Regional Tourism Economic Forecasting Model Based on GM Grey Forecasting Method

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On the basis of regional tourism economic development, this paper uses the entropy method and the coupling coordination model to analyse the comprehensive development level and the degree of coupling coordination between tourism and regional development and uses the GM (1, 1) grey prediction model to forecast the degree of coupling coordination between tourism and regional development in China in the next five years, based on the data related to tourism and regional development in China from 1996 to 2015. The results show that the degree of coupling and coordination between tourism and regional development is steadily increasing, with the coupling level moving from low level coupling to antagonistic stage and the coupling coordination level reaching from low level disorder to good level coordination.

1. Introduction

Since China’s 18th National Congress, the Chinese government has clearly put forward that “tourism is an important engine for stable growth, an important grasp of people’s livelihood, an important support for the construction of ecological civilization and an important carrier of prosperous culture,” and the important strategic position of tourism in the national economy and social development has become more prominent [1]. Territorial tourism is the overall strategy of China’s tourism development in the new era and is a new regional development concept and model that uses tourism as a regional advantageous industry in the era of mass tourism to drive and promote coordinated economic and social development [2]. Therefore, the academic research on the relationship between tourism industry and regional development in the context of all-area tourism has certain theoretical guidance significance for the implementation of all-area tourism strategy [3].

Before the 1990s, scholars mainly used traditional quantitative methods to forecast tourism demand and tourist flows, where quantitative studies used causal analysis [4] in addition to econometric methods such as moving average models and ARMA models [5]. Such methods were mainly achieved by analysing the influencing factors of tourism flows, with the disadvantage that the influencing factors are difficult to determine and too costly. After the 1990s, with the emergence and development of artificial intelligence methods and their excellent performance in the field of forecasting, scholars also began to try to introduce such methods into the forecasting of tourism traffic and tourism revenue, the most used of which are mainly BP neural networks, grey system GM (1, 1) models, and multifactor dynamic coarse forecasting models in rough set theory, genetic algorithms, etc. [6]. There is no shortage of comparisons between the results obtained using traditional research methods and artificial intelligence methods, but the final conclusions show the significant advantages of artificial intelligence methods in the field of forecasting. Because of the unique advantages of AI methods in forecasting, when the support vector machine method was introduced and performed well in the forecasting field, scholars were quick to apply it to the study of tourism demand and tourism traffic forecasting as well [7].

In support vector machine methods, the core part is the parameter selection problem, which is essentially an
optimisation search process. Before the birth of evolutionary algorithms, scholars did not find an optimal way to deal with parameter selection. With the emergence and rise of intelligent population algorithms, more and more scholars have discovered its outstanding performance in dealing with optimisation problems. Therefore, some scholars have also tried to use population intelligence algorithms, such as particle swarm algorithms and genetic algorithms, to deal with the parameter selection problem in support vector machines when doing prediction work using support vector machine methods [8].

In this paper, the GM algorithm is applied to the parameter optimisation of support vector regression and applied to regional tourism forecasting. Accurate forecasting of regional tourism traffic is beneficial not only to the management department in providing reasonable guidance on the operation and management of scenic spots, but also to the regional government in formulating relevant supportive policies and driving the overall development of the national economy with the development of tourism as the leading industry; and accurate forecasting of regional tourism revenue can also provide complete data support to the local government in formulating and improving tourism economic policies [9].

2. Related Work

The interaction between tourism and regional development has always been a hot content of academic research. Foreign research has started earlier and the relevant studies are more mature, mainly focusing on the interaction between tourism and economy and environment. Reference [10] has analysed the influence mechanism between tourism activities and ecological environment. The empirical analysis of tourism and economic growth concluded that there is an uneven relationship between tourism and economic growth in Korea [11]. Reference [12] used a comparative analysis to analyse the impact of energy and environment on regional development in China and the United States from the perspective of sustainable development.

