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Research on Forecasting the Number of Tourists in Anyang Based on Grey System GM (1, 1)

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Abstract **Original Research Article**

The scientific prediction of the number of tourists is of great significance for the rational planning of various relevant tourism departments and the formulation of various work. Based on the introduction of the current situation of the number of tourists in Anyang, the GM(1,1) model is established to predict the number of tourists. After testing, the prediction accuracy of the GM(1,1) model is higher, and the prediction results are closer to the real value, which can provide a reference for the actual prediction work. Finally, the grey GM(1,1) model is used to predict the number of tourists in Anyang from 2020 to 2023, and relevant countermeasures and suggestions for promoting the development of regional tourism are given.

Keywords: Number of tourists, GM(1,1) model, Trend prediction.

INTRODUCTION

Tourism is the product of the development of the whole economy to a certain stage. With the development of people's disposable income increases, tourism begins to rise, and the tourism market is expanding rapidly. As a sunrise industry, the tourism industry plays an increasingly obvious role in promoting the economic development of our country. In the course of tourism management, it is very important to accurately predict the number of tourists. From the perspective of macroeconomic development, the forecast of the number of domestic tourism provides a reference for the national tourism economic authorities to formulate the overall plan for the future tourism development. From the micro point of view, tourism enterprises should reasonably control the limited resources and minimize the risk and obtain the maximum income according to the forecast of the number of domestic tourists. Also provides the basis for the enterprise to formulate the strategic plan and the daily operation management.

With the development of economy and the continuous improvement of people's living standard, the contribution of tourism to the tertiary industry has gradually increased, which has become a powerful driving force to promote the growth of the national economy. To promote the development of the tourism industry, it has the use of its comprehensive driving role to promote economic growth throughout the region. The number of tourists, reflecting the degree of tourism development in a country or region, is an important index to measure the scale of tourism development in the country or region, and is also a key factor to evaluate the effectiveness of its tourism economic activities. Using appropriate methods to forecast the number of tourists and provide reference in development decision-making is necessary to ensure the successful completion of tourism planning. For this purpose, many scholars have analyzed the relevant factors that affect the number of tourists through a large number of studies, and also used various methods to predict the relevant indicators. Based on China's domestic real interest rate from 1998 to 2018, the interest rate of RMB against the US dollar, and the number of outbound tourists, a VAR model was constructed, and analysis through cointegration tests proved that there was a negative correlation between the real interest rate and the local currency value and the growth of outbound tourists in the long run in [1]. In the paper [2], the long-term trend of strong certainty in Siping city of Jilin Province from 2003 to 2017 is extracted by using the trend fitting method of nonstationary time series modeling method, and the estimation value of the model parameters is obtained by using the least square estimation method. In order to analyze the main reasons of Shanxi's tourism economy change, Zheng and Song established the regression

model of Shanxi's tourism economy by using partial least square regression according to the data of Shanxi's Statistical Yearbook from 2000 to 2017, and made cointegration test on the residual sequence in [3]. Kaslik and Neamţu generalized the existing minimal mathematical model of a given generic touristic site by including a distributed time-delay to reflect the whole past history of the number of tourists in their influence on the environment and capital flow, and they forced on the stability and bifurcation analysis of the coexisting equilibria of the mathematical model, with special emphasis on the positive equilibrium state. They also discussed the influence of the investment rate and competition parameter on the qualitative behavior of the system in a neighborhood of the positive equilibrium [4]. Based on the previous research results, the grey GM(1,1) model is used to predict the number of tourists in Anyang City in the paper, and some reliable suggestions were put forward.

MATERIALS AND METHODS

The Establishment of Grey System GM (1, 1) Model

Grey system theory is a new field of control theory. It is the product of the view and method of cybernetics applied to the social and economic system, and also the product of the combination of control theory and operations research. It takes the gray system as the research object, takes the whitening, desalination, quantization, modeling and optimization of the gray system as the core, and aims at the prediction and control of the development of various gray systems. Its main research contents include: grey system modeling theory, grey factor correlation analysis theory, grey prediction theory and decision theory, grey system analysis and control theory, grey system optimization theory and so on. In 1982, Chinese scholar professor Deng Julong established the grey system theory, which is a new method to study the uncertainty of minority data and poor information [5]. In the same year, the journal system and control communication published by north Holland publishing company published the first paper of Chinese scholar professor Deng Julong on grey system "the control problem of grey system". The publication of these two pioneering papers marked the beginning of the grey system theory. This as soon as a new theory was born, was domestic academia, foreign academics and the general practitioners of positive attention, many famous scholars and experts give full affirmation and support, many young and middle-aged scholars have join the grey system theory research, with great enthusiasm to carry out the theoretical exploration and application research in different fields [6].

