Evaluation on Green Transformation Competitiveness of Oil-gas Resource-based Cities in China

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Abstract. The green transformation is an important direction of the transformation of oil-gas resource-based cities. From the three aspects of environmental protection, resource utilization and transformation, a comprehensive evaluation index system for the competitiveness of the green transformation of oil-gas resources-based cities has been established, and the entropy method has been used to determine the index weights and the correlation matrix method to calculate the comprehensive evaluation score. The green transformation competitiveness of 10 typical oil-gas resources-based cities in China is evaluated. The results show that the green transformation effect of oil-gas resources-based cities in China is generally not obvious. Different cities have very obvious differences in transformation structures.

Keywords: Oil-gas resource-based cities; green transformation; sustainable development.

1. Introduction
The oil-gas resource-based city is an significant part of the resource-based city, and it is also an important basis for the modern economic system and an important catch for the coordinated development strategy of the urban. However, since the 1980s, oil-gas resource-based cities in China have entered the late stages of development, and many problems have emerged, such as: reduced resource reserves, single industrial structure, slow economic growth, and serious environmental pollution. In this context, the transformation of resource-based cities has become an important issue that has been widely concerned by governments and academia at all levels. In 2011, China's 12th Five-Year Plan for National Economic and Social Development clearly stated: "We must achieve a green transition in national economic and social development." In 2012, The report of the 18th National Congress of the Party further put forward the idea of "integrating resource consumption, environmental damage, and ecological benefits into the evaluation system of national economic and social development". The green transformation has become an important direction for the transformation of oil-gas resource-based cities, and has also become a hot spot in the study of oil-gas resource-based cities transformation. According to the current research results, there are little references about "green transformation", but more about "sustainable transformation", and "green transformation of resource-based cities" is a research theme with Chinese characteristics. China's research on "green transformation of resource-based cities" focuses on two aspects: First, the definition of green transformation in resource-based cities. Chun-bin LIU(2009) proposed a three-dimensional structure model with green transformation definition. And compared the differences between green transformation and general transformation of resource-based cities[1]; Xiu-xiu HOU(2018) defined the definition of the green transformation of resource-based cities based on the theory of human-land relationship coordination[2]. The second is the evaluation of the green transformation of resource-based cities. Chun-bin LIU(2009) designed seven guidelines(economy, society, resources, environment, enterprises, industry, and government) and evaluated Taiyuan City's green development capacity by using analytical hierarchy process[3]; Yan-qiU WANG(2012) examined the green transformation capacity of Daqing City by using...
the entropy method from five sub-systems of economy, society, resources, environment, and science and technology[4]; Gui-rong XIAO(2016) designed indicators based on the DPSIR model from five aspects of driving force, pressure, state, influence, and response to evaluate Taiyuan City's green transformation status combining the entropy method with TOPSIS[5]. Xiu-xiu HOU(2018) evaluated the green transformation situation of Dongying City from three aspects: green economy, green social development and green ecology by using a comprehensive scoring method[6]. Although green transformation in oil-gas resource based cities has not at all achieved in China, but it is a trend of sustainable development and the oil-gas resource based cities have already started green transformation.Chinese scholars have made some achievements in the study of the "green transformation of resource-based cities", but they have not yet formed a systematic theoretical system. They have basically reached a consensus on the core content of the connotation of the green transformation of resource-based cities. That is, "transformation from the general development style of excessive waste of resources, environment pollution, to the scientific style of resource conservation, recycling, and ecol-environment friendship, and from the development pattern in which people and nature deviate from each other and the economy, society, and ecology are separated, to the harmonious symbiosis between man and nature and the coordinated development of economy, society, and ecology[6]. However, the study on the evaluation of the green transformation of resource-based cities is still in the exploration stage. There are many views on the evaluation indicator system, and the systematic and representative selection of indicators is also worth discussing. Based on the research results, this paper selected 10 typical oil-gas resource-based cities to explore a comprehensive evaluation system combining entropy method and correlation matrix method for the competitiveness of oil-gas resource-based cities in green transformation development.

