Article

Evaluate on the Decoupling of Tourism Economic Development and Ecological-Environmental Stress in China

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Abstract: Tourism economic development is increasingly dependent on resources and environment. Exploring the relationship between tourism economic development and ecological-environmental (eco-environmental) stress is of great significance to promote the high-quality growth of tourism and the sustainable and coordinated development of ecological environment. By constructing a tourism economic development index and an eco-environmental stress index, this study analyzes the temporal and spatial evolution of tourism economic development and eco-environmental stress from 2009 to 2018 in China. It uses a decoupling model to evaluate the relationship between tourism economic development and ecological-environmental stress, and analyzes the reasons for the changes of decoupling relationship. The results show that: (1) During the study period, the development of tourism economy and the eco-environmental stress present a certain time-space effect characteristics. The stress index of China's tourism economic development and ecological environment showed a fluctuating trend of first decreasing and then increasing, with obvious spatial hierarchical differences and weak agglomeration characteristics, and prominent regional imbalances. The tourism economic development level in the eastern region was higher than that in the central and western regions, while the ecological environment stress in the central region was greater than that in the eastern and western regions. (2) The relationship between tourism economic development and ecological environmental stress of China's provinces has experienced eight states: Expansive negative decoupling, strong negative decoupling, weak negative decoupling, recessive coupling, expansive coupling, strong decoupling, weak decoupling, and recessive decoupling. During the study period, the state of optimal strong decoupling tends to weaken. Under the constraints of local policy orientation and regional economic development level, the overall decoupling optimization could not be achieved spatially. The decoupling state was always in an unsustainable non-optimal stage. (3) The reasons for the differential changes in the decoupling index between tourism economic development and ecological environmental stress in Chinese provinces come from investment-driven, resource-driven, innovation-driven, and environmental compliance push. This study can provide practical reference for promoting the high-quality development of tourism and the sustainable development of ecological environment.

Keywords: tourism economy; eco-environmental stress; decoupling evaluation; spatio-temporal difference

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1. Introduction

In recent years, China's tourism economy has entered a stage of rapid growth, with increasing demand for tourism. The process of tourism economic growth is the process of sustainable development and utilization of resources, and at the same time, it will continue to discharge waste to the environment. The dependence of tourism economic development on resources and environment is increasing [1]. Tourism economic activity inevitably certain stress and the influence on the ecological environment [2]. The process of tourism

economic development is usually to focus on the short-term economic interests and to ignore the sustainable healthy development of resources and environment. The extensive economic growth mode is especially serious beyond the tourist ecological carrying capacity as it causes irreversible damage to the ecological environment. Therefore, exploring the tourism economic development and ecological environment sustainable development has important practical significance. In the report of the 19th National Congress of the Communist Party of China, the concept of ecological civilization is proposed. It should be fully integrated into economic construction, sticking to the fact that green water and green mountains are valuable, and fully promoting green development. With the emergence of a series of problems such as air pollution, water pollution, resource depletion, and deterioration of the ecological environment, the relationship between economic growth and ecological-environmental stress has gradually attracted widespread attention. Tourism is the world's largest service sector, and it continues to grow [3]. The sustainable development of the tourism economy, an important strategic pillar industry of the national economy, plays a role in boosting the sustainability of the entire national economy. However, the intrinsic requirement of sustainable development of the tourism economy is that tourism activities do not destroy the existing environment of the tourist destination, and the existing tourism resources should be protected and rationally-utilized without damaging the potential tourism resources, to ensure the harmonious development of the tourism economy and the natural environment. Under the background of the development strategy of ecological civilization in the new era, research is needed in how to optimize resource allocation and improve utilization efficiency in accordance with the inherent requirements of sustainable economic development, how to guide high-quality development of tourism economy, and how to realize tourism economic growth without sacrificing the ecological environment. These have become an urgent problems to be solved. Based on the realistic requirements of harmonious coexistence between humans and nature, correctly handling the relationship between tourism economic development and ecological environment is of great significance to promote the sustainable, healthy, and high-quality development of tourism.

At present, some achievements have been made in the study of the relationship between tourism and ecological environment. Foreign studies on the relationship between tourism and ecological environment mainly focus on the impact of tourism activities on specific ecological factors [4,5], tourism environmental capacity [6], tourism environmental carrying capacity [7], and tourism ecological security [8]. Domestic studies on the relationship between tourism and ecological environment mainly focus on the coupling mechanism of tourism and ecological environment [9,10], the coordination of tourism resource development and ecological environment [11], tourism ecological security [12], and tourism environmental carrying capacity evaluation [13]. In addition, domestic and foreign scholars have also discussed the relationship between tourism and ecological environment from the perspective of sustainable tourism [14–17]. Sustainable tourism emphasizes that ecological environment protection should be paid attention to in the process of developing tourism, and avoiding the destruction of ecological environment caused by the excessive development of tourism resources. The content of the research on the relationship between tourism and the ecological environment is becoming increasingly abundant, and the research methods are gradually diversified, especially when the coupling coordination model and the stress-state-response (PSR) model are most widely used. The term “decoupling” was first applied in the field of physics, which refers to the process in which the interaction relationship between two or more physical quantities no longer exists and is separated from each other [18]. In 1966, Carter first applied the concept of “decoupling” to explain the relationship between economic growth and energy consumption [19]. In 2002, the Organization for Economic Cooperation and Development (OECD) first proposed the “decoupling theory” to explore how to block the relationship between economic growth and environmental impact [20]. At present, decoupling theory has become an effective analysis method to measure the relationship between economic development, resource

consumption and environmental stress, and has been widely used abroad. At first, OECD used decoupling theory to comprehensively explain the decoupling relationship between economic growth and environmental stress in 30 member states. And then it combined the theory to analyze the equilibrium relationship in the fields of agriculture [21], energy [22], transportation [23], environment [24], atmospheric emissions [25], etc. The application of decoupling model in the study of the relationship between economic development and resources and environment has gradually become a hot topic in academic circles. In recent years, domestic scholars have gradually applied decoupling theory to the study of the relationship between economic development and resources environment [26], environmental pollution [27], energy consumption [28], arable land [29], water resources utilization [30], urbanization [31], construction land [32], carbon emissions [33], etc. In summary, the decoupling method has not been used to systematically discuss the relationship between tourism economic development and ecological environmental stress in the existing studies.

