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An Analysis of Regional Economy and Resources and Environment Coordinated Development Based on PSR Model a Case Study of Zhongyuan Urban Agglomerations

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Abstract

With the acceleration of urbanization, the resources and environment problem has become more and more prominent in Zhongyuan urban agglomerations. Based on evaluation model of resources and environment coordination degree of Pressure-State-Response (PSR), this study adopted the coordination degree analysis methods to calculate and evaluate the resources and environment coordinated development of nine central cities in Zhongyuan Urban Agglomerations from 2006 to 2013. Results showed that: (1) from 2006 to 2013, the statuses of the nine central cities in Zhongyuan Urban Agglomerations were in moderate coordination, elementary coordination, on the verge of imbalance and moderate imbalance, the economic development and the resources and environment statuses were not optimistic; (2) from 2006 to 2009, those cities' statuses were in moderate imbalance, on the verge of imbalance and elementary coordination, the overall development coordination degree was not high, could not reach the state of coordinated development. Luoyang, Jiaozuo, Xuchang and Luohe's coordinated development situation was not up to standard, whose status was in moderate imbalance; (3) from 2010 to 2013, the nine cities were on the verge of imbalance, elementary coordination and moderate coordination, coordinated development was improved.

Keywords*: Economic Development, Resources and Environment, PSR Model, Coordination degree, Zhongyuan Urban Agglomerations*

1. Introduction

Chinese urban agglomeration is an inevitable product accompanied by the new-type national industrialization and new-type urbanization development up to a higher stage, its driving and radiation function makes it be a new geographical unit of global competition and international division[1]. Growing in the context of globalization, information technology, new-type industrialization and rapid transportation, Chinese urban agglomeration exhibits the "three high" characteristics that are high density clustering, high-speed growth, high-intensity operation[2]. However, the high-intensity operation releases huge energy and pollution, especially in dense urban distribution of urban agglomerations which has homogeneous effect on resource utilization [3], additive effect on environmental pollution, whereby the pressure on resources and environment system is larger than a single city[4-5]. Thus, in the current context of rapid development, strengthening the study of Chinese urban agglomeration's resources and environment

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coordination has important theoretical and practical significance to improve the international competitiveness of the country and keep sustained and stable development of the national economy 6-7].

In this paper, the analysis method conducted by PSR model and its expansion model to measure the Central Plains city group including Zhengzhou, Luoyang, Kaifeng, Xinxiang, Jiaozuo, Xuchang, Luohe, Pingdingshan, Jiyuan. Those nine regional central cities' coordination degree of economy, resources and environment, eventually, evaluate its coordination, analyze several problems that exist in the coordinated development according to the results based on the data and provide a scientific decision-making for relevant departments.

2. Study Area

Zhongyuan urban agglomeration includes 26 cities as Kaifeng, Xinxiang, Jiaozuo, Pingdingshan, Luohe, Jiyuan, Gongyi, Xinmi, Yuzhou, Xinzheng, Yanshi, Xingyang, Dengfeng, Wugang, Ruzhou, Huixian, Weihui, Qinyang, Mengzhou, Changge, 33 counties, 340 towns, Zhengzhou is its central city, Luoyang is its deputy central, the land area is 58,700 square kilometers, the population is 39.5 million, accounting for 35.3% and 40.3% of the provincial land area and the total population, respectively. In 2008, GDP is 1.0568 trillion yuan, ranking first in the Central China, secondary and tertiary industry account for 89.7 percent of GDP, ranking first in the Central China. Therefore, continue to strengthen the research of environmental and resources coordination is not only a strong impetus to the healthy development of the Chinese urban agglomeration, but also an important strategic significance to build a resource-saving and environment-friendly society.

3. Zhongyuan Urban Agglomeration Resources and Environment Coordination Degree Assessment

3.1. Research Ideas and Data Sources

In this paper, use PSR (Pressure-State-Response) concept model, the pressure - state – response model, take into account the impact of society, economy, resources and environment, combine with the practice of Chinese urban agglomeration, through combination of qualitative and quantitative research methods as the basis for constructing the index system, establish a scientific index system, and use the weighted function method to calculate the coordination degree of each indicator[8-9].

The data is from the "Henan Statistical Yearbook" (2007～2014), Municipalities Statistical Yearbook of those nine cities (2006～2014),National Economic and Social Development Statistical Report, Environmental Statistical Yearbook, statistical bulletin of Henan Province Environmental Protection Agency.