Based on the gray system theory, the discrete data is regarded as continuous variables in its changing process The discrete values taken in, replace the original sequence with a sequence of generating numbers, weakening the randomness of the original time series, so that differential equations can be used to process the data. It is mainly used for singular sequence data with short time span and increasing trend. The steps to establish the grey prediction model are as follows:

1) Create a cumulative sequence of numbers. Let the original data sequence $x^{(0)}$ be a non-negative sequence

$$x^{(0)} = \{x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n)\}.$$

In order to weaken the volatility and randomness of the random sequence $x^{(0)}$, the first order accumulation sequence of $x^{(0)}$ is obtained as (1-AGO):

$$x^{(1)} = \{x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \cdots, x^{(1)}(n)\},$$

$$\text{Where } x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), \quad k = 1, 2, \cdots, n$$

2) Generate a sequence of immediately adjacent equal weights of $x^{(1)}$:

$$z^{(1)} = \{z^{(1)}(2), z^{(1)}(3), \cdots, z^{(1)}(n)\},$$

$$\text{Where } z^{(1)}(k) = 0.5x^{(1)}(k-1) + 0.5x^{(1)}(k),\ k = 2, 3, \cdots, n.$$

3) The albino differential equation corresponding to the GM(1,1) model is:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = u$$

Where, t is the time, a, u are the parameter to be estimated, and the effective interval of a is $(-2, 2)$, a, u are called the development gray number and endogenous control gray number. And the matrix formed by a, u is the gray parameter $\hat{a} = \begin{pmatrix} a \\ u \end{pmatrix}$, as long as we get the parameter a, u; we can find the value of $x^{(1)}(k)$。

4) For the matrix B composed of $z^{(1)}$ and the constant vector y_n:

$$B = \begin{bmatrix} z^{(1)}(2) & 1 \\ z^{(1)}(3) & 1 \\ \vdots & \vdots \\ z^{(1)}(n) & 1 \end{bmatrix} = \begin{bmatrix} -\frac{1}{2}[x^{(1)}(1) + x^{(1)}(2)] & 1 \\ -\frac{1}{2}[x^{(1)}(2) + x^{(1)}(3)] & 1 \\ \vdots & \vdots \\ -\frac{1}{2}[x^{(1)}(n-1) + x^{(1)}(n)] & 1 \end{bmatrix},$$

$$y_n = \left[x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n)\right]^T.$$

According to the least square method, we can get a, u:

$$\hat{a} = \begin{bmatrix} a \\ u \end{bmatrix} = (B^T B)^{-1} B^T y_n.$$

5) Find the GM(1,1) prediction model:

$$\hat{x}^{(1)}(i+1) = (x^{(0)}(1) - \frac{u}{a})e^{-ai} + \frac{u}{a},$$

The original value can be obtained by subtracting the above results:

$$\begin{cases} \hat{x}^{(0)}(1) = \hat{x}^{(1)}(1) \\ \hat{x}^{(0)}(i) = \hat{x}^{(1)}(i) - \hat{x}^{(1)}(i-1), i = 2,3,\cdots,n \end{cases}$$

6) Check the accuracy of the model. The relative residual is:

$$\varepsilon(k) = \frac{\left| x^{(0)}(k) - \hat{x}^{(0)}(k) \right|}{x^{(0)}(k)}, k = 1,2,\cdots,n,$$

