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Dynamic Evolution Characteristics and Drivers of Tourism-Related Ecological Security in the Beijing–Tianjin–Hebei Region

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Abstract: Revealing the characteristics of the spatial and temporal evolution of regional tourism-related ecological security and exploring its driving factors are of great theoretical and practical value to promoting the coordinated and sustainable development of the tourism economy and the ecological environment. Taking the Beijing–Tianjin–Hebei region as a case study, this study constructed a tourism-related ecological security evaluation index system based on the DPSIR theoretical framework. The tourism-related ecological security index was measured from 2011 to 2022 and its spatiotemporal characteristics and dynamic evolutionary process were analyzed. Finally, the panel quantile regression model was used to analyze its driving factors. The results show that: (1) in time, the average value of tourism-related ecological security fluctuates and rises, and the differences between the units show a convergent trend, which is mainly manifested in the catching-up effect from low-value cities to higher-value cities; (2) in space, Beijing and its southeastern cities have a high level of tourism-related ecological security, and although the study area is mainly at the less secure level, it is developing continuously and progressively; (3) in terms of the dynamic evolution characteristics, the type transfer of tourism-related ecological security has certain "path dependence" and "self-locking" effects, often occurring between neighboring levels, and the type transfer under the influence of different neighborhoods has significant differences; (4) in terms of driving factors, environmental pollution has a significant inhibitory effect on the level of tourism-related ecological security, and the level of economic development has the largest positive marginal effect on tourism-related ecological security, while other influencing factors such as the level of tourism development have certain differences in terms of their positive role in the promotion of the level of tourism-related ecological security. This study can provide a reference for decisionmakers to promote ecological protection and high-quality tourism development in the Beijing–Tianjin–Hebei region.

Keywords: tourism-related ecological security; dynamic evolutionary characteristics; driving force; panel quantile regression; Beijing–Tianjin–Hebei region

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1. Introduction

Tourism is regarded as an important carrier for the transformation of "green mountains" into "silver mountains" and bears the important responsibility of building an ecological civilization and common prosperity. However, similar to many other industries, there exists a contradictory and unifying relationship between it and the ecological environment. The World Tourism Organization (UNWTO) believes that tourism can make a significant contribution to the achievement of the Sustainable Development Goals (SDGs) and tourism is considered to play an active role in protecting, restoring, and promoting the sustainable use of terrestrial ecosystems and halting biodiversity loss. In addition, after studying different cases, some scholars have found that the appropriate development of tourism has a positive impact on the urban ecological environment [1], green development efficiency [2], and residents' awareness of environmental protection [3].

However, with the expansion of the global tourism market, the rapid growth of the tourism economy has also exerted great pressure on the ecological security of tourist destinations. In some areas with vulnerable ecosystems, the prevalence of overtourism has brought with it a series of ecological and environmental problems, such as air pollution [4], soil erosion [5], water pollution [6], and marine debris pollution [7]. Venice, for example, is the world's most popular tourist destination, but suffers from the serious adverse effects from overtourism. In particular, the decline in service capacity of the lagoon ecosystem, due to excessive cruise tourism, is the most concerning [8]. In recent years, the fierce conflict between tourism and ecology has also led to protests by local civil society organizations [9]. In the Middle East, coastal and marine tourism is widespread in the Persian Gulf and the Red Sea, which reduces the quality of marine ecosystems. Specifically, the construction of coastal infrastructure and land reclamation has led to severe damage to coral reefs, wetlands, and mangrove swamps. The uncivilized behavior of tourists and the discharge of wastewater have also led to problems with the marine environment, such as marine snowpack, coral disease, etc. [10]. Some niche destinations also face a contradiction between tourism development and the ecological environment, such as tourism activities in the Galapagos Islands, which have caused ecological degradation [11].

China is one of the fastest-growing countries in tourism, and the Chinese government attaches great importance to the balance between economic growth and environmental protection. The report of the Twentieth National Congress of the Communist Party of China (CPC) proposed that the realization of harmonious coexistence between human beings and nature is one of the five characteristics of Chinese-style modernization. Tourism-related ecological security as an important part to play in the "harmonious coexistence of man and nature", which is not only related to the sustainable development of tourist destinations but is also an inevitable choice to achieve the development goal of Chinese-style modernization. The revitalization of the tourism industry, while unleashing the potential of consumption and setting off a consumption boom, shows that the surge of tourists is also prone to having a strong impact on the ecosystem, which will limit the resilience of the tourism industry's sustainable development. How to balance ecological protection and tourism development under the guidance of the China-style modernization strategy has become an important proposition of the times.

The Beijing–Tianjin–Hebei region, with its superior natural conditions, profound history, and strong economic foundation, has gradually become one of the regions with the largest volume in terms of the tourism economy and the most development potential and vitality in the northern part of China, due to its unique advantages in tourism development, and has a strategic position in the development of China's tourism economy. Exploring the spatial and temporal evolution of tourism-related ecological security in Beijing–Tianjin–Hebei and its driving factors is of great practical significance in helping the Beijing–Tianjin–Hebei region to collaborate in building a strong ecological barrier, exploring the path toward green development, and promoting the high-quality development of the regional tourism industry.

Tourism-related ecological security is ecological well-being that concerns the interests of tourists, and it is also a form of ecological support that builds up the high-quality development of tourism [12]. At present, scholars have explored tourism-related ecological security from multiple perspectives. Early studies focused on the interpretation of the concept of tourism-related ecological security, and due to differences in perspective and specialization, the definition of this concept has not yet been unified. However, a consensus has been reached on the point that "when the natural resources and ecological environment system of a tourist site operates in an orderly and balanced manner without threats and meet the needs of human survival and sustainable development, the tourist ecology of the site is considered to be in a safe state" [12,13]. After that, scholars either resorted to using technology for the processing of spatial information [14,15], or established an evaluation system combined with measurement models, such as the linear weighting method, improved TOPSIS method [16], ecological footprint method [17], Lotka–Volterra symbiosis model [18], DEA model [19], and fuzzy object–element model [20], etc., to quantitatively assess the status of tourism-related ecological security. On this basis, the temporal and spatial differentiation characteristics of tourism-related ecological security have been explored, and scholars mostly use spatial analysis tools, spatial measurement models, Gini coefficients [21], etc., to explore its spatial patterns, spatial agglomeration, spatial differences, and other spatial dynamics [22–24]; or evolution over time [25–27], and further predicting future trends [23,26,28]. With the depth of the study, the focus of scholars shifted to a higher level of analysis concerning influencing factors. Scholars generally believe that population density, economic level, government capacity, and scientific and technological investment are the main factors affecting tourism-related ecological security [29,30], usually with the help of the gray correlation projection method [31], barrier degree model [32], geographic detector [33], structural equation modeling [34], etc., and the large quantity of practical evidence that has been collected. The research objects involve watersheds [35,36], provinces [36], cities [37–39], parks [40,41], scenic areas [42,43], islands [44,45], and mountains [46,47]. In addition, a small number of scholars have explored the construction of an early warning system for tourism-related ecological security [24,48].

Previous studies on tourism-related ecological security have achieved fruitful results, but there are still aspects worthy of in-depth exploration: ① Most of the existing studies have explored the spatial and temporal characteristics of tourism-related ecological security based on the determination of the ecological security level [15,28,37,49], which has weakened the correlation between regions due to the cross-diffusion of elements, resulting in a lack of studies on the correlation characteristics of tourism-related ecological security and the law of transfer. ② Current research is mostly focused on identifying the linear influence of factors on tourism-related ecological security [19,26,47], which can clarify the key driving factors, but ignores the dynamic changes in the degree of influence of factors on tourism-related ecological security at different points, and fails to comprehensively grasp the characteristics of the changes in the driving factors of tourism-related ecological security. ③ The existing results are mostly aimed at the whole country [18], provinces [37], individual cities [17], or individual scenic spots [40], key ecological function areas [43], ecologically fragile areas [50], and other typical areas, but not enough research has been carried out on the ecological security of tourism in the Beijing–Tianjin–Hebei region, which has an important strategic position in China's national development.

Given this, this paper takes the Beijing–Tianjin–Hebei region as the research area, based on the "Driving Force-Pressure-State-Impact-Response"(DPSIR) model to construct a tourism-related ecological security evaluation index system. The tourism-related ecological security index is measured in the 2011–2022 period using the improved TOPSIS model; on this basis, a box-and-line diagram and kernel density estimation are used to portray its time-series characteristics, visualize and analyze their spatial correlation with the help of ArcGIS software (version 10.8.2), then further explore its spatial dynamic transfer characteristics by utilizing the traditional and spatial Markov chains. Finally, the panel quantile regression model is introduced to grasp the dynamic influence of factors on tourism-related ecological security at different quantiles and explore the core driving factors, aiming to provide decision-making references for the healthy and coordinated development of tourism and the ecological environment in Beijing–Tianjin–Hebei, which are in different units of tourism-related ecological security, as well as collaborating with the construction of ecological barriers and promoting the high-quality development of tourism in Beijing–Tianjin–Hebei.

