An Evaluation on the Transformation of Energy-Based Cities in China

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Abstract. This paper selects 11 typical energy-based cities in China, constructs the transformation evaluation index system of energy-based cities, and adopts the principal component analysis to conduct comprehensive evaluation on transformative capability and transformation effect of these cities. The study found that, due to the solid economic base and abundant human resource reserve, supporting capacity of industrial transformation is strong in petroleum-based cities, whose transformation effects are also fairly good. Whereas there exists great difference in transformation effects among coal-based cities, which is mainly attributed to the significant difference in development stage, economic base, resource condition and industrial transformation policy of each city. Local governments are suggested to closely combine specific conditions of their city and take following measures to further promote the smooth transformation, such as optimize and upgrade the original industrial system, strengthen support for finance and monetary, create favorable external environment for the transformation etc.

1. Introduction
Since the “Tenth Five-Year Plan” period, energy-based cities in China have gradually introduced a series of policies in order to promote cities’ transformation and upgrading. After the “Eleventh Five-Year Plan”, energy-based cities have regarded adjustment of industrial structures and continuous industry cultivation as priorities, and have formulated fairly comprehensive mid-and-long term goals and plans for the industrial transformation. However, city transformation is a complex and long-term process. Therefore, in formulating the mid-and-long term plans and specific policies for transformation, it is necessary to define the socio-economic and cultural foundation of the city, by which the economic transformative capacity can be fully realized. In the course of transformation, with the change of social and economic environment, it is essential to monitor the transformation process and its effects in order to see if factors under existing transformation policies have advanced towards planned goals, and if the speed and quality of transformation have achieved anticipated targets. In view of this, conducting the comprehensive evaluation on energy-based cities’ transformation is of great practical significance.

Research in terms of the transformation of resources-based cities (including energy-based cities) of many scholars such as Melham et al. [1], Van der Ploeg and Poelhekkey [2], Nie et al. [3], Xue [4], Li and Zou [5], Wang and Zhang [6], etc. mainly focus on the adjustment of industrial structure, countermeasures of industrial transformation as well as the influence of life cycle, sustainable development on resources-based cities and market mechanism construction. The differences between this paper and previous studies are as follows. In accordance with the classification of dominant
resources, this paper conducts targeted research on energy-based cities (including coal-based cities, petroleum-based cities, gas-based cities) in the range of resource-based cities, which is rare in the existing studies. In addition, in the respect of research object, the previous research of resource-based cities mainly focuses on the development of resource-based industries from two perspectives: petroleum / coal industry development and mining area construction. In terms of research methods, the existing studies are lack of comprehensive research on the development situation of resource, ecological environment, society, economy and culture of specific Chinese resource-based cities. This paper concentrates on the systematic research of overall transformation of energy-based cities. It emphasizes the objective evaluation on transformative capacity and transformation effects of Chinese energy-based cities. Meanwhile, based on the deep analysis, some countermeasures and suggestions are put forward.

2. Design of the Index System

The transformation of energy-based cities focuses on transforming the former economic development mode which heavily depends on the resource-oriented industry, and avoids the situation of “mineral depletion and urban decay”. The stages of economy slowdown and unemployment rate increase may appear during the process. Therefore, without the guarantee of economic, social and cultural foundation, it would be difficult for energy-based cities to maintain the long process of economic transformation. At the same time, the transformation of energy-based cities not only includes the transformation of the industrial structure, but also includes the all-round transformation of employment structure, social psychology and urban environment. It covers many aspects and lasts for a long time. Therefore, it is required to timely evaluate transformation effects, summarize the experience and adjust the relevant policies in order to ensure the smooth transformation process. Considering the availability and observability of data, this paper selects 21 indexes as the research objects, and adopts the principal component analysis to study on the transformation of energy-based city [7], and adopts the principal component analysis to study on the transformation of energy-based cities (table 1).

3. Empirical Measurement

Applying standardized data of 21 indexes in 2006 and 2015, this section adopts principal component analysis to calculate and analyze the transformation process of 11 energy-based cities and sort the results. By adopting the statistical software to conduct principal component analysis, the variance contribution rate of every principal component in 2006 is obtained. In accordance with the requirements that the values of characteristic root and variance cumulative contribution rate are bigger than 85%, 5 principal components are selected in 2006 while 6 principal components are selected in 2015. Then the score of every principal component of 11 energy-based cities is obtained. Next, the total score and ranking of cities in 2006 (shown in table 2) are achieved according to the variance contribution rate of each principal component as the weight. In the same way, we can get the total score and ranking of cities in 2015.