2. Research Design

2.1. Construction of the Indicator System

The purpose of constructing the assessment index system is to describe the status of the competitiveness in the green transformation of oil-gas resource-based cities. By comparing the competitiveness index, it is helpful to find out the problems existing in the green transformation of oil-gas resource-based cities. It also provides a scientific basis for effective recommendations for improvement. The evaluation index system was constructed following the principles of systematization, science, comparability and purpose. The specific construction ideas are: the index system is divided into four levels: the target level, the guideline level(the first-level indicator), the second-level indicator, and the third level indicator. The target level reflects the coordination of the green development and transformation development of oil-gas resource-based cities. The guideline level reflects the specific path to achieve the goal. It can also be regarded as a primary indicator. The secondary indicators develop specific areas with green transformation and development capabilities as the main theme within the subsystem constructed by the first-level indicator. The third-level indicators are based on the specific areas pointed out by the second-level indicators, and select measurable and comparable basic indicators to carry out the next operational quantitative analysis. Based on the "National Key Indicators for Sustainable Development of Resource-Based Cities" proposed in the National Plan for Sustainable Development of Resource-Based Cities(2013-2020)and the "Green Transition Development Regional Evaluation Indicator System" proposed by Zuo-jun Li[6], according to the characteristics of oil-gas resource-based cities, a comprehensive assessment index system for the competitiveness of oil-gas resource-based cities in green transformation was established, including 9 secondary indicators and 18 tertiary indicators(see table 1).
### Table 1. Evaluation index system of green transformation in resource-based cities.

| Target level | guideline level | The second-level indicator | The third-level indicator |
|--------------|----------------|---------------------------|---------------------------|
| green transformation in resource-based cities | environmental protection $P_1$ | emission reduction capacity | $P_{11}$ industrial waste-water emissions, $P_{12}$ industrial sulphur dioxide emissions, $P_{13}$ industrial smoke(powder) dust emissions |
| | | green capacity | $P_{14}$ urban park green area per capita |
| | | sewage control capacity | $P_{15}$ sewage treatment plant centralized treatment rate |
| | resource utilization $P_2$ | resource support capacity | $P_{21}$ water resources per capita |
| | | resource intensive capacity | $P_{22}$ energy consumption, $P_{23}$ water consumption per GDP, $P_{24}$ general industrial solid waste comprehensive utilization rate |
| | transformation development $P_3$ | economic development capacity | $P_{31}$ GDP per capita, $P_{32}$ GDP growth rate |
| | | structure optimization capacity | $P_{33}$ proportion of tertiary industry to GDP, $P_{34}$ proportion of tertiary industry employees |
| | | people's livelihood improvement capacity | $P_{35}$ number of registered unemployed persons in towns, $P_{36}$ average wage of employed workers |
| | | technological innovation capability | $P_{37}$R&D personnel, $P_{38}$R&D internal expenditure, $P_{39}$ patent applications |

2.2. Data Acquisition and Processing

The data needed for this paper are mainly from the "China Urban Statistics Yearbook 2018" and the "Urban Statistics Yearbook" of each target city. Some of the data are from the city statistical bulletin. A few missing data are replaced by the data of the previous year. Using the association matrix method to calculate the comprehensive score requires that the score of the indicator is comparable. The original data of the indicator has different dimensions and needs to eliminate the impact of different dimensions. Therefore, the linear proportional transformation method is used to standardize the original data of the indicator, namely:

For positive indicators $x_{ij}$, $y_{ij} = \frac{x_{ij}}{\max_{1 \leq i \leq n} x_{ij}}$, for reverse indicators $x_{ij}$, there are $y_{ij} = \frac{\min_{1 \leq i \leq n} x_{ij}}{x_{ij}}$.

$x_{ij}$ is the original data of the evaluation indicator, $y_{ij}$ is the standardized indicator score value. After the linear transformation, the indicator value is between 0 and 1, and the inverse indicator is uniformly positive. The optimal value is 1, and the worst value is 0.

2.3. Evaluation Methodology

The index weight is determined by entropy method and the comprehensive score of green transformation competitiveness is calculated by correlation matrix method. The entropy method determines the weight of the index based on the judgment matrix of the index value, which can exclude the influence of subjective factors, and the calculated weight is more objective. Therefore, the entropy method is chosen to determine the weight of the evaluation index. Since the entropy weight method has been widely used to determine the weight of indicators, the specific calculation process is not repeated. The principle of the correlation matrix method is to weighted average the score of individual indicators with the weight of the index. If the indicator number is $n$, the score of the indicator $j$ of city $i$ is expressed as $y_{ij}$, that is,
the value after the standardization of the original data; \( w_j \) indicates the weight of the indicator \( j \); \( V_i \) indicates the comprehensive score for the city \( i \); The calculation formula is:

\[
V_i = \sum_{j=1}^{n} w_j y_{ij}
\]

### 3. Empirical Analysis

According to the classification of resource-based cities in the *National Plan for the Sustainable Development of Resource-Based Cities (2013-2020)*, in accordance with the principle of comparability of sample selection and the principle of data availability, 10 typical cities were selected from oil-gas resource-based cities. As the research object of this article, they are: Daqing City, Dongying City, Kelamayi City, Tangshan City, Panjin City, Yan'an City, Yulin City, Songyuan City, Puyang City, and Nanyang City. The index data of the above 10 cities for 2017 are calculated by entropy method according to the classification of environmental protection, resource utilization, and transition development, and the weight of the third-level index relative to the guideline level can be obtained. It is possible to calculate the competitiveness scores of each city in environmental protection, resource utilization and transformation and development (see Table 2). According to the requirements of green transformation, these three aspects should be coordinated, so they are considered equally important.