Although the research on the relationship between tourism and the ecological environment and the theory of decoupling has made great progress, there are still limitations. Firstly, the research object focus on agriculture, the environment pollution, energy, land use, urbanization of decoupling analysis. Using decoupling theory systemic evaluation of China's tourism economy development and ecological environment stress has not been found. It is not conducive to the sustainable healthy development of tourism. Then, the sustainability of the tourism industry and its promotion of the ecological environment is difficult to measure. Secondly, the research paradigm is mainly focused on the interpretation of mathematical models and empirical research, mainly analyzed from the perspectives of statistics, economics, and management. It lacks research from the perspective of geography, and the degree of decoupling between tourism economic development and ecological environmental stress from the perspective of space has not been found. Moreover, compared with other methods, decoupling analysis methods focus on deduction from the time series analysis method, can travel through simple quantitative relation to comprehensively reflect the internal law of economic development and ecological environment stress. It can use panel data in horizontal comparison, accurately identify the tourism economic development and ecological environmental stress in a certain stage of development of dynamic information, and can predict development trends.

Therefore, based on the existing relevant results, and relevant theories of geography and economics, this study aims to evaluate the relationship between tourism economic development and ecological environmental stress in China from 2009 to 2018 from the perspective of time and space by using decoupling model. First, the evaluation index system of tourism economic development and ecological environmental stress is constructed, and the entropy weight method is used to measure the development level of China's tourism economy and the status of ecological environmental stress. The characteristics of China's tourism economic development and the degree of ecological environmental stress are clarified. Next, considering the criteria of decoupling, this paper analyzes the degree of decoupling between China's tourism economic development and ecological environmental stress. Finally, the reasons for the change in the decoupling relationship are explained based on the results of decoupling evaluation. The research results can provide a theoretical understanding of the spatio-temporal evolution of China's tourism economic development, offer practical reference for the sustainable and healthy development of the ecological environment and the high-quality development of tourism. They also have certain reference value for the sustainable development of tourism in other countries.

2. Research Methods and Data Sources

2.1. Evaluation Index System Construction

Constructing an evaluation index system is an important basis for studying the interaction between tourism economic development and ecological environmental stress in China. Tourism economic development is a complex systematic project. The selection of indicators should be based on the stage characteristics of regional economy, and based on the

principles of the times, systematization, scientificity, rationality, and data availability of the indicators, the connotation of tourism industry is specified and indexed. This study focuses on input–output theory based on the understanding of the connotation requirements of high-quality tourism development in the new era, and on the basis of fully referring to the experience of Fang et al. [34], Guo et al. [35], and Zhou et al. [36] in constructing indicators. From the four dimensions of tourism enterprise scale, tourism capital investment, tourism reception level and tourism industry performance, this paper constructs an evaluation index system of tourism economic development level, which is composed of four primary indicators and corresponding 10 secondary indicators (Table 1). Tourism economic development and ecological environment are closely related, and the ecological environment stress index is constructed to comprehensively reflect the ecological environment. To measure the stress of an ecological environment, we should not only consider the consumption of ecological resources and energy at the input end, but also consider the material emissions and measure the ecological environment load through the threat degree of natural disasters. Therefore, this study combines the principle of circular and cumulative causation, which is in line with the connotation requirements of sustainable development. Based on the existing research results of Xu et al. [37], Zhu et al. [38], and Du et al. [39], 14 indicators were selected to characterize the eco-environmental stress from the three dimensions of resource consumption conditions, environmental pollution status, and natural threat levels, respectively. The specific evaluation system is shown in Table 1.

Table 1. Evaluation index system of tourism economic development and ecological environmental stress.

System	Primary Indicators	Secondary Indicators	Unit
Tourism economic development system	Tourism enterprise scale	Number of tourist attractions	individual
		Number of star-rated hotels	individual
		Number of travel agencies	individual
	Tourism capital investment	Total tourism investment in fixed assets	Ten thousand yuan
		Number of tourism employees	People
	Tourism reception level	Number of domestic tourists	Million people
		Number of inbound tourists	Million people
	Tourism industry performance	Domestic tourism revenue	Billion yuan
		Foreign exchange earnings from international tourism	Million dollars
Ecological environmental stress system	Resource consumption conditions	The proportion of total tourism revenue in the tertiary industry	%
		Electricity consumption	Billion kilowatt hours
		Water consumption	Billion cubic meters
		Total energy consumption	Million tons of standard coal
		Green space area	Million hectares
	Environmental pollution status	Urban construction land area	Square kilometers
		Sulfur dioxide emissions	Million tons
		Smoke (dust) emissions	Ton
		Total amount of wastewater discharge	Million tons
		Industrial solid waste generation	Million tons
	Natural threat level	Harmless disposal capacity of domestic waste	Million tons
		Amount of pesticides used	Million tons
		Area affected by natural disasters	Thousands of hectares
		Number of people affected by natural disasters	Million people
		Number of occurrences of geological disasters	Times

2.2. Evaluation Method

2.2.1. Entropy Weight Method

This study adopts the entropy weight method to comprehensively measure the level of tourism economic development and ecological environment stress. To eliminate the dimensional differences of evaluation indexes and make them more comparable, the range method was used to standardize the dimensional data [40], among which, different processing methods were chosen for positive and negative indicators, and for positive indicators: $Z'_{ij} = (Z_{ij} - Z_{ijmin}) / (Z_{ijmax} - Z_{ijmin})$; for negative indicators: $Z'_{ij} = (Z_{ijmax} - Z_{ij}) / (Z_{ijmax} - Z_{ijmin})$. After standardization, the weight values of the indicators were determined, and finally the linear weighting model was used to solve the tourism economic development index and eco-environmental stress index of China's provinces from 2009 to 2018. The higher value of tourism economic development index reflects the higher level and quality of tourism economic development, and vice versa; the higher value of eco-environmental stress index indicates the greater stress on the ecological environment, and vice versa. Among them, the calculation formula of each index weight value is as follows:

Implementation of weight conversion:

$$S_{ij} = \frac{Z'_{ij}}{\sum_{i=1}^n Z'_{ij}} \quad (1)$$

Calculating entropy value:

$$P_j = -\frac{1}{\ln n} \sum_{i=1}^m S_{ij} \ln S_{ij} \quad (2)$$

Calculating index weight:

$$A_j = \frac{1 - P_j}{\sum_{i=1}^m P_j} \quad (3)$$

The formula for calculating tourism economic development index and eco-environmental stress index is as follows:

$$TEDI = \sum_{i=1}^n T_i A_i \quad (4)$$

$$EEPI = \sum_{j=1}^n T_j A_j \quad (5)$$

where: TEDI and EEPI are tourism economic development index and eco-environmental stress index, respectively; Z_i and Z_j are the standardized values of various indicators in the tourism economic development system and ecological environmental stress system, respectively; A_i and A_j are the weight values corresponding to T_i and T_j , respectively.