A comprehensive analysis of the environmental conditions of tourism destinations was conducted, and it was concluded that tourism development has both positive and negative effects on the ecological environment [13]. Reference [14] proposes a method to quantitatively measure the contribution of tourism to regional economic development, using theories such as tourism economics and input-output analysis. In [15] using a panel analysis of 254 prefecture-level cities, it was verified that the development of tourism plays an important role in driving the development of the tertiary industry and narrowing the regional development gap. An in-depth study of the degree of coordination between tourism and the ecological environment in China was carried out based on principal component analysis [16]. Reference [17] analysed the degree of coordination between tourism and regional economy and its influencing factors in 17 cities of Shandong Province using the coupling coordination model and grey correlation analysis. Reference [18] analysed the mechanism of the interaction between tourism, economy and ecological environment, and conducted an empirical study on the coastal areas of Jiangsu provinces and cities along the Yangtze River Economic Belt and Turpan using the coupled coordination model.

In general, domestic and foreign research on the relationship between tourism and regional development has mostly focused on three aspects: tourism and economy, tourism and ecological environment, and tourism-economy-ecological environment, without considering the region as a whole in a systematic way, and the content of the research has not taken into account the impact of tourism activities on social progress, which is lacking in the context of the new era. The research content does not take into account the impact of tourism activities on social progress and lacks in-depth consideration of the relationship between tourism and regional development in the context of the new era. In this paper, on the basis of exploring the mechanism of interaction between regional tourism and regional development, we construct a tourism development system and a regional development system from a regional perspective, analyse the comprehensive development level and the degree of coupling and coordination between tourism and regional development using the entropy value method and the coupling and coordination model, and forecast the degree of coupling and coordination between tourism and regional development in China in the next five years using the GM (1, 1) grey prediction model, with a view to providing a basis for it. The GM (1, 1) grey prediction model is used to forecast the degree of coordination between tourism and regional development in China in the next five years, in order to provide reference for the transformation and upgrading of China’s tourism industry and the implementation of the regional tourism strategy.

3. Mechanisms of the Role of Regional Tourism Development

In essence, regional development and tourism are intrinsically linked, with the two being mutually coupled, mutually conditional, and mutually reinforcing (see Figure 1). Tourism in the region is seen as an industry with regional advantages. By optimising and enhancing industrial, environmental, and social resources, tourism is organically integrated with the region and its resources and industries and shared by tourists and residents, thus promoting coordinated regional development [19].

As a new engine for regional development, regional tourism has become an important driving force for coordinated regional development. In recent years, the country’s economic development has entered a new normal, with economic growth rates continuing to decline, ecological and environmental issues coming to the fore, manufacturing, investment, and export pulling, and growth drivers gradually shifting from investment-driven and factor-driven to innovation-driven and consumption-driven. The tourism industry, on the other hand, has continued to grow at a high rate under the new normal, with record numbers of visitors and total tourism revenue, becoming an important means of driving domestic demand. The implementation of an all-area
tourism strategy will give full play to the tourism industry's comprehensive and driving characteristics and promote coordinated regional development.

Regional development is a multilevel complex system, covering economic, social, and environmental aspects, and coordinated regional development can provide strong support and guarantee for the implementation of the all-area tourism strategy. First of all, regional economic development can provide financial guarantee for the development of all-area tourism. Tourism itself has the characteristics of large investment, long cycle, slow benefits, etc., and the whole area of tourism development will expand the scope of tourism from attractions to the entire region, construction areas, construction content, and construction goals to achieve all need sufficient sources of funding. In addition, the region is both a tourist destination and a tourist source. The rapid economic development of the region promotes the income level of local residents, which increases the likelihood that residents will change from potential tourists to real tourists, expanding the market of tourism sources. Secondly, the improvement of the regional social environment creates a good human environment for all-area tourism. The participation of the whole population in all-area tourism can make tourists and local residents more friendly and harmonious, the residents benefit from it, the tourists improve their tourism experience, and the tourist places increase their popularity, achieving a multiwin situation. Finally, the ecological environment is an important guarantee for the development of tourism. A beautiful ecological environment provides rich natural tourism resources for tourism development and becomes a major driving force for tourism development.