3.2 Construction of Evaluation Index System

3.2.1 Principle of Construction Index System: Selecting the correct coordination degree of environment and resources is the foundation to build the evaluation system, due to its complexity and timing, follow those principles when setting indicators: (1) Comprehensiveness principle. Assessing the coordination degree of resources and environment is a sustainable development research on human natural ecosystems, we must be fully reflected all aspects of the system, accurately measure and overview all aspects of the pressure, state and response of resources and environment. (2) Dynamic variability principle. Coordinated development of resources and environment is a goal, but also a process, this determines its proper dynamic characteristics, evaluation chosen

should have a concept of time, to reflect the current situation and trends of resources and environment. (3) The scientificity and possibility of obtaining data principle. Selected indicators should both react basic situation and develop trend of all aspects and be easy to collect and calculate, or obtain though the original data. Indicators should be based on the available data and those can be operated, focusing objectivity of obtaining data, through simple and clear indicators system covers more comprehensive information.

3.2.2 Establish Indicator System: In this paper, use multi-objective decision-making model to research the coordinating development of Chinese urban agglomeration, consider the various factors and its intrinsic link including industry, agriculture, services, population and environment carrying capacity[10].Using the Pressure - State - Response this kind of logical thinking way when selecting indicators, in which the pressure reflects the impact and stress on resources and environment caused by human activity, state indicators reflect the changes and results of economy, society and resource environment, response indicators reflect the measures that society or personality alleviate and prevent the adverse effects of human activities on the resources and environment. Specific indicators are shown in Table 1.

Table 1. Index System of Resources and Environment CoordinatedDevelopment in Zhongyuan Urban Agglomerations

Target layer	Criterion layer	Index layer
Index System of resources and environment development of Chinese urban agglomeration	Pressure	Population Discharge of industrial waste water Smoke and dust emission Agricultural chemical fertilizer application Rural electricity Water Consumption
	State	Gross product Added value of Third industry The per capita disposable income of urban residents Grain production Urbanization rate
	Response	Comprehensive utilization rate of industrial solid wastes The total power of agricultural machinery Urban fixed asset investment Investment in water conservancy, environment and public facilities management

3.3. Consistency Check of Calculation Index Weight

The weight value given by each index will reflect the relative importance of the index to the resources and environment of the Zhongyuan urban agglomeration. In this paper, based on the actual local situation, use AHP to determine the index weight, in order to establish the basis of an orderly handover of the index system, by comparing the relative importance of each index in the same level to calculate the composite index weight and check its consistency (See Table 2 toTable 7).The specific steps are as follows.

(1)Make a pairwise comparison of each index on the lower and higher layer, to determine the importance and impact of the lower level indicators on the upper level indicators, build a comprehensive evaluation according to document to evaluate the score value ranging from 1 to 9, as shown in Table 2.

Table 2. The Relative Importance of Scale

A B Indicator ratios	Extremely important	Very important	Important	Slightly important	Equivalent	Slightly minor	Secondary	Very secondary	Extremely secondary
A value index evaluation	9	7	5	3	1	1/3	1/5	1/7	1/9
Remark	Taking 8,6,4,2,1/2,1/4,1/6,1/8 as the intermediate value of the above evaluation value								

(2)Average each row vector of judgment matrix *A*, then normalize it, the obtained row vector is the weight vector. The maximum characteristic root of the *A* is λ_{max}, the corresponding characteristic vector is *W*, then has $AW = \lambda_{max}W$. The calculation process of AHP method is as follows:

Calculate product of each element of the matrix, $M_i = \prod_{j=1}^{n} b_{ij}$ i=1,2,...， n .

Calculate nth root of Mi, $\overline{W}_i = \sqrt[n]{M_i}$.

Normalize vector $W = \left[\overline{W_1}, \overline{W_2}, ..., \overline{W_n}\right]^T$, $w_i = \overline{W_i} \Big/ \sum_{i=1}^{n} \overline{W_i}$, W is the index weight.

Calculate the maximum characteristic root $\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{w_i}$.

(3) AHP method can express and process the subjective judgment formally, and gradually eliminate the subjectivity, thus describe it objectively as far as possible[11]. Its correctness depends largely on whether the objective analysis can achieve reasonable point，because of the objectivity of things and the subjectivity of decision-makers' cognition, test the consistency of judgment matrix become an indispensable part, consistency index $CI = \frac{\lambda_{\max} - n}{n-1}$.

