The evaluation of the coordination degree between resource-environment and economic development in the yellow river delta-a case study on Dongying city

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Abstract. Dongying city is located in the mouth of the Yellow River and it is the most important central city in the Yellow River Delta. This area’s ecological environment is very weak. When we maintain the economic development, we must coordinate the relationship between the environment and economy. This paper used principal component analysis and coordination degree evaluation index system and the calculation model to assess the coordination degree of economic and environmental development in Dongying city from 2011 to 2015. The results showed that the coordinate degree of Dongying’s environment and economic development belonged to the type of coordinated development. However, the economic level was significantly higher than its level of the environment. The coordination of the economy and environment in Dongying was not stable, with a certain degree of volatility. This paper analyzed the causes of the coordination degree situation in Dongying, and put forward some suggestions of coordinated development of the ecological environment and economic in Dongying city.

1. Introduction
With the increasingly serious global environmental problems, the sustainable development becomes the consensus of the world. As we all know, the environment is not only the resources but also the restriction conditions of development. Today, the essence of environmental problems is that the speed of human asking to the environment for resources in the economic activities is faster than the regeneration speed of resource itself and its substitutes significantly. And the quantity of waste discharged into environment more than the self-purification ability of environment. Therefore, coordinated development has become the best choice to deal with the relationship between environment resources and economic development. It is the only way to realize the sustainable
development strategic goal of the human society (Zhou Detian, et al, 2010; LU Ning, et al, 2015; Li N, Wang Kuifeng, 2016, DU Zhongchao, B Wenting, 2015).

Yellow River delta is located in the northeast of Shandong province. It is the only river delta which has not been fully developed and it is a piece of young land. Because of the Yellow River delta became land time is short, its ecological environment is fragile and the environmental bearing capacity is low. The environmental quality must be improved to realize the sustainable development of the Yellow River delta regional economic. Promote coordinated development of environment and economy. Therefore, this article selects environmental and economic data of Dongying City in 2011-2015, using principal component analysis (PCA) method and the data model to calculate the coordination degree between them, to fully recognize the coordination degree of Dongying City resources environment and economic development situation. To make corresponding policy adjustment according to the changes of the coordination degree in a timely manner, in order to promote the efficient ecological economic zone of Dongying City and even the sustainable development of the Yellow River delta. The coordination level between the two states were calculated with coordination degree C model, Countermeasures and suggestions were put forward based on the evaluation results, the index and flow chart of research were shown in the following table 1, table 2.

2. Construction of Index System and Model

2.1. Index Selection Principle

The sustainable development evaluation index system of oil and gas resource-based city reflected the development present situation and trends of economy, society, resource, environment four systems in complex system, as well as the coordination of the four systems. In addition to consider the basic ideological and the general principles of sustainable development, it should reflect the characteristics of oil and gas resources city. The system of urban economic development and resources environment is complex, so it should be evaluated objectively and right. We must establish a set of quantitative factor index system that could reflects regional economy and environmental quality from different sides and possess statistical significance under the guidance of scientific, comprehensive, operability, dynamics and stability. According to the specific condition of Dongying City and the difficulty to obtain index, we selected Xi (i = 1, 2, 3,..., 11) as the indexes of economic characteristics to set up the economic evaluation index system (table 1), and selected Yi (I = 1, 2, 3,..., 8) as the indexes of resources environment characteristics to set up the resources and environment index system (table 2). The index system of resources environment and economy coordinated development of Dongying City has been constructed.