2. Materials and Methods

2.1. Construction of an Indicator System

The DPSIR model was proposed by the Organization for Economic Cooperation and Development (OECD) in 1993 and later adopted and promoted by the European Environment Agency (EEA). The model was further improved based on comprehensive PSR and DSR, which can not only objectively respond to the interaction between tourism activities and the ecological environment, but can also scientifically explain the autonomous and positive feedback mechanism of human society, and thus has been widely used in ecological environment management, sustainable development, and other research fields [51]. In this paper, the DPSIR model is introduced into the study of tourism-related ecological security, and the corresponding conceptual model is constructed by combining the actual situation of the Beijing–Tianjin–Hebei region (Figure 1). In this model, the socioeconomic factors that lead to the dynamic evolution of ecological security in tourism sites being a long-term driving force (D) will subtly produce pressure on society and ecology (P), so that it is visually manifested in the state of the tourism economy, resources, and ecology (S), which in turn has an impact on human society and the ecosystem (I). To promote the ecological security and sustainable development of tourism, human beings take a series of measures to respond positively (R). The response (R) not only plays a role in the driving force (D) constituted by the socioeconomic and other factors, but also plays a direct role in the pressure (P) and the state (S), and so on to form an organic closed system.

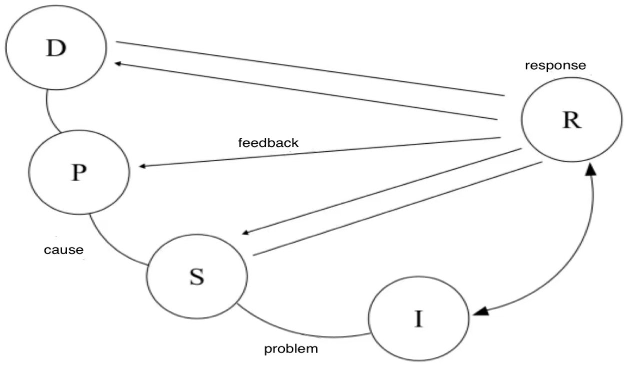


Figure 1. Schematic diagram of the DPSIR model.

Based on the DPSIR model, drawing on existing research results and taking into account the availability of data and the comprehensiveness and systematicity of indicators, this paper constructs a tourism-related ecological security evaluation index system as shown in Table 1.

Table 1. Beijing–Tianjin–Hebei tourism-related ecological security evaluation system.

Standardized Layer	Indicator Layer	Description of Indicators	Bibliography
Driving force	Tourist growth rate Natural population growth rate	Reflecting the impacts on the ecosystems of tourist destinations due to the growth of their inhabitants and tourists	[3] [24]
	The growth rate of tourism revenue	Reflecting the rate of increase in tourism receipts	[3]
	Tertiary growth rate	Reflecting the growth rate of the tertiary sector in tourist destinations	[18]
	GDP growth rate	Reflecting the level of growth of the national economy of the destination	[18]
	Urbanization rate	Reflecting the level of urbanization in tourist destinations	[38]
Pressure	Spatial density of visitors	Reflecting the occupation of local ecological space by the influx of tourists to tourist destinations, characterized by the ratio of tourist arrivals to the area of the region	[39]
	Pressure on tourist transportation support	Reflecting the impact of tourists on transportation facilities	[9]
	Intensity of utilization of tourism resources	Reflecting the consumption of tourism resources by tourists, characterized by the ratio of the number of tourists to the number of A-class and above scenic spots	[40]
	SO_2 emissions per unit of GDP Wastewater discharge per unit of GDP Smoke emissions per unit of GDP	Reflecting the potential damage to the ecology of tourist destinations caused by the by-products of industrial production, characterized by the ratio of "three wastes" emissions to the regional GDP	[13]

Table 1. *Cont.*

Standardized Layer	Indicator Layer	Description of Indicators	Bibliography
State	Tourist Attractions Taste Index	Reflecting the quality of tourism resources, characterized by the ratio of the number of 4A and 5A level scenic spots to the number of A level and above scenic spots	[13]
	Tourist Attractions Density Index	Reflecting the density of tourism resources, characterized by the ratio of the number of scenic spots of grade A and above to the area of the region	[13]
	Density of star-rated hotels Travel agency density	The capacity of tourist destinations to receive tourists is characterized by the ratio of the number of star-rated hotels, the number of travel agencies, and the area of the region.	[41] [23]
	Forest cover Green space per capita	Reflecting the ecological health of the tourist site	[31] [41]
Impact	Proportion of good days per year PM 2.5 annual average concentrations	Reflecting air quality in tourist destinations	[18]
	Tourism revenue as a share of GDP	Reflecting the impact of tourism development on the national economy and the income of rural inhabitants in tourist destinations	[39]
	Per capita income of rural residents		[42]
	Urban registered unemployment rate	Reflecting the impact of tourism development on urban employment	
Response	Sewerage compliance rate Comprehensive utilization rate of industrial solid waste Non-hazardous treatment rate of domestic waste	Reflecting the technology and capacity of regional environmental protection and pollution prevention	[16,43] [44] [47]
	Environmental investment as a share of GDP University students per 10,000 population	Reflecting the strength of government investment in environmental protection Reflecting the level of quality of the population in the place of tourism	[3] [13]

2.2. Research Methods

2.2.1. Improved TOPSIS Model

According to the index system established by DPSIR, the improved TOPSIS model is used to calculate the tourism-related ecological security value.

The technique for order preference by similarity to an ideal solution (TOPSIS) is a multi-objective system decision-making method that is currently more widely used. The classical TOPSIS model considers the evaluation indexes to be of equal importance, resulting in the weights lacking a certain degree of objectivity and scientificity. Therefore, this paper adopts the entropy value method to improve the classical TOPSIS model. It first calculates the optimal and inferior solutions according to the indicators, then calculates the proximity of each indicator to the optimal and inferior solutions and judges the advantages and disadvantages of each solution based on the distance from the positive and negative ideal solutions. In this paper, the improved TOPSIS model is used to measure the tourism-related ecological security evaluation index, and the specific steps are as follows:

(1) Indicators are standardized with the following formula:

$$x_{ij} = \begin{cases} (X_{ij} - \min X_j) / (\max X_j - \min X_j) & X_{ij} \textit{ is positive indicator} \\ (\max X_j - X_{ij}) / (\max X_j - \min X_j) & X_{ij} \textit{ is negative indicator} \end{cases} \tag{1}$$

Here: x_{ij} is the normalized value; $X_{ij}(i = 1, 2 \cdots, m; j = 1, 2 \cdots n)$ is the raw value of indicator j in year i. This paper takes $m = 12, n = 28$.

(2) Indicator weight determination: this paper adopts the entropy value method for the objective weighting of indicators, the formula is as follows:

$$e_j = -h\sum_{i=1}^{m}\left[\left(x_{ij}/\sum_{i=1}^{m}x_{ij}\right)\times\left(x_{ij}/\sum_{i=1}^{m}x_{ij}\right)\right],\ h = 1/\ln m$$
$$w_j = (1-p_j)/\sum_{j=1}^{n}(1-p_j) \tag{2}$$

Here: w_j denotes the weight of the jth indicator; p_j is the entropy value of the jth indicator.

(3) For creating a weighted normalization matrix A_{bc}, the formula is as follows:

$$A_D = \sum_{j=1}^{6}x_{ij}w_j;\ A_P = \sum_{j=7}^{12}x_{ij}w_j;\ A_S = \sum_{j=13}^{18}x_{ij}w_j;$$
$$A_I = \sum_{j=19}^{23}x_{ij}w_j;\ A_R = \sum_{j=24}^{28}x_{ij}w_j;\ i = 1,2,\cdots,12 \tag{3}$$

To construct a weighted normalization matrix:

$$A_{bc} = A_{r\times 5} = \begin{pmatrix} A_{11} & A_{12} & A_{13} & A_{14} & A_{15} \\ A_{21} & A_{22} & A_{23} & A_{24} & A_{25} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_{r1} & A_{r2} & A_{r3} & A_{r4} & A_{r5} \end{pmatrix} \tag{4}$$

Here: b is the number of study units. $b = 1,2,\cdots,r$; c is the number of indices in the DPSIR model, which is taken in this paper as $c = 5$.

