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An Analysis of the Measurement of Symbiosis Intensity in Scenic Spots and the Influence Mechanism

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Abstract: Scenic symbiosis, which is of great research significance, is an important way to achieve high-quality coordinated development of regional tourism. Based on the symbiosis theory, this paper defines the symbiosis intensity of scenic spots and establishes a calculation scheme. On the one hand, it measures the spatiotemporal evolution characteristics of symbiosis intensity of 281 scenic spots in Hunan Province from September 2018 to December 2021. On the other hand, it uses a multiple linear regression model to quantitatively explore its influence mechanism. The results indicate that: (1) From September 2018 to December 2021, the tourism demand in Hunan Province presented fluctuations due to the impact of the COVID-19 pandemic, which can be divided into three stages: "slight increase before the COVID-19 pandemic", "rapid decline during the COVID-19 pandemic", and "slow recovery after the COVID-19 pandemic"; (2) The symbiosis intensity of scenic spots is mainly at a low, low-middle level; with Changsha City and the Western Hunan Area as dual cores, it reflects obvious "core-edge" characteristics; (3) Quality index, market attention level, connection breadth, and distance index jointly affect the symbiosis intensity of scenic spots. Among them, the quality index, market attention level, and connection breadth all have positive impacts on the symbiosis intensity, whereas the distance index has a negative impact on it. Finally, this paper discusses how to improve the symbiosis intensity of scenic spots and promote the mutual benefit and symbiosis development to provide a theoretical basis and practical reference for the promotion of the sustainable development of regional tourism.

Keywords: symbiosis intensity; multiple linear regression; scenic spot; sustainability

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1. Introduction

As one of the fastest-growing emerging industries in the world, tourism is known as the sunrise industry. With the continuous growth of people's income, it will effectively drive the mass tourism market, the development of all-for-one tourism, and the expansion of tourism consumption. As a smoke-free, green, and happiness industry, tourism is the easiest way to form a new blue ocean of high-quality economic development. This can be realized by increasing the supply of high-quality tourism resources, optimizing the environment for tourism development, and expanding domestic tourism consumption. At present, the development of China's tourism industry is facing both opportunities and challenges, such as unbalanced regional coordinated development, and insufficient depth and breadth of integrated development. In the context of domestic and international dual circulation, further research is urgently needed to improve the quality of scenic spots, reconstruct tourism development space, break down administrative barriers, and address unbalanced tourism development based on the factors such as resources, market, and transportation.

Since the 21st century, the growth of tourism has entered a stage of high-quality development in an all-round way. Harmonious symbiosis among scenic spots is an important manifestation of the high-quality and coordinated development of regional tourism. Since

scenic spots are the core elements of regional tourism development, a harmonious relationship between them is indispensable to regional tourism development in the long term. The phenomenon of "scenic spots group" with a core-edge structure and other features has already emerged in the development of regional tourism, showing the dependence on tourism resources and the dual drive of supply and demand [1]. Cooperation and competition between scenic spots coexist. Therefore, reshaping a new type of tourism relationship by integrating resources, merging routes, and innovating business formats has become the key to the symbiosis and co-prosperity of regional tourism [2]. The regional tourism symbiosis relationship takes the form of a complex, scenic symbiosis network structure in which each node functions and plays its own role. They operate and develop collaboratively so as to create value together. Based on the symbiosis theory, this paper introduced the concept of symbiosis intensity which reflects the strength of symbiosis in scenic spots and the overall level of symbiosis in the research region. Then it took Hunan Province as a case study area and 281 scenic spots as symbiotic units to define the symbiosis intensity of scenic spots and construct a calculation scheme. We collected the monthly data of the 7 major OTA websites in Hunan Province from August 2019 to December 2021, using Python program to extract the sales data of scenic spots and to calculate the symbiosis intensity index. Based on this, this paper analyzed the spatiotemporal evolution characteristics of symbiosis intensity with the application of the kernel density function and explored the main influencing factors of symbiosis intensity by the multiple linear regression model. After that, the corresponding regression model is constructed. It is expected to provide a reference for the effective realization of the symbiotic comprehensive benefits of scenic spots and the promotion of the high-quality development of regional tourism and regional-coordinated sustainable development.

2. Literature Review

Proposed by German biologist Heinrich Anton de Bary in 1879, the concept of symbiosis derived from biology refers to "an interaction and interdependence for the survival of biological species with different attributes", also refers to "the cooperative relationship formed by different species due to their dependence on the same resource" [3]. With the gradual deepening of the symbiosis theory in sociology, economics, management, and other fields [4], scholars have realized that tourism destinations have the potential to complement and benefit from each other [5,6]. After that, researchers began to study the collaborative symbiosis of tourism destinations [7] and made a series of research achievements. In 1976, Gerardo Budowski proposed three development models: conflict, coexistence, and symbiosis between tourism and environmental protection, and discussed the possibility of tourism and environmental protection symbiosis [8]. In 1984, Stringer and Pearce applied the theory of symbiosis to tourism research for the first time to explore the symbiotic relationship between tourism research and social psychology, and they proposed a people-oriented humanistic tourism developmental concept [9]. Taking collaborative tourism planning as an example, Getz and Jamal explained how the Dongdao community keeps the symbiosis with the natural environment to achieve sustainable tourism [10]. The "endosymbiosis theory" was further introduced to explain the interdependence between youth employment and tourism, and this theory systematically explained the mutually beneficial relationship between tourism and youth workers in terms of employment [11].

