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Research on Green Port Evaluation Based on Cloud Reasoning and Improved TOPSIS

Yuye Yang [1,*], Nan-nan Yan [2], Mei Sha [3]

[1] Institute of Logistics Science & Engineering, Shanghai Maritime University, Shanghai 201306, China

[2] School of Information Engineering, Shanghai Maritime University, Shanghai 201306, China

[3] School of Transport & Communications, Shanghai Maritime University, Shanghai 201306, China

Corresponding author. Email: 1016710664@qq.com (YANG Yu-ye).

Abstract

In order to better evaluate the green development status of ports and solve the problems of ambiguity and randomness in the process of green port evaluation, a TOPSIS green port evaluation model based on cloud reasoning and improvement was established. Firstly, construct a green port evaluation index system, realize the conversion of qualitative evaluation and quantitative value through cloud reasoning. Secondly, use the entropy method to calculate the weight of each index, and improve TOPSIS with the help of symmetric cross-entropy. Finally, an example analysis proves that the method can not only increase the objectivity of the evaluation results but also improve the discrimination of the results.

Keywords

Green Port Evaluation; Cloud Reasoning; Entropy Method; Symmetrical Cross-Entropy; TOPSIS.

1. Introduction

"Green port" refers to a port that implements the concept of green development during production, operation and service, actively fulfills legal and social responsibilities, and comprehensively adopts technology and management measures to save resources and energy, protect the environment and ecology, and respond to climate change[1]. In order to promote its construction, the Ministry of Transport has issued the "In-depth Promotion of Green Port Construction Action Plan (2018-2022)", proposing to integrate green development into port planning, construction and operation. my country's requirements for the green level of ports are increasing year by year, and its evaluation system is constantly improving. Under the environment of digitalization and open innovation, the construction and development of green ports is also full of new vitality.

Domestic and foreign scholars have done in-depth research on the indicator system and evaluation methods of green ports. Peris [2] designed a port evaluation index system based on the principle of sustainable development, and carried out a multi-objective analysis of the economic development factors of the port. Abood [3] drew on the green building evaluation system and selected indicators such as geographic location and energy consumption efficiency to construct a green port indicator system.Y. Lu [4] used foreign green building models to build a green port evaluation system based on the characteristics of domestic ports, and used the analytic hierarchy process to conduct an empirical analysis of Ningbo Port. S.L.Chen [5] combined ecological, social, economic, cultural, resource and other factors to establish a DPSIR

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(Drive Press State Impact Response) green port evaluation model, and used fuzzy comprehensive evaluation to analyze Shanghai Port. Y.J.Han [6] used the gray cloud clustering model to transform the qualitative description of the green port competitiveness evaluation index into a quantitative description, and conducted empirical research on Dalian Port, Tianjin Port, and Qingdao Port. Y.J.Fan [7] combined the network analytic hierarchy process and GRA to build an evaluation model that includes development, system, special governance, technological innovation and green concepts, and conducts green evaluation of coastal ports in Fujian Province. Y. Yang [8] started from the three dimensions of ecology, economy and society, combined the fuzzy analytic hierarchy process with TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), quantified the fuzzy factors based on the membership function, and carried out the analysis of the Bohai Sea Ports. Green level performance ranking and corresponding recommendations.

From the above research, we can see that the evaluation index system of green ports usually contains a large number of fuzzy and random qualitative indicators such as ecology, society, and culture. Analytic hierarchy process, fuzzy comprehensive evaluation and fuzzy hierarchical analysis can determine the importance of port index elements and provide a quantitative basis for evaluation. However, subjective factors still have a large impact and the coverage is limited, ignoring the randomness of uncertainty in the evaluation process. Grey cloud clustering can more accurately express the randomness in the evaluation, but it lacks thinking about the ambiguity in the evaluation of green ports. In order to solve the above problems, C.L.Liu [9] used the concept of normal cloud in the cloud model to correct the scoring results of experts with cloud images, deal with the ambiguity and randomness of uncertainties in the evaluation process, and evaluate the port's green rating. Based on the above research and comprehensively considering the fuzziness and randomness in green port evaluation, this paper proposes an improved TOPSIS green port evaluation model based on cloud reasoning [10] and symmetric cross entropy [11], and applies this model to Shanghai Port and Ningbo Evaluation of the green ports of Zhoushan Port, Dalian Port, Qingdao Port and Tianjin Port.

