Analysis and Forecast of Coupling Coordination Between Theme Park and Urban Development: A Case Study of Fante Theme Park in Wuhu

Deming Li¹*, Guoxing Zhu¹, Xiangyang Yu¹ and Junxiang Zhang¹

¹School of Tourism, Huangshan University, Huangshan, China

*Corresponding author e-mail: 1009905969@qq.com

Abstract. The construction and development of theme parks play an important role in promoting urban economy, society and environment. At the same time, the city also plays a supporting and safeguarding role in the construction and management of theme parks. Based on the discussion of the interaction mechanism between theme parks and urban development, this paper takes Fante theme park in Wuhu as an example to analyze the development level of the city and the coupling coordination degree of theme parks, in which the Entropy method and the coupling model are applied. GM (1.1) forecasting model is also used in hope of predicting the coupling coordinative degree of Fante theme park and Wuhu city in the next five years. The results show that the development level of Fante theme park and Wuhu city keeps increasing despite a slight fluctuation. The coupling coordinative degree presented a steady upward trend, with the coupling level rising from low coordination in 2008 to an antagonism stage, a comparatively moderate coordination in 2015. Therefore it is safe to say that in the next few years, the coupling coordinative degree of Fange theme park and Wuhu city will be significantly improved. The rising of coupling level and the evolution of coordination degree will be kept at the same pace. However, there is still a long way to go before the coupling coordination level of the two to develop to higher stage.

1. Introduction

Theme parks, as a kind of tourism form formed by the fusion of various elements, play an important role and unique significance in improving the comprehensive strength, image and the quality of the city. Meanwhile, the city also plays a supporting and guaranteeing role in the construction, development and later operation and management of theme parks. At present, domestic and foreign scholars mainly focus on the theme park's tourist market, tourist behavior, site layout, management, visitor satisfaction, theme park capacity and the interactive relationship between theme park and city[1-5]. However, quantitative research on the coupling coordination between theme parks and urban development is rarely involved. Based on this, this paper takes wuhu fante theme park as the research object, and uses entropy method and coupling and coordination degree model to analyze the comprehensive level and coupling coordination degree of Fante theme park and Wuhu city development. In addition, the GM (1.1) grey forecasting model was used to predict the coupling coordination degree between Fante theme park and Wuhu urban development. On this basis, this paper proposes an effective approach to promote the coordinated development and overall improvement of
2. Research methods & data sources

2.1. Research methods

(1) Entropy method

In this paper, entropy method is adopted to measure the comprehensive level of theme parks and urban development. Entropy method based on data support can effectively avoid the possible errors of subjective weighting laws such as expert scoring method and Delphi method[6], which has high credibility and can make the measurement results more accurate and reasonable. Therefore, this paper uses the entropy method to measure the theme park and urban development level. Due to space limitations, the specific steps are not described here.

(2) Coupling coordination degree model

Based on the concept of capacity coupling and the formula of capacity coupling coefficient in physics and the experience of Zhao Chuansong and Ren Jianlan in establishing the model of coupling coordination degree[7], this paper constructs the model of coupling coordination degree between theme park and urban development, which is used to analyze and determine the coupling degree and coupling coordination degree between theme Park and urban development system. The specific calculation formula is as follows

\[ C = \frac{\sqrt{(u_1 \times u_2)}}{u_1 + u_2} \]  
\[ D = \sqrt{C \times T} \]  
\[ T = \alpha u_1 + \beta u_2 \]

In the above formula, C is the coupling degree, D is the coupling coordination degree, and T is the comprehensive coordination index of theme parks and urban development. \( u_1 \) & \( u_2 \) respectively represent the comprehensive level of theme parks and urban development. \( \alpha \) and \( \beta \) are two subsystems weight respectively. By consulting the experts, 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 C value is to 1, it indicates that the coupling between the theme park and the urban development system is better. The closer the C value is to 0, it indicates that the coupling degree between theme parks and urban development system is minimal.

