each country, which are presented in detail in the analytical section of the study.

III. RESULTS

This section presents the results of time series modeling of tourist overnight stays for the Slovak Republic, Hungary, and the Czech Republic, based on monthly data covering the periods 2001–2025 for Hungary, 2002–2025 for the Czech Republic, and 2003–2025 for Slovakia. The primary objective of the analysis was to identify long-term trends, seasonal fluctuations, and to generate short-term forecasts using SARIMA-type models. The results provide a basis for direct cross-country comparison.

To optimize the selection of the most suitable forecasting models, a set of evaluation metrics was applied, including the MAPE, the BIC, and the R^2. These indicators are standard and widely accepted tools in predictive modeling, used to assess the accuracy, predictive performance, and robustness of models. A more detailed description of each metric, along with its interpretative framework, is provided in the methodological section. The model validation process also included diagnostic tests to detect autocorrelation in the residuals, assess the normality of residual distributions, and evaluate discrepancies between predicted and actual values—ensuring comprehensive quality control of the final models.

A. Descriptive and Decomposition Analysis of the Development of Overnight Stays

Figure 1 shows the development of the number of tourists overnight stays in the Slovak Republic, Hungary, and the Czech Republic from the beginning of data availability—2001 for Hungary, 2002 for the Czech Republic, and 2003 for the Slovak Republic—through to March 2025. The time series for all three countries exhibit clear signs of seasonality, long-term trends, and significant deviations during periods of crisis.

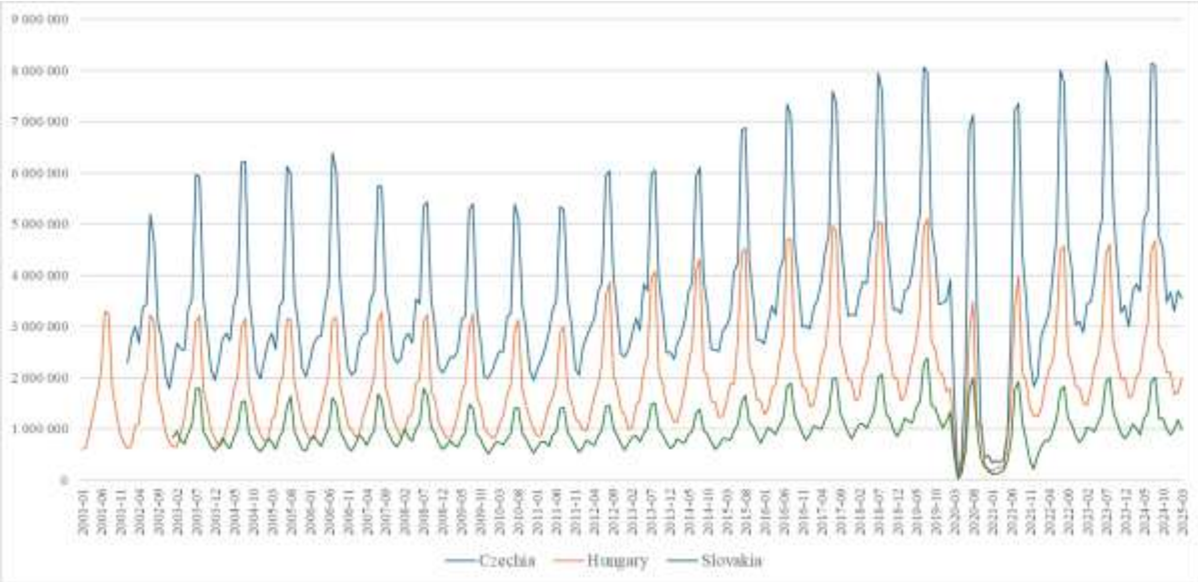

Fig. 1 Development of overnight stays in the Slovak Republic (green), Hungary (orange), and the Czech Republic (blue) (2001–2025).