2. Establishment of green port evaluation index system

The green port evaluation index system plays an important role in guiding and standardizing the construction of green ports in China. In this paper, referring to the " Green Port Grade Evaluation Guide " officially implemented by the Ministry of transport in July 2020, according to the principles of scientificity and operability, a green port evaluation index system including the general target layer, the first level index layer and the second level index layer is formed. As shown in Figure 1, the environmental protection ecology C18 and the low carbon saving C19 are the quantitative indicators, C1, C2...... C17 is a qualitative index.

3. Establishment of green port evaluation model

3.1. Cloud model

Cloud model [12] can realize the conversion of qualitative concepts and quantitative data, and associate the randomness and fuzziness in the uncertainty of things. There is a qualitative concept A on the universe U. For any element x in U, there is a certain degree of x for A. $u(x)$ is a stable normal random number. The distribution of x on the universe is called cloud, and $(x, u(x))$ is called a cloud drop, which is expressed as $drop(x, u(x))$ [13].

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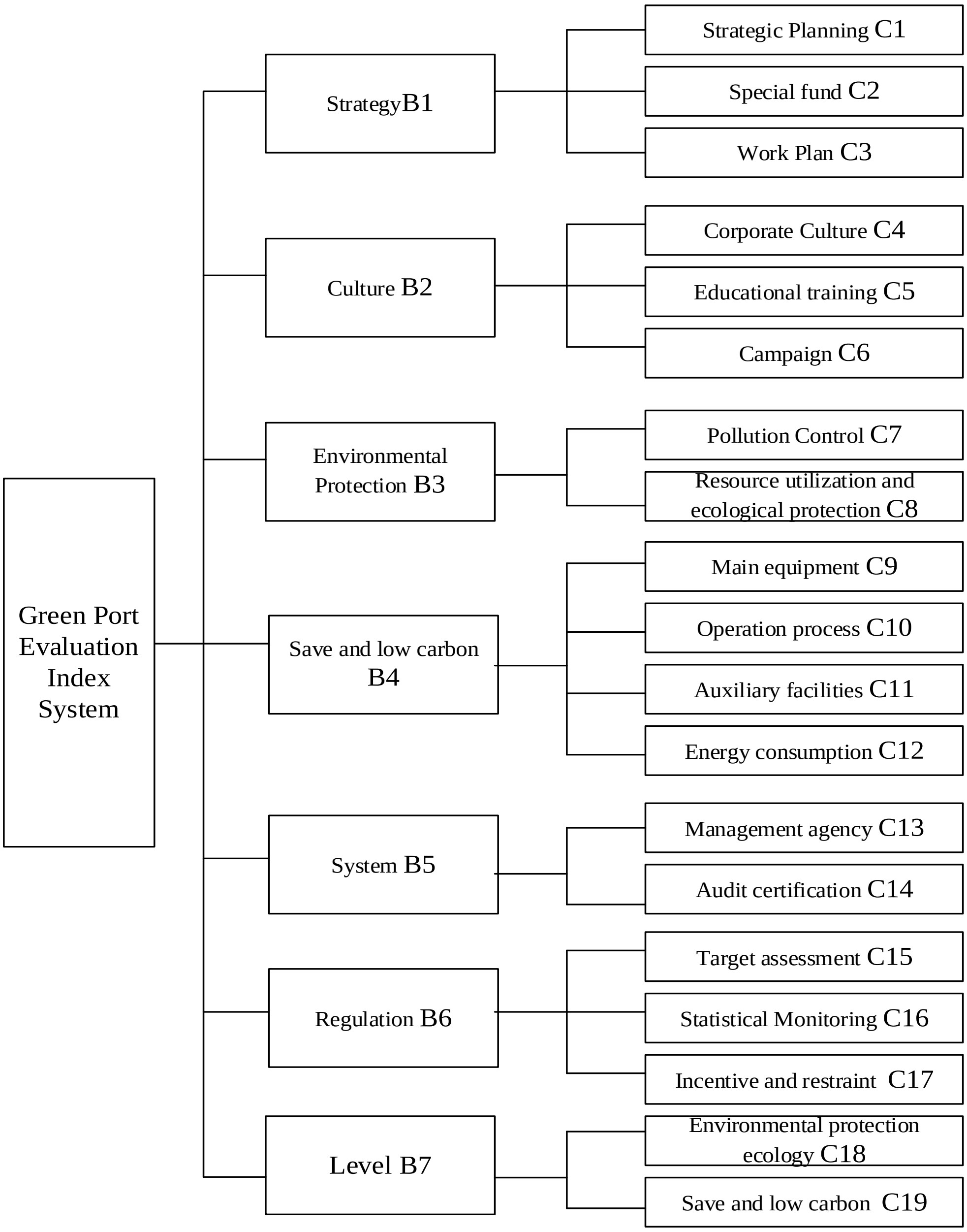

