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Analyzing the Influence of Each Influencing Factor on the Freight Rate of Coastal Coal Based on Analytic Hierarchy Process

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Abstract

Under the influence of the COVID-19, the China coastal bulk(coal) freight index released by Shanghai Shipping Exchange fluctuated violently. In order to explore the causes of the tariff fluctuation, this paper uses the Analytic Hierarchy Process to analyze the influence of tariff generation factors on the tariff, and finally concludes that the coal inventory of the six coastal power plants has the highest influence on the coastal area, followed by the average daily coal consumption of the six coastal power plants.

Keywords

Analytic Hierarchy Process; China coastal bulk(coal) freight index; Six coastal power plants.

1. Introduction

Impact of COVID-19, domestic and international commodity trading by affected, all kinds of shipping freight index dramatic ups and downs, coastal coal freight index from 707.05 in January 3, 2020, fell to 463.53 on March 13, 2020, down by more than 30%, and low time, implement bottomed out in April 24, rose to 627.73, up by more than 30% month-on-month and at the same time the northern port coal prices, coal inventories and downstream from coal-fired power plants all kinds of data are all a hotchpotch of volatility. In order to quantify the influence of each factor in the shipping market on the new edition of coastal coal freight index, this paper uses Analytic Hierarchy Process to briefly analyze the influence of each factor.

2. Background and description of the topict

At the beginning of 2020, under the dual influence of the Spring Festival and the epidemic, the demand for electricity consumption downstream could not be guaranteed, plus the high eras of the coastal power plant, the downstream demand for coal continued to be weak, the entire coastal coal transportation market was dismal, shipowners were forced to reduce the coastal coal freight rate one after another to maintain the operation. At the same time, due to the coastal coal transport in the coastal dry bulk market share of more than 50%,often the fluctuation of coal freight prices will bring a chain reaction, coastal iron ore, coastal grain freight prices fell, and eventually the overall coastal dry bulk freight prices fell below the cost line, the Bohai rim port is no longer in port prosperity, March 6, 2020, Qinhuangdao port anchorage only 5 ships, year-on-year March 26, 2019. Forty ships are far apart. With the government's steady coal prices, supply-keeping policies, the market gradually tilted to the demand end, the coal supply end recovered faster than the demand side, the production of production intensified, the port continued to hoard coal, but the demand did not recover, the Bohai thermal coal index from February 26, 2020 559 points to April 29, 2020 530, reached. Lowest since 2017. At the same time, the volatility of international oil prices, the expansion of the advantages of imported coal prices have increased the pressure of shipowners to increase prices. In order to measure the overall situation of coastal coal freight rates, this paper selects the new version of China Coastal Coal Freight Index published by Shanghai Shipping Exchange as the overall index of coastal coal

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freight rates. The new china coastal coal freight index covers 14 routes, with loads ranging from 10,000 tons to 70,000 tons, with specific routes as shown in Table 1. At the same time, in order to comb the port supply, downstream demand, and market impact on coastal coal freight rates and the extent of influence, in a comprehensive consideration of various research methods and combined with the actual situation, it is believed that the hierarchical analysis of the system, qualitative analysis and quantitative analysis of the combination of the required information and simple and practical characteristics can better solve the above problem.

Table 1 The new coastal coal freight index covers routes.

Routes.	the tonnage of the ship.
Qinhuangdao–Guangzhou	60,000 -70,000 DWT
Qinhuangdao–Guangzhou	50,000 -60,000 DWT
Qinhuangdao–Xiamen	50,000 -60,000 DWT
Qinhuangdao–Fuzhou	30,000 -40,000 DWT
Qinhuangdao–Shanghai	40,000 -50,000 DWT
Huang Qi–Shanghai	30,000 -40,000 DWT
Tianjin–Shanghai	20,000 -30,000 DWT
Jingtang/Caofeidian-Ningbo	40,000 -50,000 DWT
Qinhuangdao-Ningbo	15,000 -20,000 DWT
Qinhuangdao-Zhangjiagang	40,000 -50,000 DWT
Qinhuangdao-Zhangjiagang	20,000 -30,000 DWT
Tianjin-Zhenjiang	20,000 -30,000 DWT
Tianjin-Zhenjiang	10,000 - 15,000 DWT
Qinhuangdao-Nanjing	30,000 -40,000 DWT

3. Modeling

3.1 Model building

3.1.1 Establish a hierarchy of hierarchical levels

According to the analysis of the problem, the factors contained in the problem are clarified, the correlation and affiliation of each factor are determined, and according to the common characteristics of these factors, they are divided into the target layer, the rule layer, the policy makers.