Based on qualitative research, scholars have further conducted quantitative research on tourism symbiosis, involving the symbiosis model [12], regional cooperation [13], market-driven mechanisms [14], benefit distribution mechanisms [15] and so on. Mathematical models and statistical methods were introduced to quantitatively measure symbiotic units and complete quantitative research on them from the degree of symbiosis [16], the coefficient of symbiosis [17], the energy of symbiosis [18], and the level of symbiosis development [19]. Meanwhile, the structural equation model was used to examine the symbiotic effect of the scenic spot image [20], with the two statistics of tourist arrivals and tourism income in the study area often used as quality parameters [21,22]. A small number of schol-

ars used symbiosis correlation and symbiosis density to identify tourism symbiotic units. They established a tourism symbiosis quality evaluation model [23] and comprehensively applied the Lotka-Volterra model to measure the level of symbiosis in both tourism and urban subsystems [24]. Besides, some new symbiotic evolution models about regional tourism integration were proposed, that was, the point-core model, point-axis corridor model, multi-center ring-axis model, and the network integration model. They all provided a reference for the research on the sustainable development of regional tourism integration at home and abroad [25]. In recent years, scholars have begun to analyze symbiosis from the regional and spatial levels. They tried to create a mathematical model of the bionic spatial relationship of tourist destinations [26] and proposed a regional multi-center nested symbiosis structure model [27] so as to analyze the evolution model of the symbiotic system of tourist destinations [28]. Some studies also dissected the symbiotic relationship of tourist destinations from the perspective of energy level, external relationship, and outward function to investigate the spatial characteristics of the symbiotic development of regional multi-subjects [29,30]. Moreover, the symbiotic potential energy index was introduced to reveal the spatial structure of the symbiotic system [31].

In the field of tourism symbiosis research, predecessors have done a lot of work and achieved certain research results. Taking a review of the existing research, more attention is paid to regional space symbiosis, industry symbiosis, and benefit symbiosis, mainly applied research and few theoretical innovations. Regarding basic issues, especially how the research on spatial symbiosis of regional tourism focuses on specific scenic spots, there are not many pieces of research literature, and further research is needed. Considering the limitations of data sources, existing research generally uses tourism destinations as symbiotic units since it facilitates the acquisition of data from major statistical yearbooks. However, it is not suitable to be studied as a symbiotic unit due to the destination itself containing too many elements and its intricate internal relationship. Therefore, existing studies are of inadequate guiding significance to practice. As the quantitative research on symbiotic units in regional tourism is still in the exploratory stage, the scenic spot symbiosis measurement index and its influence mechanism will be one of the important breakthrough points for future research. In addition, the fragility of tourism makes it vulnerable to disturbances from the external environment. In early 2020, the large-scale global outbreak of Corona Virus Disease 2019 (COVID-19 pandemic) has struck a severe blow at the tourism industry and future tourism activities are still full of unprecedented uncertainties [32]. Against the backdrop of the post-pandemic era, it is of great significance to scientifically expose the symbiosis measurement indicators of scenic spots and their influencing mechanisms, and to explore the disturbance effect of COVID-19 pandemic on regional tourism symbiosis.

3. Research Design and Data Sources

3.1. Study Area

Hunan, known as "the Hometown of Great People", boasts abundant tourism resources and favorable tourism market. In recent years, Hunan's tourism development has achieved historic breakthroughs and it is now making every effort to build a global tourism base and a strong tourism province. The 14th Five-Year Tourism Development Plan of Hunan Province pointed out that by 2021, Hunan Province should already have 10 5A-level tourist attractions, 120 4A-level tourist attractions, 2 national-level tourist resorts, and 10 provincial-level tourist resorts, and the number of province's star-rated rural tourist areas (spots) should reach 1243. Recently, tourism has been playing an increasingly important role in driving and supporting economic development. In 2019, the province had a total amount of 832 million tourist arrivals and achieved a total tourism income of 976.232 billion yuan. In 2020, though affected by the COVID-19 pandemic, it still received 693 million tourist arrivals throughout the year, with a total tourism income of 826.195 billion yuan and the added value of tourism accounting for 6.18% of GDP. It is one of the regions that have the best recovery of tourism in China. Hunan's experience in promoting cultural and

tourism enterprises to resume work and production has been selected as a typical case of the Ministry of Culture and Tourism. Taking Hunan Province as an example, measuring the symbiosis intensity of scenic spots and discussing its influence mechanism can provide scientific guidance for the rational and sustainable development of tourism resources. In addition, it can also provide a reference for the symbiotic development of scenic spots in other similar regions.

3.2. Variable Description and Statistics

(1) Symbiosis intensity. The concept of symbiosis intensity is introduced and defined as follows: among all the routes collected during the research period, the sum of the symbiotic passenger flow generated by a specific scenic spot with all other scenic spots through all collected routes is the symbiosis intensity of it, that is, the sum of tourism flows connecting two scenic spots in all routes collected during the study period, which reflects the overall level of symbiosis in the research region. The scenic spots work together in the same route and have inseparable attributes. At the same time, they are relatively independent of each other and have their own roles in the symbiotic system. This kind of contrast between quantities exists objectively and inevitably has a certain degree of superposition in the calculation process, which cannot be measured simply by an average value. Therefore, this paper indexed the symbiosis intensity by taking the logarithm to solve the regional comparability and additivity problems in mathematical logic. The formula is as follows:

$$S_i = \ln \sum_{j=1}^{n} s_{ij}$$

In the formula: S_i is the symbiosis intensity index of the scenic spot i, s_{ij} is the sales value between scenic spot i and other scenic spots j on all routes.

