

Grey Relational Degree Analysis of Tourism Income based on Grey System Theory

Rui Chen¹, Liang Fang², Manli Zhang³, Jing Kong⁴

**College of Mathematics and Statistics, Taishan University, Tai'an, Shandong, China*

Abstract: This paper applies the Grey correlation analysis method in the Grey system theory and takes the Grey correlation degree as the measurement index to analyze the relevant factors affecting the tourism income. It finds that the leading factors affecting the domestic tourism income of a certain region are the per capita consumption expenditure of rural residents and the number of domestic tourists. At the same time, it reveals the correlation degree between the tourism income and various influencing factors from an empirical point of view. To make recommendations for the increase of regional tourism revenue.

Keywords: Tourism revenue; Grey system theory; Grey relational degree analysis; Influencing factors; per capita consumption expenditure of rural residents; Disposable income of rural residents.

I. INTRODUCTION

A. Research Background

In the ten years from 2010 to 2018, with the leapfrog improvement of development level and the change of people's living needs, China's tourism industry has developed rapidly, continuously expanded in scale, and constantly improved in quality. Tourism has become an important indicator of improving living standards and an important way for Chinese people to live a well-off society. The position of tourism as a strategic pillar industry of the national economy has also been more consolidated.

Shandong Province enjoys superior geographical location and rich tourism resources. Tourism has become one of the fastest growing industries in the province's national economy. As an important industry in Shandong Province, tourism is of great significance to Shandong Province [1]. After more than 40 years of rapid development, the tourism industry in Shandong Province has experienced the development process from scratch to existence, from small to large, from weak to strong, from the edge to the core, and has now become the pillar industry supporting the economic development of Shandong Province and the happiness industry affecting the daily life of the people. In 2018, Shandong received 814.228 million domestic tourists, an increase of 9.6%, and realized domestic tourism revenue of 1,285.13 billion yuan, an increase of 13.7%. According to the Statistical Communique of Shandong Province's National Economic and Social Development in 2022, Shandong received 590 million domestic tourists in 2022, and the domestic tourism income was 602.63 billion yuan [2]. Tourism has become a new growth point of Shandong's national economy.

B. Research Status

Chinese scholar Gu Jianbin [3] used the grey correlation degree measurement model earlier to analyze the influencing factors of tourism economic income in Mount Putuo and found that tourism facilities were the key influencing factors. Subsequently, Wang Yaobin et al. [4], Zhang Jinfeng et al. [5], Yan Rong et al. [6] conducted further studies and found that economic development, tourism services, information services and other factors have a significant impact on tourism income. To provide scientific basis for tourism planning, evaluation, decision-making, and so on, the Grey correlation dynamic analysis method is used to identify the factors affecting the development of tourism in China, and reveal the leading factors affecting the development of tourism. At present, Grey correlation analysis method is widely used in tourism research in China, and there are many mature research results. Grey correlation analysis has highlighted its research advantages in the research and application of tourism. It reflects the strength of the association between dependent variables and explanatory variables with correlation values for various complex variables and factors. It has the characteristics of high data utilization rate and high model accuracy, and can clearly explain the impact of changes in variables on dependent variables.

II. GREY RELATIONAL DEGREE ANALYSIS OF INFLUENCING FACTORS OF REGIONAL TOURISM INCOME

Gray relational degree analysis focuses on the uncertain correlation between things, that is, the uncertain correlation between system factors or factors and the main behavior of the system [7]. The principle of the Grey relational degree model is that the time series of the research object is usually taken as the reference series, and the time series of its influencing factors is taken as the comparison series. If the change situation of the two sequences is basically consistent or similar, the degree of synchronous change is higher, that is, the gray correlation degree is larger. On the contrary, the Grey correlation degree is smaller. Regional tourism income refers to all monetary income obtained by providing tourism resources, tourism facilities and tourism services to all tourists in a certain region within a certain period of time, including income from the sale of goods, service income and other income [8].

Considering the serious impact of the novel coronavirus outbreak on the tourism industry since the end of 2019, this paper only studies the influencing factors of tourism income in Shandong Province from 2010 to 2018. Tourism is an industry with a high degree of correlation and strong dependence, and various social and economic factors may have different degrees of influence on domestic tourism income. Therefore, whether the index is reasonable or not will directly affect the effectiveness of the final data analysis. Based on the research and analysis of the factors affecting tourism income by previous scholars and the availability of data from real economic activities, this paper analyzes the main factors affecting tourism income from the aspects of the number of tourists, per capita tourism expenditure, gross regional product, per capita disposable income and per capita consumption expenditure.