Figure 1 Hierarchy diagram

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3.1.2 Establish a judgment matrix

According to the nine-point scale method, and invited experts to select two indicators at the same level to score two at a time, the scoring structure summary into the judgment matrix A

Table 2 Nine-point scale table.

Scale a_{ij}	Defined.
1	Factor i is as important as factor j
3	Factor i is slightly more important than factor j
5	Factor i is significantly more important than factor j
7	Factor i is very important than factor j
9	Factor i is heavily important than factor j
2,4,6,8.	Factor i is more important than factor j between the two adjacent scales above
The inverse of the corresponding scale value.	Factor j is critical relative to factor i

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots \\ a_{21} & a_{22} & \dots \\ \dots & \dots & a_{nn} \end{bmatrix} \tag{1}$$

3.1.3 Verify that the matrix is determined to be a consistency matrix.

In order to verify whether the judgment matrix given by the expert is reasonable, it is necessary to carry out the consistency test of the judgment matrix, and when the inspection structure is reasonable, the next step is carried out, and if it is not reasonable, the first step is returned.

The verification steps are as follows:

Step 1: Calculate the consistency indicator CI.

$$\mathrm{CI} = \frac{\lambda_{MAX}-n}{n-1} \tag{2}$$

Where is the maximum characteristic value for judging matrix A, and n is the number of indicators.

Step 2: Find n for the average random consistency indicator RI, as follows.

Table 3 Average random consistency indicator.

N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

Step 3: Calculate the consistency ratio CR.

$$\mathrm{CR} = \frac{CI}{RI}$$

If CR<=0.1, the judgment matrix passes the consistency test, otherwise it does not pass.

3.1.4 Calculate and sort the corresponding metric weights.

There are three methods to calculate the weight of indicators, arithmetic average, geometric average and feature value.

Method 1: The average method of arithmetic.

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Step 1: Naturalize the judgment matrix A by column (each element is divided by the sum of the elements in which its column is located).

Step 2: Sum the naturalized matrix case and get a column vector.

Step 3: Divide each element of the resulting column vector in step two by n, which is to gain a weight. The formula is as follows.

$$\omega_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (i=1,2,3\ldots n) \tag{3}$$

Method 2: Geometric mean method.

Step 1: Each column element in matrix A is multiplied to get a column vector.

Step 2: Each element in step one is opened n times to get a new column vector.

Step 3: The normalization of the matrix obtained by step two is treated to get the corresponding weight of each indicator. The formula is as follows.

$$\omega_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}}}{\sum_{k=1}^{n}\left(\prod_{j=1}^{n} a_{kj}\right)^{\frac{1}{n}}} (i=1,2,3\ldots n) \tag{4}$$

Method 3: Feature value method.

Step 1: Find out the characteristic value and corresponding feature vector of matrix A.

Step 2: The evidence of the resulting feature vector is treated as a normalization, i.e. the weight is obtained.

In order to make the weight calculation result more stable, we can combine the results of the three methods, and average the weight of the corresponding indicators of the three methods as the final weight calculation results.

Finally, the weight of the decision-making level indicator =weight of the standard level relative to the target level index×The decision level is relative to the criteria level metric weight.

4. Solve

4.1 Establish an evaluation system.

By reading the relevant literature and consulting relevant experts, the evaluation system established to the new version of coastal coal freight rates as the target layer is as follows.

Table 4 Evaluation System.