4. Research Methodology and Data Sources

4.1. Indicator System Construction. The tourism development system and the regional development system are complex. Considering the aforementioned coupling mechanism between regional tourism and regional development and previous research results, according to the principles of comprehensiveness, scientificity, and operability in the construction of the index system, fully considering the characteristics of regional tourism development, attaching importance to the selection of basic and dominant indicators, and constructing a coupled and coordinated evaluation index system of tourism development and regional development in China.

4.2. Research Methodology. This paper borrows the capacity coupling coefficient and coupling coordination degree from physics and constructs the coupling coordination degree model of tourism development and regional development by referring to the ideas of scholars at home and abroad on the establishment of the coupling coordination degree model between systems. The specific calculation formula is

\[ C = \sqrt{\left( \frac{u_1 \times u_2}{u_1 + u_2} \right)^c} \]

\[ D = \sqrt{C \times T} \]

\[ T = \alpha u_1 + \beta u_2, \]

where \( C \) is the coupling degree value, \( D \) is the coupling coordination degree value, \( T \) is the comprehensive coordination index of tourism development and regional development, \( u_1 \) and \( u_2 \) represents the combined level value of tourism development and regional development, respectively, and \( \alpha \) and \( \beta \) are weights to be determined. As tourism development is only one factor contributing to regional development, regional development is the result of a combination of factors, so the values of \( \alpha \) and \( \beta \) are set to 0.4 and 0.6, respectively. \( c \in [0, 1], \ d \in [0, 1], \) the closer the value of \( c \) is to 1, the better the coupling between tourism development and regional development system is, the closer the value of \( d \) is to 1, the more the two systems tend to orderly coordination.
Referring to the study of [20] on the classification of coupled coordination levels, the coupled coordination status of tourism development and regional development was classified into two categories and twelve levels (see Table 1). Further, according to the comparison between tourism development and regional development levels, if \( u_1 > u_2 \), the level of regional development is relatively lagging; if \( u_1 = u_2 \), tourism development is synchronised with regional development; if \( u_1 < u_2 \), the level of tourism development is relatively lagging [21].

The tourism development system and the regional development system are complex giant systems, and the coupling process of the two has the characteristics of stage, uncertainty, dynamics, etc. [22]. It is difficult for the general linear or nonlinear model to accurately predict its development trend. Grey system theory is a kind of system theory for specific description, prediction, decision making, and control of systems with incomplete information. Grey prediction includes topological prediction, disaster prediction, series prediction, etc. In this paper, we adopt series prediction method to quantitatively predict the development change of tourism development and regional development coupling degree and coupling coordination degree. The modelling method and specific steps are as follows:

(i) Set the original time series:
\[
X_0 = \{x_0(1), x_0(2), \ldots, x_0(n)\}
\]
where generating a new sequence by \( x_1(k) = \sum_{i=1}^{k} x_0(i), k = 1, 2, 3, \ldots, n \) accumulation:
\[
X_1 = \{x_1(1), x_1(2), \ldots, x_1(n)\}.
\]

(ii) Defining the immediately adjacent mean series:
\[
Z_1 = \{z_1(2), z_1(3), \ldots, z_1(n)\},
\]
where \( z_1(k) = 0.5x_1(k) + 0.5z_1(k-1) \), \( k = 2, 3, \ldots, n \).

(iii) The column of least squares estimated parameters for GM (1, 1) model \( x_0(k) + az_1(k) = b \) satisfies
\[
\alpha = (a, b)^T = \left( B^T B \right)^{-1} B^T Y_n,
\]
where
\[
B = \begin{bmatrix}
-z_1(2) & 1 \\
-z_1(3) & 1 \\
\vdots & \vdots \\
-z_1(n) & 1
\end{bmatrix},
\]
\[
Y_n = \begin{bmatrix}
x_0(2) \\
x_0(3) \\
\vdots \\
x_0(n)
\end{bmatrix}.
\]

(iv) The error test of the grey prediction model was carried out in Table 2 to determine the accuracy of the prediction results based on the magnitude of the P and C values.