(4) Determination of positive ideal solutions ${A_c}^+$ and negative ideal solutions A_c^-:

$${A_c}^+ = \{\max A_{bc}|b = 1,2,\cdots,r\};\ {A_c}^- = \{\min A_{bc}|b = 1,2,\cdots,r\} \tag{5}$$

(5) Distance from target value to positive and negative ideal solutions D_b^+, D_b^-:

$$D_b^+ = \sqrt{\sum_{c=1}^{5}\left(A_{bc}-A_c^+\right)^2};\ D_b^- = \sqrt{\sum_{c=1}^{5}\left(A_{bc}-A_c^-\right)^2} \tag{6}$$

(6) Calculation of the closeness of the evaluation object to the ideal solution (tourism-related ecological security index) Z_b:

$$Z_b = \frac{D_b^-}{D_b^+ + D_b^-} \tag{7}$$

Here: Z_b takes the value range of [0, 1], the larger its value, the safer the ecological status of tourism, and vice versa, i.e., the more deteriorated.

At present, no uniform standard has been formed for the classification of tourism-related security, and this paper divides tourism-related ecological security into five levels based on reference to existing classification standards [26,52,53] and according to the results of tourism-related ecological security measurements (Table 2).

Table 2. Classification criteria for the level of tourism-related ecological security.

Security Status	Insecurity	Less Secure	Criticality Security	General Security	Security
security level	I	II	III	IV	V
security index	(0, 0.15)	(0.15, 0.35)	(0.35, 055)	(0.55, 0.75)	(0.75, 1)

2.2.2. Markov Chains

Markov chains (MC) is a Markov process that is discrete in both time and state, and is used in this paper to analyze the probability of transfer of tourism-related ecological security level types over time. The model discretizes the continuous phenomenon of tourism-related ecological security into k states, and then calculates the probability distributions of the corresponding states and their transfers [54,55]. Remember that the state probability vector of the tourism-related ecological security grade type in year t is $p_t = [p_{1,t}, p_{2,t}, \cdots p_{k,t}]$, then the Markov transfer probability matrix M between tourism-related eco-security level types for consecutive years is represented as follows:

$$M = \begin{pmatrix} m_{11} & m_{12} & \cdots & m_{1j} \\ m_{21} & m_{22} & \cdots & m_{2j} \\ \cdots & \cdots & \cdots & \cdots \\ m_{i1} & m_{i2} & \cdots & m_{ij} \end{pmatrix} \quad (8)$$

Here: m_{ij} denotes the probability that a research unit whose tourism-related ecological security is state i in year t is transferred to state j in year t + 1, $m_{ij} = n_{ij}/n_i$ is taken in this paper, and n is the sum of the number of research units.

2.2.3. Spatial Markov Chain

The spatial Markov chain is the introduction of a spatial lags operator based on the traditional Markov chain [35], which is used in this paper to analyze the spatial interaction relationship in the process of tourism-related eco-security state change, and to reveal the relationship between the transfer probability of the tourism-related eco-security state and the neighboring research units, to make up for the insufficiency of the spatiality of the traditional Markov chain.

Conditional on the spatial lag type of the region in the initial year t, the spatial Markov transfer probability matrix divides the traditional $k \times k$ order transfer probability matrix into k, $k \times k$ conditional transfer probability matrices, and in the kth conditional transfer probability matrix, the element $m_{ij}(k)$ denotes the one-step transfer probability of a cell of type i transferring to a cell of type j in the next year, conditional on the spatial lag type, i.e., the neighboring type, being k. The value of the cell–space lag term is obtained by weighted averaging of the peripheral cell observations, which is given by the formula:

$$Lag = \sum Y_i W_{ij} \quad (9)$$

Here: Yi is observations for the unit, W_{ij} is the spatial weight matrix, geospatially adjacent is 1 and non-adjacent is 0.

2.2.4. Spatial Panel Quantile Regression Model

Compared with ordinary linear OLS regression, the quantile regression model combined with spatial panel data can not only better control individual heterogeneity and exclude the interference of outliers in the explanatory variables, but also effectively observe the regression coefficients at different quantiles, and more comprehensively portray the influence of the explanatory variables on the range of variation in the explanatory variables and the conditional distribution [56,57], which has higher practical significance. It has a higher practical significance. The expression is:

$$Q_{z_{it}}(\tau|X_{it}) = a_i + {X_{it}}^T\beta(\tau), (i = 1, 2 \cdots n;\ t = 1, 2 \cdots T) \quad (10)$$

Here: $Q_{z_{it}}$ is the conditional quantile function of tourism-related ecological security; Z_{it} is the tourism-related eco-security index; X_{it} is the matrix of explanatory variables; $\beta(\tau)$ denotes the coefficient of influence at the τ quantile; a_i is a constant term; n is the study sample size; T is the study period.

$$\beta(\theta) = \min \sum_{k=1}^{q} \sum_{i=1}^{n} \sum_{t=1}^{T} w_k \rho_{\tau_k} \left[Z_{it} - a_i - {X_{it}}^T \beta(\tau_k) \right] \quad (11)$$

Here: $\beta(\theta)$ is the impact factor; q is the number of quantile arrays; k is the kth group quantile; w_k is the kth quantile weighting factor; ρ_{τ_k} is the quantile loss function; $\beta(\tau_k)$ is the impact coefficient for the kth quantile.

Based on the principles of typicality and representativeness, combined with the results of indicator weighting, a model system for tourism-related ecological security drivers in the Beijing–Tianjin–Hebei region is constructed. The spatial and temporal dynamic evolution of tourism-related ecological security in the Beijing–Tianjin–Hebei region is quantified in terms of the level of economic development, tourism development, tourism load, environmental pollution, level of tourism attraction, regional greening, education level, and government intervention (Table 3).

Table 3. Main variables of the panel quantile regression model and their descriptive statistics.

Variable Type	Name	Description	Mean	Sd	Min	Max
Explained Variables	Tourism-related ecological security y	From the improved TOPSIS model	0.3471	0.1840	0.1280	0.8634
Explanatory variable	Level of economic development x_1	Urbanization rate	58.6461	13.5955	35.4500	88.0000
	Level of tourism development x_2	The growth rate of tourism revenue	13.1030	29.0923	−79.4000	85.2200
	Tourism load level x_3	Pressure on tourist transportation support	36.6760	48.1822	1.3253	199.4900
	Environmental pollution x_4	SO_2 emissions per unit area	4.2990	5.4679	0.0300	24.9809
	Level of tourist attraction x_5	Tourist attractions taste index	0.3008	0.1766	0.0600	0.8966
	Degree of greening of the area x_6	Green space per capita in parks	14.8503	4.1005	6.9000	25.8800
	Educational level x_7	University students per 10,000 population	218.4224	158.3675	15.0000	748.0000
	Government intervention x_8	Environmental investment as a share of GDP	4.5756	2.0263	0.4000	9.9500

2.3. Data Sources

The study area includes 2 municipalities directly under the central government, Beijing and Tianjin, as well as 13 cities, including Shijiazhuang, Tangshan, Qinhuangdao, Handan, Xingtai, Baoding, Zhangjiakou, Chengde, Cangzhou, Langfang, and Hengshui. The data for the study were mainly obtained from the *Statistical Yearbook of Chinese Cities* (2011–2020), the *Statistical Yearbook* of each city (2011–2020), the *Statistical Bulletin of National Economic and Social Development* of each city (2011–2022), and the official websites of each city, such as the city's ecological environment bureau, culture and tourism bureau, and other official websites of each city, with some missing data made up by interpolation. The base map data comes from the National Geographic Information Resources Catalog Service System (https://www.webmap.cn, accessed on 22 March 2023.).

3. Results

3.1. Spatial and Temporal Characteristics of Tourism-Related Ecological Security

3.1.1. Characteristics of Time-Series Evolution of Tourism-Related Ecological Security

The improved TOPSIS model was used to calculate the tourism-related ecological security value and make a box plot according to Table A1. Figure 2a shows that the average value of tourism-related ecological security in the Beijing–Tianjin–Hebei region fluctuates upward from 2011 to 2022, and the differences between the various cities in the region tend to narrow, showing a certain convergence trend. In order to further explore the temporal evolution characteristics of tourism-related ecological security, 2011, 2014, 2017, 2020, and 2022 were selected for kernel density estimation analysis (Figure 2b), and the position of the kernel density curve shifted to the right over time. This indicates that although the tourism industry entered a "hibernation" due to COVID-19, the ecological security of the tourism industry was not significantly affected during the study period, and it was still continuously improved. From the shape of the curve, the long-tailed starting peak feature is obvious, which shows that the tourism-related ecological security knowledge of most cities is gathered in the low values, with only a few cities having higher values, and that there are significant differences between cities. From the shape of the curve's crest, compared with the smooth movement to the lower right in other years, the crest in 2020 suddenly narrowed and soared, and the right tail of the curve has obvious signs of rising. The reason for this is that, under the influence of the outbreak of COVID-19 in late 2019 and early 2020, tourism demand was concentrated in a few cities, resulting in large fluctuations in the differences in tourism-related ecological security between cities, while the differences in the remaining years narrowed, consistent with the conclusion of Figure 2a.

