8-25-2023

Research on performance evaluation system of shipping enterprises under "Double Carbon" strategy

Xiaoyu Xue

WORLD MARITIME UNIVERSITY

Shanghai, China

RESEARCH ON PERFORMANCE EVALUATION SYSTEM OF SHIPPING ENTERPRISES UNDER "DOUBLE CARBON" STRATEGY

by

XUE XIAOYU

A dissertation submitted to the World Maritime University in partial
Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

(ITL)

2022

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ACKNOWLEDGEMENTS

I would like to thank the people who gave me love and help during my thesis!

First of all, I would like to thank my tutor, Professor Zhang Chuan, and my fellow senior brothers and sisters. Professor Zhang gave me valuable advice. Even at 11:00 p.m., she was still communicating with me by telephone. I would also like to thank the elder martial brothers and sisters I have never met. Due to the epidemic situation, I can only hold group meetings online. Thank you very much for pointing out the shortcomings of my article and the parts that need to be modified. I can't do this without you.

Secondly, I would like to thank my family, my mother, father, brother, and grandmother. Due to the outbreak of the epidemic in Shanghai and the implementation of sealed management in the region, I had to finish my thesis at home alone. Thank you for your care and encouragement in my life.

Finally, I would like to thank myself and every cell in me who keeps working hard. It is you who let me finish this graduation thesis.

ABSTRACT

Title of Dissertation: **RESEARCH ON PERFORMANCE EVALUATION SYSTEM OF SHIPPING ENTERPRISES UNDER "DOUBLE CARBON" STRATEGY**

Degree: **Master of Science**

Climate warming has been one of the severe problems facing the world. In 2020, China proposed the development goal of "striving to peak carbon dioxide emissions before 2030, and strive to be carbon neutral by 2060". The shipping industry, accounting for nearly 90% of the global trade and transportation volume, is a pillar industry relating to national security and the lifeline of the national economy. Accordingly, with ESG (Environment, Society, and Governance) as the starting point in combination with ESG indicators, this study aims to build a feasible performance assessment of shipping enterprises and actively serve IMO and the national carbon emission reduction plan to achieve the zero-carbon development goal.

First, the research methods used in performance assessment, the relevant theoretical basis, and the implementation status of ESG are summarized. The author elucidated conventional enterprise performance assessment methods, and highlighted the necessity and feasibility of introducing ESG indicators. Secondly, the three dimensions' objectives are decomposed, and the author select the key indicators suitable for the low-carbon development of shipping enterprises. Secondly, the performance assessment system of shipping enterprises based on the "Double Carbon" strategy is preliminarily built through the analytic hierarchy process. Thirdly, the assessment indicators are further optimized and refined with COSCO SHIPPING Energy as the sample, and development suggestions are proposed according to the performance. Lastly, this study stresses that it is imperative for shipping enterprises to pay attention to IMO's greenhouse gas emission reduction strategy and China's "Double Carbon" strategy. The Chinese government is required to facilitate the formulation of carbon emission reduction laws and regulations. Hopefully, this study can provide a novel perspective for the performance assessment of shipping enterprises.

KEYWORDS: Performance evaluation system, ESG, shipping enterprises, carbon neutralization, carbon peak

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1. Preface

1.1 Background

On September 22, 2020, the Chinese government proposed at the 75th Session of the United Nations General Assembly: “China will increase its nationally determined contribution, adopt more powerful policies and measures, strive to peak carbon dioxide emissions before 2030, and strive to be carbon neutral by 2060”. When the Chinese government is committed to achieving its aim for carbon neutrality by 2060, the management and control from the source of production should be strengthened. Accordingly, carbon emission enterprises shoulder important historical missions and responsibilities and are a vital important force to achieve the aim of carbon neutrality. On October 24, 2021, the State Council issued the “Carbon Peaking Action Plan before 2030”, which raised the requirements for guiding enterprises to actively adapt to green and low-carbon development and stressed the implementation of the Top Ten Actions for Carbon Peaking”. Thus, analyzing and constructing the strategic path of corporate carbon neutrality takes on a critical significance in promoting China’s overall realization of the “Double Carbon” goal.

1.2 Research objectives and significance

Shipping logistics, an essential industry supporting the national economy, is also an important industry for energy conservation and emission reduction under the hard constraints of the aim of “dual carbon”. A "low carbon" transformation is urgently required in Shipping logistics. In 2018, the International Maritime Organization (International Maritime Organization, IMO) survey report highlighted that the CO2 emissions of the shipping industry has surged from 960 million tons in 2012 to 1.06 billion tons in 2018. If not controlled, CO2 emissions from the shipping industry by 2050 may be increased by 250% compared with the data of 2012, which may hinder the achievement of global greenhouse gas reduction targets. To well implement the low-carbon transformation of shipping enterprises well, a performance evaluation system that better meets the current needs of reality should be selected, and the goal

of low-carbon transformation should be ultimately achieved.