(2) Connection breadth. It refers to the number of scenic spots connected by a specific scenic spot among all the routes collected during the research period, that is, the total number of scenic spots that have a symbiotic relationship with the specific one. The breadth of connection is a scalar that reflects the range and diversity of symbiotic connections between scenic spots. Besides, it plays an important role in the research on the symbiosis of scenic spots.

(3) Quality index. The quality index is expressed in two aspects: the quality of tourism resources that highlights the "quality" of the scenic spot and the scale that reflects the "quantity" of it. The quality score of tourism resources is based on the A-level tourist attractions stipulated by the National Tourism Bureau, whereas the scale score is based on the total time spent on projects available for play. A total of 1–5 points are assigned to the quality and the scale of tourism resources in a scenic spot, respectively, and the two scores are added up to obtain the scenic spot quality index.

(4) Market attention level. The market attention level reflects information such as the popularity of scenic spots and the degree of network attention. It is measured by the Baidu Index, a data-sharing platform relying on Baidu search engine. It can not only provide the network attention of searched keywords in various time periods all over China, but also provide a number of keywords that are highly relevant to the searched one. Moreover, it can analyze the user's attention level.

(5) Distance index. According to the law of distance decay, with other conditions the same, the interaction between geographic elements is inversely proportional to the square of the distance. The longer the distance, the smaller the interaction. Therefore, the distance index is introduced and defined as the average geographical distance between a specific scenic spot and all other scenic spots in the study area.

The description of relevant variables is shown in Table 1 and the sample descriptive statistics are shown in Table 2.

Table 1. Connotation and assignment description of related variables.

Variable Name	Definition
Symbiosis intensity	The total passenger flow of scenic spots forming tourist routes
Connection breadth	The number of scenic spots connected by tourist routes
Quality index	The sum of quality assignment and scale assignment of tourism resources
Market attention level	The overall daily average value of Baidu Index of scenic spots during the research period
Distance index	Average geographical distance between scenic spots and other scenic spots (unit: km)

Table 2. Sample descriptive statistics.

Variable	Sample Size	Mean	Standard Deviation	Minimum	Maximum
Symbiotic intensity	281	10.189	4.681	0.693	19.431
Connection breadth	281	50.46	51.031	1	231
Quality index	281	5.11	1.933	2	10
Market attention level	281	2.56	2.387	1	10
Distance index	281	229.5	41.195	172.119	374.209

3.3. Methodology

3.3.1. Kernel Density Estimation

Kernel Density Estimation (KDE) refers to a nonparametric test method used in probability theory to estimate unknown density functions. Though the kernel density function is weakly dependent on the model, it enjoys good statistical properties, which accounts for its wide application in the study of non-equilibrium spatial distribution. In this paper, the changes in the distribution shape, kurtosis, and location of the nuclear density curve are used to analyze the spatial structure evolution characteristics of the symbiosis intensity of scenic spots. The formula is as follows [33]:

$$\hat{f}_h(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

In the formula: $x_1, x_2, x_3, \ldots x_i$ are n sample points of independent distribution; f is the probability density function; $K(x)$ is the kernel density function; h is the bandwidth; the smaller the bandwidth, the less smooth the curve and the higher the estimation accuracy.

3.3.2. Multiple Linear Regression Model

Theoretically, the symbiosis intensity of scenic spots is subject to numerous factors [34]. In the first phase, the purpose of this study is to determine whether the above four explanatory variables are the factors that affect the symbiosis intensity. Therefore, a discrete selection model based on random utility theory is selected for analysis. Considering that the symbiosis intensity, connection breadth, and distance index are all continuous random variables that obey the normal distribution, this study initially uses the generalized linear model Probit to perform regression analysis so as to determine its influencing factors. Firstly, the dependent variable "symbiosis intensity" is converted into a restricted binary

variable: "0" means that there is no symbiosis, whereas "1" means that the symbiosis intensity is generated. After determining the influencing factors of symbiosis intensity, the multiple linear regression model is further employed to analyze the effect of each influencing factor. This is accomplished by restoring the dependent variable Y to a continuous numerical variable, and the model is established as follows [35]:

$$SYMI_i = \alpha + \beta_1 breadth_i + \beta_2 quality_i + \beta_3 market_i + \beta_4 distance_i + \varepsilon_i + v_i$$

$$i = 1, ..., n$$

The subscript i represents the scenic spot, $SYMI$ represents the symbiosis intensity of the dependent variable, breadth represents the connection breadth, quality represents the quality index, market represents the market attention level, distance represents the distance index, ε_i represents the individual effect, and v_i represents the random error term.

3.4. Data Sources and Schemes

(1) The data on the symbiosis intensity and connection breadth of scenic spots all stem from seven well-known domestic tourism websites (hereinafter referred to as the 7 major OTA websites), including Ctrip, Qunar, Mafengwo, Tongcheng, Tuniu, Lvmama, and Fliggy, in which sales data is updated in real-time. The monthly travel routes and sales of the 7 major OTA websites are regularly collected at the end of each month through the Yishuyun data collection software. From August 2018 to December 2021, a total of 560,000 pieces of data are collected from 548 scenic spots in Hunan Province. On this basis, the collected raw data is filtered according to whether the route contains scenic spots in Hunan Province and whether there are sales data. The Python program is applied to extract all scenic spots in Hunan Province and their sales data of the corresponding routes as original data sources, which are taken logarithm to obtain the symbiosis intensity value of scenic spots. Finally, it calculates the connection breadth based on the number of scenic spots included in the route and accumulates the number of other scenic spots in all routes, including the same scenic spot to obtain the connection breadth value of the scenic spot.