In order to measure whether there is a satisfactory consistency of different order matrix, average random consistency index RI value of judgment matrixshould be introduced. RI value of value judgment matrix ranging from 1 to 15 are shown in Table 3, higher order average random consistency index RI value can be found in the literature[12]. When the order is greater than 2, judgment matrix consistency ratio CR=CI/RI <0.10, that is considered satisfactory consistency judgment matrix, otherwise the judgment matrixneed to be adjusted, in order to make it have a satisfactory consistency.

Table 3. Average Random Consistency Index RI Value

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

(4) The calculation results are shown in Table 3, Table 4, Table 5, Table 6.

Table 4. Comparison Matrix and the Weights of Target Layer and Criterion Layer

Zhongyuan Urban Agglomeration Coordinated Development System	Pressure	State	Response	Weight
Pressure	1	2	3	0.54
State	0.50	1.00	2.00	0.30
Response	0.33	0.50	1.00	0.16

λ_{max} =3.0056；CI=0.0028；RI=0.5200；CR=0.0053 < 0.10

The judgment matrix of criterion layer- index layer.

Table 4. Comparison Matrix and the Weight of Pressure

Pressure	Population	Discharge of industrial waste water	Smoke and dust emission	Agricultural chemical fertilizer application	Rural electricity	Water Consumption	Weight
Population	1.00	3.00	3.00	2.00	5.00	5.00	0.34
Discharge of industrial waste water	0.33	1.00	1.00	4.00	4.00	3.00	0.21
Smoke and dust emission	0.33	1.00	1.00	4.00	3.00	3.00	0.20
Agricultural chemical fertilizer application	0.50	0.25	0.25	1.00	4.00	4.00	0.11
Rural electricity	0.20	0.25	0.33	0.25	1.00	1.00	0.06
Water Consumption	0.20	0.33	0.33	0.25	1.00	1.00	0.07

λ_{max} =6.6209；CI=0.1241；RI=1.2600；CR=0.098 < 0.10

Table 5. Comparison Matrix and the Weight of Status

State	Gross product	Added value of Third industry	The per capita disposable income of urban residents	Grain production	Urbanization rate	Weight
Gross product	1.00	4.00	6.00	3.00	3.00	0.48
Added value of Third industry	0.25	1.00	3.00	2.00	2.00	0.20
The per capita disposable income of urban residents	0.17	0.33	1.00	2.00	2.00	0.12
Grain production	0.33	0.50	0.50	1.00	0.50	0.09
Urbanization rate	0.33	0.50	0.50	2.00	1.00	0.11

λ_{max} =5.4090； CI=0.1023； RI=1.1200； CR=0.0912 < 0.10

Table 6. Comparison Matrix and the Weight of Response

Response	Comprehensive utilization rate of industrial solid wastes	The total power of agricultural machinery	Urban fixed asset investment	Investment in water conservancy, environment and public facilities management	Weight
Comprehensive utilization rate of industrial solid wastes	1.00	2.00	0.17	3.00	0.18
The total power of agricultural machinery	0.50	1.00	0.25	3.00	0.14
Urban fixed asset investment	6.00	4.00	1.00	5.00	0.60
Investment in water conservancy, environment and public facilities management	0.33	0.33	0.20	1.00	0.07

λ_{max} =4.2607； CI=0.0868； RI=0.8900； CR=0.0976 < 0.10

The results show that the consistency of judgment matrix is satisfied.

Table 7. The Weight of Index at All Levels for Evaluating the Degree of Coordination in Zhongyuan Urban Agglomeration

Zhongyuan Urban Agglomeration coordination degree of resource and environment assessment	PressureIndex：0.54	Population	0.34
		Discharge of industrial waste water	0.21
		Smoke and dust emission	0.20
		Agricultural chemical fertilizer application	0.11
		Rural electricity	0.06
		Water Consumption	0.06
	State Index：0.30	Gross product	0.47
		Added value of Third industry	0.20
		The per capita disposable income of urban residents	0.12
		Grain production	0.09
		Urbanization rate	0.11
	Response Index：0.16	Comprehensive utilization rate of industrial solid wastes	0.18
		The total power of agricultural machinery	0.14
		Urban fixed asset investment	0.60
		Investment in water conservancy, environment and public facilities management	0.07

3.4 Index Data Standardization

To eliminate the impact of dimension, positive index and inverse index, normalize data firstly, direct and inverse indicator are used in the following formula.

$$\text{Direct indicator } X_{ij}^{'} = (x_{ij} - x_{ij}^{\min}) / (x_{ij}^{\max} - x_{ij}^{\min})$$

$$\text{Inverse indicator } X_{ij}^{'} = (x_{ij}^{\max} - x_{ij}) / (x_{ij}^{\max} - x_{ij}^{\min})$$

X_{ij} is processed value, X_{ij} is the original value of i index of j or j years, $x_{ij}^{\min}$ is the minimum value of i index of $j$or j years, $x_{ij}^{\max}$ is the maximum value of i index of j or j years. Nondimensionalize original data and get standardized data of resources and environment development of Zhongyuan urban agglomeration.