| C      | Coupling level           | D      | Coordination grade     |
|--------|-------------------------|--------|------------------------|
| \( C = 0 \) | Minimum level coupling | \( D = 0 \) | Not coordination        |
| \( 0 < C \leq 0.3 \) | Low level coupling       | \( 0 < D \leq 0.4 \) | Low coordination         |
| \( 0.3 < C \leq 0.5 \) | Antagonistic              | \( 0.4 < D \leq 0.5 \) | Moderate coordination    |
| \( 0.5 < C \leq 0.8 \) | Running-in                | \( 0.5 < D \leq 0.8 \) | Good coordination        |
| \( 0.8 < C \leq 1 \) | High level coupling       | \( 0.8 < D \leq 1 \) | High coordination        |
| \( C = 1 \) | Highest level coupling   | \( C = 1 \) | Extreme coordination    |

The closer the D value is to 1, the more orderly and coordinated the theme park and urban development systems are. According to Cheng Yu and Zhang Guanghui’s research on the grading standards of coupling degree and coordination degree, the coupling degree and coordination degree of theme parks and urban development are divided into six grades (See table 1). On this basis, according to the comparison between the tourism development level of the theme park and the level of urban development, If \( u_1 > u_2 \), then the level of urban development is relatively lagging, \( u_1 < u_2 \), the level of tourism development in theme parks is relatively lagging behind, if \( u_1 = u_2 \), the theme park tourism development is synchronized with urban development.

(3) GM (1.1) grey prediction method

The theme park system and the urban development system are complex systems, the coupling process of the two is characterized by uncertainty, stage and dynamics, it is difficult to predict the development trend of the coupling degree and coupling coordination degree between theme parks and urban development system accurately with conventional linear model or nonlinear model. The GM
(1.1) grey prediction method has a good prediction effect on the discrete state variables of the system, therefore, this paper adopts GM(1.1) grey prediction method to make quantitative prediction of the development and changes of the coupling degree and coupling coordination degree of theme parks and urban development system. The modeling method and specific steps are as follows[8]:

1. Set the original time series
   \[ X_0 = \{x_0(1), x_0(2), \ldots, x_0(n)\} \]

2. Generate a new sequence by \[ x_i(k) = \sum_{i=1}^{k} x_0(i), \quad k = 1, 2, 3, \ldots, n \] accumulation:
   \[ X_1 = \{x_1(1), x_1(2), \ldots, x_1(n)\} \]

3. Define the sequence next to the mean value:
   \[ Z_i = (z_i(2), z_i(3), \ldots, z_i(n)) \]
   Coupling level among them: \[ z_i(k) = 0.5x_i(k) + 0.5x_i(k-1), \quad k = 2, 3, \ldots, n \]

4. The least squares estimation parameter column of GM(1.1) model \( x_0k + az_k = b \) satisfies:
   \[ \alpha = (a, b)^T = (B^T B)^{-1} B^T Y_n \] (4)
   among them: \[ B = \begin{bmatrix} -z_0(2) & 1 \\ -z_0(3) & 1 \\ \vdots & \vdots \\ -z_0(n) & 1 \end{bmatrix} \]
   \[ Y_n = \begin{bmatrix} x_0(2) \\ x_0(3) \\ \vdots \\ x_0(n) \end{bmatrix} \]

5. Constructing the whitening equation of grey differential equation:
   \[ \frac{dx_i(k)}{dk} + \alpha x_i(k) = b \] (5)
   GM(1.1) differential equation can be obtained by solving directly:
   \[ \alpha_e(k+1) = \left[1 - e^a\right](x^{(0)}(1) - \frac{b}{a})e^{-adk} \] (6)

4. The error-tested of grey prediction model is checked by Table 2. The accuracy of the prediction results was judged according to the values of P and C.
2.2 Construction of evaluation index system

