

Based on Regression Analysis and Time Series of Shaanxi Province Tourism Trend Forecast Research

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Abstract. To study the influencing factors and the future development trend of tourism in Shaanxi province, China, this paper analyzes the 12-item index data of the Shaanxi tourism industry from 1990 to 2021, including the Gross Domestic Product (GDP). In this paper, the total income of tourism and the total number of tourists per year are taken as the evaluation indicators of tourism development, and the other 10 indicators are taken as the factors that may have impacts on tourism. First of all, this paper uses Principal Component Analysis (PCA) to screen these 10 variables and finds that the two indicators of GDP and the number of domestic visitors contain more than 99% of the independent variable information. Therefore, this paper takes these two indicators as independent variables, and separately takes the total income of tourism and the total number of visitors as dependent variables to design a multiple regression analysis. Then, the Autoregression Integrated Moving Average (ARIMA) model is established by time series analysis to fit the parameters and forecast the development trend of tourism in the next five years. The result of the model shows that the tourism industry in Shaanxi province is significantly impacted by COVID-19. Finally, this paper puts forward the problems and suggestions from four aspects of ecology, laws, resources, and talents to help the revival and development of Shaanxi tourism in the post-epidemic era.

Keywords: Tourism of Shaanxi Province, Principal Component Analysis, Multivariate Regression Analysis, Time Series Analysis, Forecast.

1. Introduction

In early 2020, the COVID-19 outbreak occurred in Wuhan, China, then spread rapidly to the whole country, causing a significant impact on the tourism industry. Take Shaanxi Province, one of the worst-hit areas, as an example. In 2019, the province's total tourism revenue reached 721.2 billion yuan, with 707.14 million tourist trips. In 2020, the total tourism revenue of Shaanxi province was 276.6 billion yuan, and the number of tourists was 357.1 million, which was significantly lower than that of 2019. In addition, a survey of 108 A-level tourist attractions in Shaanxi province showed that 76.9 percent of the tourist attractions revenue in the first quarter of 2020 was only 20 percent or less than the same period in the previous year. In the third quarter, 63% of the scenic spots recovered more than 60% of the tourism revenue in the same period; 64.9% of the scenic spots were thought to reduce the total revenue by at least 40% [1].

Based on historical data, many scholars have predicted the situation of the development of tourism in the next few years. Yin Ying et al established a Support Vector Machine (SVM) time series forecasting model to process and simulate the continuous years' tourist volume data of Yunnan Province, China [2]. By establishing a modified Electronic Design Automation (EDA) model to measure the efficiency of tourism development, Fang Yelin et al analyze the spatial and temporal evolution of provincial tourism efficiency [3]. Hossein et al collected international tourist data from nine countries from 2000 to 2013 and made parametric and non-parametric predictions respectively. The results showed that the random forest model and ARIMA model had the best effect [4].

According to the comparison results, reasonable suggestions can be made on the optimization measures of tourism policy and the future development direction. Liao Xuewen analyzed the effect

of economic factors on the development of tourism in the district and county and predicted the tourism income in the coming year after the policy optimization [5]. Dogan et al pointed out that the development of the tourism economy can be promoted through the coordination of social policies and the management of scenic spots, attracting private investment and other measures [6]. Nie Qian collected and sorted 29 index variables related to the tourism industry. By conducting a principal component analysis, five factors with the largest contribution rate of variance were summarized [7].

In addition, the development of tourism cannot be separated from the promotion of cultural industry. Li Xue focused on the period before the outbreak of the epidemic, using a comprehensive evaluation model to measure the level of cultural and tourism industry integration in that period. She also used the state space model to analyze the dynamic effect of the cultural tourism industry integration development on the economic growth in Shaanxi Province [8]. After the outbreak of the epidemic, Shaanxi province issued a series of policies to promote the combination of tourism and cultural industry, form a more mature and perfect cultural tourism, and accelerate the construction of a strong tourism province in Shaanxi [9]. Liu Shuying and Song Danying pointed out that the existing literature shows the impact of COVID-19 on the tourism industry, relevant sector response strategies, future development trends, and other related issues [10].