(2) The quality score of tourism resources in the quality index comes from the list of A-level scenic spots published on the official website of Hunan Provincial Department of Culture and Tourism. This paper adopts the standard: 5A-level tourist attractions, 5 points; 4A-level tourist attractions, 4 points; 3A-level tourist attractions, 3 points; 2A-level tourist attractions, 2 points; A-level tourist attractions and general non-tourism resource scenic spots, 1 point. The assignment of high-quality scenic spots with non-A-level tourism resources is fulfilled according to the corresponding assignments of wetland parks and geological parks. The scale score is derived from the expert scoring method, which is provided by relevant experts in the tourism industry in Hunan Province. In accordance with the total time spent on the scenic spots' projects available for play, each scenic spot is assigned 1–5 points, respectively. A score of 5 means that there are many projects available for play and the playing time is long, whereas a score of 1 means that there are few items that can be played and the playing time is short. According to the assignment principle, the quality score and the scale score are calculated, respectively, and the sum of the two is the quality index of the scenic spot.

(3) The data of market attention level is derived from the network attention of Baidu Index official website. Selecting the names of the most popular scenic spots and their abbreviations used by Baidu users when learning about scenic spots as keywords, this paper obtained the daily average (PC+ mobile) network attention of Baidu users across the country to the keywords of scenic spots in Hunan Province from August 2018 to December 2021. A Baidu index of more than 1000 is considered an extremely high value, with a uniform assignment of 10 points. For scenic spots with Baidu Index below 1000, it can be observed that there are obvious fractures every 100. Therefore, 100 is used as the interval to divide them. The Baidu Index is assigned 9 points in the range of 900–1000,

and 8 points in the range of 800–899. By analogy, a Baidu index below 100 is an extremely low value, assigned only 1 point.

(4) The distance index is calculated by the map of Hunan Province from the standard base map with the approval number GS (2019) 1697 of the Standard Map Service System of the Ministry of Natural Resources. Firstly, the longitude and latitude of each scenic spot are obtained through Baidu Pickup Coordinate System. After that, these data are imported into ArcGIS 10.8 software and the Spatial Analyst module is employed to calculate the spatial distance value between two scenic spots. Finally, the average value of the spatial distance between a specific scenic spot and all other scenic spots is taken as the distance index of the scenic spot.

(5) Stage division. The outbreak of the COVID-19 pandemic in 2020 hit the tourism industry greatly. In view of the particularity of the current situation, it can be divided into three stages according to the development trend of the COVID-19 pandemic in different periods. Based on the actual situation, the division criteria are derived from two iconic events. One is that since 25 January 2020, due to the large-scale spread of the COVID-19 pandemic, travel agencies and online travel companies have been suspended from operating inter-provincial team tours and other businesses; the second is on the evening of 14 July 2020, the Ministry of Culture and Tourism issued the "Notice on Promoting the Resumption of Work and Resumption of Tourism Enterprises", which mentioned that with the approval of local provincial (regional and municipal) party committee and government, the cultural and tourism administrative departments of all provinces (autonomous regions and municipalities) can resume operating inter-provincial (regional, municipal) team travel and "air ticket + hotel" business of travel agencies and online travel companies under the premise of prevention and control. According to this, it can be divided into the following three stages:

1. The pandemic-free era, from 1 August 2019 to 25 January 2020;
2. The pandemic outbreak era, from 26 January 2020 to 13 July 2020;
3. The post-pandemic era, from 14 July 2020 to 31 December 2021.

4. Results

The collected raw data were filtered according to whether the routes included scenic spots in Hunan Province and whether they had sales. 281 scenic spots in routes and their corresponding sales were obtained, accounting for 51.18% of the total number of scenic spots in Hunan Province. Among them, in terms of symbiosis intensity, the top three scenic spots are Tianmen Mountain National Forest Park, Phoenix Ancient City, and "Charming Xiangxi" Theater, whereas the scenic spots with the lowest symbiosis intensity are Anhua Longquan Cave, Leiyang Agricultural Culture Museum, and Wuyunjie Huayuanli Ecotourism Area. Since they lie in remote regions, they are little known to us and few tourists pay a visit to them, leading to extremely low sales of routes. Hence, it remains to be further developed.

4.1. Temporal Evolution Characteristics of Symbiosis Intensity

The monthly symbiosis intensity index was used to measure the temporal evolution characteristics of symbiosis in scenic spots. This paper calculated the symbiosis intensity index of 281 scenic spots in Hunan Province from August 2019 to December 2021, of which the variation characteristics are classified into three stages according to the development of COVID-19 pandemic (see Figure 1).

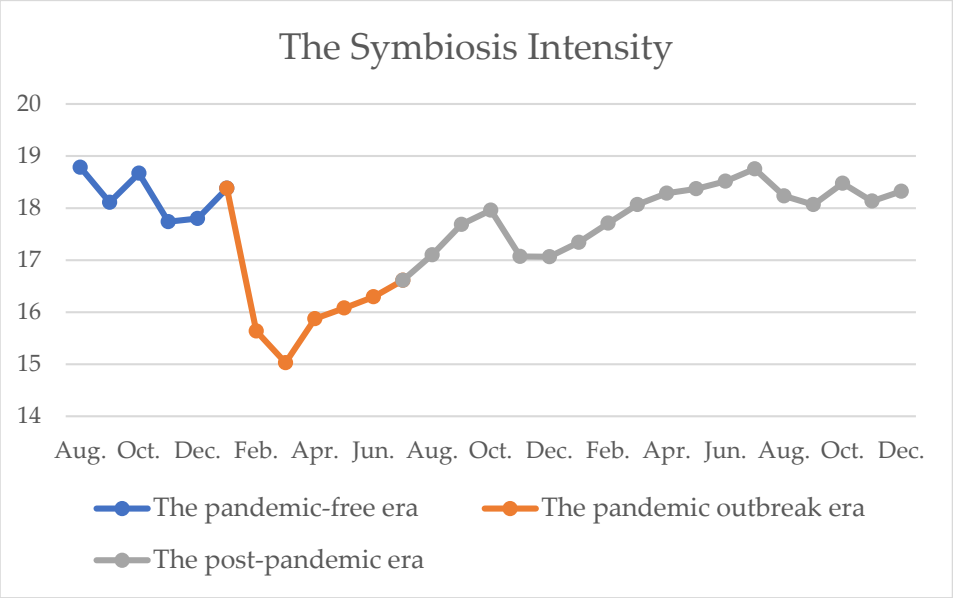

Figure 1. Temporal evolution characteristics of symbiosis intensity.