Table 3  The index system of the coupling coordination between theme parks and urban development

| Target layer | Project layer | Primary indicator | Secondary indicators | Type |
|--------------|---------------|-------------------|----------------------|------|
| Theme park system | Tourism development Level | Total tourism revenue | + |
| | | Total number of tourists | + |
| Urban development system | Economic level | GDP | + |
| | | Third industry accounts for GDP share | + |
| | | Total retail sales of social consumer goods | + |
| | | Investment in urban infrastructure | + |
| | Social development | Urbanization rate | + |
| | | The proportion of employees in the third industry | + |
| | | The number of cultural institutions | + |
| | | Number of College Students | + |
| | Infrastructure | Total postal and telecommunications services | + |
| | | Ten thousand people in the city own public transport | + |
| | | Urban per capita road area | + |
| | | Urban water supply capacity | + |
| | | Urban per capita park green area | + |
| | Environmental protection | Urban sewage treatment rate | + |
| | | Municipal waste innocuous treatment rate | + |
| | | Sulfur dioxide emission compliance rate | + |
| | | Environmental protection investment accounts for GDP expenditure | + |
| | | Investments in environmental governance | + |

According to the internal relationship between theme parks and urban development, this paper selects four urban development factors including economic level, social development, infrastructure and environmental protection as the first-level indicators of urban development system. The tourism development level of theme parks is selected as the primary indicator of the theme park system. Based on the consultation of 10 relevant tourism experts, in accordance with the principles of operability, comprehensive and scientific indicators[9], 20 indicators were selected to build an evaluation index system for the coupling coordination of theme parks and urban development (see table 3).

2.3 Data Sources

This paper mainly selects the data of 8 years related indicators of Wuhu City and Fante theme park from 2008 to 2015. Because this paper focuses on issues such as the coupling coordination degree of theme parks and urban development, Therefore, the data of the urban areas of wuhu city are mainly adopted, excluding the data of the counties and cities subordinate to wuhu city. The tourism development level of the theme park is derived from the internal statistics of wuhu fante theme park, the index data of urban development system are mainly derived from the "Wuhu Statistical Yearbook" from 2009 to 2016.

3 The empirical research

3.1 Survey of research area

Wuhu Fante is located in Wuhu City, Anhui Province. It is the fourth-generation high-tech theme park invested by Shenzhen Huajiang Fante Culture Technology Group Co., Ltd. Since 2007, Wuhu has built four theme parks with different characteristics headed by Fante happy world. In August 2016, Wuhu Fante was rated as a 5A level scenic spot. By the end of 2016, Wuhu Fante had received more than 30 million tourists. Fante Theme Park has rapidly enhanced the image and attraction of Wuhu,
and has a significant role in promoting the social, economic, cultural and environmental aspects of Wuhu.

3.2. Result analysis

Table 4 The value and grade of the coupling coordination degree between fante theme park and wuhu city development

| Years | $u_1$ | $u_2$ | C    | T     | D     | Coupling level    | Coordination level |
|-------|-------|-------|------|-------|-------|-------------------|--------------------|
| 2008  | 0.0001| 0.2324| 0.0211| 0.1395| 0.0543| Low level coupling| Low coordination   |
| 2009  | 0.0061| 0.2334| 0.1571| 0.1425| 0.1496| Low level coupling| Low coordination   |
| 2010  | 0.0098| 0.3223| 0.1696| 0.1973| 0.1829| Low level coupling| Low coordination   |
| 2011  | 0.0529| 0.3736| 0.3296| 0.2453| 0.2843| Antagonism        | Low coordination   |
| 2012  | 0.0526| 0.4531| 0.3052| 0.2929| 0.2990| Antagonism        | Low coordination   |
| 2013  | 0.0597| 0.5583| 0.3156| 0.3588| 0.3256| Antagonism        | Moderate coordination |
| 2014  | 0.0731| 0.5314| 0.3261| 0.3481| 0.3369| Antagonism        | Moderate coordination |
| 2015  | 0.1041| 0.7059| 0.3346| 0.4652| 0.3945| Antagonism        | Moderate coordination |

According to the entropy method and the coupling coordination degree model constructed in the paper, the comprehensive evaluation index $u_1$, $u_2$ and coupling coordination degree of Fante theme park and Wuhu urban development from 2008 to 2015 were calculated, the results are shown in Table 4. According to this, the coupling coordination type is divided (See Table 4).