The resources and environment indexes in this system included qualitative and quantitative indexes, and the social and economic indexes in this system were all quantitative indexes. Quantitative indexes were calculated with the data which mainly referred to Shandong Statistical Yearbook, Dongying Statistical Yearbook, Yearbook of Counties of Dongying, National Economy and Society Developed Statistical Bulletin of Dongying, China Environmental Statistics Yearbook, Dongying Water Gazette and Dongying Environment Gazette in 2011-2016. Qualitative indexes were mainly graded through various industries (e.g., land, environmental protection, land, forestry, Marine and other) investigation and study reports in recent years, their credibility and reliability were high.
Table 1 Resource and Environmental indicators, Dongying City, 2011-2015

| Year indicators                                                                 | 2011    | 2012    | 2013    | 2014    | 2015    |
|--------------------------------------------------------------------------------|--------|--------|--------|--------|--------|
| Resources abundance of oil and gas                                            | 2.8    | 3.2    | 3.4    | 3.4    | 3.8    |
| Per capita area of available cultivated land (Ha/per)                         | 0.152  | 0.15   | 0.142  | 0.14   | 0.136  |
| Land development intensity (The proportion of construction land area) (%)     | 17.702 | 18.024 | 18.536 | 19.166 | 19.646 |
| Total water consumption (10K m$^3$)                                           | 100212 | 93300  | 90274  | 92354  | 97478  |
| Repeat utilization rate of industrial water (%)                               | 50.792 | 45.32  | 54.2771| 72.594 | 68.04  |
| Irrigative water effective utilization coefficient                             | 0.627  | 0.621  | 0.63904| 0.6438 | 0.65   |
| Qualified rate of industrial waste water discharge (%)                        | 98.2   | 97.8   | 98.8   | 99.2   | 99.6   |
| Decontamination rate of urban refuse (%)                                      | 100    | 100    | 100    | 99.4   | 98.4   |
| Qualified rate of centralized drinking water sources quality (%)              | 100    | 100    | 100    | 99.6   | 98.8   |
| Fineness rate of air quality (%)                                              | 90.8   | 89.6   | 86.6   | 83.4   | 80.4   |
| Mean annual concentration of inhalable particle (mg/m$^3$)                    | 0.1196 | 0.1232 | 0.1446 | 0.1434 | 0.1572 |
| Mean annual concentration of SO$_2$ (mg/m$^3$)                               | 0.4244 | 0.4524 | 0.7414 | 0.7924 | 0.8466 |
| Mean annual concentration of NO$_2$ (mg/m$^3$)                               | 0.0448 | 0.053  | 0.0546 | 0.0602 | 0.0658 |
| Solid waste comprehensive utilization rate (%)                                | 94.72  | 96.114 | 97.096 | 97.158 | 98.124 |
| Per capita area of urban greenbelt (m$^2$)                                    | 21.232 | 24.68  | 26.76  | 27.318 | 27.848 |
| Forest coverage rate (%)                                                      | 22.698 | 21.71  | 23.466 | 24.694 | 24.616 |
| Wetland area relative ratio                                                   | 2      | 2.2    | 2.4    | 2.6    | 3      |
| Shoreline development intensity                                               | 2.2    | 2      | 1.6    | 1.6    | 1.6    |
| Regional crustal stability                                                    | 2.8    | 2.4    | 2.2    | 2.2    | 1.8    |
| Geological disasters risk                                                     | 2.8    | 2.4    | 2.4    | 1.8    | 1.8    |
| Relative area of all kinds of ecological reserve                              | 1.8    | 2      | 2.4    | 2.8    | 2.8    |
| Pollution level of water and soil caused by oil                               | 3      | 3      | 2.8    | 2.4    | 2      |

Remarks: These seven indexes including resources abundance of oil and gas, wetland area relative ratio, shoreline development intensity, regional crustal stability, geological disasters risk, relative area of all kinds of ecological reserve, pollution level of water and soil caused by oil were qualitative indexes.
Table 2 Economic indicators, Dongying City, 2011-2015