A. Data selection

This paper uses the Grey relational analysis method to take tourism related data of Shandong Province from 2010 to 2018 as samples. Data of domestic tourism income, number of domestic tourists in Shandong Province, per capita tourism expenditure in Shandong Province, gross regional product of Shandong Province, per capita disposable income of residents in Shandong Province, per capita disposable income of urban residents in Shandong Province, per capita disposable income of rural residents in Shandong Province, per capita consumption expenditure of urban residents in Shandong Province, and per capita consumption expenditure of rural residents in Shandong Province were selected. All data are from Shandong Statistical Yearbook 2022.

B. Grey relational degree data calculation

List the reference series and comparison series that affect the tourism income. X_0 represents the domestic tourism income of Shandong Province, which is the reference series. X_1, \dots, X_8 represent the number of domestic tourists in Shandong Province, the per capita tourism expenditure in Shandong Province, the GDP of Shandong Province, the per capita disposable income of residents in Shandong Province, the per capita disposable income of urban residents in Shandong Province, the per capita disposable income of rural residents in Shandong Province, the per capita consumption expenditure of urban residents in Shandong Province, and the per capita consumption expenditure of rural residents in Shandong Province, which are comparative series. The specific data are shown in Table 1.

Table 1 Reference series and comparative series of Grey correlation of tourism in Shandong Province

| A given year | 2010 | 2011 | 2012 | 2013 | 2014 |
|-----------------------------|----------|----------|----------|----------|----------|
| X_0 /Hundred million Yuan | 2915.80 | 3573.70 | 4335.03 | 5014.74 | 5711.20 |
| X_1 /Ten thousand people | 34990 | 41696 | 48739 | 54262 | 59577 |
| X_2 /Yuan | 833.3 | 857.1 | 889.4 | 924.2 | 958.6 |
| X_3 /Hundred million Yuan | 33922.49 | 39064.93 | 42957.31 | 47344.33 | 50774.84 |
| X_4 /Hundred million Yuan | 12922 | 15077 | 17127 | 19008 | 20864 |
| X_5 /Yuan | 18971 | 21678 | 24496 | 26882 | 29222 |

| | | | | | |
|-------------|-------|-------|-------|-------|-------|
| x_6 /Yuan | 7034 | 8395 | 9506 | 10687 | 11882 |
| x_7 /Yuan | 12761 | 14164 | 15349 | 16646 | 18323 |
| x_8 /Yuan | 4472 | 5489 | 6304 | 6877 | 7962 |

| A given year | 2015 | 2016 | 2017 | 2018 |
|-----------------------------|----------|----------|----------|----------|
| x_0 /Hundred million Yuan | 6505.11 | 7399.61 | 8491.46 | 9661.50 |
| x_1 /Ten thousand people | 65045 | 70716 | 77966 | 85899 |
| x_2 /Yuan | 1000.1 | 1046.4 | 1089.1 | 1124.7 |
| x_3 /Hundred million Yuan | 55288.79 | 58762.46 | 63012.10 | 66648.87 |
| x_4 /Hundred million Yuan | 22703 | 24685 | 26930 | 29205 |
| x_5 /Yuan | 31545 | 34012 | 36789 | 39549 |
| x_6 /Yuan | 12930 | 13954 | 15118 | 16297 |
| x_7 /Yuan | 19854 | 21495 | 23072 | 24798 |
| x_8 /Yuan | 8748 | 9519 | 10342 | 11270 |

Calculation steps of Grey correlation degree [9]:

Step 1: Find the initial value image of each sequence,

$$X'_i = \frac{X_i}{X_0} = (x'_i(1), x'_i(2), \dots, x'_i(n)), i = 0, 1, 2, \dots, m.$$

Step 2: Find the absolute value sequence of the difference between the corresponding components of the initial value image of X_0 and X_i ,

$$\Delta_i(k) = |x'_0(k) - x'_i(k)|, \Delta_i = (\Delta_i(1), \Delta_i(2), \dots, \Delta_i(n)), i = 1, 2, \dots, m$$

A.