On the whole, the symbiosis intensity of scenic spots in Hunan Province shows a fluctuating trend due to the influence of COVID-19 pandemic, which can be characterized by three stages: ① Slight increase before the pandemic. In the pandemic-free era, the symbiosis intensity of scenic spots fluctuated slightly due to seasonal effects, which increased significantly during the peak tourist seasons such as August and December. However, in the off-season, from September to December, the symbiosis intensity decreased somewhat; ② Rapid decline during the pandemic. In the pandemic outbreak era, the symbiosis intensity of scenic spots has dropped rapidly, from 18.38 in January to 15.64 in February, falling continuously in February and March, and began to rebound slightly in April. Nevertheless, it was still significantly lower than the level of the same period owing to the impact of the pandemic; ③ Slow recovery after the pandemic. In the post-pandemic era, the symbiosis intensity of scenic spots has slowly recovered. In addition to the impact of the fluctuation of COVID-19 pandemic, it is also affected by seasonal factors but has gradually recovered to the level of the pandemic-free era.

4.2. Spatial Distribution Characteristics of Symbiosis Intensity

StataMP16 software and the Kernel density function were used to estimate the symbiosis intensity of scenic spots in Hunan Province during the above three stages, so as to intuitively reflect the spatial distribution characteristics of it. According to Figure 2, the results indicate that: (1) During the study period, the symbiosis intensity of the scenic spots shows an "M"-shaped double-peak distribution on the whole and there is a "double-peak" evolution trend from the left to right, with peaks from high to low. It indicates that the symbiosis intensity of scenic spots in Hunan Province has obvious two-level differentiation, and the distribution of symbiosis intensity in scenic spots of different types and regions varies greatly. (2) Judging from the peak value of the wave crest, the peak efficiency value of the first wave is clustered around 5 and the second wave is clustered around 13–15, indicating that the symbiosis intensity of scenic spots is mostly distributed in low-intensity areas. (3) From the perspective of peak height, the peak heights of high and low levels show a downward trend overall, and the kernel density curve at each stage shows a changing trend from sharp peaks to broad peaks. It can be inferred that the regional differences in the symbiosis intensity are gradually decreasing. (4) From the perspective of location, the kernel density curves of the pandemic outbreak era and the post-pandemic era are all shifted to the left, demonstrating that the variation trend of the symbiosis intensity is increasing, with small fluctuations in the high-value area yet large in the low-value area.

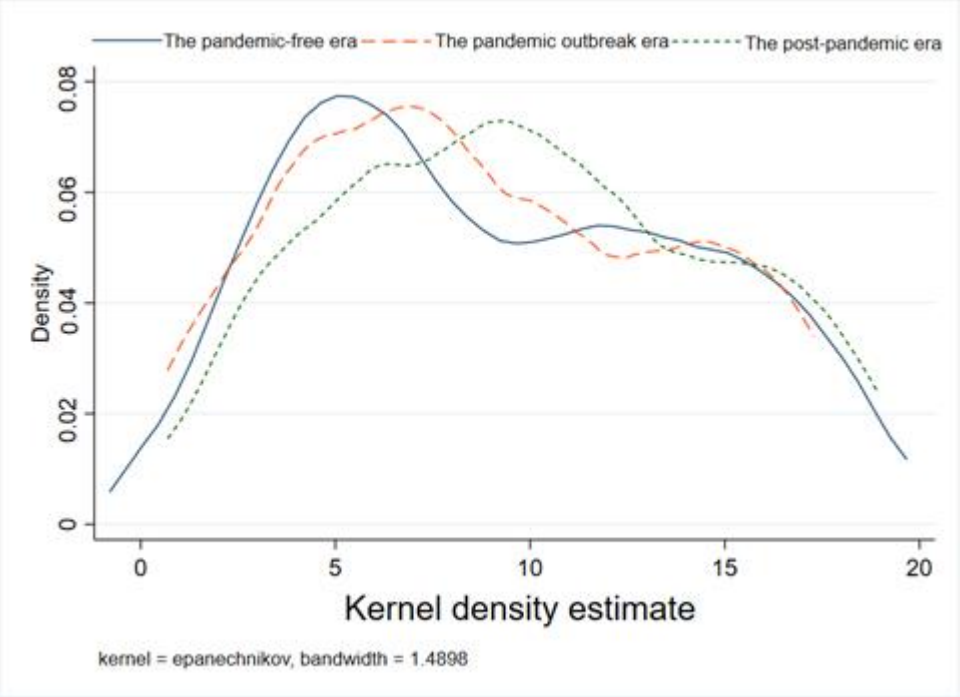

Figure 2. Symbiosis intensity kernel density curve of scenic spots.