The average relative residual is: $\bar{\varepsilon} = \frac{1}{n}\sum_{k=1}^{n}\varepsilon(k)$. Calculate the mean square error S_0 of the original series $x^{(0)}(i)$ based on the mean $\bar{x}^{(0)} = \frac{1}{n}\sum_{i=1}^{n} x^{(0)}(i)$:

$$S_0 = \sqrt{\frac{\sum_{i=1}^{n}[x^{(0)}(i) - \bar{x}^{(0)}]^2}{n-1}}.$$

Then calculate the mean square error S_1 based on the average $\bar{\varepsilon}^{(0)} = \frac{1}{n}\sum_{i=1}^{n}\varepsilon^{(0)}(i)$ the residual sequence

$$\varepsilon^{(0)}(i) = x^{(0)}(i) - \hat{x}^{(0)}(i) : S_1 = \sqrt{\frac{\sum_{i=1}^{n}\left[\varepsilon^{(0)}(i) - \bar{\varepsilon}^{(0)}\right]^2}{n-1}}.$$

Finally, calculate the mean square error ratio $c = \frac{S_1}{S_0}$ and the small error probability $p = \left\{\left|\varepsilon^{(0)}(i) - \bar{\varepsilon}^{(0)}\right| < 0.6745 \cdot S_0\right\}$.

According to the prediction accuracy grade division table (see Table 1), the prediction accuracy of the model is verified.

Table-1: Classification criteria for G (1, 1) model prediction accuracy

Level of accuracy	Mean residual $\bar{\varepsilon}$	Mean square error ratio c	Small error probability p
Level 1 (Good)	<0.01	<0.35	>0.95
Level 2 (Qualified)	<0.05	<0.5	>0.80
Level 3 (Barely Qualified)	<0.10	<0.65	>0.70
Level 4 (Failed)	≤0.20	≥0.65	≤0.70

7) If the test is qualified, the model can be used to predict.

$\hat{x}^{(0)}(n+1) = \hat{x}^{(1)}(n+1) - \hat{x}^{(1)}(n)$, $\hat{x}^{(0)}(n+2) = \hat{x}^{(1)}(n+2) - \hat{x}^{(1)}(n+1)$,

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Can be as some prediction value of $x^{(0)}$.

Empirical Analysis

Anyang is located in the northernmost part of Henan Province. It is located at the intersection of Shanxi, Hebei, and Henan. It leans against the towering Taihang Mountains in the west and the endless East China North Plain. It is the central city of northern Henan. Anyang is one of the seven ancient capitals of China, a national historical and cultural city, the hometown of Oracle, the birthplace of Zhouyi, and the birthplace of Hongqiqu spirit. Anyang is rich in tourism resources, and has complete tourism service facilities such as hotel industry, catering industry and commerce. There are 8 national cultural relics protection units in Yinxu Museum, Yuefei Temple, Tianning Temple Tower, Xiuding Temple Tower, Mingfu Temple Tower, Xiaonanhai Grottoes, Yuli City and Lingquan Temple Grottoes, and 2 national patriotic education bases, 38 provincial-level cultural relics protection units. Anyang has convenient transportation and geographical advantages. The Beijing-Guangzhou Railway runs through the urban area, the Beijing-Zhuhai Expressway, and the 106 and 107 National Highways run through the north and south. The urban roads are intertwined, and the bus lines extend in all directions, which has formed a traffic network pattern of intranet and external links.

This paper selects the original data of the number of tourists received in Anyang City from 2010 to 2019. The data are derived from the statistical bulletin of national economic and social development in Anyang City over these years, as shown in Table 2.

Table-2: Number of Tourists in Anyang from 2010 to 2019 (Unit: 10,000 persons)

Years	2010	2011	2012	2013	2014
Quantity	1885.88	2206	2504.05	2735.43	2968.9
Years	2015	2016	2017	2018	2019
Quantity	3431	4025	4743.04	5338.9	4967.82

The steps to establish and solve the model are as follows:

Step 1 Create the original data sequence:

$$x^{(0)}=\left\{\begin{matrix}1885.88, 2206, 2504.05, 2735.43, 2968.9,\\ 3431, 4025, 4743.04, 5338.9, 4967.82\end{matrix}\right\},$$

Accumulate the sequence to generate a new sequence:

$$x^{(1)}=\left\{\begin{matrix}1885.88, 4091.88, 6595.93,9331.36, 12300.26,\\ 15731.26, 19756.26, 24499.30, 29838.20, 34806.02\end{matrix}\right\}$$

Step 2 Calculate $\begin{bmatrix}a\\u\end{bmatrix}=(B^TB)^{-1}B^Ty_n$ according to the least square method. Calculated by MATLAB programming, we get that $a=-0.111384$, $u=1919.08$. Therefore the differential equation is:

$$\frac{dx^{(1)}}{dt}-0.111384x^{(1)}=1919.08.$$

Since $|a|=|-0.111384|<2$, then the GM(1,1) model is meaningful.