In all three countries, the annual seasonal cycle is clearly evident, with peaks occurring during the summer months of July and August, which represent the core of the tourist season. However, the extent of seasonal fluctuations differs slightly across countries. The Czech Republic consistently records the highest number of overnight stays, while the Slovak Republic has long reported the lowest figures. These differences in both the absolute volume of overnight stays and the intensity of seasonal variation can be attributed to several factors: population size, the countries' positions in the international tourism market, the structure of domestic versus foreign demand, and the prominence of key tourist destinations (e.g., Prague as a dominant attraction in the Czech Republic). The Czech Republic benefits from a consistently higher share of foreign visitors, which contributes to both a higher total number of overnight stays and greater seasonal variability. In contrast, Slovakia, with a smaller overall tourist base, relies more heavily on domestic and regional cross-border demand, leading to less pronounced seasonal swings. Hungary occupies a middle position, with Budapest and its well-developed thermal spa tourism playing a key role, which shapes a slightly different seasonal pattern compared to the other two countries.

Characteristic low periods can also be identified in the time series. In the Czech Republic, these minima typically occur during the winter months of December and January. In Hungary, the lowest values are usually observed in January and February. In Slovakia, prior to the COVID-19 pandemic, two distinct minima were regularly recorded: one in the winter months (December–January), similar to the Czech Republic, and a second often in April. The April minimum was related to the late start of the summer season combined with the end of the winter ski season. However, since 2020, the seasonal pattern in Slovakia has shifted significantly, becoming more aligned with the pattern observed in the Czech Republic.

The 2020–2021 pandemic period significantly disrupted traditional seasonal tourism patterns in all three countries. Overnight stays declined sharply due to travel restrictions, border closures, mobility limitations, and the temporary closure of accommodation facilities. Paradoxically, the gap between the annual minimum and maximum values widened during the pandemic. This was because periods of eased restrictions allowed a temporary rebound in domestic demand during the summer months, while winter months often saw renewed waves of restrictions. Since 2022, there has been a gradual return to pre-pandemic levels, although the pace of recovery varies slightly between countries.

For a more detailed analysis of the trend and seasonal components, the time series was decomposed using STL (Seasonal-Trend decomposition using Loess–Locally Estimated Scatterplot Smoothing), which separates the long-term trend, regular seasonal patterns, and residual variations. The decomposition results are presented in Figures 2a, 2b, and 2c and provide the foundation for subsequent modeling and forecasting.

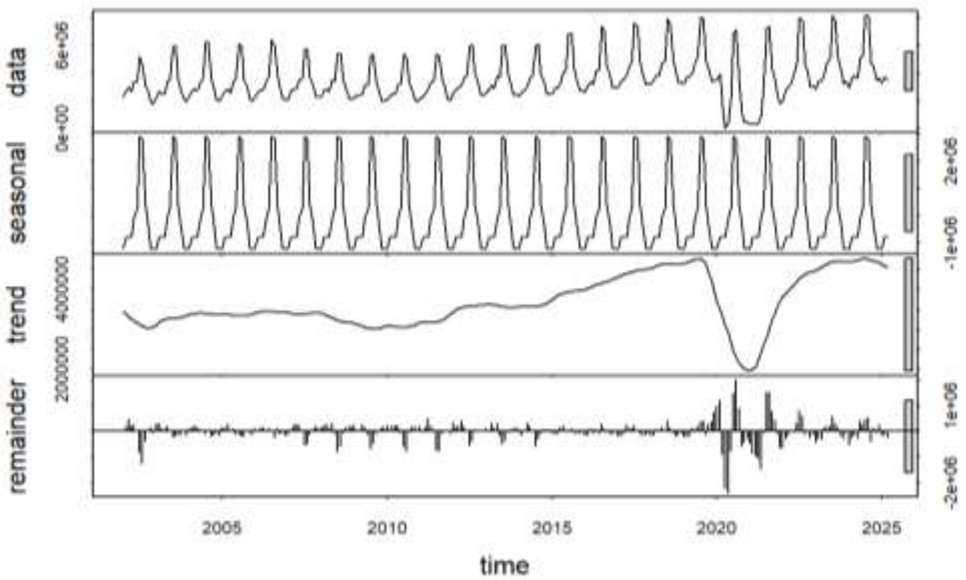

Fig. 2a. Time series decomposition of tourist overnight stays – Czech Republic.