2.2.2. Decoupling Evaluation Model

The purpose of this study is to explore the relationship between tourism economic development and ecological environmental stress, and the decoupling evaluation model can be used to determine the decoupling state of the two. According to the relevant research results at home and abroad [41–43], with full reference to Tapio decoupling elasticity coefficient method [23], this paper constructs the decoupling evaluation model of tourism economic development and ecological environment stress, according to the following expression:

$$DI_t = \frac{\Delta EEPI_t}{\Delta TEDI_t} = \frac{(EEPI_c - EEPI_b) / EEPI_b}{(TEDI_c - TEDI_b) / TEDI_b} \quad (6)$$

where: DI_t represents the decoupling index of eco-environmental stress on tourism economic development in period t ; $\Delta EEPI_t$ represents the rate of change of eco-environmental stress index in period t ; $\Delta TEDI_t$ represents the rate of change of tourism economic development index in period t ; $EEPI_c$ and $EEPI_b$ represent the eco-environmental stress index in the end and beginning years of period t , respectively; $TEDI_c$ and $TEDI_b$ represent the tourism economic development index in the end and beginning years of period t , respectively.

Combined with the range of values of the decoupling index DI , “decoupling” is divided into three categories: Decoupling, coupling, and negative decoupling. It is also divided into eight subcategories: Expansive negative decoupling, strong negative decoupling, weak negative decoupling, recessive coupling, expansive coupling, strong decoupling, weak decoupling, and recessive decoupling [44], among which the strong decoupling type belongs to the optimal development state. The specific determination criteria are shown in Figure 1.

Figure 1. Criteria for determining the decoupling index between tourism economic development and ecological environmental stress.

2.2.3. Exploratory Spatial Data Analysis Method

Exploratory spatial data analysis method is used to determine whether there is a correlation between the observation values of a certain position and its adjacent position in space, and to explore its spatial agglomeration characteristics [45]. This study uses the global Moran's I index to measure the spatial correlation and degree of agglomeration of the decoupling state of China's tourism economic development and the ecological environmental stress. Usually, Moran's I index value is in the range of $[-1, 1]$. When Moran's I value is less than 1 and close to -1 , it indicates that the decoupling state is in negative spatial correlation. When Moran's I value is equal to 0, it indicates that the decoupling state has no spatial correlation and is in a random distribution state. When Moran's I value is greater than 0, it indicates that the decoupling state is spatially positively correlated and in an agglomerative distribution state, and the closer to 1, the more significant the degree of agglomeration. The calculation formula is [46]:

$$\text{Moran's } I = n \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n \sum_{j=1}^n w_{ij} \sum_{i=1}^n (x_j - \bar{x})^2} \quad (7)$$

where: x_i and x_j represent the decoupling index of the i and j provinces, respectively; $\bar{x}$ is the average value of the decoupling index, w_{ij} is the space vector matrix; n is the number of provinces in China.

2.3. Data Sources

The data used in this paper were obtained from the “China Tourism Statistical Yearbook” (including copies), “China Statistical Yearbook”, “China Environment Statistical Yearbook”, “China Energy Statistical Yearbook”, and the statistical yearbooks of Chinese provinces, selected for a time span from 2009–2018. A small part of the missing data in individual years is supplemented by interpolation method. In addition, in view of the serious lack of data in Tibet, Hong Kong, Macao, and Taiwan, it was excluded from the research sample. This study uses the basic data of geographic information, mainly derived from the 1:4 million database of the National Geographic Information Center.

3. Results and Analysis

3.1. Characteristics of Changes in the Level of Tourism Economic Development

Equation (4) was applied in calculating China’s tourism economic development level index from 2009 to 2018, as shown in Figure 2, so as to obtain the characteristics of the development and change of tourism economy in China and various regions. From the perspective of time series change trend: China’s tourism economic development index first dropped from 0.3059 in 2009 to 0.2991 in 2011, then rose to 0.3048 in 2013, then fell to 0.2731 in 2015, and finally rose again to 0.3249 in 2018, showing an overall fluctuating change trend of first declining and then rising. The tourism economic development index of the eastern, central, and western provinces in China also showed an overall fluctuating trend of first declining and then rising, and there are significant differences among different regions. The tourism economic development index of eastern provinces was higher than the national average, while the tourism economic development index of the central and western regions was lower than the national average. *In summary*, the tourism economy of the eastern provinces of China has always been at a high level of development, which can play a role in radiating and driving the development of the central and western provinces. However, the development level of the tourism economy of the central and western provinces is relatively low. There is an urgent need to increase the scale of investment in the tourism industry and optimize the development of tourism resources, thereby promoting the high-quality development of the tourism economy.

Figure 2. Time series change trend of tourism economic development index from 2009 to 2018 in China.

In order to further explore the spatial difference characteristics of tourism economic development level of China’s provinces, this study uses ArcGIS 10.2 software to spatially

visualize the calculation results of the tourism economy development index. Combined with the Jenks natural breaks method, it is divided into 5 level-areas: Higher-level area, high-level area, medium-level area, low-level area, and lower-level area. It is selected the 3 years in 2009, 2013, and 2018 to carry out the specific analysis, and then drew the spatial evolution trend map of China's tourism economic development index (Figure 3).

Figure 3. Spatial pattern of tourism economic development index from 2009 to 2018 in China. (a–c) spatial evolution trend map of China's tourism economic development index.