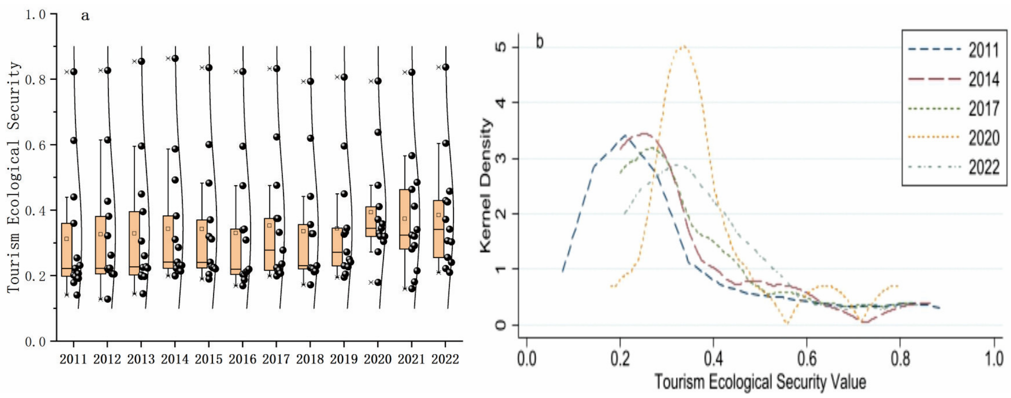
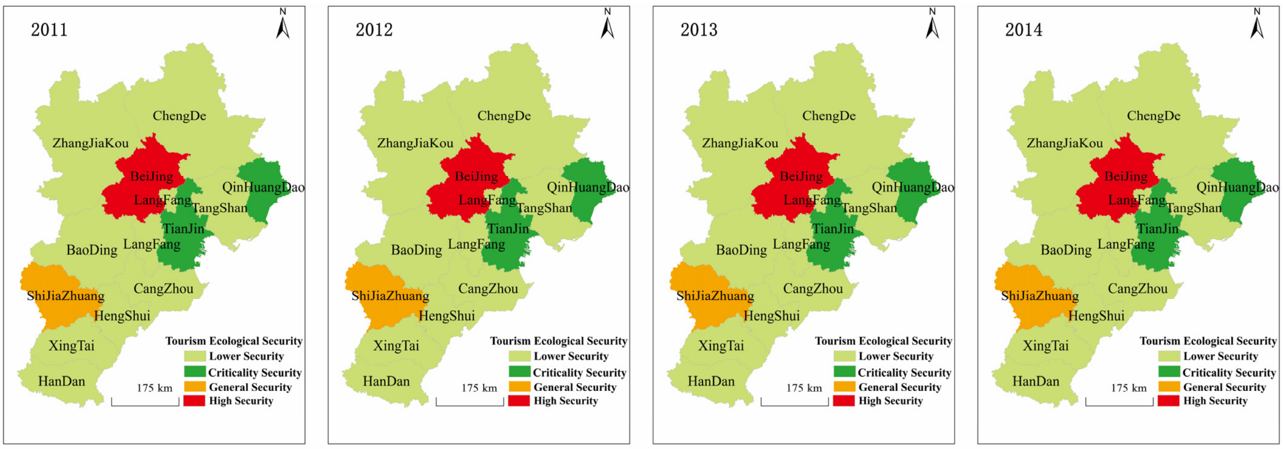


Figure 2. Box line diagram and kernel density curve of tourism-related ecological security in the Beijing–Tianjin–Hebei region.

3.1.2. Spatial Differentiation Characteristics of Tourism-Related Ecological Security

With the help of the ArcGIS platform, the state of tourism-related ecological security in Beijing–Tianjin–Hebei from 2011 to 2022 was visualized (Figure 3) to explore the spatial differentiation characteristics of tourism-related ecological security. As can be seen from Figure 3, during the study period, the tourism-related ecological security of all cities in Beijing–Tianjin–Hebei is located in the range of the II-V level: at the beginning of the period, level II dominated, accounting for as much as 69.23% of the total, and the tourism-related ecological security is in a worrisome situation. However, the overall development momentum is good, and the dominance of level II has been reduced to 46.15% by 2020, and then slightly rebounded by the impact of the epidemic, and the overall level has significantly improved compared with that at the beginning of the study period. The overall level has significantly improved compared with the beginning of the study period.



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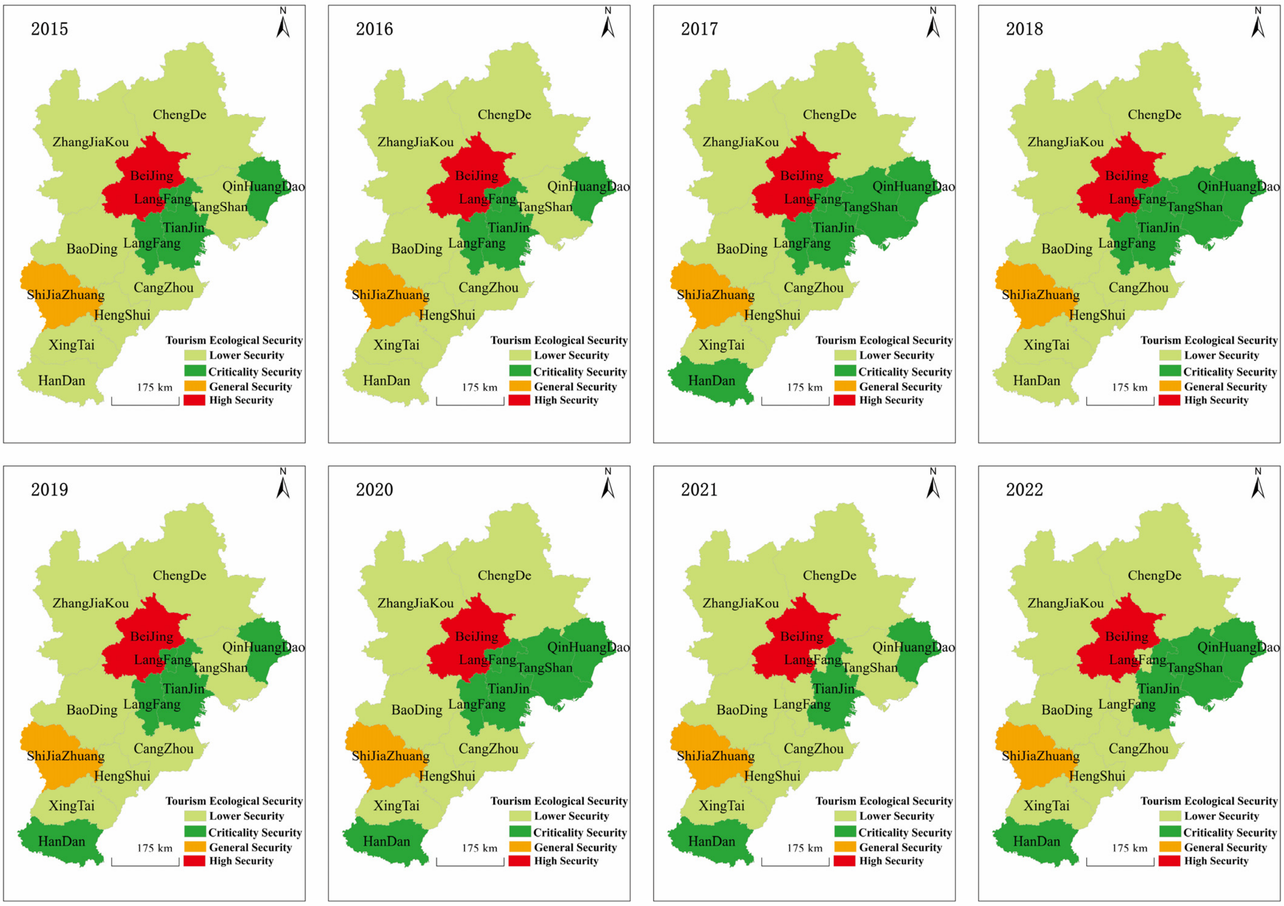

Figure 3. Spatial distribution pattern of tourism-related ecological security in Beijing–Tianjin–Hebei, 2011–2022.