3.5. Compute the Coordination Degree of Resources and Environment

Because of the complexity and chromatography of resources and environment evaluation system, the single index can only reflect its development from one side. This article mainly uses weighted function method to calculate the index.

$$C = \sum_{i=1}^{3} \left(\sum_{j=1}^{n} X_{ij} \times W_{ij} \right) R_i$$

X_{ij} is the standard value of i classified index which belongs to j single index, W_{ij} is the weight of i classified index which belongs to single index j, R_i is the weight of i classified index, $\sum_{j=1}^{n} X_{ij} \times W_{ij}$ is comprehensive evaluation value which reflects pressure, state, response respectively[13].

Table 8. Coordination Grade and Classification Criteria

C	Coordination grade
0~0.20	Serious disorders
0.20~0.40	Moderate disorders
0.40~0.50	On the verge of disorder
0.50~0.60	Primary coordination
0.60~0.80	Moderate coordination
0.80~1.0	Good coordination

Obtain the resources and environment development from 2006 to 2013 of Zhengzhou, Kaifeng, Luoyang, Luohe, Xinxiang, Jiaozuo, Xuchang, Pingdingshan, Jiyuan those nine central city which belong to the Zhongyuan urban agglomeration, coordination results are shown in Table 9.

Table 9. Coordination Degree of Resources and Environment

Coordination Degree	2006	2007	2008	2009	2010	2011	2012	2013
Zhengzhou	0.43	0.48	0.56	0.59	0.67	0.45	0.50	0.62
Kaifeng	0.48	0.50	0.51	0.44	0.59	0.42	0.49	0.52
Luoyang	0.40	0.52	0.57	0.43	0.59	0.61	0.70	0.68
Luohe	0.45	0.41	0.37	0.37	0.62	0.70	0.65	0.67
Xinxiang	0.40	0.46	0.55	0.50	0.64	0.55	0.60	0.62
Jiaozuo	0.39	0.48	0.56	0.46	0.61	0.58	0.63	0.68
Xuchang	0.38	0.40	0.49	0.42	0.67	0.49	0.57	0.63
Pingdingshan	0.48	0.52	0.55	0.49	0.67	0.47	0.46	0.49
Jiyuan	0.50	0.44	0.51	0.53	0.53	0.56	0.55	0.53

4. Result Analysis and Countermeasures

Use the coordination degree range state from Table 9 to analyze the spatial distribution of coordination development degree of each city from 2006 to 2013, coordinated changes of each city as shown in Figure 1.