From the perspective of spatial evolution pattern, the tourism economic development index presents the distribution characteristics of “the lower-level areas are stably concentrated in the northwest, and the higher-level areas are significantly distributed in the eastern coast”. In 2009, provinces with higher-level area of tourism economic development were concentrated in eastern developed provinces such as Shandong, Jiangsu, Zhejiang, and Guangdong. Lower-level areas were concentrated in western provinces such as Gansu, Xinjiang, Ningxia, Qinghai, and Inner Mongolia, and less developed central provinces such as Heilongjiang and Jilin. Low-level areas of tourism economic development areas were scattered in the eastern, central, and western provinces represented by Fujian, Jiangxi, and Shaanxi, respectively. Medium-level areas of tourism economic development were scattered in the eastern, central and western provinces represented by Hebei, Anhui, and Sichuan, respectively. Tourism economic development in Tianjin, Liaoning, Henan, and Shanghai were at high-level areas. In 2013, the higher-level and lower-level areas of tourism economic development were continuously and stably distributed in the eastern and north-western regions. Low-level areas were concentrated in southern China, represented by Hunan and Guangxi. Medium-level areas of tourism economic development were distributed in provinces such as Fujian, Hebei, and Shaanxi. Provinces such as Sichuan, Hubei, Henan, Anhui, Shanghai, and Tianjin had a high-level area of tourism economic development. In 2018, the higher-level areas of tourism economic development were maintained in the eastern coastal areas, while the lower-level areas of tourism economic development were basically concentrated in the northwest. Tourism economic development in western provinces such as Sichuan, Yunnan, and Guangxi jumped to a high-level area. Tourism economic development in provinces such as Hunan and Henan was located at a medium-level area. However, tourism economic development in provinces such as Fujian, Shanxi and Guizhou was located at a low-level area. In addition, the number of provinces in China whose tourism economic development index reached the medium (and above) level increased from 16 in 2009 and 2013 to 18 in 2018, and the overall development was above the medium level. But the number of provinces at the lower-level area as a proportion of the total study sample size showed an increasing trend over time, indicating that the imbalance of China's tourism economic development level is prominent.

3.2. Characteristics of Ecological Environment Development

The eco-environmental stress index was calculated by Equation (5) from 2009 to 2018, and the results are shown in Figure 4. It was also integrated with ArcGIS 10.2 to plot the evolution trend of the spatial pattern of China's eco-environmental stress (Figure 5).

Figure 4. Temporal variation trend of eco-environmental stress index from 2009 to 2018 in China.

Figure 5. Spatial pattern of eco-environmental stress index from 2009 to 2018 in China. (a–c) year pattern of eco-environmental stress index.

According to the perspective of temporal changes, China's eco-environmental stress as a whole presents the characteristics of fluctuating increase. The eco-environmental stress index of Eastern, Central, and Western China has significant differences, which show fluctuating changes over time. Among them, the eco-environmental stress index of the central region is greater than that of the eastern and western regions, and the eco-environmental stress index of both the central and eastern regions is higher than the national average ecological environment stress. However, the eco-environmental stress of the western region has been in a low value state, lower than the national average stress on the ecological environment. The trough value of China's eco-environmental stress index appeared in 2011, 2013, and 2016. But China's eco-environmental stress index reached its peak in 2015. After 2016, China's eco-environmental stress index gradually increased, reflecting the increasing trend of China's eco-environmental stress, and the increasing consumption of resources, environmental pollution, and the degree of threat to nature.

In terms of spatial evolution pattern, eco-environmental stress index can be divided into five stages. The result shows an overall trend of “high in the east and low in the west, high in the south and low in the north”. In 2009, higher-level areas of eco-environmental stress were concentrated in central regions such as Henan, and eastern coastal regions such as Jiangsu and Shandong. High-level areas were scattered in provinces such as Sichuan, Hubei, Anhui, and Liaoning, while medium-level areas were concentrated in six provinces such as Guangxi, Shaanxi, and Inner Mongolia. However, the number of lower-level and low-level areas reached 13, mainly in the western region. In 2013, Guangdong and Shandong were the only provinces with higher-level of eco-environmental stress, and the number of high-level areas increased by 1 compared to 2009. The eco-environmental stress levels of Sichuan and Henan have been maintained at a high-level area, and the number of medium-level areas increased by 2 compared to 2009. In addition, the eco-environmental stress in provinces such as Liaoning, Anhui, and Hubei decreased, the number of lower-level and low-level areas increased to 15. And the eco-environmental stress in provinces such as Jiangsu and Fujian weakened. In 2018, the eco-environmental stress index of provinces with high and higher level-areas remained unchanged compared to 2009, and the number of provinces in the medium-level area decreased by one. Mainly, the reason is that the eco-environmental stress in Zhejiang was reduced to a lower-level status. With the exception of Shaanxi, Guizhou, and Fujian, where the eco-environmental stress level has risen from a low-level to a lower-level state, the eco-environmental stress values of provinces that were previously at a low-level and lower-level state remained unchanged. On the whole, China’s eco-environmental stress has decreased over time, but has remained at a higher-level in the central region and some eastern provinces, and is obviously weaker in the western region.

3.3. Evaluating the Decoupling State between Tourism Economic Development and Ecological Environmental Stress

To more comprehensively reflect the phased changes of the relationship between tourism economic development and eco-environmental stress, based on the principle of equidistant sampling, the study period (2009 to 2018) was divided into two periods: 2009–2013 (T1) and 2014–2018 (T2). It will carry out comparative analysis of decoupling state, and the specific results are shown in Table 2. According to the results, the research shows that the number of decoupling types of tourism economic development and eco-environmental stress in China presents a diversified development trend with different development stages.

During the T1 period, the decoupling types included types 1–8, and 16 provinces in a decoupling state (including strong decoupling, weak decoupling, and recessive decoupling) comprised Hebei, Chongqing, and Inner Mongolia, accounting for 53.33% of the total sample size, of which strong decoupling accounted for 40%. Four provinces in a coupling state (including recessive coupling and expansive coupling) comprised Jiangsu, Henan, Hainan, and Ningxia, accounting for 13.34 of the total sample size. Ten provinces in a negative decoupling state (including expansive negative decoupling, strong negative decoupling, and weak negative decoupling) comprised Beijing, Heilongjiang, and Gansu, accounting for 33.33% of the total sample size. The results reveal that the T1 period is mainly dominated by decoupling state, during which the development of China’s tourism industry is relatively low. The development of tourism economy exerted less stress on the ecological environment.

