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Measurement and Spatial Evolution of the Coupling Coordination among Ecological Civilization Construction, Tourism Industry, and High-Quality Economic Development in China

Huan Wang[1], Quanxi Feng[1,2*]

[1]School of Mathematics and Statistics, Guilin University of Technology, Guilin, China
[2]Key Laboratory of Applied Statistics of Guangxi Colleges and Universities, Guilin, China
Email: 3378947886@qq.com, *fqx9904@163.com

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Abstract

Based on panel data from 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region) from 2000 to 2024, this study employs the coupling coordination degree model and the standard deviation ellipse method to systematically examine the coupling coordination level and spatial evolution characteristics of ecological civilization construction, tourism industry development, and high-quality economic development. The findings are as follows: 1) The coupling degree among the three systems remains persistently high, ranging from 0.752 to 0.910 over the long term, while the coupling coordination degree increases only from 0.209 to 0.310, indicating a structural dilemma characterized by "high coupling but low coordination". 2) The coordination level across these 31 provincial-level administrative divisions exhibits a pattern of "high in the east and low in the west, with widening disparities". Beijing, Shanghai, Guangdong, Zhejiang, and Jiangsu constitute the first tier, while western regions such as the Ningxia Hui Autonomous Region and Qinghai Province remain locked in low-value zones over the long term. 3) The coordination degree in all four major regions shows a continuous upward trend; the eastern region takes the lead in entering moderate disorder, the central region registers the largest increase, while the western region remains in extreme disorder. 4) Spatial evolution exhibits a northeast-southwest orientation, with the azimuth angle decreasing steadily. The ellipse first becomes more circular and then more elongated, while spatial disparities first converge and then diverge. The center of gravity covers the three major coastal economic circles. This study reveals the underlying characteris-

tics of close systemic interconnections yet lagging coordination, providing empirical evidence for regionally coordinated development policies.

Keywords

Ecological Civilization Construction, Tourism Industry Development, High-Quality Economic Development, Coupling Coordination

1. Introduction

The report of the 20th National Congress of the Communist Party of China clearly states that Chinese modernization aims to comprehensively advance the great rejuvenation of the Chinese nation, with its core lying in achieving high-quality development and emphasizing the harmonious coexistence between humanity and nature. From a global perspective, ecological civilization construction has become a crucial issue in national development. Particularly in China, it has been integrated into the "Five-in-One" overall layout, which requires that economic construction, political construction, cultural construction, social construction, and ecological civilization construction must progress in a coordinated manner. Therefore, ecological civilization construction is not only a key direction for China's future development but also a major strategic area and core task. To achieve high-quality economic development, it is necessary to abandon the traditional brown model characterized by high energy consumption, high pollution, and high emissions, and instead transition toward an intensive, efficient, and green model of deep green development [1].

As the foremost of the five happiness industries, high-quality development of the tourism industry has become an important issue in the context of the new era [2]. Since the implementation of China's reform and opening-up policy, the tourism industry has experienced remarkable growth and has gradually established itself as a pillar industry of the national economy. This process is the result of the synergistic efforts of multiple forces, with both the government and various sectors of society actively participating in and promoting the comprehensive development of the tourism industry [3]. Across multiple dimensions, including economic, cultural, and social construction, the tourism industry has demonstrated a positive promoting effect. It has not only accelerated economic growth but also significantly raised the level of national income, playing an important role in advancing the construction of a modern socialist country.

At present, China still faces numerous challenges in the fields of green development and ecological environment protection, including the need to improve the level of green development and the relatively heavy industrial structure. Since 2020, the global tourism industry has suffered severe setbacks, with a sharp contraction in market size, and China's tourism industry has also faced severe challenges [4]. Given this realistic context, coordinating the relationships among eco-

logical civilization construction, the tourism industry, and economic development, and exploring pathways for high-quality coordinated development among the three, holds significant practical value for advancing China's ecological civilization construction, deepening the concept of green development, and injecting new momentum into the tourism industry. This study aims to deeply analyze the interaction mechanism of the "ecology-tourism-economy" system and examine its coordinated development dynamics, in order to explore effective pathways for promoting high-quality coordination among the three and fostering sustainable social development.

2. Analysis of Coupling Coordination Mechanism

A deep understanding of the interaction mechanism among ecological civilization construction, the tourism industry, and the high-quality economic development system serves as the theoretical foundation for analyzing the coupling coordination development of the three. Existing research indicates that the coupling effect of the three systems is primarily reflected in the following three dimensions.