At present, most of the performance evaluations of China's shipping enterprises are based on shareholder value orientation, and they pay insufficient attention to other stakeholders, thus hindering the low-carbon sustainable development of shipping enterprises. In the new era of high-quality economic development in China, low-carbon economy and stakeholder theory have aroused rising attention. This conventional performance evaluation method not only fails to correctly assess the performance of shipping enterprises, but also slows down the low-carbon economy of shipping enterprises. carbonization development. Accordingly, under the "Double Carbon" strategy, a performance evaluation system that better meets the actual needs of current shipping enterprises should be selected.

2. Literature review

2.1 Related theories of enterprise performance evaluation

2.1.1 Research status of strategic performance evaluation index system

Scholars have divided the development process of corporate strategic performance evaluation into different stages. Fang Zhenbang (2003) has suggested that the development process of corporate strategic performance evaluation can be nearly divided into three stages as follows. At the primary stage, corporate strategic performance evaluation was divided into performance evaluation methods based on cost analysis from the 19th century to the beginning of the 20th century. From the beginning of the 20th century to the 1990s, the financial performance evaluation method was divided into financial analysis as the evaluation object. At the contemporary stage, from the 1990s to the present, it was divided into financial and non-financial factors as the evaluation object and methods of assessing strategic performance.

In the late 1940s, as the consumer market had become a buyer's market instead of a seller's market, consumers demanded that enterprises take social responsibilities, the establishment of industry standards, and the improvement of production technology levels, etc. More requests were made. An enterprise seeking to gain a firm foothold in the fierce market competition must place stress on the construction of sustainable

competitive advantages at the strategic level, indicate the core factors in the process of performance evaluation, and employ financial performance indicators and non-financial performance indicators. The strategic performance evaluation index system is adopted to assess the overall performance of the enterprise from multiple perspectives. In the 1980s, economic globalization had led to a more intense international market, and increasing business operators began to realize that only using financial performance evaluations can no longer satisfy competition conditions. Peter Drucker (1995) stated that appropriate resources, matching competitiveness, and others should be obtained in the process of production and operation of enterprises. The above views are not limited to the scope of an ordinary performance evaluation. Although his ideas were not introduced into an actual model system, his summary of a few things laid a basis for refining performance reviews, i.e., adding non-financial metrics to it. From the 1990s to the early 2000s, non-financial metrics has been included in numerous performance evaluation systems. In 1995, the performance pyramid model proposed by Kelvin Cross & Richard Lynch (1995) integrated corporate financial, non-financial information and overall strategy while stressing the correlation between performance indicators and overall strategy. In 1992, Robert Kaplan & David Norton jointly proposed the Balanced Scorecard performance evaluation system. Moreover, they also introduced non-financial and financial indicators into the system with four dimensions (e.g., customer dimension, financial dimension, learning and development dimension, as well as internal process dimension). Andrew Neely & Chris Adams & Mike Kernerley (2002) proposed a novel performance evaluation theory, called the performance prism, which initially considered the balanced scorecard and stakeholder theory.

2.2 Research status of ESG

Cristiana bemardi, Andrew W. Stark (2018) investigated the change of the reporting system in South Africa. The study has suggested that the degree of disclosure of environmental, social and governance performance will be greater the greater with the rising impact of comprehensive reporting. The level of environmental, social and governance disclosure serves as an intermediate variable to determine the effectiveness of investor relations, and the result is the level of environmental disclosure.

Eccles et al. (2011) calculated the number of user access to ESG data (i.e., number of clicks) using the data from Bloomberg database. They found that from November

2010 to April 2011, the ESG database was clicked 2395230 times, thus suggesting that the market is increasingly interested in the level of transparency of the enterprise. Moreover, the interest in governance (1337078 clicks) and environmental (1238417 clicks) information is higher than that of social information (978541 clicks). PI Maria Baldini et al. analyzed the global samples using Bloomberg database from 2005 to 2012. As revealed by the research results, structural national factors significantly affect the ESG disclosure of enterprises, and political, labor and cultural systems play a critical role in the system theory. The national characteristics having the same impact on ESG disclosure comprise corruption and unemployment rate. For the former, state-owned enterprises with high-level corruption are more reluctant to disclose ESG information; For the latter, managers will try to attract highly skilled employees through ESG information disclosure tools, while the disclosure of detailed ESG information can be determined as a good career prospect for the enterprise

Bauer, Hoepner, Calver et al(2016) highlighted that considering non-financial factors in the investment process can lead to a wide variety of comparative advantages in increasing profitability and optimizing risk management. Some financial enterprises have argued that ESG factors are likely to facilitate asset management in the fixed income market

Capelle blancard (2016) suggested that good ESG practice is correlated with low default risk and low bond spread. ESG performance should be considered in the design of transnational strategic asset allocation. The correlation between ESG performance of foreign countries and long-term sovereign bond spreads is stronger than that between ESG performance of a nation and its short-term bond spreads

Socrates(2018) involves the Russell 3000 index, S & P 500 index, as well as all complete ESG and CBI reports published in the global investment field.

