

Construction of coordination evaluation system of Economy-Tourism-Ecological environment coupling based on entropy method——Taking three cities in the Dongting Lake Eco-economic Zone as an example

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Abstract. Dongting Lake Ecological Economic Zone is an emerging development group, among which Yueyang, Changde, and Yiyang have similarities in climate, environment, history, culture, and basic industries. This paper used the entropy method to construct the evaluation system of the coupling coordination degree of the three indexes of economy, tourism, and ecological environment in Yueyang, Changde, and Yiyang, calculated Yueyang, Changde, and Yiyang's coupling coordination degree, studied and analyzed the relationship of its three subsystems in 2009, 2012, 2015 and 2018 of Yueyang, Changde and Yiyang, and analyzed their coupling coordination level. The results show: (1) the three major system evaluation indexes were generally on the rise, except for the Yiyang tourism evaluation index, which declined from 2012 to 2015; (2) These three systems' coupling degrees were maintained at a very high level, and the development correlation is strong; (3) Some of Yiyang's data fluctuated in some years. By 2018, all the cities had reached the verge of imbalance from the extreme imbalance in 2009; The imbalance had greatly improved.

Keywords: Coupling coordination degree, economy, ecological environment, travel, Dongting Lake ecological Economic zone.

1. Introduction

Over the past decade, the economic development, as well as ecological progress of China have obtained milestone significance of major harvest - economic development has been continuously improved, ecological environment has been greatly improved; In addition, tourism continues to develop, and the link between tourism and the economy is becoming closer. Reasonable development of tourism can effectively facilitate the local economy, and vigorously developing the economy can facilitate the tourism; However, developing tourism and economy will bring about environmental damage. Once tourism and economic development exceed the ecological carrying capacity, it will cause irreversible harm to the local environment. The correct handling of the relationship among economy, tourism, and ecology is helpful to the study of urban sustainable development in the future. Domestic and foreign researchers have analyzed the relationship among tourism, economy, and environment in pairings or comparisons with the three together. In terms of environment and economy, Grossman and Krueger examined the link between economic and ecological development in Mexico and substantiated that when the national income is at a low level, the concentration of pollutants will increase with the increase of per capita GDP, but when the income level is at a high level, the concentration will decrease with the increase of GDP. Proposed environmental Kuznets curve [1]; For the study of environment and tourism, Chen Changyu et al. took five provinces in Northwest China as objects of study and studied the relationship among these three elements [2]. For the study of economy and tourism, Zhou Wei et al. built a coupling degree and coupling coordination model for Beijing, Tianjin and Hebei. Results of the study show that the tourism industry agglomeration level in this area was relatively high, but there were obvious discrepancies in the tourism industry agglomeration level within the region and the coupling stage of the tourism industry agglomeration and regional economic development in this region maintained a coordinated coupling [3]. Investigating the connection among the economy, tourism and environment, for example, Zhong Xia

constructed three systematic evaluation index systems, used SPSS and GIS software, principal component analysis method and coupled coordination degree function modeling method in physics, and carried out quantitative analysis on the coupled coordination degree of tourism[4], economy and environment in 21 cities in Guangdong and the results indicated that the coupling coordination degree of these cities was improving overall, but there were big differences in growth rates among cities.

This paper takes the coupling coordination degree of tourism, economy and environment of Yueyang, Changde, and Yiyang as the object of study, and uses the statistical yearbook of Yueyang, Changde, and Yiyang in 2009, 2012, 2015, and 2018 and the Chinese City Statistical Yearbook, drew on the existing research results to construct the evaluation index system of economy, environment, and tourism. This system mainly took economy-ecological environment-tourism as three subsystems, which were divided into 21 indicators, and constructed the coupling coordination degree grade judgment standard to evaluate the development status of Yueyang, Changde and Yiyang.