Step 3 Due to that $\frac{u}{a}=-17229.45$, we get the GM (1, 1) prediction model:

$$\hat{x}^{(1)}(i+1)=1.9115.327e^{-0.111384i}-17229.45,$$

The original value can be obtained by subtracting the above results:

$$\begin{cases}\hat{x}^{(0)}(1)=\hat{x}^{(1)}(1),\\ \hat{x}^{(0)}(i)=\hat{x}^{(1)}(i)-\hat{x}^{(1)}(i-1), i=2,3,\cdots,n.\end{cases}$$

Step4 Model testing. According to the GM(1,1) model, the forecast value of the number of tourists received in Anyang city from 2010 to 2019 is calculated, and then compared with the actual value and the error test is carried out (see Table 3)

Table-3: Actual value and forecast value of the number of tourists in Anyang from 2010 to 2019

Years	Actual value	Predictive value	Residual	Relative residual (%)
2010	1885.88	1885.88	0	0
2011	2206	2252.04	-46.04	2.08
2012	2504.05	2517.42	-13.37	0.53
2013	2734.43	2814.06	-79.63	2.91
2014	2968.9	3145.67	-176.77	5.95
2015	3431	3516.35	-85.35	2.49
2016	4025	3930.71	94.27	2.34
2017	4743.04	4393.90	349.14	7.36
2018	5338.9	4911.67	427.23	8.00
2019	4967.82	5490.46	-522.64	10.52

The average relative residual error is:

$\bar{\varepsilon}=0.0422<0.05$,

The mean square error ratio is $c=\frac{S_1}{S_0}=0.2166<0.35$ and the mean square error ratio is

$$p=\left\{\left|\varepsilon^{(0)}(i)-\bar{\varepsilon}^{(0)}\right|<0.6745\cdot S_0\right\}=1>0.95.$$

It shows that the prediction model has high precision precision, the precision grade reaches the second level, and the prediction results are reliable, which can truly reflect the dynamic trend of the number of tourists received at home and abroad in Anyang City, and can be used as an ideal prediction model for the number of tourists in Anyang City.

In addition, it can be seen from figure 1 that the actual value of the number of tourists received at home and abroad in Anyang City has little error with the predicted value of the model built in this paper, and the graph shows more intuitively the agreement between the actual values and the predicted values.