3.Related concepts of “Double Carbon” strategy and performance evaluation system

3.1 Significance and connotation of “Double Carbon” strategy

3.1.1 Definition of “Double Carbon” strategy

In September 2020, in a speech at the general debate of the 75th session of United Nations General Assembly, the Chinese government promised that “China will increase its independent national contribution, adopt more powerful policies and measures, strive to reach the peak of carbon dioxide emissions by 2030, and strive to be carbon neutral by 2060”. On April 30, 2021, during the 29th collective study of the Political Bureau of the Central Committee of the Communist Party of China, General Secretary Xi Jinping highlighted that achieving the aims of carbon peaking and carbon neutrality is China’s solemn commitment to the world, and it is also an extensive and profound economic and social change that is difficult to achieve. Carbon peaking and carbon neutrality should be incorporated into the overall layout of ecological civilization construction, the momentum of grasping iron and traces should be shown, and the aims of carbon peaking by 2030 and carbon neutrality by 2060 should be achieved as scheduled.

3.1.2 Connotation of “Double Carbon” strategy

The notice of the State Council on Printing and Distributing the action plan for achieving carbon peak by 2030 on October 24, 2021 mentioned that we should build a novel development pattern, adhere to the system concept, and adequately cope with the correlation between development and emission reduction. It is necessary to make overall plans for stable growth and structural adjustment and incorporate carbon peak and carbon neutrality into the overall situation of economic and social development.

The document stresses the green and low-carbon action of transportation. It is necessary to expedite the formation of green and low-carbon transportation modes and ensure that the growth of carbon emissions in the transportation sector is still in a

reasonable range. The low-carbon transformation of transportation tools and equipment should be promoted, a green and efficient transportation system should be built, and the construction of green transportation infrastructure should be accelerated. In 2018, the International Maritime Organization (IMO) survey report highlighted that the CO2 emissions of the shipping industry increased from 960 million tons in 2012 to 1.06 billion tons in 2018. If not controlled, the CO2 emissions of the shipping industry may increase by 20% in 2050 compared with the data of 2012, which may hinder the realization of the global reduction goal of greenhouse gas emissions. Thus, it is challenging to reduce the carbon emission in the shipping industry.

3.2. Enterprise performance evaluation and evaluation methods

3.2.1Cost performance evaluation

From the middle of the 19th century to the beginning of the 20th century, the concept of enterprise performance evaluation gradually rose in western nations. In this period, the enterprise managers only conducted simple cost measurement and accounting to gain insights into the profitability of the enterprise, so the performance evaluation indicators in this period only involve the cost indicators. The cost performance evaluation method is the most conventional and simple performance evaluation method. At first, the cost performance evaluation method has only used the calculation of production cost to understand the level of business performance, which is termed the simple cost evaluation method. The disadvantage of this method lies in the lack of cost control in advance and in the process, and it can only achieve cost control after the event, when the timeliness is relatively low. Subsequently, the new concept of standard cost was introduced, and the standard cost method was achieved. Its working principle is to analyze the difference in accordance with the standard to assess the operation of the enterprise.

Although the standard cost has optimized the cost performance evaluation system to a certain extent, it still does not solve the most significant drawback of focusing on cost accounting and ignoring other factors. It only focuses on the production cost, and long-term separation from the external environment hinders the long-term sustainable development of the enterprise.

3.2.2 Financial performance evaluation

In the 20th century, DuPont built a comprehensive performance evaluation system with the rate of return on owner's equity as the core. With the rate of return on owner's equity as the apex, it was decomposed layer by layer to determine the effect of specific indicators on the enterprise's financial performance to achieve the aim of comprehensive evaluation of the enterprise's financial situation. The application of this method continues to the present.

The financial performance evaluation method enriches the performance evaluation index system. Moreover, most of its data sources originate from the financial statements of enterprises, which is available and reliable. However, the biggest problem with this method is the lack of consideration of non-financial information, and the lack of consideration of the level of business management and the performance of social responsibility. This causes the financial performance evaluation method to pay excessive attention to short-term benefits and ignore the long-term development of enterprises

3.2.3 Economic value added

The concept of economic value added (EVA) was initially proposed by the enterprise. It is primarily capable of measuring the enterprise's ability to operate capital and realize the value-added ability of capital, and helping enterprise managers gain insights into the completion rate of enterprise business objectives. Its core idea is that capital investment should pay the corresponding cost. To appreciate shareholder value, it is imperative to control the cost of capital while pursuing enterprise profits. Taking economic value added as the core standard of the enterprise performance evaluation system can fully consider the capital operation of the enterprise when analyzing the financial statements, so that the owners and shareholders of the enterprise can gain a full insight into the value-added that can be achieved in the daily operation of the enterprise.

However, EVA is a result index based on financial data, which determines its great limitations. It only places stress on financial indicators, without considering environmental impact, scientific and technological innovation, product or service quality and other non-financial indicators, thus managers ignore all processes in the

business chain and only focus on financial status. Furthermore, EVA mainly assesses the enterprise performance from the perspective of shareholders, and pays little attention to creditors, suppliers, consumers and other stakeholders, thus hindering the long-term development of the enterprise.