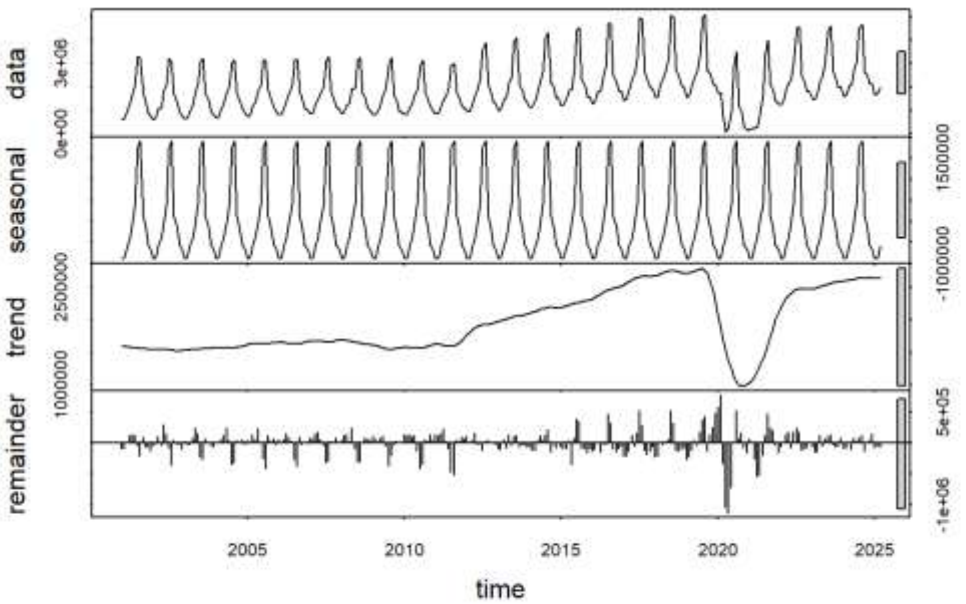

Fig. 2b. Time series decomposition of tourist overnight stays – Hungary.

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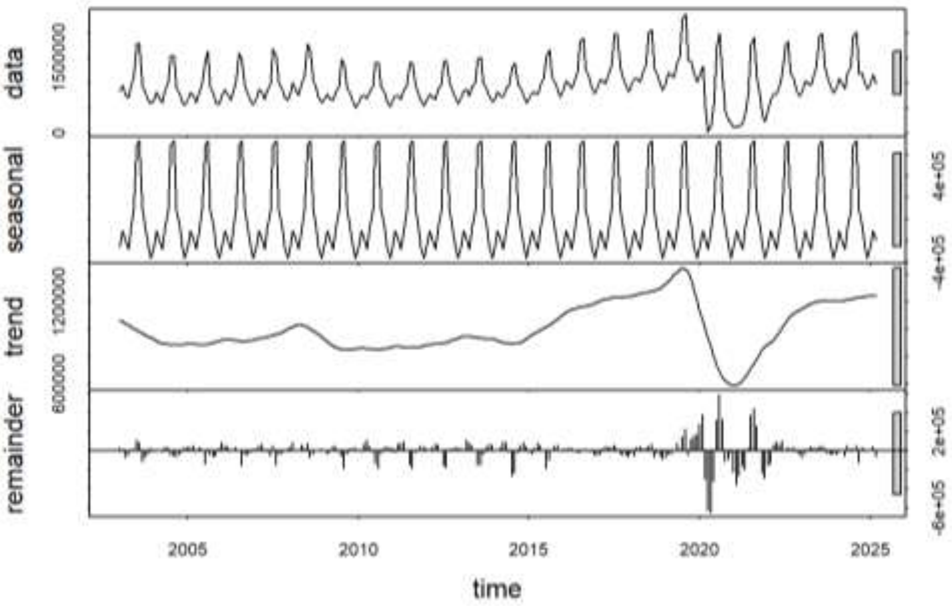

Fig. 2c. Time series decomposition of tourist overnight stays – Slovak Republic.

The overall time series of overnight stays during the observed period exhibits non-stationarity, characterized by a clear underlying trend. Seasonal fluctuations are dependent on this trend, with their magnitude varying over time in line with the rise or fall in the total number of overnight stays. This behavior will be examined in greater detail through subsequent time series modeling.