Fig. 1 Evaluation index system of green ports

3.2. Digital characteristics of clouds

The uncertainty of the cloud model is expressed by the digital feature (Ex, En, He), and Figure 2 is a normal cloud graph. Expectation Ex represents the value of qualitative concept; entropy En is the measure of fuzziness of qualitative concept and uncertainty measure of expectation Ex; super entropy He is the measure of uncertainty of entropy En, which reflects the uncertainty aggregation degree of cloud drops, and its size is determined by the fuzziness and randomness of entropy En. In this paper, the calculation formula of digital characteristics of a certain qualitative grade evaluation is as follows:

$$\begin{cases} Ex = \dfrac{c_{\max} + c_{\min}}{2} \\ En = \dfrac{c_{\max} - c_{\min}}{6} \\ He = K \end{cases} \tag{1}$$

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Where $c_{\max}$ represents the minimum value in the grade, $c_{\min}$ represents the maximum value in the grade, K is the variable, taking 0.01 [14].

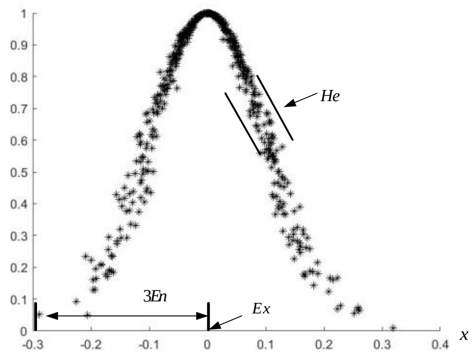

Fig. 2 normal cloud graph

3.3. Cloud reasoning

There are two kinds of cloud model generators[15]: forward cloud generator and reverse cloud generator. The forward cloud generator generates cloud droplets from digital features, while the backward cloud generator uses a certain number of cloud droplets in accordance with normal distribution to determine the corresponding digital characteristics of cloud model. In the forward cloud, it can be divided into *X* condition cloud generator and *Y* conditional cloud generator according to the cloud generation conditions. Condition *X* cloud generator is a cloud generator with given cloud digital characteristics and specific value *a*. The cloud generator with *Y* condition is a cloud generator under the condition of given cloud digital characteristics and specific degree of certainty *u* value.

The X condition cloud is used as the antecedent cloud generator, and the *Y* condition cloud is connected as the consequent cloud generator to obtain the conditional rule cloud generator, which is used to realize the qualitative and quantitative conversion. This process is called uncertainty reasoning of cloud model [16], namely cloud reasoning.

Generally speaking, the number of antecedent cloud generators can be greater than or equal to one, while the number of subsequent cloud generators can only be one. A single condition and single rule cloud generator can be expressed as "if *P*, then *Q* ", as shown in Figure 3. *P*、*Q* represents both qualitative concepts and antecedents of cloud reasoning.

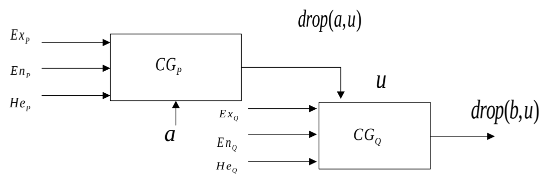

Fig. 3 Single condition single rule cloud generator

The specific algorithm is as follows:

Step1: Input the qualitative concept $P(Ex_P, En_P, He_P)$ of the antecedent, the qualitative concept $Q(Ex_Q, En_Q, He_Q)$ of the latter and the specific value *a*.

Step2: Generate a positive random number En'_P with En_P as the expectation and HeP^2 as the variance in CGP ; generate the certainty $u = \frac{-(x_P - Ex_P)^2}{2(E'n_p)^2}$ corresponding to *a*.

Step3: Generate a positive random number En'_Q with En_Q as the expectation and $He_Q{}^2$ as the variance in CGQ .

Step4: When $a < Ex_P$, The factor action score is $b = Ex_Q - E'n_Q\sqrt{-2\ln u}$, the opposite action score is $b = Ex_Q + E'n_Q\sqrt{-2\ln u}$. After performing n operations, the cloud droplets and factor action points b generated each time are uncertain, thus forming cloud reasoning.