1) The foundational supporting role of ecological civilization construction. Specifically: a) Ecological civilization construction provides basic production factors for economic development. Wei Zhenxiang [5] employed the coupling degree model and the PVAR model to confirm a significant positive interactive relationship between ecological sustainability and high-quality economic development. b) By practicing the concept of green development, ecological civilization construction not only provides new growth points for the tourism industry but also promotes its transformation toward a green and low-carbon model [6]. In the relationship between ecological civilization construction and tourism development, tourism is not only an economic phenomenon but also a social and cultural phenomenon with relatively high requirements for the ecological environment [7]. c) Ecological carrying capacity constitutes a rigid constraint. Ecological overload caused by pollution emissions and excessive tourism development can lead to tourism restrictions [8]. Exploring strategies for scientific planning, rational development, and environmental governance is essential to alleviate ecological pressure and promote ecological civilization construction.

2) The two-way interaction mechanism of high-quality economic development. High-quality economic development provides guarantees for ecological civilization construction through financial support and technological innovation [9], while simultaneously improving the infrastructure and service supply of the tourism industry. The specific manifestations are as follows: a) Economic input mechanism: By increasing investment in ecological governance, green technology innovation, and environmental protection expenditure, environmental quality is enhanced, thereby promoting ecological civilization construction. The Environmental Kuznets Curve theory suggests that there is an inverted U-shaped relationship between economic growth and environmental quality, *i.e.*, environmental quality first deteriorates and then improves with economic development [10]. b) Technology-driven mechanism: The development of the digital economy has given rise to new

technologies such as big data and the Internet of Things, promoting the development of new business forms including tourism e-commerce, smart tourism, and tourism big data analytics. This not only expands the boundaries of the tourism industry but also creates new growth points for the digital economy. c) Actively promoting new business forms of the tourism industry: Smart tourism and ecotourism have attracted increasing academic attention. However, during the process of high-quality economic development, industrial restructuring may lead to short-term transitional pains and resource crowding-out for the tourism industry, as the decline of traditional business forms and the rise of new ones require time and financial investment.

3) The pivotal role of the tourism industry. This is mainly reflected in the following aspects: a) As a model of low-energy-consumption and environmentally friendly industry, the tourism industry stimulates new momentum for green development through model innovations such as green tourism and ecotourism, generating a green effect on ecological civilization construction. b) The various elements within the tourism industry are closely interconnected, and the industry interacts intensively with many other sectors. Through industrial linkages, it drives employment growth and consumption upgrading, becoming a key force driving high-quality economic development. c) It should be noted that economic input into the tourism industry may increase the cost of the economic system, affecting resource allocation and utilization efficiency. Over-reliance on the tourism industry can weaken economic resilience. Moreover, the tourism industry is seasonal, which can easily lead to seasonal idleness and waste of resources. In addition, in economically underdeveloped regions, tourism development tends to excessively crowd out resources from other industries.

3. Research Design

3.1. Research Methods

3.1.1. Coupling Coordination Degree Model

Currently, there is no universal model for evaluating the coupling coordination degree of systems. Considering the operational characteristics of the ecological civilization construction, tourism industry, and high-quality economic development systems, this study draws on the coupled system model from physics and adopts the spatial geometric dispersion coefficient method and the entropy method, which are widely used in the field of social sciences, to construct a coupling coordination degree model for the three systems. The specific steps and related formulas are as follows:

First, evaluation of the comprehensive development level of each subsystem. To study the coupling coordination degree among ecological civilization construction, the tourism industry, and high-quality economic development, the comprehensive level of each of the three subsystems is first evaluated and analyzed.

Second, construction of the coupling coordination degree model. First, the system coupling degree model is constructed. Given $n \geq 2$ systems, let $U_i \geq 0$ repre-

sent the evaluation value of each subsystem. Then the general mathematical form of the coupling degree model for the interaction of multiple systems is:

$$C = n \times \left[\frac{U_1 \times U_2 \times \cdots \times U_n}{\left(U_1 + U_2 + \cdots + U_n\right)^n} \right]^{\frac{1}{n}} \tag{1.1}$$

In the formula, C represents the system coupling degree, ranging from [0, 1]. n is the number of subsystems, and U_i (i = 1, 2, …, n) represents the comprehensive evaluation value of each subsystem.