Table 2. Decoupling degree of China's tourism economic development and ecological environment stress.

Province/Indicator	T1 (2009–2013)				T2 (2014–2018)			
	Δ TFDI	Δ EEPI	DI	Decoupling Status	Δ TFDI	Δ EEPI	DI	Decoupling Status
Beijing	−0.1131	−0.0504	0.4456	Weak negative decoupling	−0.0771	−0.1246	1.6166	Recessive decoupling
Tianjin	−0.1432	0.0347	−0.2424	Strong negative decoupling	0.1773	−0.1140	−0.6431	Strong decoupling
Hebei	0.0055	−0.0293	−5.3357	Strong decoupling	0.1698	−0.0663	−0.3903	Strong decoupling
Shanxi	−0.0137	−0.0300	2.1887	Recessive decoupling	0.4155	0.0581	0.1399	Weak decoupling
Inner Mongolia	0.1321	−0.0434	−0.3286	Strong decoupling	0.1950	0.2184	1.1196	Expansive coupling
Liaoning	−0.1634	−0.1004	0.6146	Weak negative decoupling	−0.2591	0.0647	−0.2496	Strong negative decoupling
Jilin	0.1276	−0.0785	−0.6155	Strong decoupling	0.3042	0.0301	0.0991	Weak decoupling
Heilongjiang	−0.0762	0.1769	−2.3221	Strong negative decoupling	−0.0152	0.2125	−14.0097	Strong negative decoupling
Shanghai	−0.1267	−0.0857	0.6767	Weak negative decoupling	0.0358	−0.2346	−6.5556	Strong decoupling
Jiangsu	−0.0390	−0.0361	0.9243	Recessive coupling	−0.0355	0.0442	−1.2466	Strong negative decoupling
Zhejiang	−0.0202	0.0321	−1.5887	Strong negative decoupling	−0.0649	−0.1069	1.6465	Recessive decoupling
Anhui	0.3265	−0.1182	−0.3621	Strong decoupling	0.0445	0.0841	1.8904	Expansive negative decoupling
Fujian	0.1074	−0.0744	−0.6923	Strong decoupling	0.0887	−0.0374	−0.4216	Strong decoupling
Jiangxi	0.0294	−0.1449	−4.9340	Strong decoupling	0.3466	0.0686	0.1981	Weak decoupling
Shandong	0.0316	−0.0741	−2.3456	Strong decoupling	0.0101	0.1622	16.0458	Expansive negative decoupling
Henan	−0.1366	−0.1210	0.8856	Recessive coupling	0.3490	0.0283	0.0810	Weak decoupling
Hubei	0.1725	−0.1966	−1.1400	Strong decoupling	−0.0031	0.0026	−0.8577	Strong negative decoupling
Hunan	−0.1838	−0.2758	1.5005	Recessive decoupling	−0.0183	−0.2442	13.3374	Recessive decoupling
Guangdong	0.0443	0.0134	0.3034	Weak decoupling	0.0086	0.0424	4.8985	Expansive negative decoupling
Guangxi	0.1133	−0.2970	−2.6210	Strong decoupling	0.5212	−0.2327	−0.4465	Strong decoupling
Hainan	−0.3436	−0.3488	1.0151	Recessive coupling	0.9068	−0.5931	−0.6541	Strong decoupling
Chongqing	0.0284	−0.2298	−8.1045	Strong decoupling	−0.1930	−0.0338	0.1753	Weak negative decoupling
Sichuan	0.1866	−0.0045	−0.0241	Strong decoupling	0.2561	0.2501	0.9766	Expansive coupling
Guizhou	−0.0979	−0.2458	2.5104	Recessive decoupling	0.2999	0.1043	0.3478	Weak decoupling
Yunnan	−0.0234	−0.0083	0.3531	Weak negative decoupling	0.3706	−0.0943	−0.2544	Strong decoupling
Shaanxi	0.2793	−0.0045	−0.0160	Strong decoupling	0.2511	0.0199	0.0794	Weak decoupling
Gansu	0.0900	0.4069	4.5212	Expansive negative decoupling	0.3321	0.3646	1.0979	Expansive coupling
Qinghai	−0.2097	0.5800	−2.7662	Strong negative decoupling	0.4577	0.3654	0.7980	Weak decoupling
Ningxia	0.1810	0.1636	0.9037	Expansive coupling	3.6645	0.2173	0.0593	Weak decoupling
Xinjiang	0.0520	0.2313	4.4473	Expansive negative decoupling	0.1884	0.0748	0.3970	Weak decoupling

During the T2 period, there were 7 types of decoupling (except for the recessive coupling type 4), and the number of provinces in decoupling state reached 18, accounting for 60% of the total number of samples, of which strong decoupling accounted for 23.33%. The number of provinces in negative decoupling state was 9, accounting for 30% of the total number of samples. Only three provinces, including Inner Mongolia, Sichuan, and Gansu were in a state of expansive coupling, accounting for 10%. It can be seen that the number of strong decoupling in the optimal state in the T2 period decreased, and the number of provinces in the coupling state also decreased. While the difference between the number of provinces in the decoupling state and the number of provinces in the negatively decoupling state became larger. It leads to promote the extreme phenomenon of the stress of tourism economic development on the ecological environment. In summary, the decoupling relationship between China's tourism economic development and ecological environment shows fluctuating and changing dynamics, presenting alternating changes in two of the three: Decoupling, coupling, and negative decoupling. The repeated changes in the decoupling state of China's tourism economic development and ecological environment, and the imbalance of the decoupling relationship among provinces more intuitively indicate that: The relationship between China's tourism economic development and ecological environment is in an unstable and unsustainable state.