B. Modelling and Forecasting of Overnight Stay Time Series

After performing a descriptive and decomposition analysis of the development of overnight stays in the Slovak Republic, Hungary, and the Czech Republic, the time series were modeled to generate forecasts based on the identified trends and seasonal patterns. ARIMA and SARIMA models, alongside exponential smoothing techniques, were employed for this purpose. The results from each modeling approach were then compared to determine the most suitable model for each time series, considering both its structural characteristics and predictive accuracy.

Before modeling, a stationarity test was conducted using the KPSS test. The obtained test statistics (Czech Republic: 0.109654, Hungary: 0.142544, Slovakia: 0.12479) were all below the 5% significance level critical value of 0.148, indicating that the null hypothesis of trend stationarity could not be rejected in any case. Therefore, the time series were modeled without applying trend differentiation (d = 0). Seasonal differentiation was applied when necessary, based on the seasonal patterns identified in earlier analyses.

Model identification was carried out in SPSS Forecasting using the Expert Modeler tool, which automatically evaluates various model structures—including ARIMA, SARIMA, and exponential smoothing—and selects the best-fitting model based on predefined optimization criteria. To ensure that natural fluctuations, such as those caused by extraordinary events like the COVID-19 pandemic, were fully reflected in the analysis, automatic outlier detection was disabled during the modeling process.

The final model selection was based on several evaluation metrics, including the MAPE, BIC, R_S^2, and the results of the Ljung–Box (L–B) test for residual autocorrelation. Forecasts were generated through the end of 2026, preserving the seasonal structure of the time series and reflecting the anticipated trajectory of tourism recovery in the post-pandemic period. The parameters of the selected models are summarized in Table 1.

TABLE 1 PARAMETERS OF TIME SERIES MODELS FOR THE NUMBER OF TOURIST OVERNIGHT STAYS BY COUNTRY

Country		Czechia	Hungary	Slovakia
Model		ARIMA	ARIMA	ARIMA
Model parameters		(1,0,3)(0,1,1)	(1,1,1)(1,1,1)	(1,0,1)(1,1,1)
MAPE		14.332	12.822	12.622
BIC		25.538	24.299	23.141
Autocorr, of residuals	L–B Q	31.407	38.257	23,760
	Sign.	0.005	0.000	0,049
R_S^2		0.830	0.236	0.830
R^2		0.957	0.970	0.939

The MAPE values, ranging from 12.6% to 14.3%, indicate an acceptable level of forecasting accuracy across all three analyzed cases. The BIC values are lower for the Slovak and Hungarian models, suggesting a better fit to the observed data while accounting for model complexity. Lower BIC values reflect greater model efficiency in balancing goodness of fit with parsimony.

The R_S^2 values are highest for the Czech Republic (0.830) and Slovakia (0.830), while significantly lower for Hungary (0.236). This discrepancy likely reflects the characteristics of Hungary's time series, which exhibits more pronounced and irregular fluctuations. Although the model adequately captures both trend and seasonality, a portion of the variability remains in the nonlinear residual components. Trend differencing was not applied in any of the cases, as the KPSS test results did not indicate its necessity. The overall R^2 values are high across all countries (ranging from 0.939 to 0.970), confirming that the selected models effectively explain the long-term trends and seasonal patterns in the data.

The results of the Ljung–Box test show that, for Slovakia, the p-value (0.049) is close to the 5% significance threshold. Considering the relatively low test statistic (23.760) and a conservative interpretation in the context of larger samples, the model can be deemed acceptable. In contrast, the test results for the Czech Republic (p = 0.005) and Hungary (p = 0.000) indicate statistically significant residual autocorrelation, suggesting that the models do not fully capture the internal dependency structures of the respective time series. Nevertheless, due to the overall stability, consistency, and realistic dynamics of the forecast values—which reflect both seasonal patterns and pandemic-related disruptions—these models were retained for predictive analysis. This decision represents a trade-off between model complexity and the interpretability of results. The presence of residual autocorrelation may reflect the influence of exogenous shocks during the pandemic period, which are not fully accounted for in standard ARIMA-type models.

The forecast values for the period from April 2025 to December 2026 are presented in Figures 3a, 3b, and 3c (we see both the observed (red line) and expected (blue line) values, along with 95% confidence intervals (upper confidence limit–UCL, lower confidence limit–LCL)). The models anticipate the continuation of the seasonal cycle, with expected peaks during the summer months, and project a gradual recovery of the tourism sector over the forecast horizon.