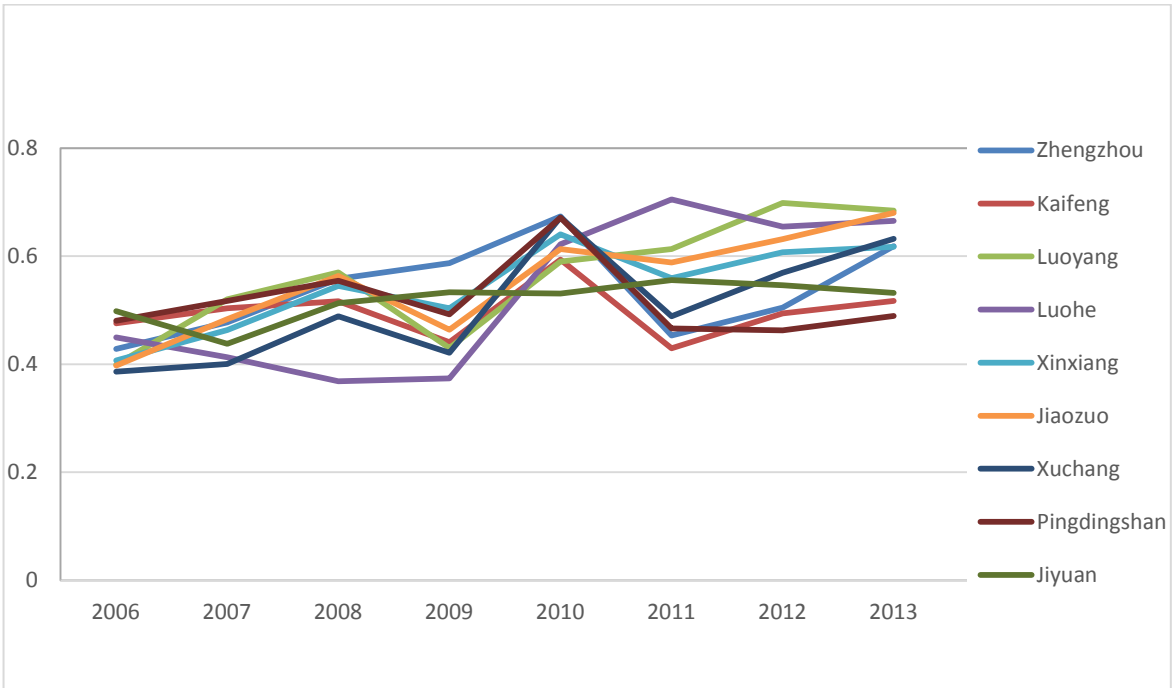

Figure 1. Coordination Degree Changes of Each City (2006–2013)

The results show nine regional central city of Zhongyuan urban agglomeration cities coordination degree from 2006 to 2013 in a moderate coordination, the imbalance force coordination, initial disturbance and moderate, municipal economic development and resource environment is not optimistic, from 2011 to 2013 except Jiyuan, Luohe there are minor changes, the environment and the level of coordination of resources and environment of other seven cities generally tend to improved.

In 2006-2009, the Zhongyuan urban agglomeration is basically at moderate imbalance, on the verge of imbalance and elementary coordination, and overall development of the coordination degree is not high, also fails to reach the state of the coordinated development of Luoyang, Zhengzhou, Xinxiang, resources and environment coordination development degree is low, the imbalance has gradually reached a preliminary. From 2010 to 2013, cities are on the verge of imbalance, elementary coordination and moderate coordination, among them, with the vigorous implementation of the rapid economic growth and pollution control, water conservation, environmental protection and scientific research policy, Luohe, Luoyang coordinated development are good and in a moderate state.

5. Conclusions and Discussion

Based on the resources and environment coordination degree assessment of PSR model, analyze the level of resources and environmental development of Zhongyuan urban agglomeration, the main conclusions are as follows:

(1) Municipal economic development and resource environment are not optimistic, Zhengzhou, Kaifeng, Luoyang, Luohe, Xinxiang, Jiaozuo, Xuchang, Pingdingshan, Jiyuan those nine regional central city of Zhongyuan urban agglomeration cities coordination degree from 2006 to 2013 in a moderate coordination, the imbalance force coordination, initial disturbance and moderate.

(2) From 2006 to 2009, each city is basically in the state of moderate disorders, on the verge of imbalance and elementary coordination, the overall level of development coordination is not high, fails to achieve coordinated development state. And coordinated development situation of Luoyang, Jiaozuo, Xuchang, Luohe is poor, which has reached a moderate imbalance. It shows that the urban infrastructure construction, urbanization construction, land, and water resources carrying capacity are weak. Turning point begins from 2010, each city has been out of the state of moderate disorders.

(3) From 2010 to 2013, cities are on the verge of imbalance, elementary coordination and moderate coordination, the coordinated development situation has improved. Luohe, Luoyang coordinated development are good and in a moderate coordination state in four years. As a well-known food city of Luohe, mainly due to strongly utilize the foreign funds and social funds for urban infrastructure construction, speed up the development and construction along the river, accelerate the new construction, its good ecological environment and infrastructure win a favor of foreign investors. Luoyang, as the deputy central city of Zhongyuan Urban Agglomeration, attach important attention to develop the heavy industry, technological innovation, new energy, environmental protection and other strategic emerging industries, promote the coordinated development of economy and resources and environment.

The results can be seen from the analysis of coordination development between environment and economic development of Zhongyuan Urban Agglomeration, the coordination degree is in low mediate level. Therefore, in the next period of time, while promoting steady economic growth, we should focus on protecting the environment, promoting the coordinated development of economy and environment. Accelerate the driving strategy of central city, strengthen the core city status of Zhengzhou City, enhance the status of deputy central city of Luoyang, develop Kaifeng and other seven growing

regional central cities, accelerate the development of developed and enhance the ordered infrastructure network system, build a sound coordination mechanisms of resources and environment, promote regional coordinated development, speed up the integration process, and make the Zhongyuan urban agglomeration be the backbone of promoting the Rise of Central China.

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