Competitiveness Analysis of Hebei Electric Power Industry Based on Factor Analysis and Cluster Analysis

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Abstract: Based on the "Diamond Model" which incorporates the factors of power industry, and starting from the industrial chain structure of power industry development, an evaluation system including three dimensions of power industry demand side, power generation side and power industry resource side is constructed. The cross-sectional data of 31 provinces in China in 2017 are selected, and factor analysis and cluster analysis are used. The Empirical Study on the competitiveness of Hebei electric power industry shows that the competitiveness of Hebei electric power industry is the fourth gradient among 31 provinces (cities and districts) in China, and the overall competitiveness of the electric power industry is weak. At the same time, factor analysis shows that the competitiveness of power industry on generation side is weak, while the competitiveness of upstream and downstream power market of power industry has advantages over other provinces, and the development coordination of the overall supply and demand structure of power industry is unbalanced, which hinders the development of the competitiveness of the whole power market. On the basis of the above analysis, this paper combines the strengths and weaknesses of Hebei electric power industry, and gives relevant suggestions for its development.

1. Introduction

In February 2002, the State Council's Notice on the Reform Plan of Printing and Generating Power System (Guofa [2002] 5) (referred to as No. 5) formally implemented the market-oriented reform of power system. On March 15, 2015, the Central Committee issued the Document No. 9 on Further Deepening the Reform of the Electric Power System, which started a new round of the reform of the electric power system. Under the background of deepening marketization of electric power industry under the background of electric power reform and the continuous promotion of industrial synergistic development strategy, the synergy of energy resources will be an inevitable trend, and this synergy of energy resources will inevitably be achieved through the way of regional electric power market. At the same time, the power industry has a strong correlation and drive. The construction of power projects not only requires a large amount of capital investment, but also promotes the development of many industries in the region, such as construction, transportation, disposable energy, steel, instrumentation, environmental protection and so on. Therefore, the development of electric power industry has a direct impetus to the growth of local economic aggregate and the development of related industries. With the deepening of the reform of the electric power market, the competitiveness of the electric power market will continue to deepen. Therefore, it is necessary to study the competitiveness of the electric power
industry in Hebei Province and provide decision-making suggestions for its development.

2. Index System Construction and data collection

2.1 Index System Construction

The key to the comparability of electric power industry is to grasp the objective standard of comparison. Similarly, an objective and comprehensive evaluation system should be established to compare the competitiveness of electric power industry. Based on Michael Porter's "Diamond Model" and the characteristics of the electric power industry, this paper integrates the influencing factors of the competitiveness of the electric power industry into the model. According to the principles of operability, systematicness, comparability, dynamic and static integration, this paper starts from the overall dimension of the industrial chain, and subdivides the resource side of the electric power industry and the electric power production. The evaluation system of power industry competitiveness is constructed from three dimensions: power generation side and power industry demand side. As shown in Table 1.

| First-level indicators | second-level indicators | third-level indicators |
|------------------------|-------------------------|------------------------|
| Overall Competitiveness of Electric Power Industry | Power Generation Side of Electric Power Industry | Demand side of power industry |
| GDP $X_1$ | Power terminal consumption $X_2$ | Electricity price for large industry $X_3$ |
| | Average Utilization Hours of Power Generation $X_4$ | Installation capacity $X_5$ |
| | Electric power generation $X_6$ | Availability of water resources $X_7$ |
| | Availability of Coal Resources $X_8$ |

2.2 Data collection, related inspection and standardization

The index data in this paper are synthetically sorted out according to the "China Electricity Yearbook 2017", "China Energy Statistics Yearbook" and the website of the National Bureau of Statistics of China.

| Province | GDP ($100 million) | Power terminal consumption (GWH) | Electricity price for large industry (10kv) | Average Utilization Hours of Power Generation | Installation capacity (MW) | Electric power generation (billion of kilowatt hours) | Availability of water resources (100 million cubic meters) | Availability of Coal Resources (10,000 tons) |
|----------|-------------------|----------------------------------|---------------------------------------------|----------------------------------------------|-----------------------------|------------------------------------------------------|-------------------------------------------------|----------------------------------------------|
| Beijing  | 24899.3           | 421                              | 0.70                                        | 3983                                         | 1103                        | 434.4                                                | 35.1                                            | 254.5                                        |
| Tianjing | 17885.4           | 623                              | 0.70                                        | 4141                                         | 1467                        | 617.6                                                | 18.9                                            | 0                                            |
| Hebei    | 31827.9           | 2498                             | 0.60                                        | 4157                                         | 6342                        | 2630.6                                               | 208.3                                           | 5422.9                                       |
| Shanxi   | 12982.3           | 2449                             | 0.51                                        | 3485                                         | 7640                        | 2535.1                                               | 134.1                                           | 66348.7                                      |
| Neimenggu| 18632.6           | 3929                             | 0.51                                        | 3656                                         | 11044                       | 3949.8                                               | 426.5                                           | 67482.3                                      |
| Liaoning | 22037.9           | 1665                             | 0.55                                        | 3857                                         | 4601                        | 1778.8                                               | 331.6                                           | 3406.6                                       |
| Jilin    | 14886.2           | 731                              | 0.59                                        | 2756                                         | 2716                        | 760.3                                                | 488.8                                           | 1943.7                                       |
| Heilongjiang | 15386.1         | 874                              | 0.59                                        | 3411                                         | 2783                        | 900.4                                                | 843.7                                           | 0                                            |
| Shanghai | 27466.2           | 793                              | 0.71                                        | 3564                                         | 2371                        | 807.3                                                | 61                                              | 0                                            |
The correlation analysis of the original data shows that the correlation of the index data is above 0.5, and the correlation is strong, so there is no need to exclude the index. Then the original data are processed by the maximum-minimum method according to the positive index and the negative index respectively.