3.4. Determination of score membership

In order to facilitate the use of cloud reasoning for data processing, the total score of each index is divided into five levels of membership. Taking C1 "Strategic Planning" index as an example, referring to the scoring rules of specialized container ports in " Green Port Grade Evaluation Guide ", the full score is 20 points. The score of 0-4 points is classified as poor (I), 4-8 points as poor (II), 8-12 points as general (III), 12-16 points as good (IV), and 16-20 points as good (V). Similarly, the classification of membership degree of other indicators can refer to table 1.

Tab. 1 Index membership level

Indicators	Total score	I	II	III	IV	V
C1	20	[0,4]	(4,8]	(8,12]	(12,16]	(16,20]
C2	20	[0,4]	(4,8]	(8,12]	(12,16]	(16,20]
C3	15	[0,3]	(3,6]	(6,9]	(9,12]	(12,15]
C4	25	[0,5]	(5,10]	(10,15]	(15,20]	(20,25]
C5	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C6	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C7	40	[0,8]	(8,16]	(16,24]	(24,32]	(32,40]
C8	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C9	20	[0,4]	(4,8]	(8,12]	(12,16]	(16,20]
C10	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C11	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C12	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C13	10	[0,2]	(2,4]	(4,6]	(6,8]	(8,10]
C14	25	[0,5]	(5,10]	(10,15]	(15,20]	(20,25]
C15	15	[0,3]	(3,6]	(6,9]	(9,12]	(12,15]
C16	45	[0,9]	(9,18]	(18,27]	(27,36]	(36,45]
C17	5	[0,1]	(1,2]	(2,3]	(3,4]	(4,5]
C18	60	[0,12]	(12,24]	(24,36]	(36,48]	(48,60]
C19	40	[0,8]	(8,16]	(16,24]	(24,32]	(32,40]

3.5. calculation of weight

In order to make the index weight more objective, the entropy weight method [17] based on the amount of information contained in each index is used to calculate its weight, and the steps are as follows:

Step 1: Suppose there are m ports and n index values, The factor action score of the j-th(j = 1,2, ……) index in the i-th(i = 1, 2,……) port is h_{ij} , and the matrix is constructed as $H = (h_{ij})_{m\times n}$.

$$H = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1j} \\ h_{21} & h_{22} & \cdots & h_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ h_{i1} & h_{i2} & \cdots & h_{ij} \end{bmatrix} \tag{2}$$

Step2: Normalize the original data, the normalized matrix is $C=\left(c_{ij}\right)_{m\times n}$, and c_{ij} is the normalized value.

The standard formula of positive index is as follows:

$$c_{ij}=(h_{ij}-\min_{n}h_{ij})/(\max_{n}h_{ij}-\min_{n}h_{ij}) \tag{3}$$

The standard formula of reverse index is as follows:

$$c_{ij}=(\max_{n}h_{ij}-h_{ij})/(\max_{n}h_{ij}-\min_{n}h_{ij}) \tag{4}$$

Step 3: Calculate the entropy of the *j*-th index e_j:

$$e_j=-\frac{1}{\ln m}\sum_{i=1}^{n}p_{ij}\ln(p_{ij}) \tag{5}$$

$$p_{ij}=c_{ij}/\sum_{i=1}^{m}c_{ij} \tag{6}$$

Where p_{ij} is the proportion of the *i*-th port under the *j*-th attribute index.

Step 4: Calculate the entropy weight of each index ω_j:

$$\omega_j=(1-e_j)/\sum_{j=1}^{n}\left(1-e_j\right) \tag{7}$$

3.6. Improve TOPSIS analysis

TOPSIS is an approximate ideal solution ranking method. According to the Euclidean distance between the evaluated object and the positive and negative ideal solutions, the closeness degree to the ideal value is calculated. The analysis principle is intuitive and the calculation is simple, which avoids the problem of low precision due to complex calculation. However, it is found that when the evaluation object is close to the positive ideal solution, it can also be close to the negative ideal solution at the same time. When the evaluation object appears on the vertical line of the two, the use of Euclidean distance is invalid [18]. Some scholars use angle measurement [19] to solve the problem of similar Euclidean distance, but when the angle between the two is the same and the length is different, they can not get the correct conclusion. M.Zhao [20] used the relative entropy sorting method to solve the problem that the angle measurement could not be measured. However, later research found that the relative entropy did not meet the symmetry, and the sorting would be inconsistent. G.X.Lu [11] replaced Euclidean distance with symmetric interactive entropy, improved it on the basis of relative entropy, redefined the closeness degree in TOPSIS to solve the problems in TOPSIS. Therefore, this paper applies the improved TOPSIS method to the evaluation of green ports.