| Economic indicators                                      | 2011      | 2012      | 2013      | 2014      | 2015      |
|---------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|
| Environmental governance investment as a share of GDP (%) | 1.468     | 1.642     | 1.648     | 1.662     | 1.78      |
| Per capital GDP (million yuan)                          | 8.0794    | 9.364     | 10.026    | 11.048    | 11.424    |
| Fiscal revenue as a share of GDP (%)                    | 9.512     | 9.952     | 7.556     | 6.98      | 6.672     |
| Growth rate of investment in fixed assets (%)           | 27.06     | 23.54     | 20.648    | 16        | 10.904    |
| Disbursement of foreign capital (million dollar)        | 11806.3   | 12005.4   | 15448     | 18735     | 11725     |
| Total export-import volume (hundred million dollar)     | 67.8186   | 75.64     | 82.44     | 86.02     | 80.35     |
| Urban per capita disposable income (yuan)                | 24961.64  | 28119.16  | 30870.6   | 33556.4   | 33614.4   |
| Per capita living space                                 | 36.354    | 37.252    | 41.03     | 41.03     | 39.76     |
| Industrial output (hundred million yuan)                | 5936.02   | 7629.1    | 9015.23   | 10444.76  | 10661.74  |
| Engel coefficient (%)                                   | 28.97     | 28.664    | 28.888    | 30.03     | 28.746    |

2.2. Standardization of Data

The raw data differ in dimension and quantity size, therefore, it need to be standardized by extremum method. The purpose is to eliminate dimension and to make all the data comparability, so that they can reflect the relative of the situation of Dongying City each year. It is important to note that the resource and environmental indexes including mean annual concentration of inhalable particle, mean annual concentration of SO2, mean annual concentration of NO2, shoreline development intensity, regional crustal stability, geological disasters risk and pollution level of water and soil caused by oil were negative indexes, others were positive indexes. In certain value range, positive indexes were the larger, the better, and negative indexes were as small as possible. The formula as:

\[
\begin{align*}
X'_{i,j} &= \begin{cases} 
  \left( x_{i,j} - x_{i,\text{min}} \right) / \left( x_{i,\text{max}} - x_{i,\text{min}} \right) & \text{for } X_{i,j} \text{ Negative index} \\
  \left( x_{i,j} - x_{i,\text{min}} \right) / \left( x_{i,\text{max}} - x_{i,\text{min}} \right) & \text{for } X_{i,j} \text{ Positive index}
\end{cases}
\end{align*}
\]

Where \( X_{i} \) is initial data, \( X_{i}' \) is the data which has been standardized, \( X_{i,\text{min}} \) is the minimum value in initial data, \( X_{i,\text{max}} \) is the maximum value in initial data.

2.3. Calculation of Comprehensive Evaluation Indexes

In order to minimize the artificial influence, principal component analysis (PCA) was used to calculate integrated development indexes in economic system and resource environment system, respectively. The standardized data was analysed by PCA using the SPSS analysis software (IBM SPSS Statistics 21), to determine the characteristic root correlation matrix, the contribution rate of each principal component and cumulative contribution rate. The cumulative contribution rate of the former \( k \) composition which is greater than 85% reflects the basic original indexes of main information.

2.4. Coordination Degree Model

Coordination degree is the degree of harmony in the development and evolution process between systems or components in system. It could reflect the trend of the system from disorderly to orderly. Coordination degree is the strength of synergy between the parameters in the process of system development, is the quantitative index to confirm the coordination between the metric systems or the internal system. From mathematical point of view, the coordination degree between two systems can be measured by the deviation between the representative function, the smaller the deviation is, the
higher the coordination degree is; on the other hand, the lager the deviation is, the lower the coordination degree is. Coordination degree C between two systems was defined as:

\[
C = \left[ \frac{f(x) \cdot g(y)}{\frac{f(x) + g(y)}{2}} \right]^2
\]

where C is coordinate degree; f(x) represents comprehensive evaluation index of the resources environment system; g(y) represents comprehensive evaluation index of economic system; k is adjustment coefficient, it means when the level of economic development and resources environment under certain conditions, in order to maximize the comprehensive coordination degree between economy and environment, k≥2, in this study k=3. The range of C values is between 0 and 1, obviously, 0≤C≤1, C=1 reflect the best coordination states, and C=0 reflect the worst coordination states.