2. The Construction Principle and Advantages of the Entropy Method

The entropy is the cost of the meter, and the information is accurate In information technology, entropy reflects the degree to which a system is organized. The higher the system, the higher the entropy of the information, and the lower the impact. The basis of the comprehensive evaluation is the estimate of the entropy difference. The law of entropy also encourages the reduction of the influence of polar values on comprehensive evaluation [5].

Entropy is a way of measuring each value in terms of the power of information. From an information perspective, it is necessary to study the role that indicators play in the system and how they change. The change of the tester is related to the increase in the information value. The amount of information can be measured in terms of entropy, that is, entropy increases. Relevant indicators [6]. To a certain extent, the distortion of subjectivity is avoided.

3. Establishment of an Evaluation Index System

3.1. Evaluation Index Selection Principle

This study drew on Liu Dinghui's research [7] to build a collaborative system in the process of establishing a regional economic, tourism, and environmental assessment system. The selection of indicators depended on the experience of previous researchers, and finally selected indicators that were more frequent and representative in empirical national and domestic studies. It could be applied to data types and baseline information in both per capita and generic indicators, then chosen positive and negative indicators.

3.2. Weight Calculation

(1) Formula

The entropy weight method was used to calculate the weight

First of all, calculate the proportion of the year i of the j index indicator p_{ij} :

$$p_{ij} = r_{ij} / \sum_{i=1}^n r_{ij} \quad (1)$$

In the second step, the entropy e_j of the j index was calculated:

$$e_j = -k \sum_{i=1}^n p_{ij} \cdot \ln p_{ij} (k = 1/\ln n) \quad (2)$$

Then calculated the entropy weight w_j of the j index:

$$w_j = (1 - e_j) / \sum_{j=1}^m (1 - e_j) \quad (3)$$

Finally, the weighted summation method was used to obtain the comprehensive evaluation index S_i

The calculation formula is as follows:

$$S_i = \sum_{j=1}^m w_j \cdot p_{ij} \quad (i = 1, 2, \dots, m) \quad (4)$$

(2) Non-dimensional processing

Non-dimensional processing of raw data

The original evaluation matrix $R = (x_{ij})_{m \times n}$, and the range normalization method is used to standardize the data. Because the standardized data has zero, it is indispensable to carry out non-zero processing of the data, and the method taken is to shift all the standardized data in the positive direction.

Calculation formula:

Positive indicator:

$$r_{ij} = (x_{ij} - x_{jmin}) / (x_{jmax} - x_{jmin}) + 0.001 \quad (5)$$

Negative indicator:

$$r_{ij} = (x_{jmax} - x_{ij}) / (x_{jmax} - x_{jmin}) + 0.001 \quad (6)$$

$$(i = 1, 2, \dots, m; j = 1, 2, \dots, n)$$

Where x is the x city, i is the i year, j is the j index, r_{ij} is the standardized number of the x prefecture-level city, the i year, and the j index data, x_{ij} is the data of the j index in the i year of the x prefecture-level city, and x_{jmax} is the maximum number of the data of the j index. x_{jmin} is the minimum number of the data for item j .

Table 1. Index system and weight of economy-tourism-ecological environment coupling coordination degree

Subsystem	Evaluation Index	Weight			Directivity
		Yueyang	Changde	Yiyang	
Economy	Local general public budget revenue (ten thousand yuan)	0.0429	0.0437	0.0423	+
	GDP Gross Regional Product (billion)	0.0387	0.0415	0.0402	+
	Tertiary industry	0.0491	0.0534	0.0502	+
	Tax (million)	0.0457	0.0399	0.0382	+
	Total retail sales of consumer goods	0.0449	0.0538	0.0448	+
	Per capita GDP	0.0384	0.0418	0.0407	+
Travel	Per Capita disposable income of urban residents	0.0415	0.0429	0.0401	+
	Share of tourism revenue in GDP	0.0582	0.0486	0.0799	+
	Gross domestic tourism revenue (billion)	0.0536	0.0521	0.0521	+
	Foreign exchange earnings from tourism (USD 10,000)	0.0445	0.0327	0.0327	+
Environment	Reception of Domestic tourists (10,000)	0.0431	0.0484	0.0484	+
	Reception of foreign tourists (people)	0.0418	0.0341	0.0341	+
	Tertiary industry employees (persons)	0.0710	0.0394	0.0394	+
	Proportion of employees in the tertiary industry	0.0347	0.0473	0.0473	+
	Green area (ha)	0.0387	0.0482	0.0482	+
	Park green area (ha)	0.0691	0.0704	0.0704	+
	Industrial soot emissions (tons)	0.0402	0.0554	0.0554	-
	Green coverage rate of urban built-up area %	0.0341	0.0647	0.0647	+
	Industrial wastewater discharge (10,000 tons)	0.0532	0.0787	0.0787	+
	Industrial sulfur dioxide emissions (tons)	0.0766	0.0405	0.0405	-
	Centralized treatment rate of sewage treatment plant	0.0399	0.0332	0.0332	-