As a province of abundant tourism resources, Shaanxi tourism is undoubtedly representative of the whole country. This study takes Shaanxi province as an example to collect data on tourism and some related industries from 1990 to 2021. At the same time, this paper designs time series analysis and regression analysis techniques based on pre-epidemic tourism data to predict the development of Shaanxi's tourism industry in 2020 without the impact of the epidemic and compares the results with the actual situation to highlight the adverse impact of the epidemic on the tourism industry. On this basis, the main influencing factors of tourism during the epidemic are analyzed, and scientific suggestions are put forward for the development of tourism in the post-epidemic era.

2. Methodology

2.1. Data Sources and Description

Most of the data in this article come from the National Bureau of Statistics, the China Statistical Yearbook, the Shaanxi Provincial Statistical Yearbook, and the Shaanxi Provincial Statistical Bulletin. Among them, the China Statistical Yearbook is a kind of informative annual publication compiled and printed by the National Bureau of Statistics, which comprehensively reflects the economic and social development of the People's Republic of China, and is the most comprehensive and authoritative comprehensive statistical yearbook in China. Shaanxi Provincial Statistical Yearbook and Statistical Bulletin are compiled and printed by the Shaanxi Provincial Bureau of Statistics, which are also quite authoritative and authentic. Meanwhile, some of the data related to the accommodation and catering industry are sourced from China Economy Net and Huaqing Intelligence Net, the former of which provides convenient and fast economic data query, and the latter of which focuses on providing industrial economic intelligence of the Greater China region, empowering business decision-making for enterprises, with a position of a leading provider of market research reports and competitive intelligence. A few other data are taken from the Foresight database.

2.2. Indicator Selection and Description

In this paper, reference [7] was made for the selection of indicators. These indicators include national GDP, Shaanxi Province GDP, Shaanxi Province disposable income per capita of urban residents, national disposable income per capita of residents, Engel's coefficient of national residents, Shaanxi Province accommodation and catering revenues, Shaanxi Province domestic tourist arrivals, Shaanxi Province international traveler arrivals and Shaanxi Province total retail sales of social consumption for each year from 1990 to 2021. Meanwhile, we selected the total tourism revenue and total tourism passenger flow of Shaanxi Province for each year from 1990 to 2022 as response

variables to represent the development of tourism in the province. The indicators and their units are shown in Table 1, and the data for 2020 is presented as an example.

Table 1. Indicator selection and description

Implications of the Indicator	Indicator Unit	Data for 2020
GDP of Shaanxi Province	Hundred million yuan	26014.14
National GDP	Hundred million yuan	1013567
Shaanxi Province's disposable income per capita of urban residents	Yuan	37868
Shaanxi Provincial Consumer Price Index	Yuan	102.5
Engel's coefficient of national residents	Percent	30.2
Shaanxi Province accommodation and catering revenues	Hundred million yuan	978.86
Total retail sales of consumer goods in Shaanxi Province	Hundred million yuan	9605.92
Shaanxi Province domestic tourist arrivals	Ten thousand people	35700.94
Shaanxi Province international traveler arrivals	Ten thousand people	8.59
National disposable income per capita of residents	Yuan	32188.8
Total income from tourism in Shaanxi Province	Hundred million yuan	2765.55
Total number of travelers in Shaanxi Province	Ten thousand people	35709.53

2.3. Introduction to Methods

2.3.1. Principal Component Analysis

PCA is mainly used to deal with the multicollinearity problem by deleting redundant variables determining the principal components, and then replacing the original principal components with new variables. In this paper, the PCA is used to find the main factors affecting the tourist flow volume and tourism income in Shaanxi province.