To further visualize the spatiotemporal evolution characteristics of symbiosis intensity, we used the ArcGIS 10.7 software to produce kernel density maps of 281 scenic spots in above three stages and revealed its spatiotemporal distribution characteristics (Figure 3). The results show that: (1) The symbiosis intensity of scenic spots in Hunan Province was mainly at a relatively low, low-middle level, with high-level spots clustered in the surrounding of Changsha City and the Western Hunan Area, which formed the dual cores structure with an obvious "core-edge" feature; (2) During the pandemic outbreak era, high-level agglomerate areas have changed from "plane" to "point" and the degree of agglomerate tends to be flat, with a decrease in the extreme value of agglomeration. While in the post-pandemic era, the point-core has connected into a plane with an expanded scope, resulting in the formation of numerous secondary centers.

4.3. Analysis of Factors Affecting the Symbiosis Intensity

4.3.1. Variable Correlation Analysis

To determine whether each explanatory variable has a correlation with the explained variable, we conduct correlation analysis and exclude variables with no correlation or those not significantly related. Consequently, we obtain the results through bivariate correlation analysis of SPSS26 software, IBM SPSS Statistics 25, Chicago, IL, USA, (Table 3). The independent variable connection breadth, quality index, market attention level, and distance index are significantly correlated with the dependent variable symbiosis intensity at the level of 0.01, and the correlation coefficients are, respectively, 0.836, 0.435, 0.679, −0.388. It can be seen that the symbiosis intensity is mainly correlated with the connection breadth, followed by the market attention level, quality index, and distance index. Except for the distance index, the other three independent variables are all positively correlated with the dependent variable, whereas the distance index is negatively correlated with it, consistent with the conclusions of existing studies.

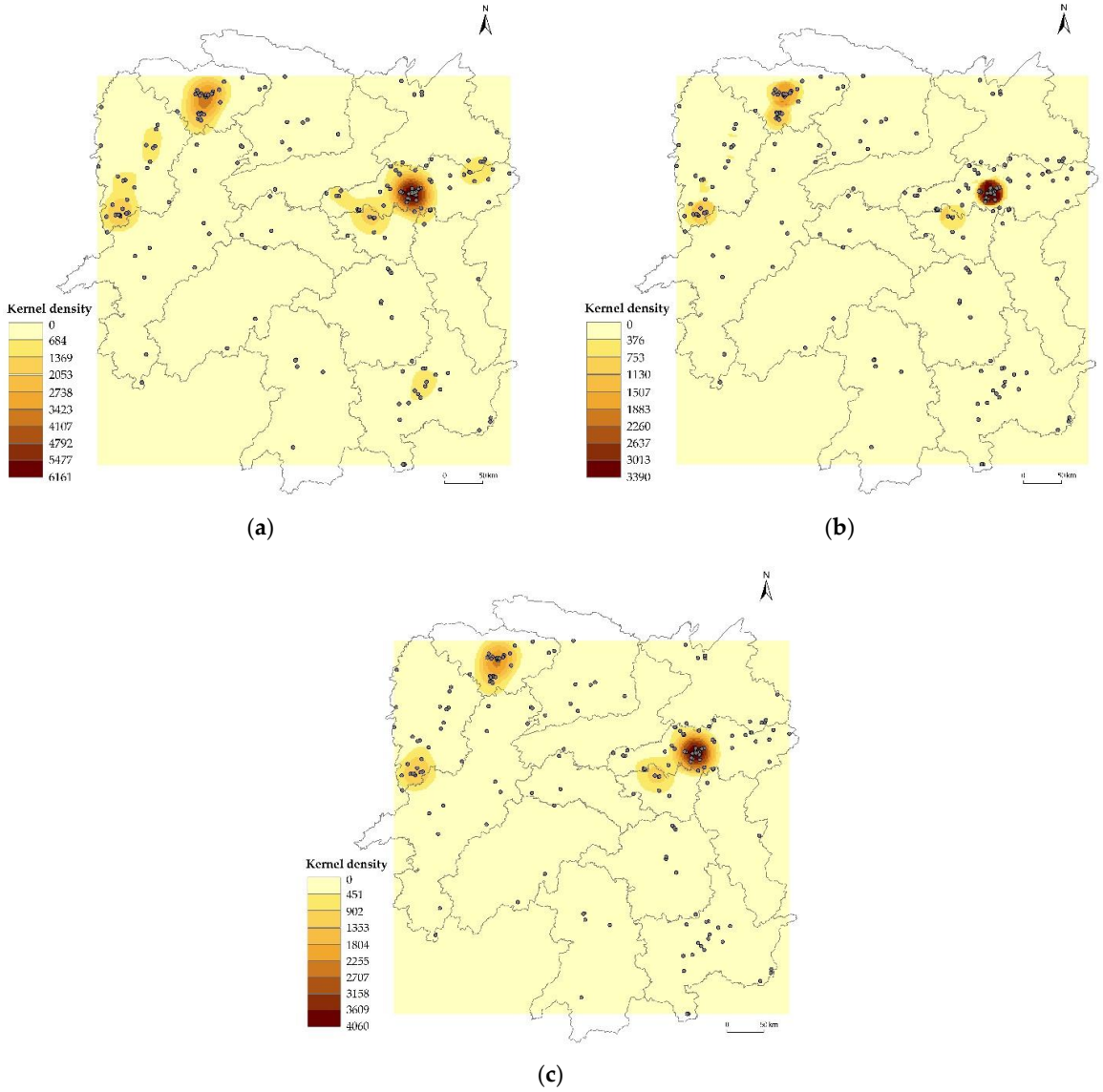

Figure 3. Kernel density distribution of symbiosis intensity in Hunan Province. (**a**) The pandemic-free era; (**b**) The pandemic outbreak era; (**c**) The post-pandemic era.