(3) Coupling coordination model

Coupling refers to the process of energy propagation from one medium to another in physics. In accordance with the concept of coupling, this paper calculated the interaction among three subsystems. By referring to the study achievements of relevant scholars [8] and combining these relevant principles of physics, the coupling degree formula is established.

$$C = \sqrt[3]{\frac{S_1 \times S_2 \times S_3}{((S_1 + S_2 + S_3)/3)^3}} \quad (7)$$

C is the coupling degree among them, and $C \in [0,1]$, The greater the C, the higher the coupling degree of the subsystem, the stronger its correlation will be, if the C is lower, the weaker its correlation will be. To further study the C among the three systems as a whole, this paper introduces the system synthesis harmonic index (T) and coupling coordination degree (D). The specific calculation method can be seen in the formula:

$$T = \alpha S_1 + \beta S_2 + \theta S_3 \quad (8)$$

Where α , β , θ respectively are the weights of the three subsystems in the comprehensive system. The paper utilizes previous research results and sets [9], and then the formula for D can be calculated:

$$D = \sqrt{C \times T} \quad (9)$$

4. Analysis of the Three Subsystems Coupling Coordination Degree in Yueyang, Changde, and Yiyang in the Dongting Lake Ecological Economic Zone

To illustrate the degree of coupling and coordination development among these three subsystems, this paper used some relevant research by Liao Chongbin for reference [10], and adopted the ten-level classification method for coupling and coordination degree.

Table 2. Classification Criteria for Coupling Coordination Degree

Coupling Coordination Degree (D) Interval	Coordination Level	Coupling Coordination Degree (D) Interval	Coordination Level
0.00~0.09	hyper dysregulation	0.50~0.599	Forced coordination
0.10~0.199	Severe disorder	0.60~0.699	Primary coordination
0.20~0.299	Moderate dysregulation	0.70~0.799	Intermediate coordination
0.30~0.399	Mild disorder	0.80~0.899	Good coordination
0.40~0.499	Borderline disorder	0.90~1.00	Quality coordination

The evaluation functions of the economy, tourism, and ecological environment in Yueyang, Changde, and Yiyang were calculated, and the results are shown in Table 3.

Table 3. Evaluation Index of the Economy-Tourism-Ecological Environment Subsystem of Yueyang, Changde, and Yiyang in the Dongting Lake Eco-economic Zone from 2009 to 2018

A given year	Yueyang			Changde			Yiyang		
	economy	travel	environment	economy	travel	environment	economy	travel	environment
2009	0.0003	0.0025	0.0388	0.0003	0.0003	0.0402	0.0003	0.1118	0.0245
2012	0.1018	0.1625	0.1015	0.0968	0.1122	0.0641	0.0978	0.2132	0.1074
2015	0.2003	0.2522	0.1550	0.1996	0.1897	0.2229	0.1984	0.0616	0.1603
2018	0.3012	0.2652	0.3428	0.3062	0.2811	0.3502	0.2965	0.2308	0.3066

The time series of evaluation indexes of the economy-tourism-ecological environment of Yueyang City are shown in Figure 1 and Table 3:

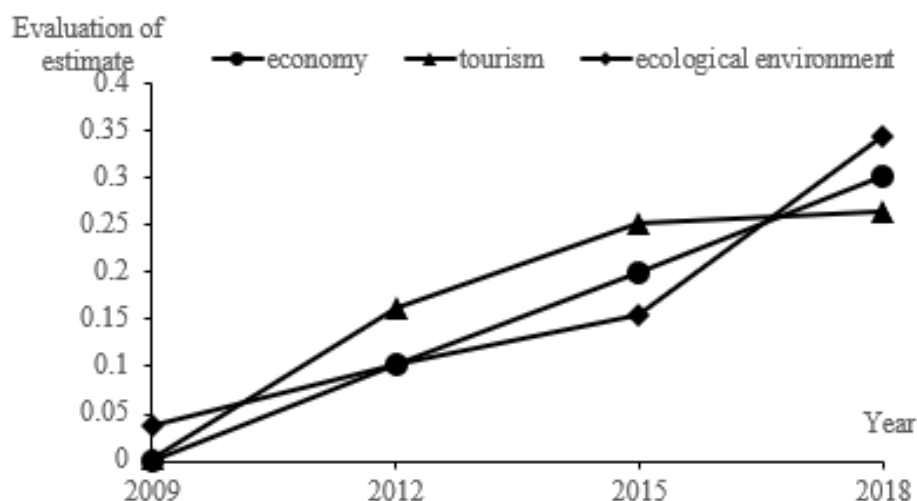


Fig. 1 Time Series Characteristics of Evaluation Value of the Three Subsystems in Yueyang (Picture credit: Original)

The time series of evaluation indexes of the economy-tourism-ecological environment of Changde City are shown in Figure 2 and Table 3:

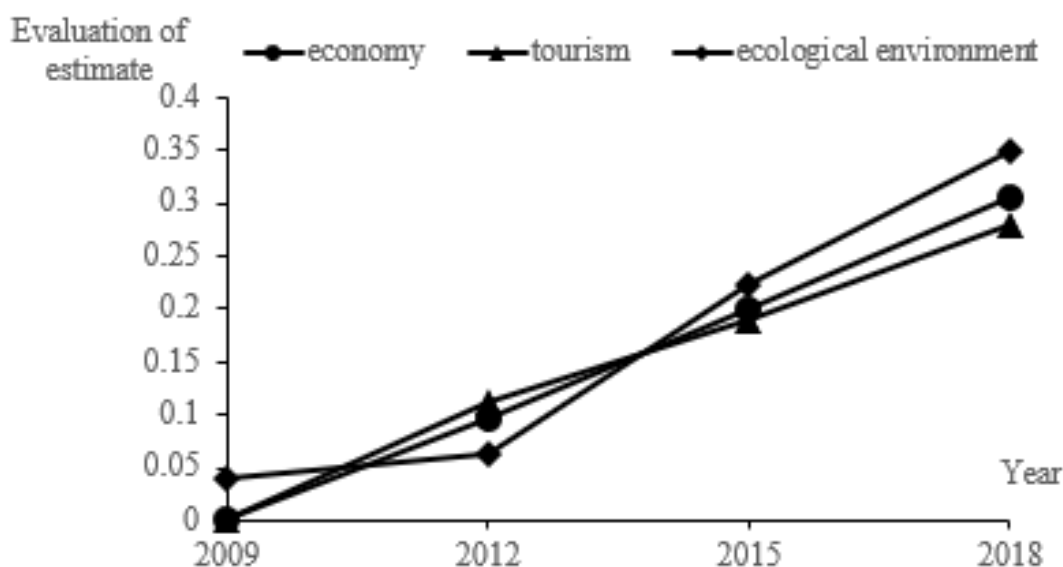


Fig. 2 Time series characteristics of the evaluation value of the Three Subsystems in Changde (Picture credit: Original)

