Environmental protection of resource-based cities around the Bohai Sea from an ecological perspective

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Abstract. The huge demand promotes the continuous increase of the demand for resources by industrial enterprises, and the exploitation of resources will also cause ecological and environmental problems. This paper takes resource-based cities in the Bohai Rim region as the research object, analyzes the development status of the Bohai Rim resource-based cities from the perspective of ecological protection and explores the problems in them, which is beneficial to provide a reference for the green development of resource-based urban industrial enterprises, thereby reducing ecological pollution. Analyze the status quo of industrial development by measuring the deviation and advancement of the industrial structure. The results show that the level of industrial advancement in resource-based cities around the Bohai Sea has a downward trend; the degree of industrial structure deviation has an upward trend. On the whole, the protective strategies for accelerating the green development of industries in resource-based cities around the Bohai Sea and promoting ecological governance are derived: industrial adjustments must be carried out in a scientific and orderly manner, and the proportion of development among the three industries must be balanced; technological innovation is used to promote the green development of industrial structure.

1. Introduction
In October 2015, the National Development and Reform Commission issued the "Outline for Cooperation and Development in the Bohai Rim Region", proposing to delimit the administrative regions of Beijing, Tianjin, Hebei, Liaoning, Shandong, Shanxi, and Inner Mongolia Autonomous Region as the ring Bohai area. This signifies that the concept of the Bohai Sea Rim has risen from spontaneous regional cooperation to a concept with a national strategic position. As the core area for economic development in northern my country, its mineral resources are generally relatively complete. The total amount is large but the per capita is small. The reserves of large-scale minerals are slightly insufficient compared with other regions, but the rare earth mineral resources are abundant, forming a rich and diverse resource structure. The sustainable development of resource-based cities plays a fundamental and crucial role in the sound operation of the regional economy. The Bohai Rim region is also a resource-based industry cluster, and the formation and characteristics of its industrial structure are affected by the resource structure. Therefore, a reasonable evaluation of the status quo of the industrial structure transformation and upgrading of the resource-based cities in the Bohai Rim region will help to explore and change the economic development model of the Bohai Rim region, thereby...
driving the region to achieve overall industrial optimization and upgrading and regional coordinated and sustainable development.

2. Literature review
The current research on the transformation and upgrading of the industrial structure of resource-based cities mainly focuses on the following two aspects: One is to study the relationship between the industrial transformation and upgrading of resource-based cities and economic growth. In the 1990s, western scholars put forward major research finding that resource enrichment has a negative correlation with economic growth [1], highlighting the urgency of the problems faced by industrial transformation. Some scholars in my country found the positive impact of industrial transformation on economic growth based on the industrial transformation index [2]. The second is to analyze the effects and influencing factors of the industrial transformation of resource-based cities. Some foreign scholars have evaluated the effects of industrial transformation in different resource-based communities [3], and the results show that the main driving factor for industrial transformation in resource-based cities is technological innovation [4]. Domestic scholars have also made relevant measurements for the industrial transformation of resource-based cities. The DEA method is currently the mainstream method for evaluating the industrial transformation and development of resource-based cities [5].

To sum up, the existing studies mostly focus on case studies of resource-based cities or start from a certain local perspective. Generally speaking, regional and macro perspectives are more general and have more reference significance. Therefore, this article takes the national strategic regional level—the Bohai Rim region as an example to measure the rationalization and advancement of the industrial structure of resource-based cities, and clarify the current problems facing industrial transformation and upgrading to propose relevant transformation strategies.

3. Research methods

3.1. Deviation degree of industrial structure
The deviation degree of industrial structure reflects an asymmetry and unsuitable state between the employment structure and the industrial structure, as well as the coupling between the output structure and the employment structure. This article is used to measure and reflect the synergy of the industrial structure. The calculation formula is:

\[
P = \sum_{i=1}^{n} \left( \frac{Y_i}{L_i} \right) \ln \left( \frac{Y_i}{Y} \right) \frac{L_i}{L}
\]  

(1)

Among them, P is the deviation degree of the industrial structure, Li is the number of employees in the i industry, L is the total employees, Yi is the output value of the i industry, and Y is the total output value. N is the number of industry categories, where N =3. The larger the value of P, the more unreasonable the industrial structure, which is a negative indicator.