Based on the above analysis, the mathematical expression of the coupling degree model for ecological civilization construction, the tourism industry, and high-quality economic development can be obtained as follows:

$$C = 3 \times \left[\frac{ECC \times TID \times HED}{\left(ECC + TID + HED\right)^3} \right]^{\frac{1}{3}} \tag{1.2}$$

In the formula, C represents the coupling degree of ecological civilization construction, the tourism industry, and high-quality economic development, ranging from [0, 1]. The larger the value of C, the higher the coupling degree among regional ecological civilization construction, the tourism industry, and high-quality economic development. ECC represents the comprehensive evaluation value of ecological civilization construction, TID represents the comprehensive evaluation value of tourism industry development, and HED represents the comprehensive evaluation value of high-quality economic development.

Based on the coupling degree, it is necessary to introduce a system coordination degree model to examine the coordinated development level of interlocking coupling under different evolutionary stages of the systems. The formula is as follows:

$$D = \sqrt{C \times T}, T = \alpha \times ECC + \beta \times TID + \gamma \times HED \tag{1.3}$$

In the formula, C represents the coupling degree of ecological civilization construction, the tourism industry, and high-quality economic development; D represents the coupling coordination degree, ranging from [0, 1]. The larger the value of D, the better the coupling coordination among the three systems. T represents the development degree, α, β, γ are harmonic coefficients (the sum of the three coefficients equals 1). In the coupled system of ecological civilization construction, tourism industry, and high-quality economic development, ecological civilization serves as the foundational support and high-quality development as the core objective, both playing leading roles, while the tourism industry acts as a bridging driver. With reference to relevant studies [9] [11], the undetermined coefficients are set as follows α = 0.4, β = 0.2, γ = 0.4.

Third, determination of coupling coordination degree classification standards. Referring to the classification methods of relevant scholars, the following evaluation standards for the coupling coordination degree of ecological civilization construction, the tourism industry, and high-quality economic development are established (**Table 1**).

Table 1. Classification criteria for coupling coordination levels of ecological civilization construction, tourism industry, and high-quality economic development.

Coupling Coordination Degree D	Level
$0.8 < D \leq 1$	High-quality coordination
$0.7 < D \leq 0.8$	Good coordination
$0.6 < D \leq 0.7$	Intermediate coordination
$0.5 < D \leq 0.6$	Primary coordination
$0.4 < D \leq 0.5$	Mild disorder
$0.3 < D \leq 0.4$	Moderate disorder
$0 < D \leq 0.3$	Extreme disorder

3.1.2. Standard Deviational Ellipse Analysis Method

The Standard Deviational Ellipse method is a spatial analysis technique used to investigate the directionality, dispersion, and central tendency of the spatial distribution of geographic elements. Currently, the standard deviational ellipse has been incorporated into the spatial statistical analysis module of ArcGIS. Its calculation formula is as follows:

$$x = x_i - \overline{x}, y = y_i - \overline{y} \tag{1.4}$$

$$\tan\alpha = \frac{\left(\sum_{i=1}^{n} x^2 - \sum_{i=1}^{n} y^2\right) + \sqrt{\left(\sum_{i=1}^{n} x^2 - \sum_{i=1}^{n} y^2\right)^2 + 4\left(\sum_{i=1}^{n} xy\right)^2}}{2\sum_{i=1}^{n} xy} \tag{1.5}$$

$$SD_x = \sqrt{\frac{\sum_{i=1}^{n} \left(x\cos\alpha - y\sin\alpha\right)^2}{n}} \tag{1.6}$$

$$SD_y = \sqrt{\frac{\sum_{i=1}^{n} \left(x\sin\alpha - y\cos\alpha\right)^2}{n}} \tag{1.7}$$

$$e = \frac{SD_y}{SD_x} \tag{1.8}$$

In the formula, (x_i, y_i) represents the coordinates of element i; (x, y) denotes the mean center of element i; α is the azimuth angle of the standard deviational ellipse; SD_x, SD_y represent the standard deviations of the minor axis and major axis of the standard deviational ellipse, respectively; e is the flattening of the standard deviational ellipse; and n is the total number of study areas.