Step 3: Find the maximum and minimum values of $\Delta_i(k) = |x'_0(k) - x'_i(k)|, k = 1, 2, \dots, n; i = 1, 2, \dots, m.$

Respectively recorded as:
 $M = \max_i \max_k \Delta_i(k), m = \min_i \min_k \Delta_i(k).$

Step 4: Calculate the correlation coefficient:

$$\gamma_{0i}(k) = \frac{m + \xi M}{\Delta_i(k) + \xi M}, \xi \in (0, 1), k = 1, 2, \dots, n; i = 1, 2, \dots, m.$$

Step 5: Find the average of the correlation

coefficients:

$$\gamma_{0i} = \frac{1}{n} \sum_{k=1}^n \gamma_{0i}(k), i = 1, 2, \dots, m.$$

When $\xi = 0.5$, the calculation result of Grey relational degree is: If the correlation coefficients are calculated as follows.

| γ_{0i} | γ_{01} | γ_{02} | γ_{03} | γ_{04} | γ_{05} | γ_{06} | γ_{07} | γ_{08} |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| result | 0.767 | 0.577 | 0.689 | 0.742 | 0.706 | 0.746 | 0.700 | 0.787 |
| | 5 | 5 | 0 | 4 | 4 | 4 | 8 | 6 |

C. Result analysis of Grey relational degree

Based on the calculation of the above Grey correlation degree, the following table 2 is made to facilitate the analysis of the results.

Table 2 Calculation results and ranking of Grey correlation degree

| index | Grey correlation degree | sort |
|--|-------------------------|------|
| Per capita consumption expenditure of rural residents in Shandong Province (X_8) | 0.7876 | 1 |
| Number of domestic tourists in Shandong Province (X_1) | 0.7675 | 2 |
| Per capita disposable income of rural residents in Shandong Province (X_6) | 0.7464 | 3 |
| Per capita disposable income of Shandong residents (X_4) | 0.7424 | 4 |
| Per capita disposable income of urban residents in Shandong Province (X_5) | 0.7064 | 5 |
| Per capita consumption expenditure of urban residents in Shandong Province (X_7) | 0.7008 | 6 |
| Gross regional product of Shandong Province (X_3) | 0.6890 | 7 |
| Per capita tourist expenditure in Shandong Province (X_2) | 0.5775 | 8 |

All Grey correlation degrees are greater than 0.50, which indicates that each comparison series has a significant impact on tourism income in Shandong Province, that is, the calculation results are of great reference value. Theoretically speaking, the closer the Grey correlation degree is to 1, the greater the effect of the comparison series on improving regional tourism income [10]. Therefore, the Grey correlation degree of the comparison series is higher than 0.70, which is called the key influencing factor. It is 0.60 ~ 0.69, which is an important influencing factor. If it is lower than 0.60, it is regarded as an insignificant influencing factor. As can be seen from the calculation results, according to the data from 2010 to 2018, there is not much difference in the correlation coefficient on the whole. The factor that has the greatest impact on the domestic tourism income of Shandong Province is the per capita consumption expenditure of rural residents in Shandong Province, followed by the number of domestic tourists in Shandong Province. The second is the per capita disposable income of rural residents in Shandong Province and the per capita disposable income of residents in Shandong Province. The less influential factor is the per capita tourism expenditure in Shandong Province.

III. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

According to the results of Grey correlation, the per capita consumption expenditure of rural residents and the number of domestic tourists in Shandong Province have the highest correlation with the domestic tourism income of Shandong Province, and have the greatest impact on the tourism income of Shandong Province. Therefore, encouraging rural residents to consume and attracting tourists is the most critical factor to increase tourism income. In addition, the calculation results show that the per capita disposable income of rural residents in Shandong Province and the correlation between the per capita disposable income of residents in Shandong Province and the domestic tourism income in Shandong Province are also very high. Considering the premise of the increase of rural residents' consumption is the increase of rural residents' per capita disposable income, the following suggestions are put forward.

B. Suggestion

Actively respond to the call of the state, further promote rural revitalization, accelerate the increase of rural residents' income, gradually shift from the orientation of urban development to the priority of rural revitalization and development in the new stage of development, effectively increase the income of rural residents, truly and effectively expand the proportion of middle groups, and substantively promote the common prosperity of all urban and rural people. Efforts will be made in the following areas:

First, speed up urbanization, promote some of the current rural low-income people to move to the existing large, small and medium-sized cities, more importantly, promote the urbanization and modernization of the countryside itself, and vigorously develop the service industry, processing industry and other non-agricultural industries.

Second, improve the education level of rural residents, improve the quality of rural education, strengthen the professional training of rural labor, and improve the employment skills of rural labor.

Third, accelerate the adjustment of agricultural industrial structure, cultivate a competitive modern agricultural cash crop industrial system, cultivate famous products and characteristic industries with market competitive advantages, promote the high-quality development of modern agriculture, and increase the proportion of operational income of rural residents.

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