Definition: two systems $M=\{M_1,M_2,\cdots,M_m\}$, $N=\{N_1,N_2,\cdots,N_m\}$, $0\le M_i\le 1$, $0\le N_i\le 1$, i=1,2,…,m, Then the difference between M and N is expressed as follows:

$$D(M,N)=\sum_{i=1}^{m}[M_i\log\frac{M_i}{N_i}+(1-M_i)\log\frac{1-M_i}{1-N_i}] \tag{8}$$

$D(M,N)$ Is the relative entropy of M to N. When $M_i=N_i$, $D(M,N)=0$, $D(M,N)$ is the symmetric cross entropy between M and N.

Symmetric cross entropy has symmetry and boundedness, which can be used to represent the single distance of the evaluation object, and can also represent the difference measure, and the discrimination rate is higher than that of the Euclidean distance.

The steps of TOPSIS based on symmetric interaction entropy are as follows:

Step 1: Normalize the initial matrix H,

$$H'=\begin{bmatrix} h'_{11} & h'_{12} & \cdots & h'_{1j} \\ h'_{21} & h'_{22} & \cdots & h'_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ h'_{i1} & h'_{i2} & \cdots & h'_{ij} \end{bmatrix} \tag{9}$$

$$h'_{ij} = h_{ij} / \sqrt{\sum_{k=1}^{n} h^2_{ij}} \tag{10}$$

Step 2: Construct the weight matrix $F = [f_{ij}]_{m\times n}$, where the weighted evaluation value is f_{ij} :

$$f_{ij} = \omega_j h'_{ij} \tag{11}$$

Step 3: Determine the positive ideal solution f_j^+ and the negative ideal f_j^- of the ideal sample:

$$f_j^+ = \begin{cases} \max(f_{ij}),\ j \in J^+ \\ \min(f_{ij}),\ j \in J^- \end{cases} \tag{12}$$

$$f_j^- = \begin{cases} \min(f_{ij}),\ j \in J^+ \\ \max(f_{ij}),\ j \in J^- \end{cases} \tag{13}$$

Among them, J^+ are positive Indicators, and J^- are negative Indicators. This paper selects the optimal index value and the worst index value of the sample as positive and negative ideal solutions.

Step 4: The symmetric interaction entropy of each evaluation object to the positive and negative ideal values is as follows:

$$D_i^+ = \sum_{j=1}^{n} \left[f_j^+ \log \frac{2 f_j^+}{f_j^+ + f_{ij}} + (1 - f_j^+) \log \frac{2(1 - f_j^+)}{2 - f_j^+ - f_{ij}} + f_{ij}^+ \log \frac{2 f_j^+}{f_j^+ + f_{ij}} + (1 - f_{ij}^+) \log \frac{2(1 - f_j^+)}{2 - f_j^+ - f_{ij}} \right] \tag{14}$$

$$D_i^- = \sum_{j=1}^{n} \left[f_j^- \log \frac{2 f_j^-}{f_j^- + f_{ij}} + (1 - f_j^-) \log \frac{2(1 - f_j^-)}{2 - f_j^- - f_{ij}} + f_{ij}^- \log \frac{2 f_j^-}{f_j^- + f_{ij}} + (1 - f_{ij}^-) \log \frac{2(1 - f_j^-)}{2 - f_j^- - f_{ij}} \right] \tag{15}$$

Step 5: Determine the closeness of each evaluation object to the ideal value:

$$Z_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{16}$$

Step 6: Comprehensively rank the evaluation objects according to the closeness. When is closer to 1, the evaluation object is closer to the optimal value, when is closer to 0, the evaluation object is worse.

4. Empirical analysis

4.1. Data source

In order to verify the validity of the model, five representative ports of Shanghai Port, Ningbo Zhoushan Port, Dalian Port, Qingdao Port and Tianjin Port are selected as samples. The scoring of the quantitative indicators refers to the 2017-2019"China Ports Yearbook", the sustainability report of each port, the corporate social responsibility report and the statistical website of each city. At the same time, according to the scores of the qualitative indicators by 5 experts, the scores will be scored according to the method in 2.4 Take the average value and sort to get Table 2.