The time series of evaluation indexes of the economy-tourism-ecological environment of Yiyang City are shown in Figure 3 and Table 3:

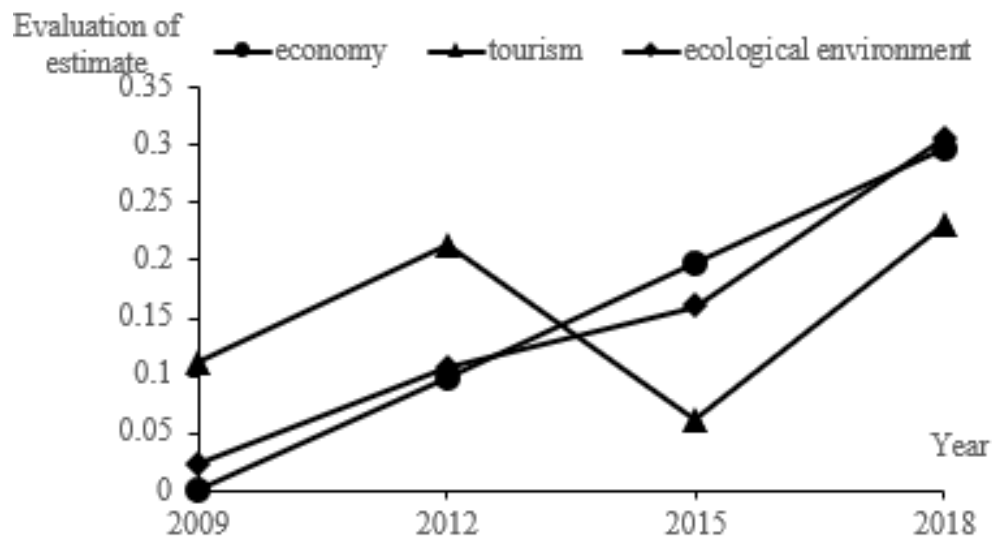


Fig. 3 Time series characteristics of the evaluation value of the Three Subsystems in Yiyang
(Picture credit: Original)

According to the S_i of the three subsystems, the D and coordination level of Yueyang City, Changde City, and Yiyang City during 2009-2012-2015-2018 could be calculated, as shown in Table 4.

Table 4. Coupling degree and Coordination Level Classification of the three Cities from 2009 to 2018

City name	2009			2012		
	Coupling degree	Coupling relationship dispatch	coordinate Lv.	Coupling degree	Coupling relationship dispatch	coordinate Lv.
Yueyang	0.2228	0.0556	hyper dysregulation	0.9748	0.3447	Mild disorder
Changde	0.1139	0.0394	hyper dysregulation	0.9736	0.2977	Moderate dysregulation
Yiyang	0.2049	0.0966	hyper dysregulation	0.9381	0.3617	Mild disorder

City name	2015			2018		
	Coupling degree	Coupling relationship dispatch	coordinate Lv.	Coupling degree	Coupling relationship dispatch	coordinate Lv.
Yueyang	0.9806	0.4456	Borderline disorder	0.9945	0.5490	Forced misalignment
Changde	0.9977	0.4512	Borderline disorder	0.9959	0.5579	Forced misalignment
Yiyang	0.8931	0.3537	Mild disorder	0.9922	0.5252	Forced misalignment

The Changing trend of the coupling coordination degree in Yueyang City, Changde City, and Yiyang City from 2009 to 2018 is shown in Figure 4.