The changes in tourism-related ecological security status between cities vary greatly, which can be divided into three stages: ① The stable stage, from 2011 to 2014—except for the four cities of Beijing, Tianjin, Shijiazhuang, and Qinhuangdao, the rest of the region's tourism-related ecological security level is class II, and remains unchanged. In the early period, most of the cities in the Beijing–Tianjin–Hebei region adopted a rough economic growth model, and although the tourism economy has been enhanced with remarkable results, the imperfect industrial structure, the non-green and low-carbon way of resource utilization, and the quality of the tourists needed to be improved, has caused a certain impact on the natural ecological environment, as exemplified by the frequent occurrence of haze, and has led to the problem of the sustainable development of the tourism industry. At this stage, the ecological security of tourism in the Beijing–Tianjin–Hebei region has not been effectively upgraded, and it is a transitional period for the Beijing–Tianjin–Hebei region to adjust the mode of economic development, make efforts to protect the environment, and guide the change in residents' ideological understanding. ② The improvement stage, from 2015 to 2017—the tourism-related ecological security of the Beijing–Tianjin–Hebei region as a whole has significantly improved, especially in Langfang, Handan, and Tangshan three cities region. This is mainly due to a series of government initiatives such as "Five-in-one", "Beautiful China", etc., as well as the issuance of the "National Eco-tourism Development Outline (2008–2015)", which effectively regulates the behavior of enterprises and tourists, and strengthens the correlation between tourism development and eco-protection so that the substantive effect of the relevant policies can be manifested in this stage. ③ The fluctuation stage, in 2018–2022—individual cities are accompanied by some small fluctuations in the process of overall favorable development of tourism-related ecological security. The reason for this is that the Beijing–Tianjin–Hebei region's demand for ecological tourism has been rising, and initiatives related to ecological pollution control and green tourism development have been continuously introduced, such as the "Outline of the Thirteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China" (2016–2020), which clearly stated that the supply of ecological products should be expanded, and the report of the "Nineteenth National Congress" emphasized the importance of ecological products in tourism. The report of the "19th National Congress" emphasized the in-depth promotion of supply side structural reform, coupled with General Secretary Xi Jinping's assertion that "green mountains and green water are golden mountains and silver mountains" to guide the nation's people to enhance the awareness of low-carbon solutions and environmental protection, to ensure that the tourism-related ecological security of the Beijing–Tianjin–Hebei region as a whole is stable and improving. Even as, in the COVID-19 outbreak in early 2020, the Ministry of Culture and Tourism Resources Development Department issued a guide on the "issuance of tourism scenic spots epidemic prevention and control measures" (December 2022 revised version), the State Council issued the 14th Five-Year "Tourism Development Plan" and other policy documents, the tourism-related ecological security of a small number of cities only fluctuated slightly even under the great encouragement and guidance of these policies. To summarize, the improvement of tourism-related ecological security in Beijing–Tianjin–Hebei is a gradual and continuous process of spiral and wave.

3.2. Characteristics of Dynamic Evolution of Tourism-Related Ecological Security

The above analysis indicates that the tourism-related ecological security in the Beijing–Tianjin–Hebei region is characterized by spatial correlation, so it is necessary to further explore its dynamic transfer law in the continuity of temporal and spatial processes. In this paper, we consider constructing traditional and spatial Markov transfer probability matrices (see Tables 4 and 5) to reveal the dynamic characteristics of mutual transfer between tourism-related ecological security levels in the Beijing–Tianjin–Hebei region.

Table 4. Markov transfer probability matrix of tourism-related ecological security types in Beijing–Tianjin–Hebei region, 2011–2022.

t	II	III	IV	V
II	0.8056	0.1667	0.0278	0.0000
III	0.1389	0.6944	0.1667	0.0000
IV	0.0588	0.0882	0.7647	0.0882
V	0.0000	0.0000	0.1081	0.8919

Table 5. Spatial Markov transfer probability matrix of tourism-related ecological security types in the Beijing–Tianjin–Hebei region, 2011–2022.

Neighborhood Types		II	III	IV	V
II	II	0.6667	0.3333	0.0000	0.0000
	III	0.0000	0.7500	0.2500	0.0000
	IV	0.0000	0.0000	0.6667	0.3333
	V	0.0000	0.0000	0.0000	1.0000
III	II	1.0000	0.0000	0.0000	0.0000
	III	0.0000	0.0000	0.0000	0.0000
	IV	0.0000	0.0000	0.0000	0.0000
	V	0.0000	0.0000	0.0909	0.9091
IV	II	0.7419	0.2258	0.0323	0.0000
	III	0.2381	0.4762	0.2857	0.0000
	IV	0.0000	0.2500	0.6500	0.1000
	V	0.0000	0.0000	0.2727	0.7272
V	II	0.8889	0.1111	0.0000	0.0000
	III	0.5000	0.5000	0.0000	0.0000
	IV	0.3333	0.0000	0.6667	0.0000
	V	0.0000	0.0000	0.0000	0.0000

As can be seen from Table 4, the elements on the diagonal line indicate the probability that the corresponding unit type is transferred to itself, i.e., the probability that no transfer occurs, while the elements on the non-diagonal line indicate the probability that the corresponding unit type is transferred to another type. As a result, the dynamic evolution characteristics of tourism-related ecological security, without considering the geospatial pattern, are obtained: ① The elements on the diagonal line are obviously larger than the elements on the non-diagonal line, i.e., the tourism-related ecological security level in the Beijing–Tianjin–Hebei region has a certain degree of stability, and the probability of maintaining the initial state of the types from II to V is 80.56%, 69.44%, 76.47%, and 89.19%, respectively, the variability of the types is weak, and the transfer of types has an obvious "own" probability. There is an obvious "self-locking" effect of type transfer. For the elements on the non-diagonal line, the value is larger near the diagonal line, and smaller farther away from it, indicating that the tourism-related ecological security types in the Beijing–Tianjin–Hebei region are mainly shifted sequentially between the neighboring levels, and the probability of jumping type is smaller, with the effect of "path dependence". For example, the probability of type II keeping the initial state is 80.56%, the probability of transferring to the higher type III is 16.67%, the probability of transferring to type IV is only 2.78%, and the probability of transferring to type V is 0. Measures should be taken to actively guide type II to break the "self-locking" and "path-dependence" effects to the higher types. Measures should be taken to actively guide type II to break the "self-locking" and "path-dependence" effect to transfer to a higher level, or even to transfer beyond the level. The probability of upward and downward transfer of tourism-related ecological security types III and IV in the Beijing–Tianjin–Hebei region is comparable, so while expanding the scale of the original level and guiding it to transfer to a higher level, it is necessary to be vigilant about its downward transfer.

Figure 4 shows the spatial distribution of tourism-related eco-security level types and neighborhood shifts in the Beijing–Tianjin–Hebei region throughout the study period. From the quantitative point of view, the cities that remain stable account for 30.76% of the total number of cities in the region, the cities that shift upward account for 69.24%, and there are no cities that shift downward, so the type of tourism-related ecological security in the Beijing–Tianjin–Hebei region is stable and rising. Among them, the cities that shifted upward have a wide distribution range and present geographic agglomeration characteristics, most of the cities started late in the tourism industry, and only in recent years have they grasped the "green value" and "green wealth" brought about by "face value", and the type of tourism-related ecological security has increased steadily. In recent years, most of the cities have only grasped the "green value" and "green wealth" brought by "face value", and the type of tourism eco-security is progressing from II to III; the cities that remain stable are characterized by point-like distribution, and their tourism-related eco-security is at relatively a higher level. Although the type of the cities has not changed significantly during the study period, the tourism-related eco-security index is steadily improving, and is expected to reach a higher level in the future.

The evolution of the tourism-related ecological security grade of a unit in the Beijing–Tianjin–Hebei region is not isolated and is often affected by the change in its neighborhood grade to a certain extent. Therefore, this paper explores tourism-related ecological security grade transfer under different neighborhood conditions by further constructing a spatial Markov transfer probability matrix. From the spatial Markov transfer probability matrix (Table 5) and the spatial pattern of tourism-related ecological security neighborhood transfer types (Figure 4), it can be seen that the probability of tourism-related ecological security grade transfer in the Beijing–Tianjin–Hebei region changes significantly due to the inclusion of the neighborhood condition. This shows that the regional context plays an important role in the process of the evolution of tourism-related ecological security status in the Beijing–Tianjin–Hebei region. For example, the probabilities of transferring from II to II, III, IV, and V are 0.8056, 0.1667, 0.0278, and 0 in order when the neighboring context is not considered, while once the neighboring context is added, the transfer probabilities become 0.6667, 0.3333, 0, and 0, respectively, which shows that whether or not to take the neighboring context into account has an important influence on the transfer of type II.

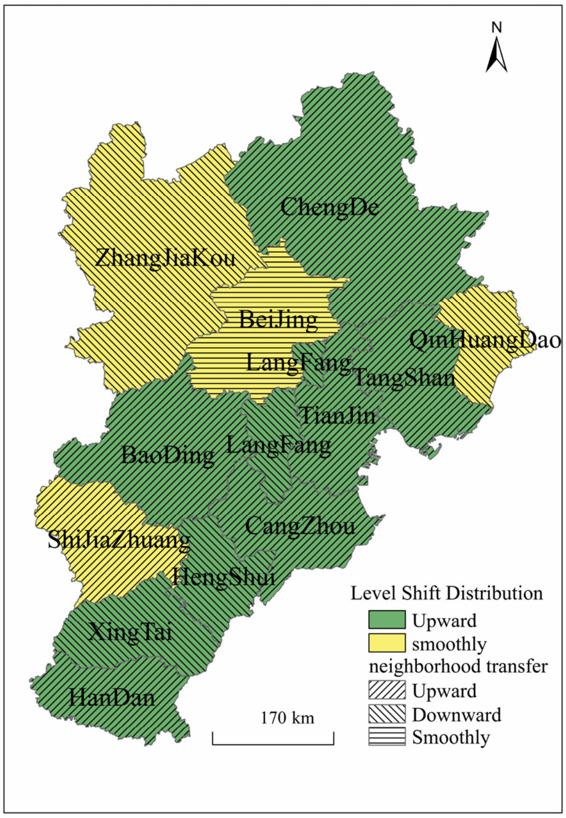

Figure 4. Spatial distribution of tourism-related ecological security types and neighborhood transfer types in Beijing–Tianjin–Hebei, 2011–2020.