Tab.2 Expert scoring results

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Shanghai port	V	V	V	V	V	IV	V	V	V	V
Ningbo-Zhoushan port	V	IV	V	IV	IV	IV	IV	V	III	III
Dalian port	V	IV	V	IV	IV	III	IV	V	II	III
Qingdao port	V	V	V	IV	IV	IV	V	V	III	III

Tianjin port	V	IV	V	IV	IV	IV	IV	V	II	III
	C11	C12	C13	C14	C15	C16	C17	C18	C19	
Shanghai port	IV	V	V	IV	III	V	III	V	III	
Ningbo-Zhoushan port	III	IV	V	IV	III	IV	III	V	IV	
Dalian port	III	IV	V	IV	III	V	III	V	IV	
Qingdao port	III	IV	V	IV	II	V	II	V	V	
Tianjin port	III	IV	V	III	II	V	II	V	IV	

4.2. Cloud inference computing

This article constructs 5 qualitative descriptions of cloud reasoning "if-then". In order to facilitate understanding and calculation, set the interval of the antecedent "IV" of the rule to [0, 2], [2, 4], [4, 6], [6, 8] and [8, 10], the rule consequence interval is set to [0, 20], [20, 40], [40, 60], [60, 80] and [80, 100], according to the formula(1).The antecedent and subsequent parameters of cloud inference are calculated as shown in Table 3.

Tab.3 Parameters of cloud reasoning

Antecedents	Digital characteristics	subsequent	Digital characteristics
I	(1, 1/3, 0.01)	low	(10, 10/3, 0.01)
II	(3, 1/3, 0.01)	Lower	(30, 10/3, 0.01)
III	(5, 1/3, 0.01)	general	(50, 10/3, 0.01)
IV	(7, 1/3, 0.01)	Higher	(70, 10/3, 0.01)
V	(9, 1/3, 0.01)	high	(90, 10/3, 0.01)

Taking Shanghai Port's indicator C3 "Work Plan" as an example, if the "Work Plan" score is at level V, the factor effect score is high. First, use the regular antecedent cloud (9, 1/3, 0.01) to input CGP, generate a normal random number, repeat the calculation 500 times, take the average of it as the specific value, and bring in the specific value of 7.207, and the calculated certainty is 0.7146. Secondly, input the certainty value into CGQ, and use the rule cloud (90, 1/3, 0.01) to generate a positive random number. Since the specific value is less than 9, the factor action score is 94.949. In the same way, the factor action scores of all indicators are obtained by MATLAB, which is shown in Table 4.

Tab. 4 Function score of cloud reasoning factors

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Shanghai port	93.647	88.187	94.949	85.128	87.423	69.645	94.154	85.123	90.955	86.879
Ningbo-Zhoushan port	89.337	71.619	85.963	72.166	66.069	73.126	68.476	90.226	45.34	54.49
Dalian port	93.19	73.482	92.005	71.005	73.306	53.63	70.005	91.607	32.301	53.244
Qingdao port	89.291	91.164	86.49	68.242	66.932	69.454	87.111	91.913	46.673	46.932

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Tianjin port	88.502	73.542	87.429	71.222	65.52	71.089	67.116	92.939	33.972	50.005
	C11	C12	C13	C14	C15	C16	C17	C18	C19	
Shanghai port	73.193	87.739	85.452	70.723	48.414	86.864	45.268	92.283	54.194	
Ningbo-Zhoushan port	53.789	66.29	93.34	69.972	54.77	68.25	46.508	89.147	74.763	
Dalian port	49.987	68.298	88.187	73.881	53.89	93.475	46.239	89.995	74.094	
Qingdao port	51.005	72.55	92.171	73.915	31.231	85.23	34.785	87.892	89.349	
Tianjin port	52.482	7.764	89.954	53.753	32.418	94.108	31.629	87.207	69.451	

4.3. Entropy weight calculation

Standardize the evaluation value according to formulas (2)-(7), and obtain the entropy weight of each index, which is shown in Table 5.

Tab.5 Weight Table

Primary indicators	Secondary indicators	Weight value
Strategy B1 (0.1863)	Strategic Planning C1	0.0558
	Special fund C2	0.0663
	Work Plan C3	0.0642
Culture B2 (0.1736)	Corporate Culture C4	0.0611
	Educational training C5	0.0877
	Campaign C6	0.0248
Environmental Protection B3 (0.0965)	Pollution Control C7	0.0708
	Resource utilization and ecological protectionC8	0.0257
Save and low carbon B4 (0.297)	Main equipment C9	0.075
	Operation process C10	0.0757
	Auxiliary facilities C11	0.0902
	Energy consumption C12	0.0561
System B5 (0.0571)	Management agency C13	0.0321
	Audit certification C14	0.025
Regulation B6 (0.1123)	Target assessment C15	0.0491
	Statistical Monitoring C16	0.0262
	Incentive and restraint C17	0.037
Level B7 (0.0772)	Environmental protection ecology C18	0.0455
	Save and low carbon C19	0.0317