3.2.4 Balanced Scorecard

The concept of Balanced Scorecard was originally proposed by Professor Robert S. Kaplan of Harvard University and CEO David P. Norrenton. It is known as the most important innovation in management accounting in the 1990s. The Balanced Scorecard theory divides the daily operation of enterprises into four dimensions: financial dimension, customer dimension, internal process dimension and learning and growth dimension. Based on the above four dimensions, the strategy and mission of the enterprise are specified, and corresponding indicators are set to measure it, so as to improve the operation efficiency of the enterprise. The main advantage of the balanced scorecard is that it breaks through the boundaries of the conventional enterprise performance evaluation, no longer simply focuses on the consideration of financial dimensions, but takes financial indicators as the core, adds non-financial indicators, expands the scope and breadth of performance evaluation, and helps managers comprehensively manage the enterprise's operations.

Although the Balanced Scorecard to a large extent reflects the non-financial situation of enterprises, it does not take low-carbon factors into account, which makes enterprises lack control and incentive in low-carbon environmental protection. In addition, the financial indicators used in the Balanced Scorecard do not consider the cost of capital and cannot reflect the value added created by the enterprise for shareholders.

4.Proposal and objectives of ESG and its implementation status at home and abroad

4.1 Key objectives of implementing ESG

Although the ESG concept has had a wide range of influence around the world since the concept of ESG was put forward, ESG index products and index systems have been released accordingly, and relevant departments have also actively promoted the development process of ESG, but they all face incompatibility when entering the Chinese market. There are many deficiencies in measuring the ESG performance of Chinese enterprises due to the lack of understanding of China's national conditions. Accordingly, this study will analyze the deficiencies in the application of international ESG in China from three aspects.

4.1.1 Improve stakeholders' right to know

In Europe and the United States, the legal system of class action, collective claim and insider trading punishment has been quite perfect, but there is still considerable room for improvement in China. Voluntary disclosure of information by Chinese listed enterprises is generally low in disclosure level and insufficient in motivation, and has a downward trend in 2015. The control power of Listed Enterprises in China is highly competitive, and non-major shareholders can hardly participate in the decision-making of the board of directors, so they cannot supervise the board of directors. In the absence of supervision by the board of directors and the management, a considerable number of enterprises have short-term behavior, ignore long-term development, and cause unnecessary losses to the interests. ESG information disclosure can enable stakeholders to gain more insights into the non-financial trends of enterprises, supervise corporate governance in combination with their own interests, and form a harmonious development ecosystem.

4.1.2 Enhance fair competition in the industry

The purpose of ESG information is to encourage enterprises to undertake corporate social responsibility. The above rules emphasize the information disclosure of priority, business strategy, enterprise system and relevant supporting data, which contains the information concerned by investors, whereas the disclosure requirements are unclear in accordance with the conventional financial importance principle. The critical principle of information disclosure design is the usefulness of information, i.e., whether the information voluntarily disclosed by the enterprise can reduce the degree of information asymmetry between the management and investors, enable investors to make independent judgments under a unified framework, and make investors' investment decisions more rational. Otherwise, the more information disclosed, the more the enterprise will suffer. Since more information is disclosed, the more people will criticize it. However, other enterprises with poor performance in ESG will criticize it less as they disclose less information or do not disclose it, thus resulting in the phenomenon of “bad currency expelling good currency” in the market competition. The establishment of a standardized ESG evaluation system is conducive to reducing the information asymmetry barriers between enterprises and investors and optimizing benign market competition.

4.2 Current implementation of ESG in China

4.2.1 Development of important ESG information disclosure policies in China

The State Environmental Protection Administration issued the first regulation on environmental information disclosure of enterprises- Announcement On Environmental Information Disclosure in September 2003. The announcement stressed that it is imperative for enterprises included in the list of polluting enterprises to publish environmental information, including five types of information (environmental protection policy, pollutant ranking, environmental pollution control, environmental compliance, as well as environmental management). Since then, the domestic regulatory authorities and exchanges have issued a series of policy documents and guidelines to force or encourage domestic enterprises for ESG information disclosure. The Shenzhen Stock Exchange issued the guidelines on social responsibility of Listed Enterprises in September 2006, and the Shanghai Stock Exchange issued the Guidelines On Environmental Information Disclosure Of Listed Enterprises in May 2008 to encourage listed enterprises to disclose social

responsibility reports. On September 11, 2015, the Political Bureau of the Central Committee of the Communist Party of China held a meeting to consider and adopt the overall plan for the reform of ecological civilization system, requiring the establishment of a mandatory environmental information disclosure mechanism for listed enterprises. The stock exchange of Hong Kong ("SEHK") issued the consultation summary document of the guidelines for environmental, social and governance reports on December 21, 2015, requiring listed enterprises in Hong Kong to issue ESG reports from the financial year beginning after January 1,2016, and upgrading part of ESG information disclosure to "interpretation on non-compliance". In July 2018, the China Fund Industry Association issued the green investment guidelines (Implementation), which put forward the ESG information disclosure framework of listed enterprises for the first time.