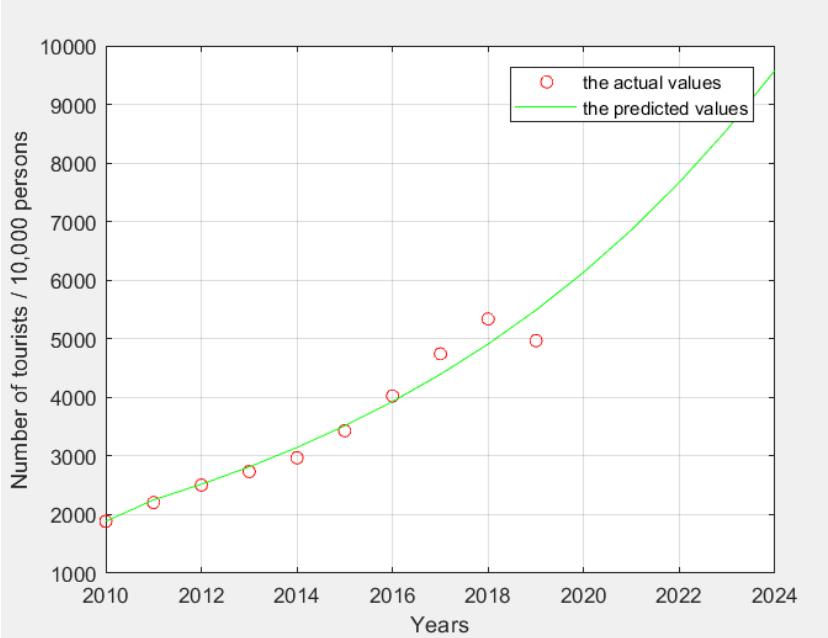

Fig-1: Comparison of actual values and GM(1,1) predicted values

Forecast of the number of tourists in Anyang

The above analysis shows that the model has high reliability. The grey forecast GM (1, 1) model is used to predict the number of domestic and foreign tourists in Anyang City from 2020 to 2024. The predicted values are as follows (see Table 4).

Table-4: Predicted Values of Tourists in Anyang from 2020 to 2023 (Unit: 10,000 persons)

Years	2020	2021	2022	2023
Quantity	6137.45	6860.68	7669.12	8572.85

It can be seen from the table that the number of tourists in Anyang City will continue to rise in the next four years. If this trend is sustained, the forecast value will reach more than 85.72 million in 2023, which will contribute more to the economic development of Anyang City and promote the further development of tourism industry. At the same time, the rapid development of tourism industry is closely related to the economic development of Anyang City and the policy support of Anyang City Government to tourism.

RESULTS AND DISCUSSION

In this paper, matrix calculation and numerical prediction are mainly performed on the calculation index data. The MATLAB matrix calculation method is used in conjunction with the grey theory to predict the GM(1,1) model. Through calculation and statistical analysis, it is found that the number of tourists in Anyang City will continue to increase in the next few years.

With the help of grey theory, the study of predicting the scale of Anyang tourism can better reflect the future development of Anyang tourism, provide scientific reference data for the dynamic evolution and rapid development of Anyang tourism, and provide effective theoretical support for relevant departments to formulate corresponding policies.

Some suggestions to strengthen the tourism industry in Anyang are as follows:

1) Integrate resources and tap potentials in depth: For some high-grade tourism resources with better market effects, such as the Yinxu Palace and the Yinxu Mausoleum site, Zhouyi Culture, Hongqiqu and Taihang Mountain series of tourism, the focus should be on the Central Plains and expand External visibility.

2) Improve the infrastructure and implement the policy tilt: With the rise of tourism, related companies, such as hotels, transportation, handicrafts, catering and shopping, are also affected by it and can achieve considerable development. Therefore, as the formulator and executor of the city's industrial development plan, the Anyang Municipal Party Committee Government should devote its efforts to the city's tourism planning and make it a top priority. Second, the rapid development of the tourism industry also depends on the construction of relevant infrastructure, such as high-quality transportation conditions, matching accommodation and catering services, etc. are all prerequisites for the development of the tourism industry. It is necessary to increase investment in these areas to develop Tourism has created a good situation.

3) Scientifically integrate routes and improve linkage benefits: Anyang City is very rich in tourism resources. In addition to important historical and cultural tourism resources, there are also natural tourism resources dominated by the foothills of Taihang, and tourism resources composed of folk culture and humanities. If you want to revitalize the city's tourism resources, you must achieve overall planning, market-oriented, on the premise of improving the infrastructure of the tourist area, scientifically and rationally plan and design tourism routes, and deepen the potential of tourism resources.

CONCLUSION

Through the establishment, inspection and empirical analysis of the GM(1, 1) model, we can see that: (1) The GM(1, 1) model has the advantages of less sample data and convenient calculation, and can be used to predict future house prices based on less historical data. To make predictions, the method is simple and easy to operate; (2) As the number of tourists will be affected by a large number of random factors, the GM(1,1) model is mainly applied to system objects with little data and little fluctuation, which leads to the gray model Randomly fluctuating data has poor fitting and low prediction accuracy. In addition, due to the limitations of the gray GM (1,1) model, a series of factors that affect tourism are not considered, making the prediction one-sided. Therefore, in subsequent research, a combination model can be established by increasing the sample size. And other methods, as much as possible to consider the main factors affecting the number of tourists, making the prediction results more convincing.

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