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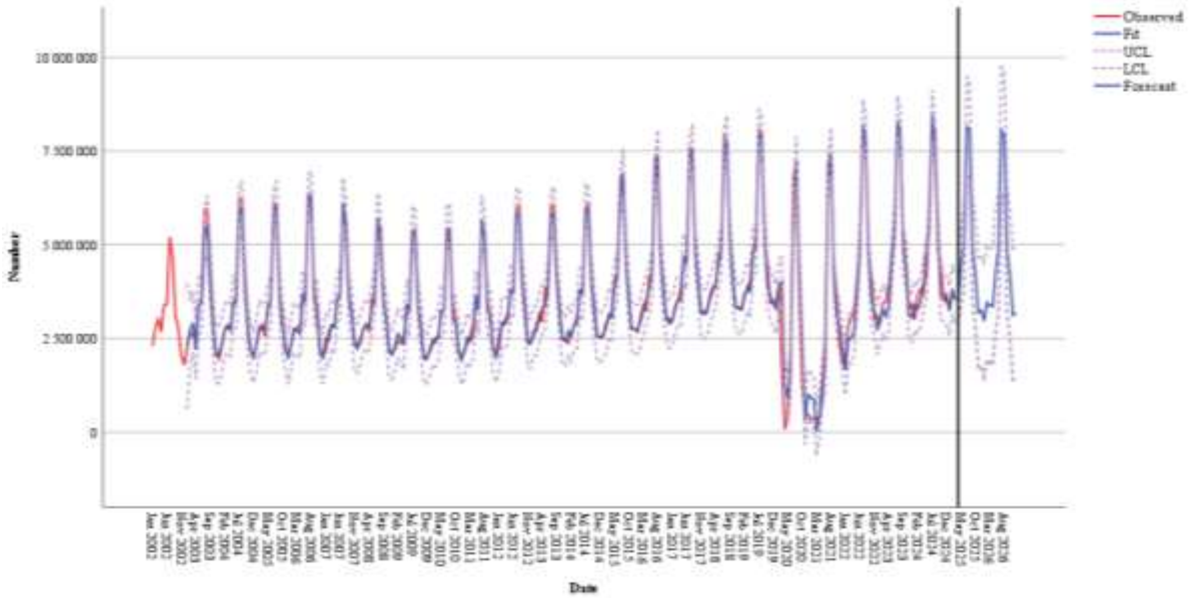

Fig. 3a. Time series models of tourist overnight stays – Czech Republic.