On the basis of the coordination degree results of resources environment system and economic system, to establish coordination degree level evaluation system. According to the meaning of the coordination degree, it can be divided into several grades, and graded into the subordinate level according to the score (table 3).

| Coordination degree (C) | Grade | Meaning               | Coordination degree (C) | Grade | Meaning         |
|------------------------|-------|-----------------------|------------------------|-------|-----------------|
| 0 ~ 0.1                | 1     | Extreme imbalance     | 0.5 ~ 0.6              | 6     | Reluctant coordination |
| 0.1 ~ 0.2              | 2     | Serious imbalance     | 0.6 ~ 0.7              | 7     | Primary coordination |
| 0.2 ~ 0.3              | 3     | Moderate imbalance    | 0.7 ~ 0.8              | 8     | Medium coordination |
| 0.3 ~ 0.4              | 4     | Mild imbalance        | 0.8 ~ 0.9              | 9     | Benign coordination |
| 0.4 ~ 0.5              | 5     | Endangered imbalance  | 0.9 ~ 1.0              | 10    | Superior coordination |

Table 4 Economic, Environmental Systems comprehensive evaluation index and the coordination degree of Dongying City, 2011—2015

| Year | f(x)     | g(y)               | C        |
|------|----------|--------------------|----------|
| 2011 | -5.450663461 | -2.633999245 | 0.678272 |
| 2012 | -3.114121556 | -1.553201278 | 0.700588 |
| 2013 | 0.514995932  | 0.634175293  | 0.968079 |
| 2014 | 2.750274686  | 2.366748164  | 0.983241 |
| 2015 | 5.299514398  | 1.186296175  | 0.21364  |

3. Resources Environment and Economic Development Coordination Degree Evaluation System

According to economic system comprehensive evaluation index f(x) and environmental system comprehensive evaluation index g(y) of Dongying City in 2011-2015, using coordination degree model and adjustment coefficient k=3, the coordination degree C was calculated and shown in table 4. Table 4 showed that economic system comprehensive evaluation index and resources and environment system comprehensive evaluation index of Dongying City were increasing in 2011-2015. The economic and resources environmental coordination degree develops stably. The minimum
coordination degree was 0.21364; the maximum coordination degree was 0.98324. According to the grade division of coordination degree in the table 3, the economic and resources environmental coordination degree level of Dongying City is the primary coordination in 2011, medium coordination in 2012, superior coordination in 2013 and 2014, and moderate imbalance in 2015, respectively.

Overall, economic and environmental development coordination degree of Dongying City belongs to the coordinated development type. The ecological environment improved gradually and the social economy developed steady. The coordination degree level of economic and social is higher than its level of resources and environment in the initial stage significantly, resources and environment level is above the economic and social level obviously late. Especially in 2015, economic and social development level lags behind the level of resources and environment development obviously, this lead to imbalances between them, which showed the moderate imbalance state. The main reason is that some of economic and social indexes present the negative growth trend in 2015. This is not in conformity with the trend of social development to a certain extent. The reasons for this phenomenon may be related department report the fuzzy statistics data, but it should belong to the short-term phenomenon. Overall, the resources environment and economic coordination degree development of Dongying City showed good momentum, it mainly in line with the coordinated development and gradually optimized trend.

4. Conclusion
Regional development focuses on coordination. In order to obtain the maximum economic benefits and social benefits, the relationship between environment and economy must be coordinated and seek a reasonable mode of development to maximize the efficiency of the resource environment.

The relationship between the resource environment and economic development is an interactive one. Once a threshold is exceeded however, it becomes the limiting factor for regional development. Economic development is not always passively subject to environmental factors. When economic activity is very high, there is commensurate level of investment in the protection of resources and the environment. In turn, this will assist in the protection and development of the resource environment. A low level of economic activity is usually paired with more eagerness to develop and use resources to further develop, but such an economy is also unable to protect environmental resources.

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