| cities      | environmental protection | resource utilization | transition development | green transformation score | ranking |
|-------------|--------------------------|----------------------|------------------------|---------------------------|---------|
| Tangshan    | 0.0748                   | 0.4984               | 0.6216                 | 0.3986                    | 3       |
| Panjin      | 0.2829                   | 0.5878               | 0.2180                 | 0.3630                    | 6       |
| Songyuan    | 0.4583                   | 0.4619               | 0.1196                 | 0.3467                    | 7       |
| Daqing      | 0.1646                   | 0.4625               | 0.2595                 | 0.2957                    | 9       |
| Dongying    | 0.1511                   | 0.4618               | 0.6174                 | 0.4103                    | 2       |
| Puyang      | 0.7116                   | 0.2483               | 0.2180                 | 0.3926                    | 4       |
| Nanyang     | 0.2262                   | 0.4520               | 0.4312                 | 0.3699                    | 5       |
| Yan'an      | 0.2411                   | 0.4950               | 0.1610                 | 0.2992                    | 8       |
| Yulin       | 0.0677                   | 0.4145               | 0.2000                 | 0.2276                    | 10      |
| Kelamayi    | 0.3212                   | 0.7033               | 0.4195                 | 0.4814                    | 1       |

It can be seen from Table 2 that the green transformation competitiveness of Chinese oil-gas resource-based cities is at a relatively primary level, indicating that the green transformation and development process of oil-gas resource-based cities is slow and the transformation effect is not obvious. Among them, Kelamayi City scored the highest score of 0.4814, the following is Dongying City, with a combined score of 0.4103, indicating that the two cities are more competitive in green transformation. The comprehensive scores of Tangshan City, Puyang City, Nanyang City, Panjin City and Songyuan City all reached more than 0.3 points, indicating that the green transformation of these cities has made certain progress. Yan'an City, Daqing City and Yulin City have low comprehensive scores, indicating that the green transformation of these three cities needs to be further strengthened. The difference between the lowest score of Yulin City and the highest score of Kelamayi City is only 0.2538, which shows that there is little difference between the green transformation competitiveness of oil-gas resource-based cities in China.

According to the analysis of the score of the first-level index, the environmental protection competitiveness score of Puyang City is the highest, indicating that Puyang City has achieved good results in environmental protection. The Environmental Protection competitiveness score of Tangshan City and Yulin City is very low, and it is necessary to improve environmental protection awareness; Kelamayi city's resource utilization competitiveness score is the highest, and resource utilization competitiveness score of other cities is not much difference; In terms of transformation development,
Tangshan City and Dongying City are the most competitive, and the transformation and development competitiveness of other cities is generally low. The typical cities, such as Tangshan City and Dongying City, scored higher in terms of transformation development, but scored lower in terms of environmental protection, indicating that these two cities are mainly based on traditional transformation models and need to further strengthen the driving force of green transformation and development.

4. Conclusion

The new development concept demands that oil-gas resource-based cities achieve green transformation. An objective evaluation of the competitiveness of the green transformation of Chinese oil-gas resource-based cities will assist in understanding the progress of the green transformation of cities, finding out the problems and deficiencies in the green transformation and development, and providing ideas for further in-depth promotion of green transformation and development. Through the evaluation of the green transformation competitiveness of 10 typical Chinese oil-gas resource-based cities, the following conclusion is drawn: (1) The green transformation of oil-gas resource-based cities in China is at the initial stage, although some progress has been made. However, the transformation performance is generally not obvious, and the gap between cities is not large. (2) There are very obvious differences in the transformation structure between different cities. Some cities attach importance to environmental protection and resource utilization, but the transformation development have not achieved much; Some cities are developing rapidly, but environmental protection needs to be strengthened. The transformation of oil-gas resource-based cities must deal with the relationship between economic development and resource environment. We need to implement the new development concept of "openness, synergy, green, innovation and sharing", establish a resource-intensive technology system and production system, develop a circular economy, implement cleaner production, and achieve harmonious development between man and nature, economy and society. To accelerate the green transformation of oil-gas resource-based cities in China, we still have a long way to go. In our future research, we need to make a typical case study of the green transformation characteristics of oil-gas resource-based cities in different stages to find out the existing problems. Therefore, it can effectively promote targeted countermeasures to the green transformation of oil-gas resource-based cities.

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