2.3.2. Multivariate Linear Regression

Firstly, the data were cleaned and pre-processed, including dealing with missing values, abnormal values, and data transformation to ensure that the data complied with the basic assumptions of multiple linear regression. Secondly, through principal component analysis, n principal components affecting the development of tourism were obtained, and the regression equation was established based on the tourism revenue (Y) and the values of these n principal components:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon_t \quad (1)$$

Y is the total revenue or number of tourists in the tourism industry. Variant X_1 , variant X_2 , ...variant X_n are the independent variables obtained by principal component analysis; β_0 , $\beta_1, \beta_2, \dots, \beta_n$ are the coefficients of the regression model, representing the extent to which each independent variable affects total income ε_t is the error term, which represents the part that the model cannot explain.

In this paper, the regression coefficients are estimated using the least squares method. After estimating the values of each parameter, the model's goodness of fit and statistical significance was assessed by the R^2 (Means of the Coefficient of Determination), the adjusted $\bar{R}^2$ (Adjusted Coefficient of Determination), the F-statistic and the residual analysis. Finally, the significance of the regression coefficients is interpreted in light of the practical implications of the modeling. The model is used to make predictions and inferences, and the reliability of the predictions is assessed by calculating confidence intervals.

2.3.3. Time Series Analysis

The tourism passenger flow volume and revenue data are imported to establish the time series, and the time series diagram is made and preprocessed, so that the research series is a stationary white noise series. Then the autocorrelation plot and partial autocorrelation plot fit the model parameters, and the optimal model is determined according to the Akaike Information Criteria (AIC).

3. Results and Discussion

3.1. Principal Component Analysis

3.1.1. Rationality Test

Before using principal component analysis, the Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests were performed on the original data. The results show that the sampling suitability of KMO is 0.791, which proves the applicability of PCA in this group of data. The values of Bartlett's sphericity test are shown in Table 2. Based on the results of Bartlett's sphericity test, it can be concluded that the data set can be analyzed by principal component analysis with 99% confidence.

Table 2. The results of Bartlett sphericity tests

Name of Index	Index value
Approximate Chi-square	1207.8
Degree of freedom	55.0
p-value	<0.01

3.1.2. Result Analysis

The correlation results of 10 independent variables show that some variables had strong multicollinearity, which did not accord with the assumption of a multiple linear model. Therefore, to eliminate the Multicollinearity and reduce the dimensionality of the independent variables, the PCA function in MATLAB is used to process the original data. As a result, the composition coefficient table and the variance contribution rate of each principal component are obtained. Since the sum of the variance contribution rates of the first and second principal components exceeds 99%, the two principal components can be considered to contain most of the valid information from the original data. Both the first and second principal components are linear combinations of the data after standardization of the original data, and the linear combination coefficients are shown in Table 3.

Table 3. PCA coefficients

Implications of the indicator	The first principal component	The second principal component
GDP of Shaanxi Province	0.02676	0.01627
National GDP	0.99708	-0.05461
Shaanxi Province disposable income per capita of urban residents	0.03529	0.00320
Shaanxi Provincial Consumer Price Index	-0.00001	0.00005
Engel's coefficient of national residents	0.00001	0.00006
Shaanxi Province accommodation and catering revenues	0.00106	0.00362
Total retail sales of consumer goods in Shaanxi Province	0.00981	0.04630
Shaanxi Province domestic tourist arrivals	0.05347	0.99722
Shaanxi Province international traveler arrivals	0.00025	0.01087
National disposable income per capita of residents	0.03038	0.00403

As can be seen from Table 3, for the first principal component, the absolute value of the linear combination coefficient of GDP is much larger than that of other variables. For the second principal

component, the absolute value of the linear combination coefficient of the number of domestic tourists in Shaanxi province is much larger than that of other variables. Therefore, the GDP plays a decisive role in the first principal component, while the number of domestic tourists in Shaanxi province plays a decisive role in the second principal component. Therefore, it is reasonable that the first principal component is represented by GDP, while the second principal component is represented by the number of domestic tourists in Shaanxi province, which restores the authenticity of the data to the greatest extent.

3.1.3. Model Evaluation

Based on the above analysis, this study takes the national GDP and the number of domestic tourists in Shaanxi province as independent variables. The correlation coefficient is shown in Fig. 1.