Specifically: ① For type II, which has the highest proportion, the probability of upward transfer is 0.3333 and 0.2258 when its neighbors are types II and IV, respectively, while the probability of upward transfer drops to 0 when it is adjacent to III, indicating that cities with type III neighbors have a certain "siphoning effect" on type II cities, while those with II and IV neighbors have a higher transfer potential, and appropriate measures can be taken in the future to focus on guiding the relevant cities to improve their security level. ② For type III, when it is neighboring with II, III, IV, and V, respectively, the probability of remaining unchanged is 0.7500, 0, 0.4762, and 0.5000, while the probability of transferring upwards is 0.2500, 0, 0.2857, and 0, and the probability of transferring downwards is 0, 0, 0, 0.2381, and 0.5000. It can be seen that, in general, the probability of staying unchanged is greater than the probability of upward or downward transfer, which also indicates the existence of a certain "self-locking" effect. ③ For type IV, when it is adjacent to II, III, IV, and V, the probability of upward transfer is 0.3333, 0, 0.1000, and 0, respectively, and the probability of downward transfer is 0, 0, 0.2500, and 0.3333, respectively, which means that the probability of upward transfer is higher when II and III are neighbors than when IV and V are neighbors, and downward transfer is exactly the opposite. This shows that there is a significant difference in the evolution of tourism-related ecological security level types in different neighborhood contexts.

3.3. Analysis of Tourism-Related Ecological Security Drivers

In the context of realizing the Chinese modernization of "harmonious coexistence of human and nature", and in order to comprehensively improve the tourism-related ecological security level and promote the high-quality and intensive development of the tourism industry in the Beijing–Tianjin–Hebei region, it is necessary to further explore the driving factors of tourism-related ecological security in the Beijing–Tianjin–Hebei region. In this paper, a spatial panel quantile model is introduced, and three quantile points are set at the same time: 25%, 50%, and 75%, in order to reveal the changes in the elasticity coefficients of the selected variables at different quantile points and the results of the traditional OLS regression are also listed for comparison.

Firstly, the smoothness of the panel data is verified, considering the data sample capacity and the applicable conditions of the test methods, this paper chooses PP-Fisher Chi-square and ADF-Fisher Chi-square unit root test methods. As can be seen from Table 6, all variables after taking logarithmic treatment pass the unit root test at a more significant level, indicating that the panel data have the smoothness in time series and can be applied to the spatial panel quantile model.

Table 6. Unit root test for panel data.

Variable	pp Test Value	ADF Test Value	Result
$\ln x_1$	77.9052 ***	47.8590 ***	smoothly
$\ln x_2$	137.2804 ***	98.9936 ***	smoothly
$\ln x_3$	41.15042 **	55.1488 ***	smoothly
$\ln x_4$	71.0983 **	46.2839 ***	smoothly
$\ln x_5$	38.7715 *	96.0467 ***	smoothly
$\ln x_6$	62.3012 ***	38.8127 ***	smoothly
$\ln x_7$	73.3449 ***	51.5605 ***	smoothly
$\ln x_8$	77.7853 ***	61.6305 ***	smoothly

Note: ***, **, * denote significant at 1%, 5%, 10% level, respectively.

3.3.1. Panel Quantile Estimation Results

From the regression results of the panel quantile model (Table 7) and its quantile regression visualization (Figure 5), overall the level of economic development (x_1), tourism development (x_2), tourism load level (x_3), tourism attraction level (x_5), the degree of regional greening (x_6), the level of education (x_7), and governmental interventions (x_8) have a significant positive promoting effect, while environmental pollution (x_4) is a significant negative inhibiting effect, and the influence coefficients of the respective variables are significantly different at different sub-locations. Specifically:

Table 7. OLS and panel quantile outcome estimates.

Variable	OLS	q25	q50	q75
$\ln x_1$	1.221 ***	1.001 ***	1.210 ***	1.288 ***
	[0.0591]	[0.0224]	[0.0092]	[0.0005]
$\ln x_2$	0.028 **	0.0155 ***	0.0162 ***	0.0338 ***
	[0.0190]	[0.0016]	[0.0008]	[0.0000]
$\ln x_3$	0.030 *	0.0172 ***	0.0188 ***	0.0615 ***
	[0.0113]	[0.0014]	[0.0011]	[0.0001]
$\ln x_4$	−0.0249	−0.0626 ***	−0.0432 ***	−0.0338 ***
	[0.0079]	[0.0045]	[0.0026]	[0.0001]
$\ln x_5$	0.1211 **	0.0279 ***	0.106 ***	0.113 ***
	[0.0189]	[0.0033]	[0.0147]	[0.0000]
$\ln x_6$	0.1724 ***	0.177 ***	0.300 ***	0.288 ***
	[0.0318]	[0.0094]	[0.0061]	[0.0003]
$\ln x_7$	0.1177 ***	0.184 ***	0.0843 ***	0.0735 ***
	[0.0125]	[0.0061]	[0.0051]	[0.0002]
$\ln x_8$	0.1195 **	0.131 ***	0.173 ***	0.154 ***
	[0.0197]	[0.0087]	[0.0050]	[0.0002]
N	156	156	156	156

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

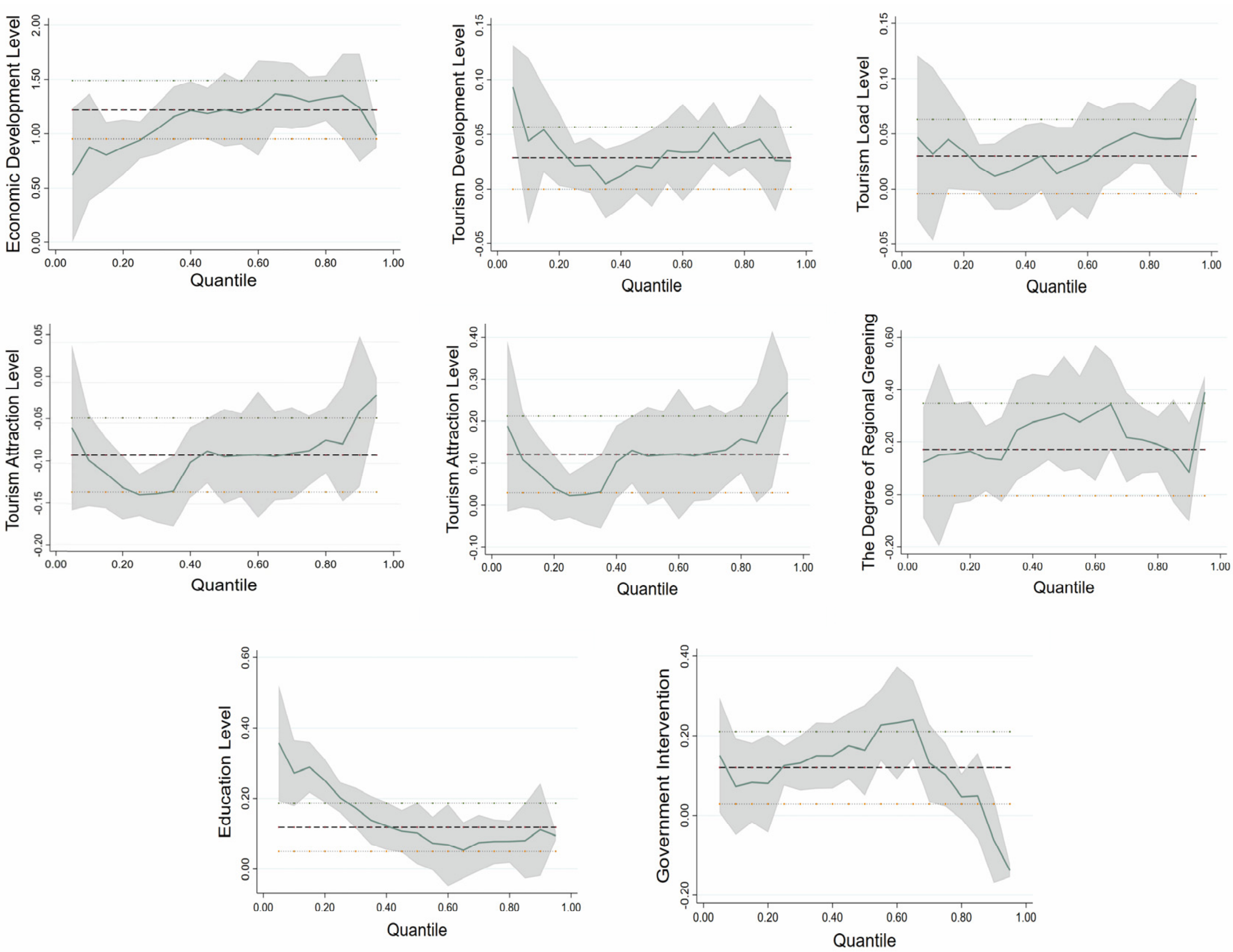

Figure 5. Plot of panel quantile results.