4. Result and Discussion

Comparing the ranking changes of the above 11 energy-based cities in 2006 and 2015, we can analyze and compare these cities’ performance in the transformation process. The ranking among the 11 cities can be divided into three categories. In the first case, the ranking is unchanged. After 10 years development, the rankings of these cities do not change. The economic transformation is steady. Some cities maintain a higher level of development. In the second case, the city ranking is rising. These cities have made great efforts to achieve better results in their transformation. In the third case, the city ranking is declining, which indicates that the transformation process of these cities is slower due to the limitation of economic foundation etc. Detailed analysis on the city transformation is conducted as followed.
Table 1. Transformation evaluation index system of energy-based cities.

| Evaluation contents                        | Index                                      | Unit       | Tendency   |
|-------------------------------------------|--------------------------------------------|------------|------------|
| Evaluation of transformative city         | Economic supporting capacity               |            |            |
|                                           | GDP per capita                             | Yuan       | Positive-going |
|                                           | Growth rate of fiscal revenue              | %          | Positive-going |
|                                           | Financial self-sufficiency ratio           | %          | Positive-going |
|                                           | Proportion of fixed investments in GDP     | %          | Positive-going |
|                                           | Asset-liability ratio of industrial enterprises | %    | Positive-going |
| Educational and cultural foundation       | The number of college students in every ten thousand people | Person | Positive-going |
|                                           | Public library holdings in every one hundred people | Copy, article | Positive-going |
| Economic index                           | Proportion of output value of tertiary industry | %      | Positive-going |
|                                           | Employment structure of tertiary industry | %          | Positive-going |
|                                           | Economic growth rate                       | %          | Positive-going |
| Residents’ life quality index             | Average wage of workforce                  | Yuan       | Positive-going |
|                                           | Urbanization rate                          | %          | Positive-going |
|                                           | Beds in social welfare institutes          | Number     | Positive-going |
|                                           | The number of doctors in every ten thousand people | Person | Positive-going |
|                                           | Proportion of urban maintenance and construction fund in financial expenditure | % | Positive-going |
|                                           | Urban road area per capita                 | Square meter | Positive-going |
| Eco-environmental index                   | Sulphur dioxide emission per square kilometres | Ton | Negative-going |
|                                           | Green area per capita                      | Square meter | Positive-going |
|                                           | Attainment rate of the industrial waste water discharge | % | Positive-going |
|                                           | Processing rate of municipal wastewater    | %          | Positive-going |
| Resource utilization efficiency index     | Comprehensive utilization ratio of industrial solid waste | % | Positive-going |

4.1. City with Unchanged Ranking
The rankings of 4 cities among the 11 energy-based cities are not change. They are Dongying (rank 1st), Shizuishan (rank 2nd), Panjin (rank 3rd) and Liaoyuan (rank 9th). It is coincidental that the Top 3 cities are unchanged. Dongying and Panjin belong to petroleum-based cities. The economic benefits of petroleum industry are generally good. The resource decline is not obvious. The GDP per capita of the two cities ranks Top 2, which indicates that the economic supporting capacity is strong. Dongying ranks first among the 11 cities in terms of GDP per capita and total fixed assets, so the economic supporting capacity of city transformation is fairly good. With regard to population quality, Dongying ranks first in the aspects of the number of college students in every ten thousand people and the number of public libraries in every one hundred people, which indicates that the knowledge capacity
of city transformation is fairly good, providing sufficient intellectual support for the transformation. In the case of environmental protection, the success rate of industrial wastewater discharge reaches 100%. The processing rate of municipal wastewater ranks third. The per capita green area ranks second, which has big difference compared with Shizuishan. It is suggested that the environmental protection of Dongying should be strengthened. From the perspective of resource utilization, the comprehensive utilization ratio of industrial solid waste in Dongying ranks second, which indicates that its resource utilization is fairly good to some extent. The proportion of employment in resource-based industries of Dongying is lower among the 11 cities, which indicates that the employment is gradually getting rid of the mode of relying on resource-based industry. The GDP per capita of Panjin ranks second among the 11 cities, which indicates that the economic base of city transformation is fairly good. The other indexes of transformation effects are overall good, for example, the number of doctors in every ten thousand people ranks first among all cities. Other indexes of Panjin have little highlights. Thus the higher ranking mainly benefits from the solid economic base. It is suggested that Panjin Municipal Government should take effective measures to consolidate the achievements of city transformation and actively improve other indexes. Though Shizuishan city in Ningxia province is a western city, it has been listed as the pilot city of resource-exhausted transformation with state approval. The indexes of economy, people’s livelihood and environmental protection are generally high, which indicates that, with the guarantee of strong economy, social security and human capital, the transformation effect of Shizuishan is consistently maintained at a higher level. At present, the city mainly focuses on “mass entrepreneurship and innovation” as the city positioning [8]. It will take a certain time to see the better effect of further improvement of transformation.

Table 2. Score table and ranking of energy-based cities in 2006.