### 4.3. Research Data.
The data required for this paper mainly come from the China Statistical Yearbook, the China Tourism Statistical Yearbook, the China State of the Environment Bulletin, and the China Environment Statistical Bulletin from 1996 to 2016, supplemented in part by the China Regional Economic Statistical Yearbook and the tourism statistical yearbooks of some provinces from 2000 to 2016 [23]. The concept of all-area tourism has been proposed for a short period of time, and a longitudinal comparison of the coupled and coordinated relationship between the tourism industry and regional development in different years from the perspective of all-area tourism can highlight the differences in the coupled and coordinated relationship between the tourism industry and regional development before and after the introduction of all-area tourism.

### 5. Analysis of Results

Figures 2 and 3 show the raw series of regional tourism overnight receipts and tourism revenue from 2010 to 2015, respectively, and the seasonally adjusted series of each component. From the raw series of data in Figures 2 and 3, it can be seen that both the regional tourism overnight receipts and tourism revenue have a clear seasonal effect: the two sets of data start to increase slowly around October each year, reaching a peak around the Lunar New Year in January-February, and then the data start to fall gradually, reaching a minimum around April each year [24, 25]. This seasonal trend in tourism numbers and revenue can be seen more clearly in the seasonally adjusted seasonal trend graphs. As can be seen from the trend element curves in Figures 2 and 3, both the number of overnight stays and tourism receipts show a clear trend of growth. This indicates that as the economy develops, people’s disposable income gradually increases, the number of overnight stays and the amount of tourism spending on Hainan Island are increasing year by year. The irregular element curves in Figures 2 and 3 show that there are large fluctuations around the Chinese New Year each year. This may be due to the fact that since the construction of the regional international tourism island started in 2010, the regional government has intensified the comprehensive management of the regional tourism environment, regulated the price order of the regional tourism market, enriched the supply of tourism products, and improved the level of tourism services, and the successful
Table 1: Coupling coordination levels.

<table>
<thead>
<tr>
<th>Coupling value C</th>
<th>Coupling Coordination value D</th>
<th>Coordination level</th>
</tr>
</thead>
<tbody>
<tr>
<td>C = 0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0&lt;C&lt;0.5</td>
<td>Lowest level coupling</td>
<td>L = 0</td>
</tr>
<tr>
<td>0.1&lt;C&lt;0.2</td>
<td>Antagonism</td>
<td>0&lt;L&lt;0.3</td>
</tr>
<tr>
<td>0.4&lt;C&lt;0.7</td>
<td>Running-in</td>
<td>0.3&lt;L&lt;0.5</td>
</tr>
<tr>
<td>0.5&lt;C&lt;1</td>
<td>High level coupling</td>
<td>0.5&lt;L&lt;0.9</td>
</tr>
<tr>
<td>C = 0.9</td>
<td>Highest horizontal coupling</td>
<td>L = 0.9</td>
</tr>
</tbody>
</table>

Table 2: Evaluation of tourism revenue projections.

<table>
<thead>
<tr>
<th>Model</th>
<th>Training set</th>
<th>Test set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RMSE</td>
<td>MAE</td>
</tr>
<tr>
<td>ARMA (no seasonal adjustment)</td>
<td>7.082</td>
<td>5.4366</td>
</tr>
<tr>
<td>ARMA (seasonal adjustment)</td>
<td>0.2757</td>
<td>0.240</td>
</tr>
<tr>
<td>GA-SVR (seasonally adjusted)</td>
<td>0.5469</td>
<td>0.3856</td>
</tr>
<tr>
<td>PSO-SVR (seasonal adjustment)</td>
<td>0.5767</td>
<td>0.3897</td>
</tr>
<tr>
<td>FWA-SVR (seasonally adjusted)</td>
<td>0.5591</td>
<td>0.4003</td>
</tr>
</tbody>
</table>

Figure 2: Seasonal adjustment of overnight tourist arrivals.
implementation of these measures has attracted more domestic and foreign tourists to come to the region to celebrate the Spring Festival holiday.

The fluctuations in the data in Figures 2 and 3 are consistent with the current state of tourism on Hainan International Tourism Island: on the one hand, as people’s disposable income increases, so does their demand for tourism consumption and their ability to actually spend. In terms of trends, since 2010, when Hainan International Tourism Island became a major national strategic deployment, the region has attracted many tourists from home and abroad with its first-class tourism resources, and the number of tourist arrivals has continued to grow rapidly, and tourism revenue has also been rising. On the other hand, in terms of the seasonal element sequence, as a typical tropical maritime monsoon climate, Hainan’s tourism data has typical seasonal characteristics, with the peak season generally occurring from early winter to early spring when it is warm and suitable, and the low season occurring from early spring to early winter when it is hot [26, 27].