3.2. Indicator System Construction

1) Construction of the indicator system for ecological civilization construction

The core of ecological civilization is a civilizational form characterized by "harmonious coexistence between humanity and nature". It represents a profound reflection on and transcendence of the "anthropocentrism" development model of industrial civilization. Its connotation has evolved from an early focus on envi-

ronmental ethics and resource protection to a comprehensive systemic transformation encompassing values, production methods, and social institutions [12]. Existing research has systematically elaborated on the multi-dimensional connotations of ecological civilization, laying a theoretical foundation for constructing an overall framework for ecological civilization construction that covers "territorial spatial optimization, ecological economy, ecological environment, ecological culture, and ecological institutions". Scholars have also verified the universality and explanatory power of key indicators from different dimensions [13]-[15]. However, existing indicator systems mostly focus on macro-level comprehensive evaluation, leaving room for improvement in terms of specificity. To address this, this study draws on the Opinions of the Central Committee of the Communist Party of China and the State Council on Accelerating the Construction of Ecological Civilization and a series of indicators issued by the Ministry of Ecology and Environment for the construction of national ecological civilization demonstration sites at various levels. Based on previous research and considering the development status and data availability of 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region), this study selects indicators related to the tourism industry and measures ecological civilization construction using 18 indicators across 5 dimensions.

2) Construction of the indicator system for tourism industry development

Tourism industry development refers to the dynamic evolutionary process in which, based on tourism resources and driven by market demand, a comprehensive economic activity cluster encompassing multiple sectors such as catering, accommodation, transportation, sightseeing, shopping, and entertainment is formed through the input of capital, labor, and other factors, ultimately achieving comprehensive economic, social, and ecological benefits [16]. Existing research indicates that, as a dynamic process of "factor input-market transformation-comprehensive output", the evaluation of tourism industry development requires the systematic integration of basic support capacity, market driving forces, and economic and social benefits, while also beginning to pay attention to the environmental impacts generated by tourism industry development. Therefore, based on input-output theory and the practical requirements of high-quality tourism development, this study measures tourism industry development using 10 indicators across 4 dimensions.

3) Construction of the indicator system for high-quality economic development

The proposal of high-quality economic development represents a major strategic shift undertaken by China's economy after a long period of rapid growth, in response to increasing resource and environmental constraints, the transformation of the principal social contradiction, and new dynamics of international competition, aiming for more sustainable, efficient, and equitable development. Its core connotation is to follow the new development philosophy of "innovation, coordination, green, openness, and sharing," driving the transformation of the development mode from scale-speed oriented to quality-efficiency oriented [17]. Based on the framework of the "Five Development Concepts," this study measures high-quality economic development using 13 indicators across 5 dimensions.

To scientifically measure the comprehensive levels of the three subsystems—ecological civilization construction, tourism industry, and high-quality economic development—across 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region) from 2000 to 2024, this paper adopts the CRITIC-entropy weight method for combined weighting of each indicator. This approach avoids the limitations of a single weighting method and ensures the objectivity and scientific validity of the evaluation results. First, the range normalization method is used for standardization to eliminate dimensional effects, and the normalized data are then shifted by 0.0001 to prevent zero values from hindering logarithmic calculations. Subsequently, the arithmetic mean method is employed to combine the weights derived from the CRITIC method and the entropy weight method, yielding the final weights. Finally, the linear weighted summation method is used to calculate the comprehensive development index for each of the three subsystems (Table 2).

Table 2. Research on the evaluation index system of ecological civilization construction, tourism industry, and high-quality economic development.

Target Layer	Criterion Layer	Indicator Layer	Attribute	Source
Ecological Civilization Construction	A1 Territorial Spatial Optimization	A11 Forest coverage rate (%)	+	Huang and Wu [18], Bi *et al.* [14], Deng *et al.* [15]
		A12 Proportion of nature reserve area to provincial jurisdiction area (%)	+	
		A13 Proportion of wetland area to regional area (%)	+	
	A2 Ecological Economy	A21 Energy consumption per unit GDP (tons of standard coal/10,000 RMB)	-	Rong [19], Yu and Cheng [20]
		A22 Proportion of tertiary industry output value to GDP (%)	+	
		A23 Comprehensive utilization rate of industrial solid waste (%)	+	
	A3 Ecological Environment	A31 Proportion of days with good or excellent air quality index in provincial capital cities to the whole year (%)	+	Lu *et al.* [21], Shu *et al.* [7], Wang *et al.* [13]
		A32 Harmless treatment rate of household waste (%)	+	
		A33 SO_2 emission per unit area (tons/km^2)	-	
		A34 Urban sewage treatment rate (%)	+	
		A35 Green coverage rate in built-up areas (%)	+	
	A4 Ecological Culture	A41 Number of cultural venues	+	
		A42 Domestic water saving rate (%)	+	
		A43 Per capita public library collection volume (volumes/person)	+	
		A44 Number of public transport vehicles per 10,000 persons (standard units)	+	