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4.4. Closeness calculation

Firstly, find the maximum value and minimum value of the weighted standardized matrix F according to formulas (10)-(14), and determine the positive and negative ideal solutions of the port to be evaluated as:

f_j^+ =(0.0257,0.0338,0.0305,0.0315,0.0474,0.012,0.0381,0.0118,0.0563,0.0489,0.052,0.0297,0.0149,0.012,0.0265,0.0128,0.0186,0.021,0.0177),

f_j^- = (0.0243,0.0265,0.0276,0.0253,0.0355,0.0088,0.0272,0.0108,0.02,0.0264,0.0355,0.0224,0.0137,0.0087,0.0151,0.0093,0.0126,0.0199,0.0105)

Secondly, according to formulas (15)-(17), calculate the closeness and ranking of the five ports' respective first-level indicators and the level of green ports, as shown in Table 6 and Table 7.

Tab.6 Evaluation results and ranking

Primary indicators	Evaluation objects	Shanghai port	Ningbo-Zhoushan port	Dalian port	Qingdao port	Tianjin port
Strategy B1	Closeness	0.9951	0.2053	0.1365	0.1322	0.1599
	ranking	1	2	4	5	3
Culture B2	Closeness	0.9781	0.0010	0.1300	0.8493	0.0157
	ranking	1	5	4	2	3
Environmental Protection B3	Closeness	0.9774	0.0143	0.0361	0.9063	0.0226
	ranking	1	5	3	2	4
Save and low carbon B4	Closeness	1.0000	0.0935	0.0087	0.0817	0.0101
	ranking	1	2	5	3	4
System B5	Closeness	0.8484	0.9581	0.9572	0.9979	0.0338
	ranking	4	2	3	1	5
Regulation B6	Closeness	0.9286	0.8851	0.9991	0.0744	0.1260
	ranking	2	3	1	5	4
Level B7	Closeness	0.0173	0.5264	0.4538	0.9871	0.5036
	ranking	5	2	4	1	3

Tab.7 Comprehensive evaluation results and ranking

main target	Evaluation object	Shanghai port	Ningbo-Zhoushan port	Dalian port	Qingdao port	Tianjin port
Green port level	Closeness	0.9449	0.2457	0.1649	0.2074	0.0485
	ranking	1	2	4	3	5

4.5. Analysis of evaluation results

(1) By observing Table 6, we can get the following conclusions:

From the perspective of strategic indicators, Shanghai Port has the most advantage, with a closeness of individual indicators of 0.9951, followed by Ningbo Zhoushan Port and Qingdao Port the worst. In recent years, Shanghai Port has formulated the "Special Plan for Building Green, Circular and Low-Carbon Ports for Energy Conservation and Emission Reduction", which has achieved the set goals and is therefore far ahead.

From the perspective of cultural indicators, Shanghai Port ranks first. Shanghai Port has integrated green awareness and concepts into the entire process of port construction, with satisfactory results. Qingdao Port ranked second and Ningbo Zhoushan Port ranked second.

From the perspective of environmental protection indicators, Shanghai Port did the best, while Ningbo Zhoushan Port had a container rollover at the end of 2018, resulting in large-scale pollution of the river on the north side of the coastal middle line, so this indicator scored poorly.

In terms of saving and low-carbon indicators, Shanghai Port has achieved a good score of 1.0, while Dalian Port has a poor performance. Combined with Table 5, it can be seen that the index of saving and low carbon has the highest weight, while the score of Dalian Port is lower, which leads to the lower ranking.

In terms of system indicators, Qingdao Port is the best. In recent years, the strategic plan of "blue sky, green land and clear water" has been implemented. Ningbo Zhoushan Port and Dalian Port are almost the same, Tianjin Port is the worst.

From the perspective of institutional indicators, Dalian Port is the best, with a closeness of 0.9991. Dalian Port has been actively carrying out the assessment of green port operations and providing appropriate incentives to outstanding departments. The remaining rankings are Shanghai Port, Ningbo Zhoushan Port, Tianjin Port and Qingdao Port.

From the perspective of level indicators, Qingdao Port ranks the highest. In recent years, the port has built coal mine system dust-proof facilities, oil and gas recycling equipment and environmental monitoring equipment. The closeness of Ningbo Zhoushan Port, Tianjin Port and Dalian Port is close, while Shanghai Port is poor in this respect.

(2) It can be seen from Table 7 that the overall ranking of green ports in descending order is Shanghai Port, Ningbo Zhoushan Port, Qingdao Port, Dalian Port and Tianjin Port.