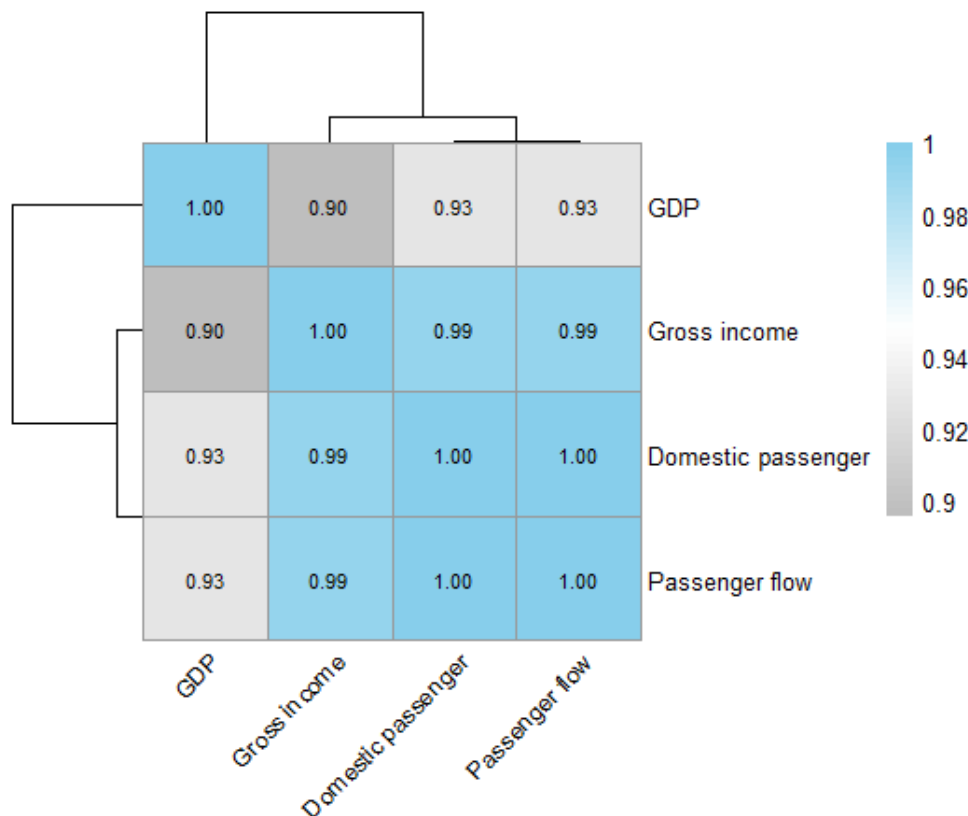


Figure 1. Principal component and dependent variable clustering heatmap (Photo credit: Original)

According to Fig. 1, the national GDP and the number of domestic tourists in Shaanxi province have a significant influence on the total tourism income of Shaanxi province, where the correlation coefficients are 0.90 and 0.99 respectively. The correlation coefficients between the national GDP and the number of domestic tourists in Shaanxi province and the total tourist flow even reach 0.93 and 1.00, which shows that the multiple regression model is very effective.

3.2. Multivariate Regression Analysis

The gross state product is denoted as X_1 , and the number of domestic tourists received in Shaanxi Province, is denoted as X_2 . The regression equations were established separately using the method of multiple regression. It should be noted that we utilize the data from 1990-2020 for model training and use the model to predict the total income and total number of tourists in Shaanxi Province in 2020 and 2021.

3.2.1. Regression Modeling of the Total Income

Taking the total tourism revenue of Shaanxi Province as the dependent variable Y_1 , the multiple linear regression model and the multiple nonlinear models are considered separately. The regression models are as follows respectively:

$$Y_1 = -0.00232X_1 + 0.13035X_2 - 33.0713 \quad (2)$$

$$\ln(Y_1) = 0.69504\ln(X_1) + 0.75735\ln(X_2) - 9.26238 \quad (3)$$

The regression effects of the two models are shown in Table 4.