4.2.2 ESG development status of Chinese capital market

Hong Kong Exchanges and Clearing Limited (HKEx) refers to one of the major exchanges worldwide. HKEx issued the environmental, social and regulatory reporting guidelines (hereinafter referred to as ESG guidelines) in December 2015, requiring enterprises to disclose environmental, social and regulatory information every year, and raising the disclosure standard of the general disclosure items at each level and the 12 critical performance indicators under the three levels of scope a (environment) to "explain without disclosure". As a result, the disclosure of some information rise from voluntary behavior to "mandatory" behavior. Since the issuance of the guidelines, the disclosure of HKEx has significantly improved the quality of corporate social responsibility reports, which is primarily reflected as follows. 1. The overall level of the report is excellent, and the degree of internationalization is high. 2. The report has good innovation in concept and structure: the disclosure of information closely complies with the theme of responsibility and development, and fully demonstrates the characteristics of corporate social responsibility. 3. The indicators within the scope of social responsibility disclose employment, health and safety, product responsibility, etc. 4. Indicators within the scope of environment, reflecting industry characteristics are comprehensively covered.

4.3 Current implementation of ESG in China

4.3.1 Investors' insufficient cognition of ESG information

In China, the asset management industry continues to be emerging, so the above enterprises are still in the learning and development stage. A considerable number of asset owners and entrusted asset management enterprises do not gain insights into ESG. Compared with the mature financial system, financial information primarily discloses historical data, while ESG information places more stress on the long-term value. At present, China's ESG investment in this market is not very influential. The scale of ESG index products is small, and the degree of attention is relatively low. Most investors have short-term speculation. Even though China pays attention to corporate social responsibility, this is not what most investors are concerned with. The above phenomenon leads to insufficient attention from the mainstream investment community to ESG. ESG information users and promoters have cognitive bias, thus hindering the promotion of ESG.

4.3.2 Imperfect standardization of ESG information

The global initiative for sustainability rates (GISR) management questionnaire survey on more than 100 sustainability rating agencies worldwide shows that different rating agencies have different scores on the same evaluation index, and many enterprises also complain about getting different scores from different suppliers. The aggregate fusion research project of the MIT Sloan School of management is working to solve this problem. They found that the correlation between different rating agencies was as low as 10%, and one rating agency thought that the best performing enterprise might be at the end of another rating agency. One consequence of so many agencies' rating is that rating agencies should also be rated. Several institutions in China have also cooperated with different international organizations over the past few years, whereas the research results are still insufficiently deep. Most of the studies only have highlighted the single factors in environment, society and corporate governance, whereas they fail to analyze ESG under China's national conditions comprehensively. Furthermore, the evaluation methods used are also quite different due to the different selection of industry information samples by various institutions.

5. Construction of performance evaluation system of shipping enterprises based on “Double Carbon” strategy

5.1 Selection principle of evaluation index

A scientific performance evaluation system should be conducive to coordinating the interests of all aspects of the enterprise, displaying the effective information of all aspects of the enterprise, and be conducive to the sustainable development and normal operation of the enterprise. The construction of the shipping enterprise evaluation system under the “Double Carbon” strategy should not only reflect the low-carbon and sustainable development requirements of general enterprises, but also reflect the development characteristics of China's shipping enterprises.

5.1.1 Practicality

When we build the evaluation index system through the analytic hierarchy process, whether the index meets the applicability will be particularly important. Indicators divorced from practical application will lack application value, just like a mirage, which will not help the effective transmission of information. Thus, in the process of selecting indicators, it is necessary to refer to the previous research experience and reasonably screen the practicability of indicators to improve the trust of indicators.

5.1.2 Feasibility

Whether the indicators are easy to obtain in practice, whether they are feasible in technology and time, and whether they can be calculated by accurate measurement methods should be considered in the design of the enterprise performance evaluation system. Moreover, the collection of indicators should strive to save money and use the least money to acquire feasible information.

5.1.3 Continuity

The performance of enterprises on environment, governance and society revealed in the indicator system should be continuous rather than temporary. The content and requirements of indicators should be conducive to enhancing the sustainable development ability of enterprises. Enterprises' low-carbon emission reduction is a long-term development, instead of a temporary event. Besides, performance indicators should reflect whether the carbon emission reduction plan is sustainable.

5.1.4 Comparability

Comparability requires that each index of the evaluation system be horizontally and vertically comparable. Vertical comparability means that indicators are comparable in the time dimension. Indicators at different time points can be compared to analyze the development of the enterprise; Horizontal comparability means that indicators are comparable among enterprises. The purpose of comparing indicators of different enterprises is to objectively assess their own enterprise performance through comparison with other enterprises

5.2Performance evaluation indicator dimension based on "double carbon" strategy

5.2.1 Environmental indicators

Environmental indicators indicate the performance of inputs and outputs of production and operation activities of enterprises and their effect on the natural environment. With the rapid development of the world economy, the number of ships in various shipping countries has been increasing over the past few years, and the trend of large-scale development of ships has become increasingly significant. The greenhouse gas emissions of the shipping industry have increased significantly, and the pressure of air pollution prevention has been rising. Environmental issues have aroused rising attention, and the environmental responsibility of shipping enterprises has been concerned by all sectors of society.

5.2.2 Social indicators

Social performance indicators indicate the direct or indirect impact of enterprise production and business activities on the social system. Corporate social performance

generally covers occupational health and safety, employment, social development, product responsibility, etc. For shipping enterprises, the degree of customer satisfaction with the transportation services provided by the enterprise takes on a critical significance, which is correlated with whether they can win in the fierce industry competition. Enterprises should make timely progress with the market situation, constantly reflect on the current situation, carry out internal self-learning, and form a good awareness of learning and improvement. In the international environment, the enterprise can prevent and respond to possible risks to ensure the safety and mental health of employees and crew members.