| City   | Principal Component 1 | Principal Component 2 | Principal Component 3 | Principal Component 4 | Principal Component 5 | Comprehensive core | Ranking |
|--------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|---------|
| Fushun | -0.5407               | 2.3562                | 0.2618                | 1.9801                | -0.7237               | 0.2689             | 4       |
| Fuxin  | -3.7469               | 0.6456                | -0.5238               | 0.2720                | -0.5963               | -1.5577            | 11      |
| Liaoyuan | -2.0956             | 2.6942                | -1.6662               | -2.2513               | -0.0165               | -0.8750            | 9       |
| Qitaihe | -3.3464              | -0.0295               | 1.5608                | -0.6603               | -0.3943               | -1.2917            | 10      |
| Huaibei | -1.0980              | -1.2399               | 0.5968                | 1.0060                | -0.1486               | -0.4942            | 7       |
| Pingxiang | -0.8213            | -2.0777               | -0.6151               | 0.7891                | 0.7906                | -0.5989            | 8       |
| Zaozhuang | 0.5499              | -0.5848               | -2.0234               | 1.7780                | 0.4621                | 0.0759             | 5       |
| Jiaozuo | 0.8494               | -1.6316               | -1.3011               | -1.4217               | 2.1507                | 0.0001             | 6       |
| Shizuishan | 1.0246             | 0.4146                | 3.7710                | -0.3069               | 1.4483                | 1.0555             | 2       |
| Dongying | 6.9750              | 1.8384                | -0.3068               | 0.0266                | -0.0782               | 3.1408             | 1       |
| Panjin  | 2.2502               | -2.3855               | 0.2461                | -1.2115               | -2.8941               | 0.2761             | 3       |

4.2. City with Rising Ranking
The rankings of 4 cities are rising, including Fuxin (from 11th in 2006 to 10th in 2015), Huaibei (from 7th in 2006 to 5th in 2015), Pingxiang (from 8th in 2006 to 7th in 2015) and Zaozhuang (from 5th in 2006 to 4th in 2015). Although the per capita GDP of Huaibei is fairly low, the average wage of workers ranks first among all the coal-based cities. In addition, the resource utilization efficiency of Huaibei is relatively high. The indexes including success rate of industrial wastewater discharge, processing rate of municipal wastewater, water consumption of one hundred million GDP and comprehensive utilization ratio of industrial solid waste are all superior to other coal-based cities. It shows that Huaibei has gradually changed the former development mode which mainly relies on high energy consumption and high pollution. However, the employment proportion of the resource-based industries in Huaibei is still high, so the government should further strengthen the guidance of
employment and the cultivation of new industries. Fuxin is free of the bottom of list; it ranks a lowly tenth in 2015. In December 2001, Fuxin was established as the first pilot city of resource-based transformation city in China by the State Council. The splendid city ever devoted nearly 700 million tons of coal to the country. However, today it presents low level of economic development and resource reduction, high unemployment rate, loss of population and serious pollution. In 2015, Fuxin ranks first in sulphur dioxide emissions per square kilometre among the 11 cities, which indicates that the city is still adopts the high-emission production. In addition, the city’s per capita urban road area also ranks the last. The government is supposed to increase the investment of urban infrastructure construction, so as to promote the smooth transformation. After the coal mining for many years, Zaozhuang’s coal production has been attenuated. In the recent transformation process, Zaozhuang has made great efforts to develop the coal chemical industry and tourism industry. The speed of new industry cultivation is accelerating. The transformation exploration has made some achievements as well. The ranking of Zaozhuang is increasing among the 11 energy-based cities. However, the proportion of the second industry in Zaozhuang is still high, which is 52.7% in 2015. The ecological environment problems are still serious. Therefore, it urgently needs to change from energy-dependent mode to innovation-driven mode in order to improve the city’s overall competitiveness [9].

4.3. City with Declining Ranking
During 2006-2015, rankings of 3 cities are declining, including Fushun (from 4th to 6th), Qitaíhe (from 10th to 11th) and Jiaozuo (from 6th to 8th). Among these 3 cities, both Fushun and Qitaíhe are located in the three provinces of Northeast China. Combining the city of Fuxin and Liaoyuan with lower rankings, the overall transformation effect of energy-based cities in the three provinces of Northeast China is poor. Due to the poor economic development of the Northeast three provinces and the depression of the coal market in recent years, Qitaíhe becomes the only city with negative economic growth among the 11 cities. Energy-based cities in the Northeast three provinces are generally faced with energy exhaustion. The speed of industrial transformation is slow. The indexes of social security and environmental protection are relatively low. It is suggested that governments should further transform their functions in order to promote the transformation and upgrading of energy-based cities.

5. Conclusion and Suggestion
Indexes of city transformation could be divided into two categories. One is evaluation index of transformative capacity, which is used for measuring economic supporting capacity, educational and cultural foundation and social security capability of city transformation. The other is evaluation index of transformation effect, which measures the city transformation effect from the perspectives of speed and structure of economic development, life quality of residents, environmental protection and resource utilization. By adopting principal component analysis to comprehensively evaluate the transformation of 11 Chinese energy-based cities, we find that due to the solid economic base and abundant human resources reserve, petroleum-based cities have better transformation effects. There exist great differences in transformation effects among coal-based cities owing to obvious differences in their development stage, regional economic environment, resource conditions and industrial transformation policies. Therefore, each government should closely combine cities’ specific conditions, formulate and timely adjust relevant policies and measures, so as to ensure the smooth transformation. For example, it is suggested to optimize and upgrade the original industrial system, promoting the development of modern agriculture and service industry. Financial supports should be further strengthened, encouraging banks to innovate financial products according to different industrial transformation projects and new industries. Moreover, it is suggested to improve the employment and social security, control environmental pollution by replanning the regional distribution of industries, and create a good external environment for transformation by building the urban cultural atmosphere which encourages the private economy development.
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