3.2. Advanced industrial structure
The measurement of advanced industrial structure selects the hierarchical coefficient of industrial structure to express. The calculation formula is:

\[
h_{i,t} = \sum_{n=1}^{3} y_{i,n,t} \times n, n = 1, 2, 3
\]

(2)

In the formula, \( y_{i,n,t} \) represents the ratio of the total output value of the n industry in city i to the regional GDP in year t, and \( h_{i,t} \) reflects the process of gradual evolution from the primary industry to the secondary and tertiary industries. The larger the value of \( h_{i,t} \), the higher the level of industrial structure, which is a positive indicator.
4. Industrial transformation and upgrading measurement

4.1. Deviation degree of industrial structure

In the process of industrial structure change, maintaining the deviation degree of industrial structure at a relatively low level is very important for the development of economic benefits. Comparing the evolution trends of resource-based cities in the Bohai Rim and all cities in the Bohai Rim, it can be seen (Fig. 1) that the deviation of the industrial structure of resource-based cities is on the rise, reflecting the increasing irrationality of employment structure and output value structure. This may be due to the failure to form substitute industries in time and the mismatch of human capital and physical capital when the mineral resources of the resource-based cities around the Bohai Sea are gradually approaching exhaustion, leading to the risk of decline in the benefits of the industrial structure. Looking at the interior of the resource-based cities around the Bohai Sea (Table 1), the top 5 cities in the ranking are Fushun, Anshan, Tangshan, Zibo, and Dongying. The bottom five are Handan, Fuxin, Jining, Chengde and Xingtai. It can also be seen from Table 1 that resource-based cities around the Bohai Sea have relatively large internal differentiation characteristics.

Figure 1. Overall evolution trend of deviation degree of resource-based cities in the Bohai Rim

Table 1. Calculation results of the deviation degree of the industrial structure of resource-based cities around the Bohai Sea from 2004 to 2018