5.2.3 Governance indicators

Governance indicators are the evaluation criteria for a set of institutional arrangements such as the supervision and control of business management and financial performance by enterprise owners. Whether the corporate governance is reasonable or not is significantly correlated with the long-term profitability of the enterprise. Whether the corporate governance structure is healthy or not determines whether the business behavior of the enterprise complies with the owner's goals and is the institutional guarantee for the steady operation of the enterprise.

5.3 Design of performance evaluation system for shipping enterprises under the "Double Carbon" strategy

The principle of index design should be followed in the process of index design and screening, with reference to the Ship Energy Efficiency Management Plan (SEEMP) proposed by IMO, MSCI database, ESG information disclosure, GRI social responsibility index system, China's accounting methods and reporting guidelines for greenhouse gas emissions, as well as relevant documents on index design issued by the government. Based on the research results of scholars on the performance indicator system of sustainable development, combined with the particularity of Chinese shipping enterprises, the performance indicators suitable for the low-carbon development of shipping enterprises are designed and selected. Based on ESG, the performance indicators fall into three criteria levels, including governance indicators, environmental indicators and social indicators. There are two-level indicators and three-level indicators at the criteria level. Now the factors for the performance evaluation of shipping enterprises are listed in Table 1:

Table 1 Factors for the performance evaluation of shipping enterprises

Target layer	Criterion layer (Primary index)	Secondary index	Tertiary indicators
Performance evaluation index of shipping enterprises	Governance	Financial performance	1. Profit 2. Profit payments and tax turnover 3. Asset liability ratio 4. Investment income ratio 5. liability with interest Asset turnover 6. Return on net assets 7. Rotation volume of freight transport 8. Crude oil transportation volume 9. Product oil transportation volume 10. Gross profit margin
		Industrial relations	1. Labor contract signing rate 2. Social insurance coverage
		Business capacity	1. Total assets 2. Owner's equity 3. Number of employees 4. Business income 5. EBITDA
	Environment	Materials &supplies	1. Self-owned ship (ship) 2. Average age performance (years) 3. LNG ship scale 4. Aggregate tonnage
		Supplier evaluation	1. New suppliers screened using environmental standards 2. Negative impact of supply chain on the environment and actions taken
		Energy	1. Total fuel consumption

			(million tons) 2. Sulfur content in marine energy 3. Utilization rate of fuel oil (low sulfur oil, high sulfur oil) 4. Water use density 5. Reduce energy consumption 6. Energy consumption within the organization
		Discharge	1. Wastewater discharge 2. NOx emissions 3. Sulfur oxide emissions 4. Hazardous waste discharge 5. Oil sewage discharge (ton) 6. Harmless waste discharge (ton)
	Society	Employment	1. Employee turnover rate 2. Employee satisfaction 3. Employee minimum wage to minimum wage ratio 4. Paid leave days
		Occupational health & safety	1. Anti-typhoon success rate 2. Success rate of anti-piracy 3. Health record coverage 4. Life casualty coverage
		Training &education	1. Employee training coverage 2. Number of employee training 3. Training duration per capita
		Diversity& equal opportunity	1. Wage ratio of male and female employees 2. Ratio of female managers 3. Number of female employees 4. Number of employees stationed abroad

5.4 Construction of AHP evaluation system

5.4.1 Introduction to analytic hierarchy process

The analytical hierarchy process (AHP) is a comprehensive evaluation method for systematic analysis and decision-making, which was developed by T.L.Saaty, an American operations research scientist and professor of the University of Pittsburgh, and evangelism in the 1970s. It is proposed based on a full study of human thinking engineering. It reasonably solves the quantitative processing process of qualitative problems.

The major feature of AHP is to transform human judgment into the comparison of the importance of several factors by forming a hierarchical structure to transform the qualitative problems difficult to quantify into the comparison of operational importance. In numerous cases, decision makers can directly use AHP for decision-making, thus significantly increasing the availability, reliability and feasibility of decision-making. However, its essence is a way of thinking. It decomposes complex problems into multiple constituent factors, while forming a hierarchical structure according to the dominant relationship. The overall ranking of the relative significance of decision-making schemes is determined through pairwise comparison. The whole process reveals the basic characteristics of human decision-making thinking.

5.4.2 Selection reason

The selection of evaluation method should consider the characteristics of the evaluation system. The selection of enterprise performance evaluation method mainly depends on the index evaluation system. The qualitative and quantitative problems of the index system. In this case, the evaluation method of analytic hierarchy process is more authentic and reliable. This method can assess the non-quantitative information of the evaluation system. At present, a complete theoretical system has been formed. The subjective judgment is quantified through modeling to improve the reliability.