Table 3. Variable correlation results.

Variable	Symbiotic Intensity	Connection Breadth	Quality Index	Market Attention Level	Distance Index
Symbiotic intensity	1	0.836 **	0.435 **	0.679 **	−0.388 **
Connection breadth		1	0.373 **	0.730 **	−0.331 **
Quality index			1	0.459 **	−0.078
Market attention level				1	−0.291 **
Distance index					1

Note: **, represent significant at the 5% levels.

4.3.2. Probit Regression

Probit regression was performed by StataMP16 software, and the results are shown in Table 4. The regression coefficient values of connection breadth and market attention level are 0.1282 and 1.5383, both of which are significant at the 0.01 level, indicating that the above two variables have a significant positive impact on the symbiosis intensity and that the influence of connection breadth is weaker than the market attention level. The regression coefficient of the quality index is 0.2351. It passed the 0.05 significance test, and the marginal effect value is 0.0223, indicating that for each unit of increase in the quality index, the magnitude of the change (increase) in the occurrence of symbiosis intensity is 2.23%. In addition, the distance index negatively affects the symbiosis intensity at the 0.05 significance level. With reference to the marginal effect value of −0.0008, for each unit of increase in the distance index, the change (decrease) of the occurrence of symbiosis intensity is 0.08%. The closer the distance, the greater the possibility of symbiosis, which is consistent with previous research conclusions. Pseudo R2 is 0.678, which could explain why the model passed the test and maintained well goodness of fit.

Table 4. Probit regression of factors influencing the symbiosis intensity.

Variable	Coef.	SE	z	*P* > |z|	MEM
Connection breadth	0.1282 ***	0.022381	5.73	0.000	0.0122
Quality index	0.2351 **	0.0965198	2.44	0.015	0.0223
Market attention level	1.5383 ***	0.5467831	2.81	0.005	0.1459
Distance index	−0.0079 **	0.0034586	−2.29	0.022	−0.0008
Constant	−2.1704 **	1.051915	−2.06	0.039	

Note: ***, ** respectively represent significant at the 1% and 5% levels.

4.3.3. Multiple Linear Regression

The SPSS 26.0 software is employed to carry out the multiple linear regression analysis. Before the empirical analysis of the selected indicators, the multicollinearity analysis of the independent variables was carried out. The variance inflation factor (VIF) of four indicators in the collinearity results were all far less than the critical value of 10, indicating that there was no multicollinearity in the independent variables and that empirical analysis can be carried out. The adjusted R-square of the multiple linear regression equation is 0.731, indicating that the model has a high degree of fit; the DW value is 1.9, indicating that the samples are relatively independent and have no serial correlation, which can exclude pseudo-regression; the residuals are normally distributed, which further verifies the rationality of this regression model. Since the multiple linear regression model has passed the test, it could be used for subsequent analysis and prediction. Based on the test analysis, the results of multiple linear regression model reveal an influence mechanism of different independent variables on the symbiosis intensity (Table 5).

Table 5. Multiple linear regression of factors influencing the symbiosis intensity.

Influencing Factors	Unstandardized Coefficients	Standard Error	Standard Coefficient	T Statistic	*p* Value
Connection breadth	0.063	0.004	0.685 ***	14.811	0.000
Quality index	0.321	0.085	0.133 ***	3.784	0.000
Market attention level	0.159	0.093	0.081 *	1.698	0.091
Distance index	−0.014	0.004	−0.127 ***	−3.848	0.000
Constant	8.285	0.981		8.444	0.000

Note: ***, * respectively represent significant at the 1% and 10% levels.

(1) Both the connection breadth and the quality index have a positive impact on the symbiosis intensity at the 1% significance level. They are the main factors affecting it and the influence coefficients are 0.685 and 0.133, respectively. Among them, the influence coefficient of connection breadth on the symbiosis intensity is the largest, indicating that the closer the connection between scenic spots, the greater the possibility of achieving symbiosis. The practice has shown that in the process of improving the quality and efficiency of the tourism industry, it is necessary to strengthen the integration of regional tourism, build a tourism coordinated development circle in Hunan Province, and expand the connection breadth between scenic spots in marginal areas. On the other hand, efforts should be made to improve the intensity and speed of the flow of regional tourism development elements from the center of urban agglomeration to the peripheral areas and promote the smooth flow, cooperation, and coordination of the development elements of the tourism industry within the region so as to enable the surrounding areas, which are driven by the trickle-down effect, to develop homogeneously. As the quality is the cornerstone of the development of scenic spots, a higher quality index is conducive to the symbiosis of scenic spots. The endowment of regional tourism resources is a necessity for the development of the regional tourism industry. To promote the high-quality development of regional tourism, scenic spots can improve their quality of tourism resources and expand popularity and reputation to increase the quality indexes.

(2) The market attention level has a positive impact on the symbiosis intensity at the 10% significance level, and the influence coefficient is 0.081. Based on the Baidu Index of scenic spots, it mainly reflects the variation trend of market demand for scenic spots. Since the development of tourism industry relies on the power of market, scenic spots must continuously meet market demands and actively adjust tourism products. For instance, they can propose corresponding promotion and optimization plans according to the market demand to carry out supply-side structural reforms.

(3) The distance index has a negative impact on the symbiosis intensity at the significance level of 1%, and the influence coefficient is −0.127, consistent with existing research conclusions. According to the law of distance decay, the farther the distance, the smaller the interaction, and the two are negatively correlated. In recent years, the tourism public service system has become more complete in Hunan Province where the tourism transportation network consisting of airports, high-speed railways, freeways, and scenic sightseeing highways has been continuously upgraded. For example, the construction of Changsha's "Four-Hour Aviation Economic Circle" is advancing rapidly. Moreover, the railway trunk line and expressway network have been continuously improved, escorting the promotion of high-quality development of regional tourism.