Table 4. Significance parameters of the two models

Method	R^2	Adjusted $\bar{R}^2$	F-statistic	Univariate t-test p-value
Linear regression	0.995	0.994	2549.191	<0.001
Nonlinear regression	0.997	0.997	3802.342	<0.001

As shown in Table 4, the t-test p-values for the independent variables X_1 and X_2 are less than 0.001, which is significant, both for the linear regression model and for the nonlinear regression model after taking the logarithm. Meanwhile, the F-test results of both models were significant, and the regression equation decidable coefficients R^2 showed high goodness of fit, indicating that both regressions have good practicality. However, considering the real economic factors, in the linear regression model, the coefficient of the independent variable X_1 (national GDP) is negative, which is not by the general economic laws, so the nonlinear regression model is chosen as the final model. In addition, as can be seen from Fig. 2, the model has a better fitting effect.

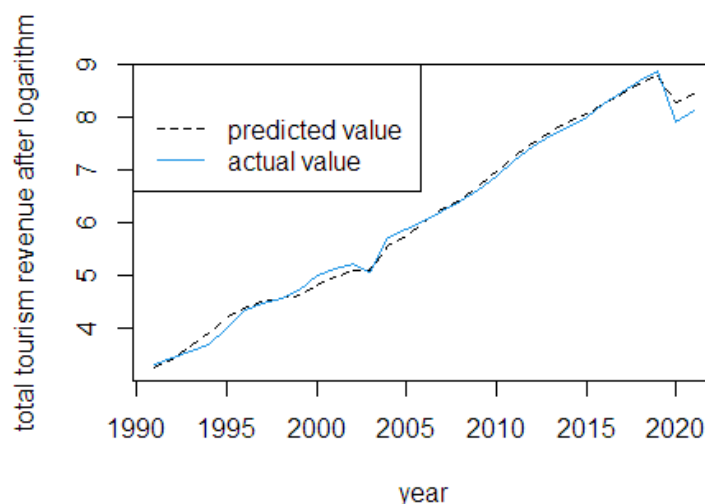


Figure 2. Nonlinear regression model of Total income from tourism in Shaanxi Province (Photo credit: Original)

3.2.2. Regression Modeling of the Total Population

Taking the total number of travelers received in Shaanxi Province as the dependent variable Y_2 , multiple linear regression models and multiple nonlinear models are considered separately. The regression models are as follows:

$$Y_2 = 0.00048X_1 + 0.99963X_2 + 15.97111 \quad (4)$$

$$\ln(Y_2) = -0.00199\ln(X_1) + 0.99701\ln(X_2) - 0.06740 \quad (5)$$

The regression effects of the two models are shown in Table 5.

Table 5. Significance parameters of the two models

Method	R^2	Adjusted $\bar{R}^2$	F-statistic p-value	Univariate t-test p-value
Linear regression	0.999	0.999	<0.001	<0.001
Nonlinear regression	0.997	0.996	<0.001	<0.001

As can be seen in Table 5, the t-test p-values for the independent variables X_1 and X_2 are less than 0.001, which is significant, both for the linear regression model and for the non-linear regression model after taking the logarithm. At the same time, the F-statistic of both models is significant, and the regression equation can be decided by the coefficient R^2 , both indicate a high degree of goodness of fit, indicating that both regressions have good practicality. However, considering the real economic factors, the coefficient of the independent variable X_1 (National GDP) in the nonlinear regression model is negative, which is not in line with the general economic laws, so the linear regression model is chosen as the final model. Fig. 3 illustrates the better fit of the model.