|        | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Mean | Ascending ranking |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------------------|
| Fushun | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 | 0.05 | 0.03 | 0.02 | 0.04 | 0.04 | 1 |
| Anshan | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.05 | 0.06 | 0.06 | 0.09 | 0.09 | 0.13 | 0.11 | 0.08 | 0.05 | 2 |
| Tangshan | 0.08 | 0.06 | 0.05 | 0.05 | 0.05 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.09 | 0.09 | 0.11 | 0.12 | 0.08 | 0.07 | 3 |
| Zibo   | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.13 | 0.13 | 0.13 | 0.12 | 0.10 | 0.12 | 0.08 | 4 |
| Dongying | 0.09 | 0.14 | 0.11 | 0.09 | 0.09 | 0.08 | 0.08 | 0.03 | 0.05 | 0.09 | 0.08 | 0.09 | 0.14 | 0.11 | 0.13 | 0.09 | 5 |
| Benxi  | 0.06 | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 | 0.07 | 0.07 | 0.08 | 0.13 | 0.12 | 0.12 | 0.10 | 0.12 | 0.10 | 0.10 | 6 |
| Zaozhuang | 0.17 | 0.18 | 0.16 | 0.16 | 0.15 | 0.15 | 0.13 | 0.10 | 0.19 | 0.30 | 0.26 | 0.28 | 0.21 | 0.20 | 0.19 | 0.17 | 0.19 | 7 |
| Huludao | 0.17 | 0.19 | 0.16 | 0.15 | 0.14 | 0.13 | 0.16 | 0.19 | 0.20 | 0.21 | 0.21 | 0.25 | 0.20 | 0.31 | 0.39 | 0.20 | 8 |
| Linyi  | 0.29 | 0.26 | 0.23 | 0.22 | 0.23 | 0.22 | 0.17 | 0.16 | 0.19 | 0.24 | 0.25 | 0.24 | 0.21 | 0.30 | 0.23 | 9 |
| Tai'an | 0.18 | 0.27 | 0.23 | 0.21 | 0.25 | 0.21 | 0.20 | 0.20 | 0.27 | 0.29 | 0.27 | 0.22 | 0.21 | 0.18 | 0.34 | 0.24 | 10 |
| Panjin | 0.26 | 0.32 | 0.34 | 0.31 | 0.30 | 0.18 | 0.24 | 0.26 | 0.25 | 0.20 | 0.19 | 0.18 | 0.17 | 0.25 | 0.21 | 0.24 | 11 |
| Laiwu  | 0.23 | 0.08 | 0.07 | 0.22 | 0.06 | 0.06 | 0.72 | 0.07 | 0.07 | 0.09 | 0.67 | 0.29 | 0.69 | 0.52 | 0.50 | 0.29 | 12 |
| Zhangjiakou | 0.22 | 0.25 | 0.26 | 0.24 | 0.27 | 0.24 | 0.27 | 0.32 | 0.22 | 0.39 | 0.42 | 0.41 | 0.40 | 0.56 | 0.43 | 0.33 | 13 |
| Handan | 0.28 | 0.29 | 0.29 | 0.32 | 0.32 | 0.36 | 0.41 | 0.17 | 0.42 | 0.43 | 0.41 | 0.40 | 0.36 | 0.35 | 0.35 | 14 |
| Fuxin | 0.32 | 0.34 | 0.24 | 0.28 | 0.30 | 0.31 | 0.38 | 0.40 | 0.38 | 0.37 | 0.30 | 0.40 | 0.36 | 0.35 | 0.79 | 0.37 | 15 |
| Jining | 0.26 | 0.44 | 0.39 | 0.37 | 0.36 | 0.37 | 0.38 | 0.37 | 0.34 | 0.39 | 0.39 | 0.38 | 0.38 | 0.39 | 0.40 | 0.37 | 16 |
| Chengde | 0.30 | 0.30 | 0.33 | 0.36 | 0.43 | 0.31 | 0.34 | 0.41 | 0.39 | 0.39 | 0.43 | 0.46 | 0.41 | 0.45 | 0.45 | 0.38 | 17 |
| Xingtai | 0.53 | 0.58 | 0.55 | 0.52 | 0.49 | 0.53 | 0.58 | 0.57 | 0.55 | 0.59 | 0.64 | 0.59 | 0.53 | 0.54 | 0.49 | 0.55 | 18 |
4.2. Advanced industrial structure

The measurement of the coefficient of advanced industrial structure can reflect the relative level of urban economic development and the overall direction of development in the region. Comparing the evolution trends of resource-based cities in the Bohai Rim and all cities in the Bohai Rim (Fig. 1), it can be seen that the industrial advancement coefficient of resource-based cities is significantly lower than the overall average level of the Bohai Rim. Combining the calculation results listed in Fig. 2 and Table 3, the changing trend of the coefficient of advanced industrial structure in many cities is relatively flat. From the perspective of the resource-based cities around the Bohai Sea, the top 5 cities with the industrial structure advancement coefficient are Tangshan, Jining, Zibo, Linyi, and Handan. The bottom five are Fushun, Benxi, Huludao, Laiwu, and Fuxin, reflecting the large differences in the industrial structure of resource-based cities around the Bohai Sea.

![Graph showing the overall evolution trend of the coefficient of advanced industrial structure with specific data points for resource-based cities around the Bohai Sea.](image_url)

**Figure 2.** The overall evolution trend of the coefficient of the advanced industrial structure of resource-based cities around the Bohai Sea