① Regarding the coefficient of the influence of the economic development level (x_1), compared with other variables, the coefficient of the influence of this variable is the largest in all quantiles, with the high quantile having the most significant influence, followed by the middle quantile, and the low quantile having the smallest, which is an important variable influencing the improvement of tourism-related ecological grade. Beijing, Shijiazhuang, and Tianjin have higher levels of economic development, which corresponds to their higher tourism-related ecological security status.

② In terms of the influence coefficient of tourism development level (x_2), the tourism development level has a positive effect on the tourism-related ecological security of Beijing–Tianjin–Hebei in all quantiles, with the 36th quantile as the extreme point, the influence coefficient of the tourism development level on the left side of the 36th quantile decreases in waves, and the influence coefficient on the right side of the 36th quantile rises slowly in waves. It shows that for the tourism-related ecological security in the low to medium level of the region, the tourism development level has a positive role that cannot be ignored, but as the tourism-related ecological security level continues to increase its level of influence continues to decline, and the higher level of tourism-related ecological security is more affected by other factors, at this time these need to be corresponding to the lower level of tourism-related ecological security unit to take appropriate measures to diversify the development. In addition to the tourist city of Qinhuangdao, the rest of the prefecture-level cities in Hebei Province do not have a high visibility of tourism resources. Development of the tourism industry starts late, the industrial structure is imperfect, while the utilization of resources is relatively elementary, the level of tourism development is relatively low, the development rate is fast.

③ In terms of the influence coefficient of the tourism load level (x_3), the tourism load level also plays a positive role in promoting the ecological security of tourism in Beijing–Tianjin–Hebei, and the influence coefficient of this variable shows an overall increasing trend as the quantile point increases. The level of tourism load is positively correlated with the level of economic development, and it has a larger positive marginal effect on areas with a higher level of tourism-related ecological security. Beijing, Tianjin, and Shijiazhuang have a high level of economic development, and emphasize their tourism infrastructure construction, so that they can receive tens of thousands of tourists without harming the ecological environment.

④ In terms of the impact coefficient of environmental pollution (x_4), environmental pollution has an obvious negative inhibitory effect on the ecological security of tourism, and the overall trend is inverted "U". Hebei Province is mainly engaged in industrial production, and in the early stage of the study, industrial production was overly dependent on natural resources, low resource utilization efficiency, and the scale of the industry was extremely high, which produced a large amount of sulfur dioxide and industrial wastewater, and caused great damage to the natural ecological environment of the Beijing–Tianjin–Hebei region.

⑤ In terms of the influence coefficient of the variable of tourism attraction level (x_5), the tourism attraction level has a significant positive effect on the tourism-related ecological security of Beijing–Tianjin–Hebei in all quantiles. The influence coefficient of tourism attraction level is larger in the middle and high quantiles, indicating that the positive marginal effect of tourism attraction level is larger in units with higher tourism-related ecological levels. Units with higher tourism-related ecological levels are generally areas with high economic development levels, an early start of tourism and a high popularity of tourism resources, which have developed tourism-related ecological security to a medium-high level by virtue of their early advantages compared with other units, such as Qinhuangdao, which has always been relying on the natural advantages of the seashore and the cool climate in the summer to stimulate the development of its tourism industry. However, as demand escalates and host–guest personalization continues to evolve, natural advantages slowly become less attractive to tourists.

⑥ In terms of the influence coefficient of the degree of regional greening (x_6), the degree of regional greening has a greater positive influence on tourism-related ecological security. Therefore, improving the degree of regional greening not only has a significant positive effect on units with a lower tourism-related ecological security level, but also strongly promotes units with higher tourism-related ecological security level to further improve their own tourism-related ecological security status.

⑦ In terms of the influence coefficient of the education level (x_7), the residents of highly educated areas have a stronger sense of environmental protection, and they put environmental protection into practice, which has a positive effect on the ecological security of tourism. For example, in the Beijing–Tianjin–Hebei region, Beijing, Tianjin, and Shijiazhuang have better tourism-related ecological security to a certain extent due to the large number of colleges and universities, many college students, and a high quality of residents. Due to the spatial dislocation of the distribution of highly educated groups, the marginal effect of a low quantile education level on tourism-related ecological security is higher than that of the medium and high quantiles, and the empirical results prove that the influence coefficient of the education level in the 25th quartile is 0.184, which is significantly higher than 0.0843 and 0.0735 in the 50th and 75th quantiles.

⑧ In terms of the impact coefficient of government intervention (x_8), the positive impact of government intervention on tourism-related ecological security varies in different subregions. The government can influence tourism-related ecological security by increasing the investment in environmental protection, formulating relevant policies and regulations, strengthening publicity, and integrating resources. The empirical results show that the coefficient of influence of government intervention on the middle and low quantiles is higher than that of the high quantiles. It indicates that the marginal effect of government intervention on middle and low-grade tourism-related ecological security units is larger.

3.3.2. Suggestions of Panel Quantile Estimation Results

① Maintaining good regional economic development can better guide and consolidate the development of higher tourism-related ecological security areas to a better state and improving the economic development level of lower tourism-related ecological security areas plays an important role in improving the tourism-related ecological security level of the whole region.

② The government should focus on improving the tourism development level of the areas in the middle and low tourism-related ecological security level, give full play to its positive marginal effect, and at the same time, actively guide the middle and low tourism-related ecological security level areas to change the rough way of development, promote the adjustment of industrial structure, and improve the level of utilization of resources, which is of great significance to improving the tourism-related ecological security level in the whole Beijing–Tianjin–Hebei region.

③ Cities in the Beijing–Tianjin–Hebei region should continuously improve their urban infrastructure, including traffic-carrying capacity, green areas, etc., according to their tourism development, so that they can receive a seasonal influx of massive tourist crowds without exceeding the reasonable tolerance of tourism-related ecological safety, so increasing the tourism load level is one of the necessary ways to raise the unit with a higher tourism-related ecological safety level.

④ The Chinese government vigorously manages the ecological environment; people's environmental awareness is generally enhanced; the cities' self-purification ability works to improve the level of the ecological security of tourism; the higher the level of environmental pollution in the region the greater the negative impact of the variable; economic development and environmental protection are never in a conflicting relationship, the two are in dialectical unity. In this regard, strengthening environmental protection and pollution control, practicing the development concept of "green mountains are golden mountains", and taking the green development path can further enhance the ecological security level of tourism in the Beijing–Tianjin–Hebei region.

⑤ With the upgrading of demand and the continuous evolution of host–guest personalization, in order to seek a higher level of tourism, it is necessary to further promote the deep integration of science and technology, culture and other elements with tourism, improve the level of tourism attractions, and give full play to their positive marginal effects, so as to transfer the region's tourism-related ecological security to a higher level.

⑥ The increase in the regional greening coverage of the unit is conducive to enhancing its ecological resilience and improving the carrying capacity of tourism. The degree of greening varies among units in Beijing–Tianjin–Hebei, based on which paying attention to regional greening construction can improve the regional resource background of the low quantile, enhance the tourism carrying capacity and restoration capacity of the high quantile region, and improve the overall environmental resilience of the region.

⑦ Education level has a positive impact on tourism-related ecological security, paying attention to educational equity, improving the education level of the whole region, rationally allocating educational resources, breaking the education threshold, increasing education investment, and deepening the reform of the education system are crucial for the upward mobility of low-level tourism-related ecological security units.

⑧ Government departments should pay more attention to and strengthen the maintenance and governance of tourism-related ecological security in low-grade tourism-related ecological security units. High-grade tourism-related eco-security units such as municipalities directly under the central government and provincial capital cities have governmental and policy advantages over low-grade units, but the long-term development of the eco-health of tourism in the whole Beijing–Tianjin–Hebei region cannot be achieved without the establishment of tourism eco-compensation mechanisms, the establishment and improvement of tourism environmental protection laws, and collaboration among governments.