The closeness of Shanghai Port's green port level is 0.9449, leading by an overwhelming advantage, especially in terms of strategy, culture, environmental protection, and low-carbon conservation. Shanghai Port is the first port in my country to carry out green research. In recent years, it has continuously formulated and improved the green port strategic plan, developed and upgraded main equipment, optimized operation technology and auxiliary facilities, such as promoting the port area LED green lighting project, shore power technology, energy feedback system Measures such as transformation. Shanghai Port should continue to take the lead in demonstrating and strive for new breakthroughs.

The closeness degree of Ningbo Zhoushan port green port level is 0.2457, ranking the second overall, but there is a big gap between Ningbo Zhoushan port and Shanghai port. At present, the environmental impact assessment system of construction projects has been effectively implemented, which makes the level of green construction significantly effective, but at the same time, cultural construction is ignored. Therefore, it is suggested to strengthen education and training and green concept and cultural publicity, so as to deepen the awareness of green port into every link of port operations.

Qingdao Port ranks third, the closeness of the green port level is 0.2074, and the green development level is in the middle of these five ports. Its system and level indicators are relatively competitive, but they are slightly weaker in terms of strategic indicators. It is recommended to continue to maintain its advantages, make use of its own development potential, enhance comprehensive strength in all aspects, formulate appropriate development strategies and work plans, and increase the investment of special funds for green port construction to improve the level of green ports.

The closeness of Dalian Port's green port level is 0.1649, ranking fourth overall. The port has an advantage in system construction, but its low-carbon index is slightly poor. Therefore, it is recommended that Dalian Port strengthen the upgrading of equipment and operating technology, learn from the measures of Shanghai Port, actively promote shore power technology, and reduce consumption and improve pollution control capabilities through energy substitution.

The closeness of Tianjin Port's green port level is 0.0485, ranking last. Although it has been effective in most aspects of green port construction, it is slightly lacking compared with other ports in terms of environmental protection, low-carbon conservation, system and institutional indicators. It can be seen from Table 5 that low-carbon conservation and strategic indicators have higher weight values, which have a greater impact on the green development level of the port. Therefore, it is recommended that Tianjin Port improve the level of operation technology and strengthen the optimization of equipment. For example, by continuing to promote the use of clean energy, improving old equipment, increasing the level of informatization of operations, and improving the efficiency of equipment to improve the level of green ports.

5. Comparative analysis

In order to verify the reliability of the model, the methods of literature [7] and literature [8] are used for green port evaluation, and compared with the method in this paper, the results in Table 8 are obtained:

Tab.8 Comparison results of different methods

Port	The model of the paper	Ranking	literature [7]	Ranking	literature [8]	Ranking
Shanghai port	0.9449	1	0.8111	1	0.8617	1
Ningbo-Zhoushan port	0.2457	2	0.5535	3	0.2907	2
Dalian port	0.1649	4	0.5648	2	0.2417	4
Qingdao port	0.2074	3	0.5358	4	0.2797	3
Tianjin port	0.0485	5	0.4628	5	0.1254	5

It can be seen from Table 8 that the method in literature [7] is different from the method in this article, and the method in literature [8] is consistent with the method in this article. The reason is that literature [7] ignores the uncertainty factor of the evaluation process. The constant of the coefficient leads to a reduction in the distribution interval of the correlation degree, thereby reducing the discrimination of the results. Although the ranking result of literature [8] is the same as that of this paper, it can be seen from the calculation results that the values of the remaining four ports are relatively close except that the value of Shanghai Port is more distinguishable from other ports. Therefore, when there are too many evaluation objects, these two methods also have certain drawbacks. The calculation results are not conducive to judgment and comparison. The method in this article can comprehensively consider the uncertain factors of the evaluation process, and calculate the distance and difference between the ideal solution Measure of sex, increase the discrimination of evaluation results.

6. Conclusion

This article refers to the relevant evaluation index system, constructs the TOPSIS green port evaluation model based on cloud reasoning and improvement, and evaluates the green development level of Shanghai Port, Ningbo Zhoushan Port, Dalian Port, Qingdao Port and Tianjin Port, taking into account the green port evaluation process The ambiguity and randomness of the evaluation have realized the qualitative and quantitative conversion of the evaluation, and reduced the influence of subjective factors in the scoring by experts, and improved the discrimination of evaluation results. According to the evaluation results of this model, the development status of green ports can be judged, and the weak links in the practice of green ports can be found, which provides a theoretical basis for promoting the development of green ports.

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