5.4.3 Setting of boundary conditions

(1) Construct hierarchy model

When the analytic hierarchy process is applied to decision analysis, the problems that should be analyzed are generally divided into three levels , including target level (a), criterion level (b), and index level (P) from top to bottom. On that basis, a hierarchical structure model is built, in which the target layer is termed the highest layer, which contains only one element and is the predetermined goal of analyzing the problem. The criteria layer is termed the intermediate layer. The elements contained in this layer are the intermediate links involved in achieving the goals. This layer often comprises several elements, including the evaluation factors to be considered. Besides, the indicator layer is termed the factor layer, and the factors covered in this layer include the optional indicators to achieve the goals. The model built by the analytic hierarchy process generally meets the mutual domination between the elements of the respective layer, i.e., the elements of the same layer are dominated by the elements of the upper layer and play a dominant role in the elements of the lower layer.

Notably, the number of layers of analytic hierarchy process and the number of elements contained in the respective layer are not limited in theory. However, too many levels and too many elements in each level will bring unnecessary burden to the evaluation and decision-making, which hinders evaluation and decision-making, whereas it is counterproductive. Accordingly, the number of layers and elements should be determined in accordance with the specific situation. If a reasonable decision cannot be made, experts can be consulted to build a reasonable analytic hierarchy process model as much as possible.

(2) Construction of judgment matrix

After the establishment of the analytic hierarchy process (AHP) structure model, the elements of each level should be compared, and appropriate assigned values should be introduced for quantification to build the judgment matrix. For the comparison of the importance of the judgment matrix, the 9-level assignment method has been usually adopted to quantify the judgment matrix according to the 9-level assignment, as shown in Table 2

Table 2 Scale method table of level 1-9

Scale a_{ij}	Definition
1	a_i and a_j have the same effect
3	a_i is slightly stronger than a_j
5	a_i has stronger influence than a_j
7	a_i is obviously stronger than a_j

9	a_i is absolutely stronger than a_j
2,4,6,8	The influence ratio of a_i and a_j is between the above two adjacent levels
1,1/2,...,1/9	The ratio of a_i to a_j is the opposite of a_{ij} above

Thus, all relevant indicators are arranged in a matrix after analysis and assignment. Assuming that a_{ij}; is used to represent a specific assignment, the corresponding matrix A is expressed as follows

$$A = \left(a_{ij}\right)_{m\times n} \quad (5\text{-}1)$$

A	a_1	a_2	.....	a_m
a_1	a_{11}	a_{12}	.....	a_{1n}
a_2	a_{21}	a_{22}	.....	a_{2n}
.....	.....	.....	.....	.....
a_n	a_{n1}	a_{n2}	.....	a_{mn}

The question in the matrix indicates the relative importance of a_i pairs to the upper level indicators. The judgment matrix exhibits the following attributes: there is a multiple correlation between rows (columns), and the value is greater than 0, $a_i=1/a_{ji}$. When the above conditions are true, we call the matrix a positive reciprocal matrix. In the analytic hierarchy process, the built judgment matrices are all positive reciprocal matrices, If positive and negative proof meets $a_{ij} \times a_{ji}=a_{ik}$, then we call it a uniform matrix.

Whether the matrix logic is consistent should be observed for examining consistency. For instance, a > b, b > C. It can be deduced that a > C, and then a is more important than C. This is the logical consistency of judging thinking.

To test whether the judgment matrix constructed by us is a consistency matrix from a linear perspective, the following consistency tests should be performed.

$$A = \begin{matrix} a_{11} & \cdots & a_{1n} \\ a_{21} & \cdots & a_{2n} \\ a_{n1} & \cdots & a_{mn} \end{matrix} \quad (5\text{-}2)$$

The necessary and sufficient conditions for the consistency matrix are:

$$a_{ij>0} \quad (5\text{-}3)$$

$$a_{11}=a_{22} = \cdots\cdots = a_{in} = 1 \quad (5\text{-}4)$$

$$[a_{ij}, a_{i2}, \cdots\cdots, a_{in}] = k_i[a_{11}, a_{12}, \cdots, a_{1n}] \quad (5\text{-}5)$$

If a is A square matrix of order n and the rank of "a" is 1, one eigenvalue of "a" is tr (A), and the other eigenvalues are 0. The rank of all consistent matrices must be 1 since the rows of the consistent matrix are proportional. It can be deduced that the eigenvalue of the uniform matrix is n, and the other eigenvalues are 0. Notably, when the eigenvalue is n, the corresponding eigenvector is $k[1/a_{11}, 1/a_{12}, \cdots\cdots, 1/a_{in}]^T (K \neq 0)$

If the judgment matrix is a consistency matrix, it satisfies $\lambda_{max} > n$ if and only if the maximum eigenvalue $\lambda_{max} = n$, the judgment matrix A is not consistent

The consistency index CI is calculated as:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (5\text{-}6)$$

The corresponding average random consistency index Ri is found, as listed in Table 3

Table 3 Judgment matrix checklist

n	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41
n	9	10	11	12	13	14	15	16
RI	1.46	1.49	1.52	1.54	1.56	1.58	1.59	

The consistency ratio CR is obtained as:

$$CR = \frac{CI}{RI} \quad (5\text{-}7)$$

If CR<0.1, the consistency of the judgment matrix is considered to be acceptable; otherwise, the judgment matrix should be modified.