In this study, ArcGIS 10.2 was used to explore the spatial heterogeneity of decoupling states in T1 and T2 periods, and the spatial pattern evolution map was drawn (Figure 6). The Moran's I value was estimated to be 0.1024 and 0.1517 in T1 and T2 periods. Respectively, it indicates that there is weak spatial autocorrelation between tourism economic development and eco-environmental stress in the two development stages, and it shows an increasing trend of change. In addition, the Z-value and P-value corresponding to Moran's I in the T1 period were 1.6372 and 0.1016. While the Z-value and P-value corresponding to Moran's I in the T2 period were 2.2403 and 0.0251. The Z-value of two periods are greater than 1.96 only in the T2 period, and pass the significance test at the 0.05 level. In a word, during the study period, the decoupling relationship between China's tourism economic development and eco-environmental stress has a certain positive spatial correlation. The decoupling state of tourism economic development and eco-environmental stress among provinces presents certain agglomeration characteristics, but the degree of spatial agglomeration is not high.

Figure 6. The evolution of the spatial pattern of the decoupling state of tourism economic development and ecological environmental stress in China. (a,b) decoupling state of tourism economic development and ecological environmental.

In Figure 6, various decoupling types are scattered in different provinces of China, and the decoupling relationship between tourism economic development and eco-environmental stress in the eastern, central and western regions of China presents different patterns of change with different development periods. The number of provinces with very good status of strong decoupling type 6 changed from 12 in the T1 period to 7 in the T2 period. The ratio of the number distributed in the eastern, central, and western provinces changed from 4:3:5 in the T1 period to 5:0:2 in the T2 period, respectively, with a tendency for the spatially good status of decoupling relationships to weaken. The number of weak decoupling type 7 and recessive decoupling type 8 increased from 4 in the T1 period to 12 in the T2 period. And the ratio of the number distributed in the eastern, central and western provinces changed from 1:2:1 in T1 to T2 of 2:5:5. It reflects that the stress on the ecological environment generated by tourism economic development in the central and western regions tended to decrease. The ratio of the number of provinces with recessive coupling type 4 and expansive coupling type 5 changed from 3:1 in the T1 period to 0:3 in the T2 period, with the coupling state of the decoupling relationship tending to be good. The ratio of the number of provinces in the poor decoupling state of expansive negative decoupling type 1, strong negative decoupling type 2, and weak negative decoupling type 3 changed from 2:4:3 in T1 to 3:4:1 in T2. And the number of provinces in the negative decoupling relationship distributed in the eastern, central and western parts of China changed from 4:1:4 in T1 to 5:2:1 in T2. This indicates that the stress of tourism economic development on the ecological environment in the eastern and central parts of China tends to increase. Whereas the stress on the ecological environment in the western part of China tends to weaken.

In summary, the strong decoupling relationship between China's tourism economic development and the optimization of ecological environment tends to weaken. In the T1 period, the decoupling status of the western region is better than that of the eastern and central regions, but the overall decoupling degree of the eastern region in the T2 period is better than that of the central and western regions. Meanwhile, the negative decoupling status of some provinces in the eastern region should not be underestimated. In recent years, the country has vigorously implemented supply-side structural reform measures, optimized and adjusted for an industrial structure, developed for the tourism industry. Meanwhile, the country is focusing on the quality and efficiency of tourism and the overall implementation of the concept of green development, which reduces the stress on the ecological environment to a certain extent. Finally, the decoupling relationship between tourism economic development and ecological environment tends to be optimized. Therefore, we should gradually reduce the stress on ecological environment in the central region, enhance the level of tourism economic development in the western region, actively play a radiation-driven role in the eastern region, and comprehensively promote the coordinated development between regions. So it is more conducive to the overall decoupling and optimization of China's tourism economic development and ecological environment stress.

4. Analysis for the Reasons of the Change of Decoupling Relationship

This study takes the decoupling status of Chinese provinces in the T2 (2014–2018) period as the benchmark. Based on the results of the three types of decoupling status, such as decoupling, negative decoupling, and coupling, each indicator of tourism enterprise scale (TS), tourism capital investment (TI), tourism reception level (TR), tourism industry performance (TP), resource consumption condition (RC), environmental pollution status (EP), and nature threat level (NT) in Table 1 were selected. They were wanted to analyze and dominate the intrinsic reasons that dominate the changes in the interrelationship between tourism economic development and ecological environmental stress in China.

4.1. Decoupling Status of Provincial Domains

4.1.1. Regression Model Construction

In the decoupling state, the resource consumption index, environmental pollution status index and natural threat index were fitted with the indicators of tourism economic development respectively by the least square method. The regression analysis was carried out using the fixed-effect model by combining the test results, thus the fitted equation models were obtained as follows:

$$RC_{ij} = 0.0389 + 0.5325TS_{ij} - 0.2916TI_{ij} + 1.037TR_{ij} - 0.5227TP_{ij} \quad (i = 1, 2, \dots, 19; j = 1, 2, \dots, 5) \quad (8)$$

$$EP_{ij} = 0.0533 + 0.5168TS_{ij} - 0.9038TI_{ij} + 1.7974TR_{ij} - 0.5218TP_{ij} \quad (i = 1, 2, \dots, 19; j = 1, 2, \dots, 5) \quad (9)$$

$$NT_{ij} = 1.2182TR_{ij} - 0.3116TP_{ij} \quad (i = 1, 2, \dots, 19; j = 1, 2, \dots, 5). \quad (10)$$

According to the fitting results, the fitting degree of resource consumption index, environmental pollution status index and the indicators of tourism economic development is general. The corresponding determination coefficient R^2 are 0.6007, 0.5165, respectively, and the P value are both 0.0000, which is obviously significant. Resource consumption index and environmental pollution are significantly positively correlated with tourism enterprise size (TS) and tourism reception level (TR), and negative correlations with tourism capital investment (TI) and tourism industry performance (TP) (Table 3). This indicates that as the scale of tourism enterprises increases and the level of tourism reception increases, the degree of resource consumption appears to increase significantly. However, with the increase of tourism capital investment and tourism industry performance, the degree of resource consumption decreases instead. The improvement of tourism enterprise scale and tourism reception level, the degree of environmental pollution increases.

Table 3. Regression results of the decoupling state of provincial eco-environmental stress and various tourism economic development indicators. Abbreviations: Tourism enterprise scale (TS), tourism capital investment (TI), tourism reception level (TR), tourism industry performance (TP), constant term (C).