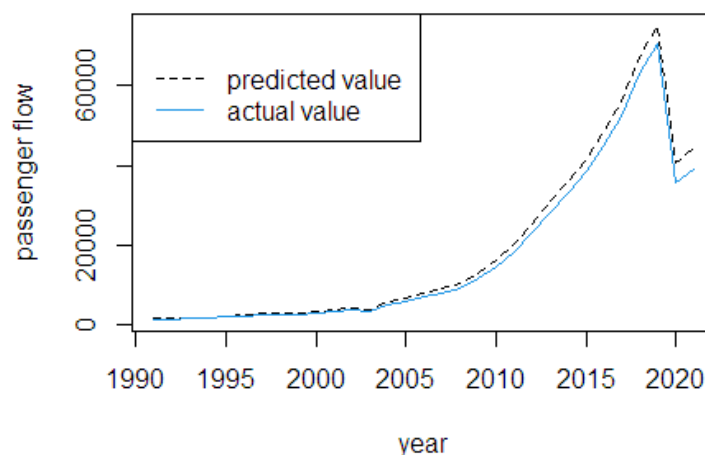


Figure 3. Linear regression model of travelers in Shaanxi Province (Photo credit: Original)

3.2.3. Model Evaluation and Forecasting

Forecasts were made for 2020 and 2021 using the two nonlinear models described above and compared with the actual values to assess the accuracy of the models. The results of the comparison error rates are shown in Table 6.

Table 6. Model prediction error rates

Model	The error rate for 2020	The error rate for 2021
Total income regression model	4.67%	3.69%
Total population regression model	1.35%	0.25%

As a result, both models have good prediction results for 2020 and 2021, and the errors of the models are less than 5%, and the predicted values are greater than the real values. Considering the actual factors, since 2020, the tourism industry has been affected by the epidemic policy and other factors, which are different from the development trend before the epidemic. Nonetheless, the model still has good accuracy and can be used to predict the future development of tourism.

3.3. Time Series Analysis

3.3.1. Total Revenue Forecast

The data of this model is derived from the total tourism revenue of Shaanxi Province from 1991 to 2019. First, logarithmic processing is performed. Then, the trend effect is extracted by third-order differential processing, and the stationary non-white noise sequence is tested as a stationary non-white noise sequence. Then the model is fitted to ARIMA (0,3,1). It is shown that finally the future trend is predicted to be linearly increasing. The fit and prediction of the data is shown in Fig. 4.

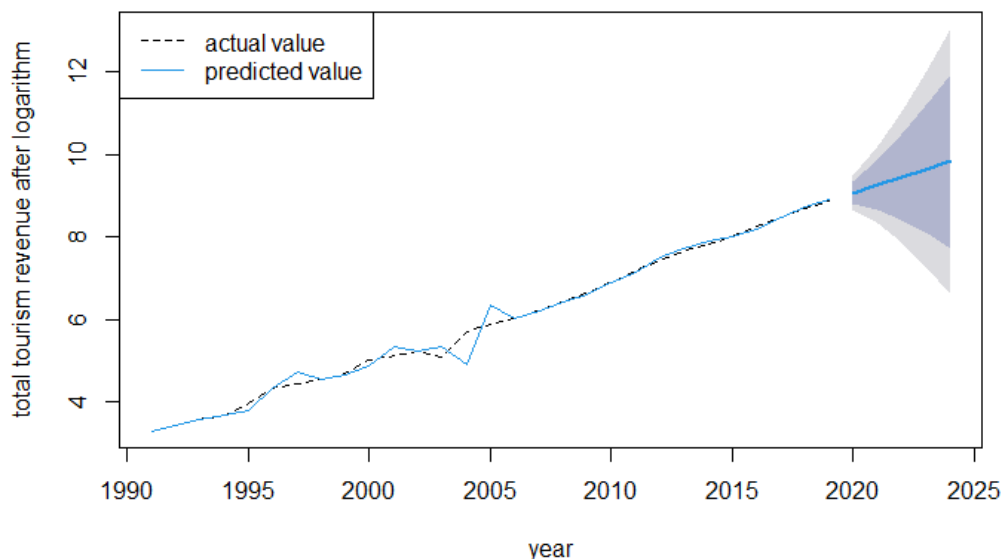


Figure 4. Logarithmic forecast of Total income from tourism in Shaanxi Province (Photo credit: Original)