| City         | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Mean | Descending ranking |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------------------|
| Tangshan     | 0.24 | 0.24 | 0.24 | 0.24 | 0.26 | 0.25 | 0.25 | 0.26 | 0.25 | 0.24 | 0.23 | 0.24 | 0.25 | 0.23 | 0.24 | 0.23 | 0.24 | 1                |
| Jining       | 0.17 | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 2                |
| Zibo         | 0.17 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 3                |
| Linyi        | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.16 | 4                |
| Handan       | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 5                |
| Dongying     | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 6                |
| Tai'an       | 0.11 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 7                |
| Anshan       | 0.14 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.09 | 0.08 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 8                |
| Xingtai      | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 9                |
| Zaozhuang    | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 10               |
| Zhangjiakou  | 0.06 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 11               |
| Chengde      | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 12               |
| Panjin       | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 13               |
| Fushun       | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 14               |
| Benxi        | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 15               |
| Huludao      | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 16               |
| Laiwu        | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 17               |
| Fuxin        | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 18               |
5. Conclusion
The overall competitiveness of a region depends on whether the city where the industry is in trouble can successfully achieve industrial transformation and upgrading, which directly determines the potential for sustainable economic development in the region. Resource-based cities are now facing major development difficulties and have attracted the attention of the central government. The Bohai Rim region is the core area of China's economic development and the forefront of its opening strategy. The transformation of the Bohai Rim resource-based cities is of great significance to its overall development. Based on this, this article uses the corresponding indicators to compare and measure the industrial development situation in the Bohai Rim region from the aspects of industrial transformation and upgrading and rationalization. The main conclusions are: the growth trend of the index of advanced industrial structure is relatively slow, and the deviation degree of industrial structure also shows an unfavorable upward trend.

through the above conclusions, relevant suggestions are put forward for the industrial transformation and development of resource-based cities around the Bohai Sea:

First, we must carry out industrial transformation in a scientific and orderly manner, and balance the development proportions of the three industries. As the resource-based cities around the Bohai Sea are located in the core area of economic development in northern my country, industrial transformation and upgrading are showing urgency, and the rash pursuit of advanced industrial structure will be counterproductive. The transformation and development of resource-based city industries need to identify their own positioning, focus on key areas, and accelerate the formation of new strategic emerging industrial clusters. To transform resource advantages into industrial advantages, it is necessary to explore new industrial development models, create distinctive urban industry labels, formulate relevant policies based on their own advantages, and eliminate blind industrial upgrading behavior.

Second, a number of high-tech clusters should be formed as soon as possible in resource-based cities. Resource-based cities should combine their own foundations to seek industries with strong transformational motivation when choosing continued industries, and appropriately develop tertiary industries. Transform and upgrade industries such as iron and steel, energy and chemical industry, equipment manufacturing, actively introduce and undertake the transfer of non-capital functional industries, vigorously develop advanced manufacturing industries such as new-generation information technology, energy-saving and environmental protection equipment, construction machinery, new materials, and new energy, and accelerate the promotion of low-end industries towards the mid-to-high-end level. At the same time, in accordance with the main function zone planning, reasonable planning guides the industrial layout of resource-based cities, and promotes the development of characteristic industrial tourism industries that take resources as the advantage. Promote the innovative development of resource-based urban industrial parks. Build a batch of national and provincial industrial parks with important influence in the Bohai Rim.

Third, to enhance comprehensive competitiveness when optimizing the industrial structure and promoting industrial development. It is necessary to give full play to the comparative advantages of the industrial base, enhance the city's technological innovation capabilities, focus on the development of resource deep processing industries, promote the transformation of resource advantages into economic advantages, extend the resource industry chain, and develop a circular economy. At the same time, it links the optimization and upgrading of the industrial structure with the increase of jobs and the protection of people’s lives, and combines the resources and industrial advantages of the resource-based cities in the Bohai Sea to develop regional logistics, characteristic tourism, cultural exhibitions and other service industries to enhance the lifting effect of industrial competitiveness of resource-based cities on economic growth. To optimize the industrial structure and improve the quality of industrial transformation as a breakthrough for resource-based cities to achieve sustainable development, transform and upgrade traditional resource-based industries, develop green extractive industries, cultivate superior alternative industries, accelerate the development of modern comprehensive service industries, and encourage experimental development strategic emerging industries.
Finally, the government of each resource-based city should actively create a social atmosphere of "Mass Entrepreneurship and Mass Innovation", increase corporate innovation awareness, and change public entrepreneurship concepts, so as to promote traditional enterprises to move toward the high end of the value chain, enhance the economic and social vitality of resource-based cities, break through the cognitive lock brought by traditional business concepts and employment concepts, and promotes the cultivation and development of advantageous alternative industries in an open and inclusive social environment.

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