Target layer G.	Guideline layer K.	Decision level B.
New coastal coal freight rate index G	Coal supply to Bohai port.	Bohai Thermal Coal Price Index
		Qinhuangdao Port coal inventory
		Weather conditions at the Bohai port
	Coastal coal demand	Coal stocks in six major power plants along the coast
		The average daily coal consumption of the six major power plants along the coast
		Temperatures in coastal areas
	Coastal dry bulk market	International crude oil prices
		China's GDP growth
		The number of ships at the anchorage of Qinhuangdao Port

After consulting the expert, the resulting G-K judgment matrix is as follows:

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$$K = \begin{bmatrix} 1 & \frac{1}{5} & \frac{1}{3} \\ 5 & 1 & 2 \\ 3 & \frac{1}{2} & 1 \end{bmatrix} \tag{5}$$

The matlab is obtained by the matlab calculation, the CR-0.0036-lt;0.1, and the matrix passes the consistency test.

The results obtained from the calculation method of the three indicator weights and the final weight calculation are recorded below.

Table 5 Criterion layer weights.

Index	Arithmetic averages	Geometric averaging	Feature value method	The mean
Coal supply to Bohai port	0.1096	0.1095	0.1095	0.1095
Coastal coal demand	0.5813	0.5816	0.5816	0.5815
Coastal dry bulk market	0.3092	0.3090	0.390	0.3361

The judgment matrix is as follows.

$$K_{1-123} = \begin{bmatrix} 1 & 2 & 3 \\ \frac{1}{2} & 1 & 2 \\ \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix} \tag{6}$$

The CR=-0.1811<0.1 is obtained through the matlab calculation, and the matrix passes the consistency test.

The results obtained from the calculation method of the three indicator weights and the final weight calculation are recorded below.

Table 6 Weights of demand metrics.

Index	Arithmetic averages	Geometric averaging	Feature value method	The mean
Coal stocks in six major power plants along the coast	0.4818	0.4819	0.4847	0.4828
The average daily coal consumption of the six major power plants along the coast	0.3354	0.3342	0.334	0.3345 33
Temperatures in coastal areas	0.1828	0.1839	0.1814	0.1827

The judgment matrix is as follows.

$$K_{3-789} = \begin{bmatrix} 1 & 2 & 3 \\ \frac{1}{2} & 1 & 4 \\ \frac{1}{3} & \frac{1}{4} & 1 \end{bmatrix} \tag{7}$$

The CR-0.0088<0.1 is obtained by matlab, and the matrix passes the consistency test.

The results obtained from the calculation method of the three indicator weights and the final weight calculation are recorded below.

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Table 7 Market indicator weights.

Index	Arithmetic averages.	Geometric averaging.	Feature value method.	The mean.
International crude oil prices	0.416	0.4161	0.4161	0.416067
China's GDP growth	0.4577	0.4579	0.4579	0.457833
The number of ships at the anchorage of Qinhuangdao Port	0.1263	0.126	0.126	0.1261

According to the decision level indicator weight =the criterion layer relative to the target level indicator weight. The decision level is relative to the criterion level index weight, and the decision-level index weight result is calculated by using excel software.

Table 8 Chart 3.6 Index Weight Sorting Table

Index.	The weight of the indicator.
Coal stocks in six major power plants along the coast	0.280748
The average daily coal consumption of the six major power plants along the coast	0.194531
China's GDP growth	0.153863
International crude oil prices	0.139826
Temperatures in coastal areas	0.10624
Bohai Thermal Coal Price Index	0.059082
The number of ships at the anchorage of Qinhuangdao Port	0.042378
Qinhuangdao Port coal inventory	0.032542
Weather conditions at the Bohai port	0.017912

5. Conclusion

From the results presented in Table 8, the biggest impact on coastal coal freight rates is the coal stocks of the six major coastal power plants, followed by the average daily coal consumption of the six major coastal power plants. Combined with specific data, coal stocks at the six major coastal power plants hovered at a high of 17 million tons during the outbreak, up about 10% year-on-year in the same period in 2019, while freight rates overall showed a sustained downward trend, overall negative correlation, while the average daily coal consumption of the six major coastal power plants was negatively correlated because of heavy losses in industrial electricity consumption, depressed and positive lying with freight rates.

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