Continued

	A5 Ecological Institutions	A51 Proportion of energy conservation and environmental protection expenditure to public fiscal expenditure (%)	+	Bi *et al.* [14], Deng *et al.* [15]
		A52 Proportion of completed investment in industrial pollution control to GDP (%)	+	
		A53 Proportion of completed investment in ecological construction and protection to GDP (%)	+	
Tourism Industry Development	B1 Industrial Foundation	B11 Resource endowment score	+	Lu *et al.* [21], Shi *et al.* [16], Huang *et al.* [22]
		B12 Comprehensive score of star-rated hotels	+	
		B13 Density of travel agencies (units/10,000 km^2)	+	
		B14 Fixed asset investment of tourism enterprises (10,000 RMB)	+	
		B15 Proportion of tourism enterprise employees to tertiary industry employment (%)	+	
	B2 Market Demand	B21 Domestic tourist per capita consumption (10,000 RMB/person)	+	
		B22 Inbound tourist per capita consumption (10,000 RMB/person)	+	
	B3 Industrial Benefits	B31 Per capita tourism income of tourism destination residents (10,000 RMB/person)	+	
		B32 Proportion of total tourism revenue to GDP (%))	+	
	B4 Undesirable Output	B41 Tourist per capita SO_2 emissions from tourism (tons/person)	-	
High-Quality Economic Development	C1 Innovative Development	C11 Number of valid patents per 10,000 persons (items)	+	Li [23]
		C12 R & D expenditure intensity (%)	+	
		C13 Full-time equivalent of R & D personnel (person-years)	+	
	C2 Coordinated Development	C21 Industrial structure rationalization: Theil index	-	Geng [24]
		C22 Industrial structure upgrading: Primary industry share × 1 + Secondary industry share × 2 + Tertiary industry share × 3	+	
		C23 Industrial structure advancement: Tertiary industry value added/Secondary industry value added	+	
	C3 Green Development	C31 Per capita park green space area (m^2/person)	+	Zhao [25]
		C32 Number of green patent applications (items)	+	

Continued

C4 Open Development	C41 Trade development level: Export value/Import value	+	Sun [26]
	C42 Domestic trade dependence: Total retail sales of consumer goods/GDP	+	
C5 Shared Development	C51 Per capita GDP (RMB)	+	Zhou [27]
	C52 Number of medical institution beds per 1000 persons (beds)	+	
	C53 Fiscal expenditure/Fiscal revenue	+	

3.3. Data Sources

This study selects 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region) from 2000 to 2024. The indicator data are primarily sourced from the China Statistical Yearbook, China Regional Economic Statistical Yearbook, China Urban Statistical Yearbook, China Tourism Statistical Yearbook, and China Environmental Statistical Yearbook for the years 2001 to 2025, supplemented by the National Economic and Social Development Statistical Bulletins of each province, the EPS database, and the China Economic Information Network statistical database. Some data, such as SO_2 emission per unit area, travel agency density, and the proportion of tourism enterprise employees, require indirect calculation. Among these, the tourism resource endowment, comprehensive score of star-rated hotels, and tourist per capita SO_2 emissions from tourism are derived from the research results of Huang Yanling *et al.* [22]. For individual missing values or data that could not be obtained, the linear interpolation method is used to fill in the gaps.

4. Empirical Analysis

4.1. Analysis of Coupling Coordination Measurement Results

1) Overall Characteristics of Coupling Coordination Degree

In terms of coupling degree, during the study period, the coupling degree of ecological civilization construction, tourism industry, and high-quality economic development in Chinese provinces is generally high, with evaluation scores ranging from 0.752 to 0.910, showing a fluctuating upward trend. It exhibited a continuous upward trend from 2000 to 2019, rising from 0.752 to 0.903, followed by a significant decline in 2020 from 0.903 to 0.879. From 2021 to 2024, it fluctuated and rebounded, reaching the highest point of the study period in 2024, indicating that China's ecological civilization construction, tourism industry, and high-quality economic development are in a high-level coupling stage. In terms of coupling coordination degree, during the study period, the coupling coordination degree of national ecological civilization construction, tourism industry, and high-quality economic development showed a slight increasing trend, rising from 0.209 in 2000 to 0.310 in 2024, with a relative growth rate of 48.3%, indicating slow growth

and a generally low coordination level. According to the classification standards of coupling coordination degree, the period can be divided into two stages:

First stage (2000-2022): The coupling coordination degree ranged from 0.209 to 0.296, indicating that the three systems were in a state of extreme disorder. Second stage (2023-2024): The coupling coordination degree exceeded 0.3, falling into the moderate disorder level. The above analysis shows that although the coupling degree has remained high, the coordination degree has consistently lingered at a low level. Although the three systems are closely interrelated, their overall development level is low, failing to form benign resonance. Coordinated interaction remains at a preliminary stage, and true coordinated development has not yet been achieved.

2) Provincial Characteristics of Coupling Coordination Degree

Regarding the coupling coordination degree and its mean value of ecological civilization construction, tourism industry, and high-quality economic development across Chinese provinces, the top five divisions with higher coupling coordination degrees in 2000 were Beijing Municipality (0.277), Shanghai Municipality (0.273), Guangdong Province (0.231), Tianjin Municipality (0.231), and the Xizang Autonomous Region (0.227). The bottom five divisions were Anhui Province (0.185), Chongqing Municipality (0.184), Hebei Province (0.184), Ningxia Hui Autonomous Region (0.169), and Guizhou Province (0.166). By 2010, the top five ranking changed: the top three remained unchanged, while Zhejiang Province (0.284) and Jiangsu Province (0.282) entered the top five, and Tianjin Municipality and the Xizang Autonomous Region dropped out. The bottom five also changed, becoming Gansu Province (0.242), Hainan Province (0.230), Qinghai Province (0.229), Guizhou Province (0.225), and Ningxia Hui Autonomous Region (0.211). By 2024, regarding the divisions with the highest coupling coordination degree, Beijing Municipality (0.374) and Shanghai Municipality (0.365) remained the top two, Zhejiang Province (0.342) replaced Guangdong Province as the third, with Guangdong Province (0.339) and Jiangsu Province (0.333) ranking fourth and fifth. Regarding the divisions with the lowest coupling coordination degree, the main ones were Chongqing Municipality (0.289), Hainan Province (0.282), Qinghai Province (0.279), Ningxia Hui Autonomous Region (0.278), and Shanxi Province (0.262). It can be seen that Beijing Municipality and Shanghai Municipality are the absolute leading regions in the coupling coordinated development of ecological civilization construction, tourism industry, and high-quality economic development, while Ningxia Hui Autonomous Region and Qinghai Province have long remained in low-value areas, exhibiting spatial lock-in effects.

From the perspective of the mean coupling coordination degree of each provincial-level administrative division, Beijing Municipality (0.320) ranks the highest, followed by Shanghai Municipality (0.311), with Guangdong Province (0.298), Zhejiang Province (0.294), and Jiangsu Province (0.290) closely behind. These five divisions constitute the "first tier" of coordinated development levels in China. A total of 11 divisions—Tianjin Municipality, Fujian Province, Shandong Province,

Liaoning Province, Inner Mongolia Autonomous Region, Hubei Province, Chongqing Municipality, Jilin Province, Heilongjiang Province, Shaanxi Province, and Henan Province—have mean coupling coordination degrees between 0.26 and 0.29, belonging to the "second tier". The remaining 15 divisions have mean coupling coordination degrees below 0.26, belonging to the "third tier", accounting for half of the total study area. In summary, the coupling coordination degree of ecological civilization construction, tourism industry, and high-quality economic development across 31 provincial-level administrative divisions (excluding Hong Kong, Macao, and Taiwan region) exhibits a pattern of overall improvement, widening disparities, and being high in the east and low in the west. Beijing Municipality, Shanghai Municipality, and Guangdong Province continue to lead, while Ningxia Hui Autonomous Region, Qinghai Province, and Guizhou Province have long been at the bottom, though Guizhou Province has made significant progress. Overall, economically developed regions have higher coupling coordination degrees, while economically underdeveloped regions have lower coupling coordination degrees.

3) Regional Characteristics of Coupling Coordination Degree

Based on the coupling coordination degree values of ecological civilization construction, tourism industry, and high-quality economic development in 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region) from 2000 to 2024, the coupling coordination degrees and their means for the four major economic regions—Eastern, Central, Western, and Northeast China—are further calculated.