3. Data analysis and results

3.1 Determining Factor Variables

In this paper, Rstudio is used to analyze the processed data. First, KMO test is carried out. The results show that 0.6 > 0.5, which shows that it meets the requirements of factor analysis. Factor analysis was used to extract the values of variables. The results are as follows: Table 3:

| Table 3. Factor extraction results |
|-----------------------------------|
| Factor1 | Factor2 | Factor3 |
| SS loadings | 3.787 | 1.528 | 0.916 |
| Proportion Var | 0.473 | 0.191 | 0.115 |
| Cumulative Var | 0.473 | 0.664 | 0.778 |

From the above results, it can be seen that the cumulative contribution value of the first three factors is 77.8%, which indicates that 77.8% of the original data is extracted, and the information is extracted adequately. Therefore, the first three factors represent the whole index system to analyze the competitiveness of Hebei electric power industry.

3.2 Calculating the Factorial Load Matrix after Rotation

The maximum likelihood method is used to extract the common factor, and the initial factor load matrix is rotated by a church-state rotary valve with large variance. The factor load matrix after rotation is as follows:
Table 4. Factorial Load Matrix after Rotation

| Factorial Load Matrix | Factor1 | Factor2 | Factor3 |
|-----------------------|---------|---------|---------|
| GDP                   | 0.787   | 0.614   |         |
| Power terminal        | 0.993   | 0.81    | 0.102   |
| consumption           |         |         |         |
| Electricity price for | 0.443   | 0.317   |         |
| large industry        |         |         |         |
| Average Utilization   | 0.45    | -0.191  | 0.772   |
| Hours of Power        |         |         |         |
| Generation            |         |         |         |
| Installation capacity | 0.972   |         |         |
| Electric power        | 0.991   | 0.116   | -0.356  |
| generation            |         |         |         |
| Overall Competitiveness of Electric Power Industry |         |         | -0.356 |
| Demand Side GNP       |         |         |         |
| Power terminal        | 0.228   | -0.509  | 0.249   |
| consumption           |         |         |         |

According to the load of each factor, the factors are named and explained. The competitiveness of power industry suppliers in $F_1$, power market is centered on the generation end, $F_2$ is the bargaining competitiveness of upstream buyers in power industry, and $F_3$ is the bargaining competitiveness of downstream suppliers in power industry. The factor score coefficients were calculated by regression method as follows:

$$F_1 = 0.787X_1 + 0.993X_2 + 0.45X_4 + 0.972X_5 + 0.991X_6 + 0.228X_8$$
$$F_2 = 0.614X_1 + 0.81X_2 + 0.443X_3 - 0.191X_4 - 0.509X_8$$
$$F_3 = 0.102X_2 + 0.317X_3 + 0.772X_4 + 0.116X_6 - 0.356X_7 + 0.249X_8$$

### 3.3 Calculating factor score

Through the comprehensive evaluation model, the main factor score and the comprehensive factor score are obtained as shown in Table 5:

Table 5. Factor score and total score

| Province    | Factor1 | Factor2 | Factor3 | score   |
|-------------|---------|---------|---------|---------|
| Beijing     | 2.00152134 | 1.63488196 | 0.43495854 | 1.68036  |
| Tianjing    | 2.248876113 | 0.61602546 | 0.85251513 | 1.64239  |
| Hebei       | 2.003918525 | 1.87492429 | -1.8473413 | 1.40375  |
| Shanxi      | 0.953519251 | 0.5696519 | -0.0987893 | 0.70405  |
| Neimenggu   | 0.982050408 | -0.61016209 | 0.04709968 | 0.45364  |
| Liaoning    | 0.640370278 | 0.42267997 | -0.5743224 | 0.40768  |
| Jilin       | 0.393237427 | 0.07738369 | 0.82657617 | 0.37977  |
| Heilongjiang| 1.419134391 | -2.30260953 | 0.50245042 | 0.37129  |
| Shanghai    | 0.38360948 | 0.12348953 | 0.05654243 | 0.27155  |
| Jiangsu     | 0.048293502 | -0.09789386 | 1.13583627 | 0.173    |
| Zhejiang    | -0.008844161 | 0.31706833 | 0.38712473 | 0.12952  |
| AnHui       | -0.334812747 | -0.06651419 | 1.22067776 | -0.0394  |
| Fujian      | -0.216388033 | 0.03091179 | 0.53627353 | -0.0446  |
| Jiangxi     | 0.527183814 | -1.47577358 | -0.1362425 | -0.0619  |
| Shandong    | 0.377682184 | -1.47538803 | 0.24749153 | -0.0959  |
| Henan       | -0.285652987 | 0.86822531 | -1.0667493 | -0.118  |
Hubei  -0.805974353  0.5069505  1.28215921  -0.1758
Hunan  0.492909604  -1.88037023  -0.4214482  -0.224
Guangdong -0.134736251  -0.89118109  0.4617235  -0.2322
Guangxi  -0.776396254  1.19262582  -0.4309197  -0.2426
Hainan  -1.158238317  1.45995202  0.54912459  -0.2642
Chongqing  -0.445786434  0.03948625  -0.1271901  -0.2798
Sichuan  -1.117537777  0.86397928  1.21921891  -0.2867
Guizhou  -0.77440872  0.20406944  -0.2139749  -0.4518
Yunnan  -0.903500317  0.55772502  -0.3996955  -0.4709
Xizang -1.467002084  0.18075763  1.71816025  -0.5928
Gansu  -0.905693928  -0.71735205  -1.7182159  -0.9795
Qinghai  -0.741650669  0.11771191  -1.6124389  -0.6595
Shanxi  -1.306696995  -0.26893885  -1.904192  -1.1405

From the above factor analysis results, it can be seen that the competitiveness factor score of the supplier bargaining Party of the power industry in Hebei Province is 0.393, which is weak at the disadvantage. However, the power industry's upstream buyer bargaining example and downstream supplier bargaining power is stronger, for the overall development of the power industry, it shows that the coordination degree between supply and demand is poor. The supply capacity of the electric power industry needs to be enhanced.

3.4 Cluster analysis by factor score
According to the results of factor scores, cluster analysis was carried out in 31 provinces (cities and districts) in China. The results are shown in Fig. 1.

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According to the structure chart of cluster analysis, the competitiveness of power industry in 31 provinces (cities and districts) can be divided into four gradients. The first gradient includes Beijing, Tianjin, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangxi, Hainan, Chongqing, Guizhou, Ningxia and Hunan; the second gradient includes Tibet, Gansu and Qinghai; and the third gradient package. Including Jiangsu, Shandong and Guangdong. The fourth gradient is residual (city, district). From the above clustering analysis results, we can see that the competitiveness of Hebei electric power industry belongs to the fourth gradient, and the competitiveness level of the electric power industry is low.

4. Conclusion and suggestion

(1) Make full use of the competitive advantage of Hebei electric power industry. According to the above research, the competitiveness of the upstream and downstream power industry of Hebei electric power industry is in a dominant position. From the perspective of resources needed for future development, the maintenance of this advantage is guaranteed. Therefore, Hebei Province should make full use of the advantages of the electric power industry, promote the development of the power generation side of the electric power industry, on this basis, drive the development of relevant industries in the province, and strive to form a sustained development advantage nationwide and even internationally, so as to build a pillar of the economic development of Hebei Province. That is to say, the development of power industry will drive the development of power equipment manufacturing and transmission and transformation equipment manufacturing, and the development of related industries will be promoted by strengthening the new energy equipment industry, including wind power, photovoltaic, transformer, savings power equipment and so on.

(2) Hebei Province has the geographical advantage of encircling Beijing and Tianjin, so it should strive to become the base to guarantee the electricity consumption in Beijing and Tianjin and expand the supply of electricity market in this region. It must be noted that in order to ensure the power supply of Beijing, the transmission channels connecting Hebei, Shanxi, Shandong, Inner Mongolia and Northeast China have been built in Beijing, and these areas are basically surplus areas of power production, which objectively forms a competitive relationship with Hebei Province. Therefore, how to make use of the advantages of its geographical position to better expand the supply of electricity market in Beijing and Tianjin needs to be carefully studied.

(3) Make full use of the development strategy of Xiongan New Area to promote the connection and integration of Hebei electric power industry and Beijing-Tianjin power grid. In the national strategy of coordinated development between Beijing, Tianjin and Hebei, the construction of Xiongan New Area has become a major project at the national level. As "Xiongan New Area" goes deep into the hinterland of Hebei Province, the electric energy needed for the construction and operation of its new area will inevitably be embedded in the Hebei power grid. Hebei Province should make full use of this opportunity to realize the integration of Hebei power grid and Xiongan New District power grid, and extend it to Beijing power grid, so as to realize the integration of Beijing-Tianjin-Hebei power grid and become the main power and standby power grid in Beijing-Tianjin area. Specifically, from the integration of power grid construction to the realization of coordinated dispatch of electricity, so as to achieve the situation of "you have me, I have you", as far as possible, Beijing-Tianjin electricity market and Hebei electricity market will be integrated.

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