The ARIMA (0,3,1) model fitted using the Arima model is

$$x_t = 3x_{t-1} - 3x_{t-2} + x_{t-3} + \varepsilon_t - \varepsilon_{t-1} \quad (6)$$

It can be seen from Figure 4 that the model fitting effect is better. According to the results of time series analysis, the total tourism revenue forecast of Shaanxi Province in 2020 and 2021 is 868.968 hundred million yuan and 1048.776 hundred million yuan. However, according to the statistics of the Shaanxi Statistical Yearbook, the actual total tourism revenue of Shaanxi Province was 276.555 hundred million yuan and 343.400 hundred million yuan respectively.

3.3.2. Tourism Visitor Flow Forecast in Shaanxi Province

The model data is derived from the tourism passenger flow in Shaanxi Province from 1991 to 2019. After the trend effect is extracted by the third-order difference, the Augment Dickey-Fuller (ADF) test and the pure randomness test are considered to be stationary non-white noise sequences, and the optimal model ARIMA (1,3,1) is fitted. The fit and prediction of the data is shown in Fig. 5.

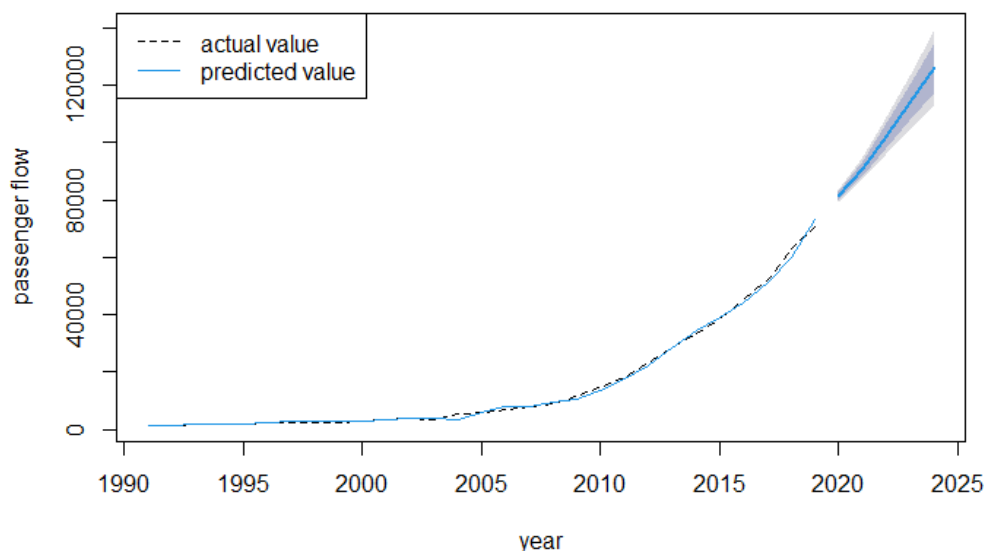


Figure 5. Forecast of travelers in Shaanxi Province (Photo credit: Original)

The ARIMA (1,3,1) model fitted using the Arima model is

$$x_t = 2.3707x_{t-1} - 1.1271x_{t-2} - 0.8729x_{t-3} + 0.6243x_{t-4} + \varepsilon_t - 0.8338\varepsilon_{t-1} \quad (7)$$

As can be seen in Figure 5, the forecast value of tourism passenger flow in Shaanxi Province in 2020 and 2021 is 813,132,900 people and 910,996,800 people. According to the statistics of the Shaanxi Statistical Yearbook, the actual passenger flow was only 357.09 million people and 390.58 million people respectively.

3.3.3. Model Analysis

By comparing the predicted fitting figure with the tabular data, we can see that the total tourism revenue and the 2021 flow of Shaanxi Province in 2020 and 2020 are both on a downward trend, which is the impact of the COVID-19 epidemic. In terms of statistics, 2020 was the worst year for the tourism industry, with both the number of people and income in the industry experiencing a historic decline, well below the level of 2019. With the 2021 vaccines and the relaxation of travel restrictions, both travel and income have recovered to a certain extent, but still below the levels of 2019.