From the perspective of the mean coupling coordination degree of the four major regions, the order is: Eastern region (0.282) > Northeast region (0.254) > Central region (0.252) > Western region (0.251). That is, the coupling coordination levels of the three systems in all four major regions are generally at the extreme disorder level. Among them, the Eastern region reached moderate disorder after 2016, the Central region reached moderate disorder after 2023, and the Northeast region reached moderate disorder after 2024, while the Western region remains overall in a state of extreme disorder.

All four major regions show a continuous upward trend, with the coordination degree steadily increasing from 2000 to 2024. A slight decline occurred in 2020 for all regions, followed by a recovery after 2021, with accelerated growth in 2023-2024. Specifically, the coupling coordination degree in the Eastern region increased from 0.226 in 2000 to 0.327 in 2024, with a growth rate of 44.7%. The Western region increased from 0.202 in 2000 to 0.298 in 2024. The Central region experienced a relatively rapid increase, rising from 0.195 at the beginning of the period to 0.306 at the end, an increase of 56.9%. The Northeast region also maintained a generally upward trend in coupling coordination degree from 2000 to 2024.

Overall, from 2000 to 2024, the coupling coordination degree of ecological civilization construction, tourism industry, and high-quality economic development

across China's four major regions exhibits a pattern of overall increase, slightly narrowing disparities, and being high in the east and low in the west. The Eastern, Northeast, and Central regions have transitioned from extreme disorder to moderate disorder, while the Western region remains in extreme disorder but is on the verge of crossing the threshold. The Central region has the fastest growth rate, and regional disparities have slightly narrowed, but the task of coordinated development remains arduous, with the Western region being the focus of future efforts.

4.2. Spatial Directional Evolution of Coupling Coordination Degree

The standard deviation ellipse method is used to analyze the spatial directional distribution of the coupling coordination level of ecological civilization construction, tourism industry, and high-quality economic development in China, in order to reflect the central tendency, dispersion, and directional trends of the coupling coordination degree. According to the calculation method of the standard deviation ellipse, six time nodes (2000, 2005, 2010, 2015, 2019, 2024) are selected, covering the start and end of the study period at five-year intervals. The coordinates of the capitals of each provincial-level administrative division serve as spatial centers. The main parameters of the standard deviation ellipses for each year are shown in Table 3.

Table 3. Changes in standard deviational ellipse parameters of the coupling coordination degree of ecological civilization construction, tourism industry, and high-quality economic development.

Year	2000	2005	2010	2015	2019	2024
Azimuth angle α/°	60.348	59.941	56.726	54.788	54.293	53.087
Minor axis (X)/km	2171.654	2161.980	2145.342	2140.998	2131.252	2125.862
Major axis (Y)/km	2481.498	2457.544	2432.078	2425.302	2420.466	2443.628
Flattening e	1.143	1.137	1.134	1.133	1.136	1.149

1) In terms of the spatial distribution range of the standard deviation ellipse of the coupling coordination degree, the northernmost point is located at the junction of Inner Mongolia Autonomous Region and Liaoning Province, the southernmost point is within Guangxi Zhuang Autonomous Region, the westernmost point reaches the border between Sichuan Province and the Xizang Autonomous Region, and the easternmost point is distributed along the eastern coastal area. The ellipse boundary covers the three major economic circles—the Bohai Rim, the Yangtze River Delta, and the Pearl River Delta—indicating that the coupling coordinated development of ecological civilization construction, the tourism industry, and high-quality economic development is relatively consistent with regional economic levels.

2) From the perspective of changes in the azimuth angle of the standard deviation ellipse, the azimuth angle shows a continuous decreasing trend from 2000 to

2024, dropping from 60.348˚ in 2000 to 53.087˚ in 2024, a total decrease of 7.261˚. The overall spatial distribution of the standard deviation ellipse of the coupling coordination degree is oriented in a northeast-southwest direction, and exhibits a weak overall trend of gradually shifting toward an east-west direction.

3) In terms of changes in the major and minor axes of the standard deviation ellipse, the standard deviation along the Y-axis fluctuated from a maximum of 2481.498 km in 2000 to 2443.628 km in 2024, showing an overall trend of first continuously decreasing and then slightly rebounding during the study period, with a total shortening of 37.870 km. This indicates that the coupling coordination degree first contracted and then slightly expanded in the northeast–southwest direction, with an overall tendency toward contraction. The standard deviation along the X-axis continuously decreased from 2171.654 km in 2000 to 2125.862 km in 2024, a total decrease of 45.792 km, with the minor axis continuously shortening, indicating an overall continuous contraction trend in the northwest–southeast direction.