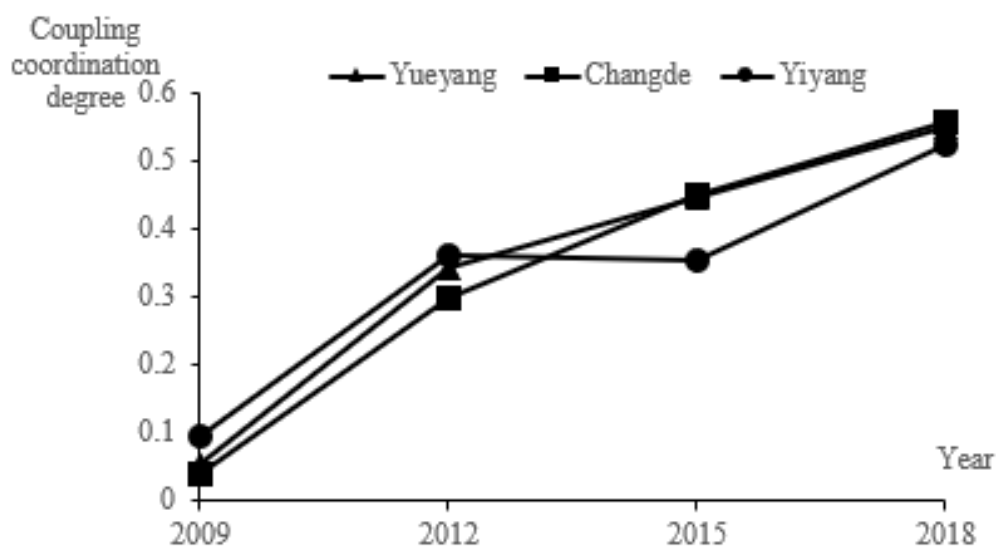


Fig. 4 Trends of Coupling Coordination Degree of Economy-Tourism- Ecological Environment in Yueyang, Changde, and Yiyang (Picture credit: Original)

By referring to the statistical yearbook of Hunan and the official website, the relevant data on ecology, economy, and tourism of Yueyang, Changde, and Yiyang of Hunan Province in 2009, 2012, 2015, and 2018 were collected, and the T and D were introduced. To explore the coupling and coordination in three cities in the Dongting Lake Ecological Economic Zone. It showed that the tourism subsystem's evaluation index of Yiyang City decreased after 2012, and the evaluation index of the three subsystems of other cities and Yiyang City in other years showed an upward trend. The C in Yueyang, Changde, and Yiyang was basically above 0.9 after 2009, The progress of three subsystems in these cities was highly correlated, and the three affected and promoted each other. The D of the three major systems in Yueyang, Changde, and Yiyang was on the rise, and the overall coordination of the three subsystems was on the rise. By analyzing the results of the economy-tourism-ecological environment coupling coordination in Yueyang, Changde, and Yiyang, and comparing the development status of the three cities, the author considered eliminating some abnormal data and selecting relatively stable and more representative data to conduct a deeper study on Yueyang, Changde, and Yiyang. Given the shortcomings, finally put forward a feasible plan to help Dongting Lake's three cities' three subsystems comprehensive and coordinated development.

5. Conclusion

The following ecosystem management systems, including the Economy, Tourism, and Environment subsystems (subsystems of the three subsystems developed in this paper), accurately assess the price relationships between the three ecosystem subsystems from 2009 to 2018. Based on economic tourism and environmental objectives, the analysis of energy domes in the three cities and the mechanisms of interconnection, the dynamic process of domes, financial markets, and domes in 2009, 2012, 2015, and 2018 was very simple and efficient. Using the feedback model and related equations can provide a scientific basis for the global development strategy of Yueyang, Changde, and Yiyang in the Dongting Lake Eco-economic Zone. In the comparison of different regions and different years, the development strategies of these three cities were of great significance.

The calculation results show that the three cities all reached a barely coordinated level in 2018, which could show that environmental protection had a promoting effect on economic development, while tourism lagged economic development from 2015 to 2018, indicating that the degree of attention paid to tourism was not enough, indicated that economic development should continue under the premise of environmental protection, and actively responded to policies to develop tourism. It's essential to protect the ecological environment and develop ecological tourism and ecological

economy. Economic development needs to be carried out at the same time as industrial structure adjustment to replace high pollution and cooperate with the construction of a green economy, and the pursuit of a sustainable development strategy, The goal should be to maximize the benefits of them and facilitate the coordinated economic development, environmental protection and tourism in the region.

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