(1) The comprehensive level of fante theme park and wuhu city development is gradually rising

From Table 4, we can see that the comprehensive level development index $u_1$ and $u_2$ of Fante theme park and Wuhu urban development in 2008-2015 are gradually rising. From the perspective of the comprehensive level index $u_1$ of the Fante theme park, the comprehensive level index of the Fongte Theme Park has generally shown a gradual upward trend, it rose from 0.0001 in 2008 to 0.1041 in 2015, reaching its peak. Although the comprehensive level index $u_1$ of the fante theme park in 2012 was 0.0003 lower than that of 2011, showing a certain degree of decline, it returned to a gradual upward trend after 2013. From the perspective of the urban development index $u_2$, the urban development level of Wuhu has been steadily increasing since 2008, and it recovered rapidly in 2015 despite a certain decline in 2014.

(2) The coupling coordination degree between Fante theme park and Wuhu city development is constantly improving

Table 5 Error test based on GM(1.1) grey prediction model

| Years | Coupling value C | Coupling and coordination value D |
|-------|------------------|----------------------------------|
|       | Observation value| Fitted value | Absolute error | Relative error % | Observation value | Fitted value | Absolute error | Relative error % |
| 2009  | 0.1571           | 0.2020 | -0.0449 | -0.2857 | 0.1496 | 0.1851 | -0.0355 | -0.2370 |
| 2010  | 0.1696           | 0.2225 | -0.0530 | -0.3123 | 0.1829 | 0.2109 | -0.0280 | -0.1530 |
| 2011  | 0.3296           | 0.2451 | 0.0845 | 0.2563 | 0.2844 | 0.2403 | 0.0440 | 0.1549 |
| 2012  | 0.3052           | 0.2700 | 0.0351 | 0.1150 | 0.2990 | 0.2738 | 0.0251 | 0.0840 |
| 2013  | 0.2955           | 0.2975 | -0.0020 | -0.0068 | 0.3256 | 0.3120 | 0.0136 | 0.0417 |
| 2014  | 0.3261           | 0.3277 | -0.0016 | -0.0049 | 0.3369 | 0.3555 | -0.0186 | -0.0552 |
| 2015  | 0.3346           | 0.3610 | -0.0264 | -0.0788 | 0.3945 | 0.4051 | -0.0106 | -0.0269 |

Test value

$P=0.9375$, $C=0.2365$, $P=0.9874$, $C=0.1329$

As can be seen from Table 4, the coupling degree between Fante theme park and Wuhu urban development increased year by year from 2008 to 2015. Among them, the coupling value in 2011 was...
0.3296, which was 0.16 higher than that in 2010. The increase was larger, and the coupling value in 2012 was slightly lower than that in 2011. In general, the coupling degree has been between 0.3052 and 0.3346 since the coupling level from low level to antagonistic stage, the long-term antagonism shows that there is still much room for improvement between Fante theme park and Wuhu urban development. The coupling coordination between fante theme park and the development of wuhu city is on the rise steadily, the coupling coordination level reached the middle coordination level in 2015 from the low coordination level in 2008, and the growth rate in 2011 was larger, an increase of 0.1014 over 2010. On the whole, the development process of coupling and coordination can be divided into two stages: In the first stage, from 2008 to 2012, it is a low coordination stage. The value of coupling coordination degree increases from 0.0543 in 2008 to 0.2990 in 2012. The second phase, from 2013 to 2015, was a moderate coordination phase, with the coupling and coordination value growing from 0.3256 in 2013 to 0.3945 in 2015. The evolution trend of coupling coordination degree indicates that the interaction between Fante theme park and Wuhu City development is continuously strengthened, and the internal coordination degree between the theme park system and the urban development system is gradually improved.

(3) Prediction and analysis of the coupling coordination degree between fante theme park and Wuhu city development

In order to further grasp the future development trend of coupling coordination degree between theme parks and urban development, this paper uses GM (1.1) grey prediction model to simulate the coupling coordination degree between Fante theme parks and Wuhu urban development in recent 8 years. After simulation verification, the fitting $P=0.9375$, $C=0.2365$, the coupling coordination fitting $P=0.9874$ and $C=0.1329$ were obtained (See Table 5). Compared with the accuracy test grade standard of grey prediction model, the model can be used to predict the coupling coordination degree between Fante theme park and Wuhu urban development. The above-mentioned fitting model is used to predict the coupling coordination degree between Fante theme park and Wuhu urban development. The results are shown in Table 6. From Table 6, it can be seen that the coupling degree between the Fante theme park and the development of Wuhu city is between 0.3977 and 0.5856 in 2016-2020, and the overall trend is increasing year by year. The value of the coupling coordination between Fante theme park and the development of Wuhu city increased from 0.4617 in 2016 to 0.7783 in 2020, and the annual average growth rate reached 13.71%. From the forecast results, we can see that the coupling coordination degree between Fante theme park and Wuhu urban development in the next few years has been improved obviously. The speed of coupling level and coordination level is basically the same as that of evolution, however, the coupling coordination level of the two systems will take a long time to enter the high level and highly coordinated stage.