4) From the perspective of the flattening (ratio of the major axis to the minor axis) of the standard deviation ellipse, the flattening shows a U-shaped evolution during the study period. It continuously decreased from 1.143 to 1.133 (the lowest point) from 2000 to 2015, and then increased from 1.133 to 1.149 (the highest point) from 2015 to 2024, with an overall increase of 0.006. This indicates that the spatial directionality of the coupling coordination degree of ecological civilization construction, the tourism industry, and high-quality economic development in China first weakened and then strengthened, with 2015 as the turning point, and the directionality has significantly strengthened in recent years. The series of changes in the standard deviation ellipse parameters indicate that the coupling coordination degree first contracted and then expanded in the northeast-southwest direction, with an overall contraction trend; showed a continuous contraction trend in the northwest-southeast direction; rotated counterclockwise as a whole; the gap between the major and minor axes first narrowed and then widened; the ellipse first became more circular and then more elongated; and the spatial disparity of the coupling coordination level exhibited a trend of first converging and then diverging.

5. Conclusion and Prospect

5.1. Conclusion

Through a systematic analysis of the coupling coordination relationship among ecological civilization construction, the tourism industry, and high-quality economic development in 31 provincial-level administrative divisions in China (excluding Hong Kong, Macao, and Taiwan region) from 2000 to 2024, this study draws the following main conclusions:

First, from the perspective of overall characteristics, the coupling degree of the three systems has remained at a high level above 0.75 over the long term, indicating a close interrelationship among ecological civilization construction, the tour-

ism industry, and high-quality economic development. However, the coupling coordination degree increased only from 0.209 to 0.310, with a growth rate of 48.3%, remaining in the disorder range for a long period. Although it entered the moderate disorder level in 2023-2024, the structural contradiction of "high coupling, low coordination" remains prominent, and the three systems have not yet formed a pattern of benign interaction.

Second, from the perspective of provincial characteristics, the coupling coordination degree exhibits a spatial pattern of "overall improvement, widening disparities, and being high in the east and low in the west". Beijing Municipality, Shanghai Municipality, Guangdong Province, Zhejiang Province, and Jiangsu Province constitute the first tier, while divisions such as Ningxia Hui Autonomous Region, Qinghai Province, and Shanxi Province have long remained in low-value areas, showing a significant spatial lock-in effect. The coordination development gap between economically developed and underdeveloped regions has not shown obvious convergence.

Third, from the perspective of regional characteristics, the coupling coordination degree of the four major economic regions shows a continuous upward trend. The eastern region takes the lead in entering the moderate disorder level, followed by the central and northeastern regions, while the western region remains in extreme disorder but is on the verge of crossing the threshold. The central region, with an increase of 56.9%, has become the fastest-growing region. Regional disparities have slightly narrowed, but the task of coordinated development remains arduous.

Fourth, from the perspective of spatial directional evolution, the standard deviation ellipse of the coupling coordination degree exhibits a northeast-southwest orientation, with the azimuth angle continuously decreasing, indicating a counterclockwise rotation of the spatial distribution. Both the major and minor axes tend to contract, and the flattening shows a U-shaped evolution, with 2015 as the turning point. In recent years, the spatial directionality has significantly strengthened, and the spatial disparity of the coupling coordination level shows a trend of first converging and then diverging. The center of the ellipse covers the three major economic circles—the Bohai Rim, the Yangtze River Delta, and the Pearl River Delta—further validating the spatial matching between the coupling coordination level and regional economic strength.

5.2. Prospect

Future research can be further expanded in the following directions:

First, attention should be paid to the heterogeneity and convergence of regional coordinated development paths. Future studies can further adopt spatial econometric models, threshold regression, and other methods to identify the differentiated paths and threshold conditions for achieving coordinated leapfrogging in different development stages and regional types, and to explore the mechanisms for breaking spatial lock-in effects, thereby providing scientific support for narrowing

regional disparities.

Second, the dynamic analysis of multi-dimensional interaction mechanisms should be extended. Future research can introduce methods such as network analysis and system dynamics to reveal the multi-dimensional interaction effects, transmission mechanisms, and time-lag characteristics among ecological civilization construction, the tourism industry, and high-quality economic development. Special attention should be paid to the recovery process after the decline in coupling degree in 2020 and the underlying policy and environmental factors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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