Index	Variable	Coef.	Std.Err.	t-Stat.	Prob.
Resource consumption conditions	C	0.0389	0.0075	5.1583	0.0000 **
	TS	0.5325	0.1018	5.2285	0.0000 **
	TI	−0.2916	0.1213	−2.4028	0.0183 *
	TR	1.0370	0.1957	5.2996	0.0000 **
	TP	−0.5227	0.1292	−4.0466	0.0001 **
Environmental pollution status	C	0.0533	0.0119	4.4657	0.0000 **
	TS	0.5168	0.1610	3.2089	0.0018 **
	TI	−0.9038	0.1919	−4.7102	0.0000 **
	TR	1.7974	0.3094	5.8087	0.0000 **
	TP	−0.5218	0.2043	−2.5542	0.0123 *
Natural threat level	C	0.0184	0.0088	2.0886	0.0396
	TS	−0.1678	0.1189	−1.4104	0.1619
	TI	−0.0990	0.1417	−0.6985	0.4866
	TR	1.2182	0.2285	5.3303	0.0000 **
	TP	−0.3116	0.1509	−2.0652	0.0418*

Note: ** and * represent passing significance tests at 0.01 and 0.1 levels.

The degree of natural threat and the indicators of tourism economic development have a low degree of fit, with a determination coefficient R^2 of 0.3085 and a P -value of 0.0000. The degree of natural threat showed a positive correlation with tourism reception level (TR) and a negative correlation with tourism industry performance (TP). It shows that the continuous increase in tourism reception level and the increasing number of tourists, the degree of natural threat emerges continuously.

4.1.2. Cause Analysis

Innovation-driven green transformation is the key to achieving harmony between tourism economic development and ecological environment. The tourism economic development are decoupled from the eco-environmental stress in Beijing, Tianjin, Shanghai, and Zhejiang. It has a significant positive correlation with the scale of tourism enterprises and the level of tourism reception but presents a negative correlation with tourism capital investment and tourism industry performance. The reason is that in the decoupling state, the provinces pay more attention to the construction of tourism infrastructure and the development of tourism market, continuously optimize and adjust the structure of tourism industry. In addition, they improve the quality of tourism service, make full use of existing resources to implement green innovation, and vigorously promote the green transformation of tourism. It is worth noting that most of the national eco-tourism demonstration zones are concentrated in these provinces. The state vigorously cultivates emerging demonstration zones, strengthens innovation drive, adheres to the path of green and high-quality development, and provides a good market environment for tourism economic development. So, they are playing an important role in the sustainable coordination of tourism economic development and ecological environment.

The ecological environment has a positive effect on tourism economic development. Western regions such as Guizhou, Yunnan, Qinghai, and Guangxi have better ecological conditions and rich natural resources, and have a number of national natural scenic areas due to their superior natural environmental conditions, so as to provide a guarantee for the growth of the tourism economy. However, due to the relatively backward traffic conditions in the western region and the relative lack of talents and funds, the development of the tourism economy is thus restricted to a certain extent and the level of development is relatively backward, which in turn produces little stress on the ecological environment. The level of tourism economic development and eco-environmental stress increase or decrease simultaneously, which eventually puts the two in a good state of decoupling.

4.2. Provinces with Negative Decoupling Status

4.2.1. Regression Model Construction

According to the above analysis methods and principles for provinces with decoupling status, regression models of ecological environment stress and various tourism economic development indicators in provinces with negative decoupling status are as follows:

$$RC_{ij} = 0.5206TS_{ij} + 1.0665TI_{ij} \quad (i = 1, 2, \dots, 8; j = 1, 2, \dots, 5) \quad (11)$$

$$EP_{ij} = 0.6791TS_{ij} + 0.0528 \quad (i = 1, 2, \dots, 8; j = 1, 2, \dots, 5). \quad (12)$$

The results show that the resource consumption index and environmental pollution status index fit well with the indicators of tourism economic development. Determination coefficient R^2 are 0.9002 and 0.7689, respectively, and the P value are both 0.0000, both of which have obvious significance. The resource consumption index showed significant positive correlation with tourism enterprise scale (TS) and tourism capital investment (TI) (Table 4), insignificant negative correlation with tourism reception level (TR), and insignificant positive correlation with tourism industry performance (TP). This indicates that with the increasing scale of tourism enterprises and the increase of tourism capital investment, the degree of resource consumption also appears to increase significantly.

Environmental pollution status showed positive correlation with tourism enterprise scale (TS), insignificant positive correlation with tourism capital investment (TI) and tourism industry performance (TP), and insignificant negative correlation with tourism industry performance (TP). It reflects that the increase in tourism enterprise scale leads to a greater degree of environmental pollution.

In addition, The natural threat index has little significance with each index of tourism economic development. There was no significant linear relationship, indicating that tourism

economic development does not pose a threat to the natural ecological environment or the degree of threat is very weak.

Table 4. Regression results of decoupling negative state of provincial ecological environmental stress and various tourism economic development indicators.

Index	Variable	Coef.	Std.Err.	t-Stat.	Prob.
Resource consumption conditions	C	0.0177	0.0190	0.9325	0.3574
	TS	0.5206	0.1417	3.6747	0.0008 **
	TI	1.0665	0.3128	3.4090	0.0017 **
	TR	−0.4310	0.3428	−1.2572	0.2170
	TP	0.3780	0.2662	1.4199	0.1645
Environmental pollution status	C	0.0528	0.0224	2.3631	0.0238 *
	TS	0.6791	0.1671	4.0635	0.0003 **
	TI	0.3207	0.3690	0.8690	0.3908
	TR	−0.0243	0.4044	−0.0602	0.9524
	TP	0.1269	0.3141	0.4041	0.6886

Note: ** and * represent passing significance tests at 0.01 and 0.1 levels.

4.2.2. Cause Analysis

Tourism capital investment, as the leading driving factor, is unsustainable. The resource consumption index of developed coastal provinces such as Liaoning, Jiangsu, Shandong, and Guangdong, as well as important provinces such as Heilongjiang, Anhui, Hubei, and Chongqing, show a significant positive correlation with tourism enterprise size (TS) and tourism capital investment (TI). The reason for this is that developed provinces such as Shandong and Jiangsu rely on the existing geographical advantageous conditions, convenient tourism transportation, rich tourism resource endowment, and strong supporting industrial support to attract a large number of the population gathering. It results in the increasing consumption of resources and the increasing stress of tourism economic development on the ecological environment. In addition, many tourism investors prefer to choose Liaoning and other coastal provinces with superior conditions, so as to expand the scale of tourism development. At one time, the pursuit of high economic benefits will also consume a lot of resources, and this investment-driven tourism economic development is unsustainable and will only continue to increase the stress on the ecological environment.