3.4. Evaluation and Discussion

3.4.1. Analysis of Model Limitations

The selection of annual indicators for independent variables affecting tourism revenue and tourist numbers in this study may result in incomplete or subjective factors, which could be improved for greater comprehensiveness and generalizability.

As the results showed high ratios for GDP and domestic travelers received by Shaanxi province compared to other variables, we did not use the linear combination method but directly represented them by original data, which may result in reduced accuracy of the multiple regression model.

Additionally, time-series forecasting models assume past patterns will continue but unexpected events like COVID-19 cannot be accounted for. Meanwhile, further analysis is needed about changing policies and preferences that affect tourism development.

3.4.2. Suggestions for Improving Models

To improve performance and accuracy, it is suggested to consider introducing other factors such as weather, holidays, tourist attractions, etc., besides historical visitor data. A complex predictive model like a deep learning model could better capture complex patterns. Ensemble learning techniques can be also used for improvement.

4. Development Issues and Suggestions

4.1. Shaanxi Tourism Development Issues

4.1.1. Lack of Coordination between Tourism and Ecological Resources

During the peak seasons, tourists tend to concentrate in certain areas, leading to overloaded scenic spots with inadequate diversion and control methods. This worsens environmental pollution and degradation of the scenery.

4.1.2. Inadequate Management Regulations for Tourism

Some scenic spots are managed extensively or monopolized by certain parties, resulting in inconsistent quality and pricing such as excessive ticket prices or irregular project fees [11].

4.1.3. Insufficient Diversification of Tourism Brands

Shaanxi boasts rich cultural relics and unique landscapes that offer great potential for developing various tourism projects; however, these resources have not been fully utilized yet, resulting in a lack of diversity in tourism products centered mainly on sightseeing tours.

4.1.4. Shortage of Professional Talent for Tourism Management

The shortage of high-level professionals has hindered the integrated development of culture and tourism which is essential for endogenous growth in this industry's workforce capacity.

4.2. Shaanxi Tourism Development Suggestions

4.2.1. Improve Local Tourism Environmental Protection Regulations and Management

Relevant departments should adopt the principle of sustainable development for tourism regulations and traffic management, assess the environment before developing scenic spots, establish effective environmental protection measures to address damage and overload in tourist areas and ensure their sustainable development.

4.2.2. Enhance Service Quality while Reducing Ticket Fees

Tourist attractions are supposed to abandon the "ticket economy" mindset and embrace industrialization-led development by focusing on cultural interpretation, creative products, catering services, high-quality accommodation and service quality improvements that extend tourists' stay duration.

4.2.3. Develop Industrial Economy with Increased Publicity

It is better to strengthen industrial tourism cooperation through promoting study tours, farm trips, rental companies' partnerships and cross-border marketing such as "Tourism +" strategies which combines cloud technology with physical scenic spots for a complementing online or offline experience [12].

4.2.4. Implement Talent Development Strategy

Efforts should be made to stabilize the tourism workforce through government subsidies along with talent reserves, supporting skills training programmers and encouraging practitioners to strengthen their business capabilities whilst innovating new ideas in line with evolving travel trends and consumer needs.

5. Conclusion

This paper utilizes regression analysis and time series analysis to model and analyze tourism development indicators in Shaanxi Province. The data is collected and processed, while judgment indicators from each method are used. PCA is particularly effective for screening selected indexes, which leads to strong explanatory performance in both the fitted multiple regression model and the time series model. To support tourism growth in post-epidemic times, macro-control policies should be a focus for the government while relevant departments and enterprises innovate, develop, transform, upgrade and explore untapped target groups to boost visitor numbers. The research conclusion based on this methodology has some feasibility yet also subjective limitations. As a result, statistical methods could be refined for greater accuracy in future studies.

Authors Contributions

All the authors contributed equally and their names were listed in alphabetical order.

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