Figures 4 and 5 show the results of the regional tourism overnight receipts and tourism revenue data after using the seasonally adjusted FWA-SVR model for forecasting, respectively. In Figures 4 and 5, in addition to the FWA-SVR model proposed in this paper, the prediction results of two other types of models are used for comparison: the ARMA model without seasonal adjustment and the ARMA model with seasonal adjustment, as well as the SVR model based on the genetic algorithm and the particle swarm algorithm, respectively. The prediction evaluation results of each model are shown in Tables 2 and 3.

The trends of the curves in Figures 4 and 5 show that, in general, the seasonally adjusted forecasting model is significantly better than the nonseasonally adjusted ARMA forecasting model, which indicates that seasonal adjustment is necessary for forecasting seasonal series. The results of the forecasting evaluation in Tables 2 and 3 also show that, without seasonal adjustment, the ARMA model is not very effective in forecasting either tourism overnight receipts or tourism revenue, and the mean squared error (RMSE) is very large. After seasonal adjustment, the predictive power of the ARMA model is significantly improved. This indicates that the seasonally adjusted data is more conducive to forecasting.
As can be seen in Figure 6, the comprehensive development indexes $u_1$ and $u_2$ of China’s tourism development and regional development from 1996 to 2015 show a gradual upward trend. From 1996 to 2002, in order to stimulate the domestic consumption market and boost domestic consumption demand, the state put forward the reform idea of “double holiday” and “long holiday” system, gradually establishing tourism as a national strategic pillar industry and a regional advantage. During this period, China’s tourism industry continued to develop rapidly in the context of the country’s new normal.

### Table 3: Evaluation of tourism overnight stay projections.

<table>
<thead>
<tr>
<th></th>
<th>Training set</th>
<th>Test set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RMSE</td>
<td>MAE</td>
</tr>
<tr>
<td>ARMA (no seasonal adjustment)</td>
<td>41.1866</td>
<td>34.4256</td>
</tr>
<tr>
<td>ARMA (seasonal adjustment)</td>
<td>0.7355</td>
<td>0.6211</td>
</tr>
<tr>
<td>GA-SVR (seasonally adjusted)</td>
<td>1.2346</td>
<td>1.0279</td>
</tr>
<tr>
<td>PSO-SVR (seasonal adjustment)</td>
<td>1.3845</td>
<td>1.109</td>
</tr>
<tr>
<td>FWA-SVR (seasonally adjusted)</td>
<td>1.2378</td>
<td>1.024</td>
</tr>
</tbody>
</table>

As can be seen in Figure 4, the forecast of tourism overnight stays.
As can be seen from Figure 7, the value of the coupling between tourism development and regional development in China from 2016 to 2020 ranges from 0.5131 to 0.5225, with an overall slow upward trend. The coupling level crosses from the lower level coupling antagonism stage to the benign coupling friction stage, and the growth rate of coupling value in this stage is significantly faster than that of antagonism stage. China's tourism development and regional development coupling coordination degree value increased from 0.7011 in 2016 to 0.8715 in 2020, with an average annual growth rate of 4.45%, still maintaining a relatively fast growth rate. The coupling coordination level has achieved a leap from the good coordination to the high coordination stage and is rapidly evolving to a higher level of coupling coordination.

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6. Conclusions

This paper introduces a new intelligent optimisation algorithm to optimise the parameter selection process in the support vector regression model and considers the seasonal factors in tourism economic behaviour to construct a seasonally adjusted GM algorithm support vector regression model. The coupling and coordination between tourism and regional development will be significantly improved, and the coupling level and coordination level will enter into the grinding stage and high coordination stage, respectively, but the speed of improvement and development trajectory of the two are not consistent, and it will still take time for tourism and regional development to reach a high level of coordination.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

References