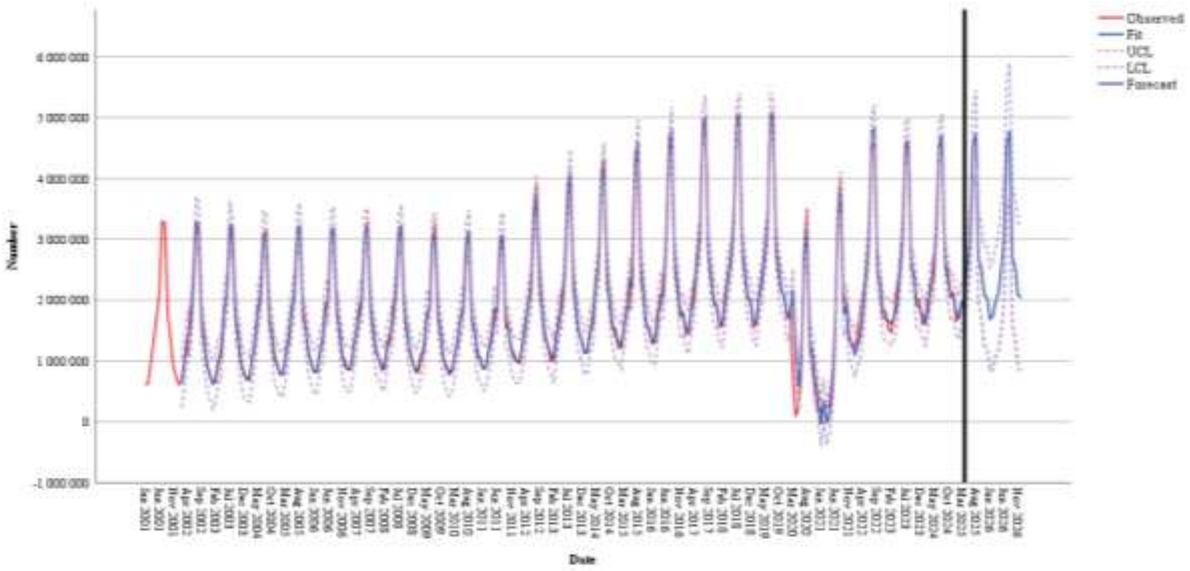

Fig. 3b. Time series models of tourist overnight stays – Hungary.

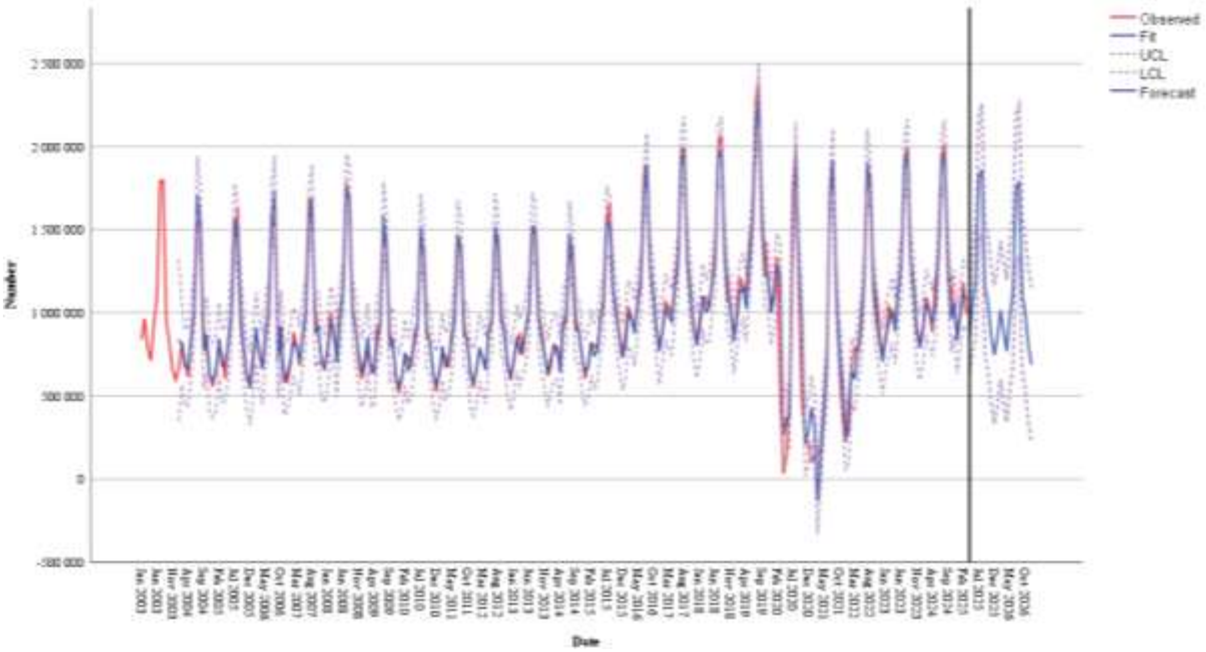

Fig. 3c. Time series models of tourist overnight stays – Slovakia.

IV. DISCUSSION

The time series analysis of tourist overnight stays in the Slovak Republic, Hungary, and the Czech Republic offers valuable insights into the dynamics of tourism as a key segment of their national economies. The forecasting models confirm the presence of pronounced seasonal cycles in all three countries, with peak demand occurring during the summer months—traditionally the most lucrative period for the service and tourism sectors. This pattern aligns with long-term trends typical of the Central European region, where seasonal peaks correspond closely with holiday periods and favorable climatic conditions [17].

Using the number of overnight stays as the primary predictor variable enables not only a robust quantification of tourism demand trends but also offers an economically meaningful perspective on the value created within tourism services. Overnight stays are closely linked to key components of tourist expenditure—such as accommodation, food, ancillary services, and the total duration of stay. As noted by [18], the tourism sector accounts for a significant share of GDP, employment, and service exports in EU countries. This establishes a natural connection between overnight stay demand and broader economic performance, particularly in the analyzed countries, where tourism plays a vital role in income generation and regional development. Furthermore, the overnight stay indicator filters out statistical noise from short-term or day visits, providing a more stable and reliable basis for assessing tourism's impact on GDP.