5. Discussion

At present, China has entered the post-pandemic era. In the critical period of promoting the high-quality development of tourism, it is of important practical significance for the sustainable development of regional tourism to analyze the symbiosis intensity of scenic spots in Hunan Province and its influencing factors, objectively evaluate the differences in the symbiosis intensity of various scenic spots, and reflect the degree of configuration of the symbiotic development. Combined with the research results in this paper and the practical problems of Hunan Province, the following discussion is proposed to further promote the symbiotic development of scenic spots.

(1) The importance of using OTA data. Since the specific sales data of scenic spots involves commercial confidences, it is too difficult to obtain, which is infeasible in a practical sense. However, the sales data of online OTA websites are publicly available and have high authenticity and reliability, which are ideal for studying the symbiosis of scenic spots. Although the sales data of OTA websites does not comprise all the data of the scenic spots entertaining tourists, they are at least comparable. Under the same system and dimension, the relationship between quantities is comparable, which can well reveal the symbiotic relationship of scenic spots.

(2) The significance of symbiosis intensity. Existing research is deeply restricted by the acquisition way of data and often uses quality parameters, such as tourism revenue and the total number of tourists, as indicators to reveal the level of symbiotic connection between scenic spots. However, this correlation is not logically established due to the properties of quality parameters selected do not express the inevitability of symbiosis. When scenic spots appear on the same route, the symbiosis between scenic spots can be ensured, so the sales of such routes have the attributes and value of a symbiotic relationship. The symbiosis intensity reveals the strength and possibility of the symbiotic relationship between scenic spots through route sales, which makes up for the limitation of previous studies in revealing the symbiotic relationship between scenic spots through insignificant correlation quality parameters.

(3) The universality of regression models. From the regression model, the influence of the selected independent variables on the symbiosis strength has commonalities, which is consistent with the previous research conclusions, so there is no instability problem of causality. The regression model has a certain generality and can be used for research in other areas.

There are still some deficiencies in this paper, which are embodied in the following aspects. Firstly, due to the complexity of tourism development and the limitations of OTA statistical data, there is still space for optimization in the calculation of scenic symbiosis intensity and the selection of influencing factors. Secondly, the alternative indicators obtained by the assignment method often leads to certain deviations in the calculation results of influencing factors. Finally, future research needs to further explore the driving mechanism of scenic symbiosis and optimize the allocation of tourism resources.

6. Conclusions and Implications

6.1. Conclusions

This paper collected the monthly data of the 7 major OTA websites in Hunan Province from August 2019 to December 2021, using Python program to extract the sales data of scenic spots and calculate the symbiosis intensity index. Based on this, we analyzed the spatiotemporal evolution characteristics of symbiosis intensity with the application of the kernel density function and explored the main influencing factors of symbiosis intensity by the multiple linear regression model. Finally, it draws the following conclusions:

(1) From September 2018 to December 2021, the symbiosis intensity of scenic spots in Hunan Province showed a fluctuating trend due to seasonality and the COVID-19 pandemic. It can be divided into three stages: "slight increase before the pandemic", "rapid decline during the pandemic", and "slow recovery after the pandemic".

(2) The regional distribution pattern of symbiosis intensity in Hunan Province has significant differences, showing a "double-peak" distribution pattern; however, with the evolution of time, the difference gradually narrows; the symbiosis intensity of scenic spots is mainly low, low-medium types, with Changsha City and the Western Hunan Area as dual cores, showing an obvious "core-edge" feature.

(3) Quality index, market attention level, connection breadth, and distance index jointly affect the symbiosis intensity of scenic spots. Among them, the quality index, market attention level, and connection breadth all have positive impacts on the symbiosis intensity of scenic spots and the connection breadth has the greatest promotion effect. By contrast, the distance index has a negative impact on it.

6.2. Practical Implication

According to the findings of this study, the quality index is the basis for the symbiotic development of scenic spots. In order to improve it, we must adhere to the needs of tourists, improve the quality of tourism products and services, increase the integration of culture and tourism resources, and continuously improve the influence and attractiveness of the Hunan tourism brand. Through promoting the "Zhang-Ji-Huai Tourism Community" and building a comprehensive tourism image of Hunan Province, we can achieve substantial break-

throughs in marketing promotion, mutual delivery of tourists, transportation construction and other aspects, and help it become an important growth pole of Hunan tourism. As far as the connection breadth and distance index, based on factors such as resources, markets and transportation, it is necessary to further reshape the development space of tourism, break down administrative regional barriers, and promote intra-provincial cooperation and inter-provincial linkage so as to tackle the problem of unbalanced tourism development. In addition, we should focus on optimizing and adjusting the tourism space layout of Yiyang, Loudi, Shaoyang, Huaihua, and other relatively underdeveloped cities to promote a more reasonable tourism layout in Hunan province and form new tourism growth poles. The role of the market attention level is also not trivial. With the wide application of new technologies such as 5G, mobile Internet, Cloud computing, big data, and biometric identification, it will promote the deep transformation of the tourism industry, bring new convenience and experience to tourism, and continuously generate new tourism products, new services, and new management. Eventually, it can accelerate the transformation of the tourism production and operation mode from offline based to online and offline two-way empowerment, bringing about a new pattern of tourism development. Taking this as an opportunity, we can continuously improve the market attention level of scenic spots, which is conducive to further realization of symbiosis.

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