4. Discussion

From 2011 to 2022, Beijing–Tianjin–Hebei tourism-related ecological security is on an upward trend across the board, and the gaps within the region are narrowing, but its level is still low by the end of the study period. A review of related studies found that the level of tourism-related ecological security in the Beijing–Tianjin–Hebei region is in the lower middle range of some economic zones in China, and Hebei Province is the tourism-related ecological security depression in the Beijing–Tianjin–Hebei region. This indicates that the development of tourism-related ecological security in the Beijing–Tianjin–Hebei region has a long way to go, which also explains the necessity of the Chinese government's "Beijing–Tianjin–Hebei coordinated development" as a development strategy. From late 2019 to 2022, tourism-related ecological security in the Beijing–Tianjin–Hebei region was slowed down by the impact of COVID-19, and the tourism industry suffered from the impact of the epidemic. From a spatial point of view, the cities with higher levels of tourism-related ecological security are characterized by "dispersion". This suggests that tourism-related ecological security may have a "polarization effect". In terms of driving factors, the level of economic development has a large positive marginal effect on tourism-related ecological security in all quartiles, and the level of pollution has an obvious negative inhibitory effect. In contrast, existing scholars did not come to the above conclusions, because they neglected the dynamic influence of driving factors on tourism-related ecological security at different sub-locations. In addition, there are some shortcomings in the studies of existing scholars, which weaken the correlation relationship between regions due to the cross-diffusion of factors, resulting in a lack of research on the correlation characteristics and transfer patterns of tourism-related ecological security and a lack of research on the tourism-related ecological security situation of the Beijing–Tianjin–Hebei region, which is strategically important for the development of the country.

Therefore, based on the shortcomings of existing research, some innovations have been made. First, most of the existing studies explore the temporal and spatial differentiation characteristics of judgement on the tourism-related ecological security level, which weakens the correlation relationship between regions due to the cross-diffusion of factors, resulting in a lack of research on the correlation characteristics and transfer laws of tourism-related ecological security. So, the traditional and spatial Markov chain is used to study the dynamic evolution process under the condition of cross-diffusion of elements. Second, at present, most of the research is based on the linear influence of simple identification factors on tourism-related ecological security, although the key driving factors can be clarified, the dynamic change characteristics of the impact of factors on tourism-related ecological security at different quantile points are ignored, and the change characteristics of tourism-related ecological security driving factors cannot be fully grasped. Therefore, panel quantile regression estimation is used to explore the impact of different influencing factors on tourism-related ecological security at different quantile points. Third, the existing results are mostly for the whole country, province, single city, or single scenic spot, and for typical areas such as key ecological function areas and ecologically fragile areas, so the Beijing–Tianjin–Hebei region, which has an important strategic position in China's development, was selected as the research area. This study makes up for the practicability of macroscale research and the lack of spatial comparison in microscale research and provides a paradigm for studying tourism-related ecological security in other urban areas.

4.1. Practical Implications

According to the findings and the development reality of the Beijing–Tianjin–Hebei region, some implications are provided.

In the process of vigorously promoting the development of tourism-related ecological security to a higher level, the following points should be noted: ① The spatial and temporal heterogeneity of the dynamic evolution process of tourism-related ecological security requires that, based on the Beijing–Tianjin–Hebei coordinated development strategy, the coordination of environmental protection and tourism development policies should be strengthened. In view of the first law of geography, the units should strengthen the collaboration among themselves, establish and improve the inter-regional protection mechanism and operation methods, and strengthen the tourism-related ecological security joint prevention and control, to establish the Beijing–Tianjin–Hebei region as "a plate chess" idea, to promote the synergistic development of tourism-related ecological security in Beijing–Tianjin–Hebei. ② Economic development, environmental pollution, tourism development and the degree of regional greening and other tourism-related ecological security factors and their relationship with each other should be correctly dealt with to improve the natural carrying capacity of the ecological environment. ③ Spatial differences require that local governments should fully explore the local ecological and tourism advantages, establish and improve the ecological compensation mechanism for tourism, and actively encourage the tourism industry and the in-depth integration of other industries. At the same time, local governments should seize the opportunity of "beautiful countryside construction", advocate low-carbon travel and green agriculture, enhance residents' understanding of environmental protection, create green rural tourism, and take measures to promote the transfer of tourism-related ecological security to a higher level in the region and according to local conditions.

4.2. Limitations

This paper can provide a reference for the high-quality and sustainable development of natural ecological protection and tourism in the Beijing–Tianjin–Hebei region, however, there are still deficiencies, and subsequent research can continue to deepen and expand it. Due to the limitations of data acquisition, the evaluation index system established in this paper, based on the DPSIR model, may not include all of the influencing factors, such as residents' and tourists' satisfaction. In the future, we can consider adopting an appropriate method to incorporate humanistic ecological security into the evaluation index system. In addition, this paper does not conduct research in a wider geospatial context and the wider range of neighboring contexts can be further studied in the future.

5. Conclusions

This paper constructs an evaluation index system based on the DPSIR model to measure tourism-related ecological security in the Beijing–Tianjin–Hebei region, analyzes its spatiotemporal dynamic evolution characteristics and intrinsic driving factors from 2011 to 2022, and the main conclusions are as follows:

(1) In time, the average value of tourism-related ecological security in the Beijing–Tianjin–Hebei region from 2011 to 2022 is slightly fluctuating and rising as a whole and the difference in tourism-related ecological security values between cities is shrinking, showing a convergent trend, mainly manifesting the catching-up effect from low-value cities to higher-value cities. In space, the tourism-related ecological security of the Beijing–Tianjin–Hebei region has been developing continuously and gradually, which is in line with the historical process of the development of things following the wave-like advance and spiral rise.

(2) In terms of dynamic evolution characteristics, the transfer of tourism-related ecological security types in Beijing–Tianjin–Hebei has certain "path dependence" and "self-locking" effects, and the transfer usually occurs between neighboring levels. The transfer of tourism-related ecological security level is not isolated in geographic

space, affected by the spatial background of the neighborhood, and the transfer probability of tourism-related ecological security level is significantly different in different neighborhoods.

(3) In terms of driving factors, the tourism-related ecological security of Beijing–Tianjin–Hebei is affected by a combination of factors. Overall, environmental pollution has an obvious inhibitory effect on the level of tourism-related ecological security in Beijing–Tianjin–Hebei, the level of economic development has the largest positive marginal effect on tourism-related ecological security, while the level of tourism development, the level of tourism load, the level of tourism attraction, the degree of regional greening, the level of education, and government intervention have a certain degree of difference in the positive role they play in the level of tourism-related ecological security in the different sub-locations. At the same time, the correct handling of the interrelationships of the above factors plays an important role in the enhancement of tourism-related ecological security in Beijing–Tianjin–Hebei.

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Appendix A

Table A1. Tourism-related Ecological Security Assessment Results for 13 Cities in Beijing–Tianjin–Hebei from 2011 to 2022.

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Beijing	0.8223	0.8264	0.8542	0.8634	0.8351	0.8227	0.8321	0.7928	0.8062	0.7939	0.8210	0.8365
Tianjin	0.4396	0.4267	0.4492	0.4921	0.4824	0.4745	0.4755	0.4417	0.4497	0.4756	0.4629	0.4293
Shijiazhuang	0.6123	0.6143	0.5955	0.5866	0.6003	0.5950	0.6234	0.6195	0.5957	0.6372	0.5661	0.6039
Tangshan	0.1782	0.3215	0.3050	0.3102	0.3192	0.3393	0.3743	0.3557	0.3263	0.3712	0.3233	0.3717
Baoding	0.2013	0.2210	0.1970	0.2006	0.2033	0.2038	0.1987	0.2238	0.1946	0.3295	0.3198	0.3066
Handan	0.1980	0.2176	0.2019	0.2221	0.2405	0.2011	0.2241	0.2225	0.2296	0.3198	0.4118	0.4249
Xingtai	0.1406	0.1280	0.1442	0.1989	0.1892	0.1689	0.2119	0.1716	0.2043	0.3444	0.1596	0.2216
Qinhuangdao	0.3595	0.3808	0.3952	0.3822	0.3702	0.3422	0.3744	0.3276	0.3324	0.3575	0.4845	0.4575
Chengde	0.2220	0.2223	0.2249	0.2414	0.2275	0.2107	0.2161	0.2206	0.2718	0.2721	0.2811	0.2553
Langfang	0.2536	0.2622	0.2604	0.2857	0.3113	0.3088	0.3319	0.3277	0.3451	0.4102	0.3404	0.3414
Zhangjiakou	0.2059	0.2051	0.2270	0.2311	0.2235	0.2140	0.2066	0.2110	0.2266	0.1791	0.2913	0.3028
Cangzhou	0.1913	0.2049	0.2226	0.2136	0.2249	0.1869	0.2353	0.2136	0.2497	0.3038	0.1808	0.2094
Hengshui	0.2309	0.2042	0.1973	0.2311	0.2203	0.2193	0.2776	0.2301	0.2412	0.3198	0.2144	0.2401

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