There is a significant dependence on a resource-driven approach to economic development. In the state of negative decoupling, the province is rich in tourism resources, and the development of tourism economy is mostly in the mature stage. However, the tourism economy in these provinces mostly follows the rough economic development method of resource consumption, relying on the existing rich tourism resources for over-exploitation, incomplete transformation of related industries. They lack new supporting industries, insufficient investment in fixed assets and environmental management, and insufficient tourism human capital. It results in adverse social, environmental, and economic effects, and makes the development of the tourism economy still exerts great stress on the ecological environment.

5. Conclusions and Discussion

5.1. Conclusions

Based on the measurement of China's tourism economic development index and eco-environmental stress index, combined with ArcGIS technology, this paper analyzes spatial and temporal evolution characteristics, evaluate the correlation between tourism economic development and eco-environmental stress with the decoupling model. At the same time, it aims at analyzing the reasons for their changes, resulting in the following conclusions:

The tourism economic development and eco-environmental stress show certain characteristics of space-time effect. During the study period, China's tourism economic

development and eco-environmental stress index as a whole showed a fluctuating trend of first decreasing and then increasing. The level of tourism economic development kept increasing or decreasing while the eco-environmental stress also exhibited an increasing or decreasing trend. China's tourism economic development and eco-environmental stress show obvious spatial level differences and weak agglomeration characteristics, with prominent regional imbalance. The level of tourism economic development in the eastern region is generally higher than that in the central and western regions, while the eco-environmental stress in the central region is greater than that in the eastern and western regions.

The relationship between tourism economic development and ecological environmental stress of China's provinces has experienced eight states, and the optimal strong decoupling relationship tends to weaken. During the study period, most of the provinces showed a trend of alternate changes in two out of three decoupling, coupling, and negative decoupling. Because most of provinces failed to achieve overall decoupling optimization in space under the constraints of local policy orientation and regional economic development level, the decoupling status was always in an unsustainable and non-optimal stage. Each province should start with technological progress, effectively improve the utilization efficiency of tourism resources and the ability of environmental governance, implement low-carbon, coordinated and green tourism development policies, and correctly handle the relationship between tourism economic development and ecological environment. Moreover, they should build a long-term mechanism for the coordinated development of the two, explore the economic development path of ecological tourism in line with the actual situation of each region. In particular, under the current situation of the outbreak of COVID-19 and the normal prevention and control, the tourism industry has been greatly impacted by the COVID-19 pandemic [47], and the tourism economy has been seriously deteriorated. Therefore, it is necessary to accelerate the sustainable recovery of social health, the environment and the tourism economy [48]. Finally, it is important to promote the innovation of China's green tourism development mode; strengthen the development of ecological health tourism to improve immunity and optimize the ecological environment; promote the integration of "health preservation + ecological tourism + health treatment". The purpose is to ensure the tourism economic development and eco-environmental stress towards a benign and sustainable decoupling direction.

The reasons for the differential changes in the decoupling state of tourism economic development and ecological environmental stress in China's provinces come from the investment-driven, resource-driven, innovation-driven, and environmental compliance push. China's tourism economic development is mostly resource-driven and investment-driven as an important driving force. With the continuous improvement of the scale of tourism enterprises and tourism reception level, the stress of tourism economic development on the ecological environment is uneven, and the instability and unsustainability are obvious. Strengthening innovation drive and paying attention to natural ecology are the key driving forces to get rid of the stress of tourism economic development on ecological environment, so as to ensure the coordinated and symbiotic development of tourism economic development and ecological environment.

5.2. Discussion

At present, tourism economic development and ecological environment issues are increasingly favored by the government and the industry. How to coordinate the relationship between tourism economic development and ecological environmental stress has become a major challenge for the regional economy to achieve sustainable development. This study not only attempts to construct a decoupling evaluation model of tourism economic development and ecological environmental stress, but also uses the spatiotemporal evolution method to evaluate the internal law of tourism economic development and ecological environmental stress. Therefore, there is some innovation in the research method. Moreover, this study combines with geographic information systems and the theory of

the statistical to analysis of tourism economic development and ecological environmental stress of spatial heterogeneity. Exploring the causes of the change in decoupling state by classificationis conducive to exploring different tourism development modes conducive to the sustainable development of ecological environment. So, this study contributes certain innovative ideas. Its finding will help the tourism department and the environmental department better understand the current development situation, provide a reference for the national formulation of macroeconomic control policies and environmental protection policies, and support the realization of high-quality tourism development and the sustainable development of the ecological environment. However, there are limitations to this study. The first limitation concerns the scope of the data analysis. The data used in this study is only for the analysis of China's national conditions, so the results of this study cannot be generalized. In future studies, researchers should analyze the situation of globalization more widely, to obtain more practical and universal results for globalization. The second limitation is that the research scale is limited to the provincial level. Due to the lack of data, future research needs to extend the analysis to the city and county scales to compensate for the missing data and reveal the law of interaction between tourism economic development and ecological environmental stress on a more refined scale. Finally, due to space constraints, we could not discuss spatial analysis on the data for each year, and only selected representative years for analysis.

Because the period covered in this study was from 2009 to 2018, the data analysis did not examine the influence of the COVID-19 pandemic, and it is necessary to conduct further research. In future studies, further research will be carried out on the recovery of tourism economic development and sustainable development of ecological environment under the situation of COVID-19 epidemic. At the same time, the impact assessment of COVID-19 epidemic on tourism and ecological environment will be discussed, and the internal action rules of the two systems of tourism economic development and ecological environment stress will be analyzed in depth. Future research should seek answer the following questions:

- What is the impact of COVID-19 pandemic on tourism economic development and ecological environment? Did the pandemic bring about a radical change to the tourism economy? Can it impose irreversible harm on the ecological environment?
- How can the tourism economy develop in a sustainable and high-quality way after the COVID-19 pandemic? How can “zero pressure” on the ecological environment be achieved?
- What sustainable development mode can support the harmonious coexistence of tourism with the ecological environment?

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