From a broader economic standpoint, the number of overnight stays serves as a key indicator reflecting the overall level of tourism activity, which often generates significant multiplier effects across various sectors. Numerous studies highlight that negative shocks to tourism can ripple through macroeconomic variables, impacting income levels and employment within the service industry [19]. Furthermore, research focusing on Central and Eastern European countries demonstrates that effectively leveraging competitive advantages and integrating tourism into comprehensive development strategies can substantially support long-term economic stability and growth [20]. Within the context of the analyzed countries, the long-term trends in overnight stays therefore offer valuable indirect insight into tourism's evolving contribution to economic growth and regional development, while stopping short of directly quantifying causal relationships.

The ARIMA forecasting models applied in this study indicate that despite the disruptions caused by the COVID-19 pandemic, recent years have shown a clear trend toward stabilization and recovery in tourism demand. This finding is consistent with international studies examining post-pandemic tourism recovery [21], [22]. Additionally, the Slovak Republic and Hungary experienced a more pronounced decline in demand, which may be attributed to their greater reliance on domestic and regional markets and a less diversified portfolio of source markets compared to the Czech Republic.

The analysis also revealed a degree of autocorrelation in the residuals for Hungary and the Czech Republic, suggesting that some variability remains unexplained by the models. This unexplained variance is likely attributable to external shocks, particularly geopolitical risks and pandemic-related factors. Lee et al. [23] highlight the significant negative impact of such geopolitical risks and the COVID-19 pandemic on international tourism demand.

Given the observed prediction accuracies, with MAPE values between 12% and 14%, the models can be regarded as sufficiently robust for economic planning and for simulating the impacts of crisis scenarios. These results align with findings from other studies applying ARIMA and SARIMA models to tourism in Central and Eastern Europe, such as [24], which examined the decline in demand in Bulgaria during the pandemic.

Further research could focus on the application of advanced hybrid models incorporating artificial intelligence techniques—such as LSTM, BiLSTM, or Transformer models—that have demonstrated the ability to capture complex nonlinear relationships in time series data [25], [26]. Additionally, exploring the relationship between tourism and macroeconomic indicators through multivariate econometric frameworks would provide deeper insights. Finally, conducting regionally disaggregated analyses is recommended, as previous studies have shown that pandemic and geopolitical shocks have had uneven impacts across different regions and tourism segments [27], [28].

From a practical standpoint, the results carry significant implications for tourism and regional development policymaking. Given the sector's proven sensitivity to external shocks, it is essential to strengthen adaptation mechanisms and implement flexible marketing and crisis management strategies, as recommended by [23].

V. CONCLUSIONS

This study focused on forecasting the number of tourist overnight stays in the Slovak Republic, Hungary, and the Czech Republic using monthly time series data from 2001 to 2025, applying ARIMA-based modeling techniques. Selecting the number of overnight stays as the primary indicator enabled a robust capture of both seasonal and long-term trends, while reflecting the economic significance of the tourism sector for these national economies.

The applied ARIMA and SARIMA models demonstrated an acceptable level of predictive accuracy across all analyzed countries, with MAPE values ranging from 12% to 14%. Although some residual autocorrelation persisted—particularly in Hungary and the Czech Republic—the forecasts effectively capture the expected seasonal patterns and anticipated recovery trends in the forthcoming period.

The results confirm that, despite external shocks such as the COVID-19 pandemic and broader geopolitical risks, tourism in the analyzed Central European countries is gradually stabilizing. Moreover, the chosen approach offers valuable support for short-term forecasting scenarios, providing a solid foundation for policymaking, destination management, and economic evaluation of tourism developments.

Given the tourism sector's sensitivity to external shocks, a valuable direction for future research is the application of advanced hybrid modeling techniques, such as neural networks or multivariate frameworks that integrate tourism development with broader macroeconomic indicators. These approaches can enhance the ability to capture nonlinear dynamics and improve the robustness of forecasts amid growing global uncertainty.

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