4. Conclusion and discussion

Firstly, this paper constructs a theme park development indicator system from two indicators at one level of tourism development level. This paper constructs the urban development index system from the four levels of economic level, social development, infrastructure and environmental protection, including 18 indicators. The entropy value method was used to determine the comprehensive level index of Fante theme park and Wuhu city development from 2008 to 2015. The results show that although the comprehensive development level of Fante theme Park and Wuhu city has a certain fluctuation, it is gradually increasing.

Secondly, the coupling coordination degree between Fante theme park and the urban development of Wuhu is quantitatively analyzed by coupling model. The results show that the interaction between Fante theme park and Wuhu urban development has been strengthened from 2008 to 2016, the
Coordination degree between the two systems has been gradually improved. The coupling coordination has been steadily increased, the coupling level has changed from low level coupling to antagonistic stage. The coupling coordination level also reached the medium coordination of 2015 from the low coordination in 2008, but far from the ideal high coupling and coordination stage.

Thirdly, this paper uses GM (1,1) gray prediction model to simulate the coupling coordination degree of Fante theme park and Wuhu city development in the past 8 years, and predicts the degree of coupling coordination between the two systems in the five years after 2015. The results show that the development of the coupling coordination degree between Fante theme park and Wuhu city development will be significantly improved in the next few years. The coupling level and the coordination level are basically the same as the speed of evolution, however, it still takes a long time for the two systems to develop into highly coupled and highly coordinated stages.

In view of the current situation of the coupling coordination degree between Fante theme park and urban development, gradually improving the energy level of Fante theme park and comprehensively improving the energy level of Wuhu city is an effective way to achieve coordinated development and overall improvement.

Acknowledgments
This work was financially supported by the key project of Humanities and Social Sciences Research of Universities in Anhui Province (SK2016A0884), National Natural Project (41571140), Educational project of Anhui Province (2015zdjy148), Research project of Huangshan University(zdxk201804,kypt201813)

References
[1] MoutinhoL. Amusement Park Visitor Behavior-Scottish Attitudes, Tourism Management.4 (1988)291-300.
[2] J.G. Bao, Systematic Analysis of Influencing Factors of Theme Park Development, Journal of Geographical Sciences.3(1997) 237-245.
[3] G.Z.Dong, H.W.Wu, Analysis on the Chain Operation of Theme Parks, Business research.8(2011)186-189.
[4] Z.X.Liang, Q.Shu, Study on the Capacity of Fantawild Adventure Theme Park Based on Queuing Theory ,Tourism Tribune.1(2012)66-72.
[5] X.H.Liu, Z.T.Zeng, On Suitability Assessment Model of Urban Developing Theme Parks, Tourism Forum. 4(2011) 29-33.
[6] S.B.Yan, Evaluation of Regional Economic Growth Quality Based on Entropy Method, Statistics and Decision.21(2017) 142-145.
[7] C.S.Zhao,J.L.Ren, Research on the Coupling Coordination and Prediction of China's Tourism and Regional Development from the Perspective of Global Tourism, Inquiry Into Economic Issues.3(2018)66-74.
[8] Y.Cheng, C.L.Xe,The Evolution Trend of Human-Land Relationship and Its influencing factors in Shandong Province from the perspective of ecological Civilization. Chinese Journal of Population Resources and Environment,11(2015)121-127.
[9] H.Yu, L.Lu, D.F.Zhu, Coordination and Influencing Factors of Urban Tourism and Urban Development in the Yangtze River Delta. Journal of Natural Resources,10 (2012) 1746-1757.