After the construction of matrix A is completed, the index weight should be calculated. If the judgment consistency matrix built by us is within the acceptable range, the following method is adopted to obtain the weight.

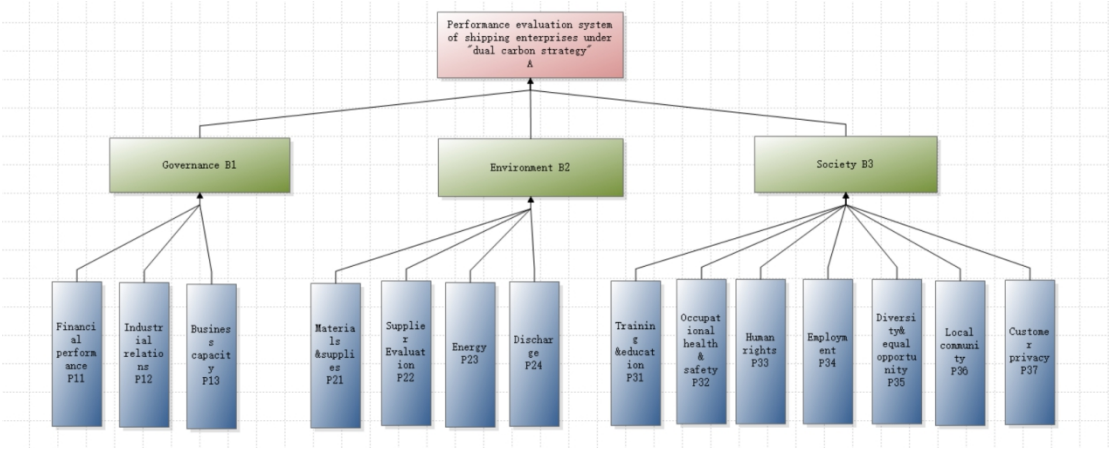
First, the maximum eigenvalue of matrix A and its corresponding eigenvector are obtained.

Subsequently, the required weight W is calculated by normalizing the obtained eigenvectors

5.5 Weight calculation by analytic hierarchy process

According to the performance evaluation indicators of shipping enterprises selected above, Yaahp is used to establish a hierarchy chart (Figure 1)

Figure 1 Performance evaluation model of shipping enterprises

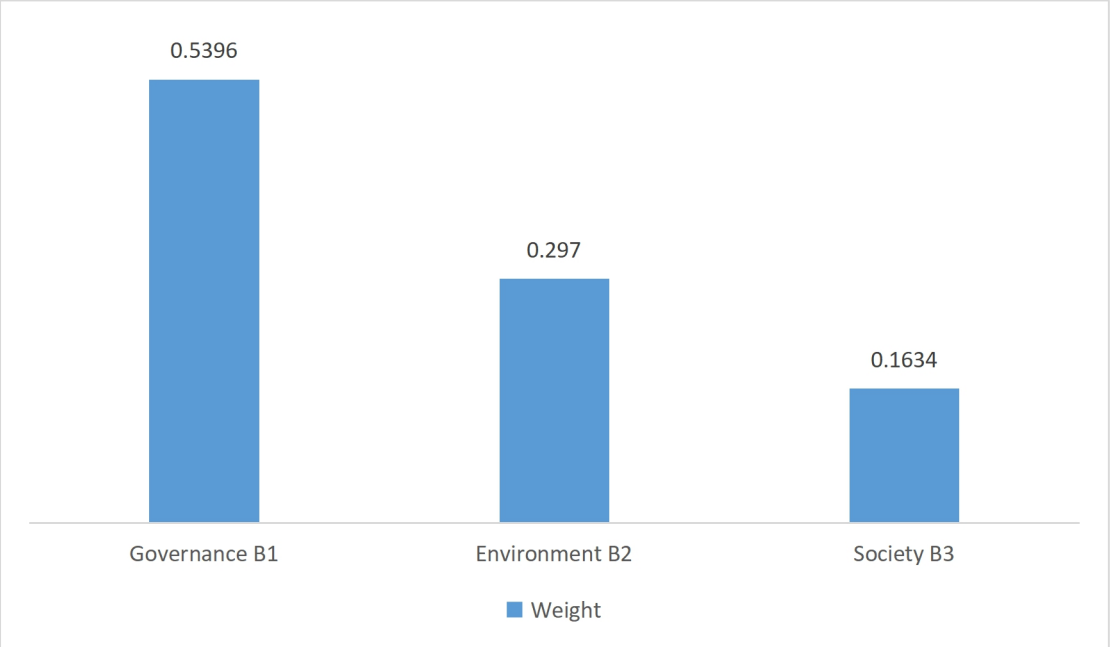


(1) Build the comprehensive performance judgment matrix of the target layer. Governance (G), Environment (E) and Society (S). The judgment matrix comprising three indicators are listed in Table 4

Table 4 Judgment matrix of criteria layer factors on general objective A

A	B1	B2	B3	W	Consistency test
B1	1	2	3	0.5396	
B2	1/2	1	2	0.297	CR=0.008
B3	1/3	1/2	1	0.1634	λ max = 3.0092

Figure 2 Factor weight histogram of criteria layer



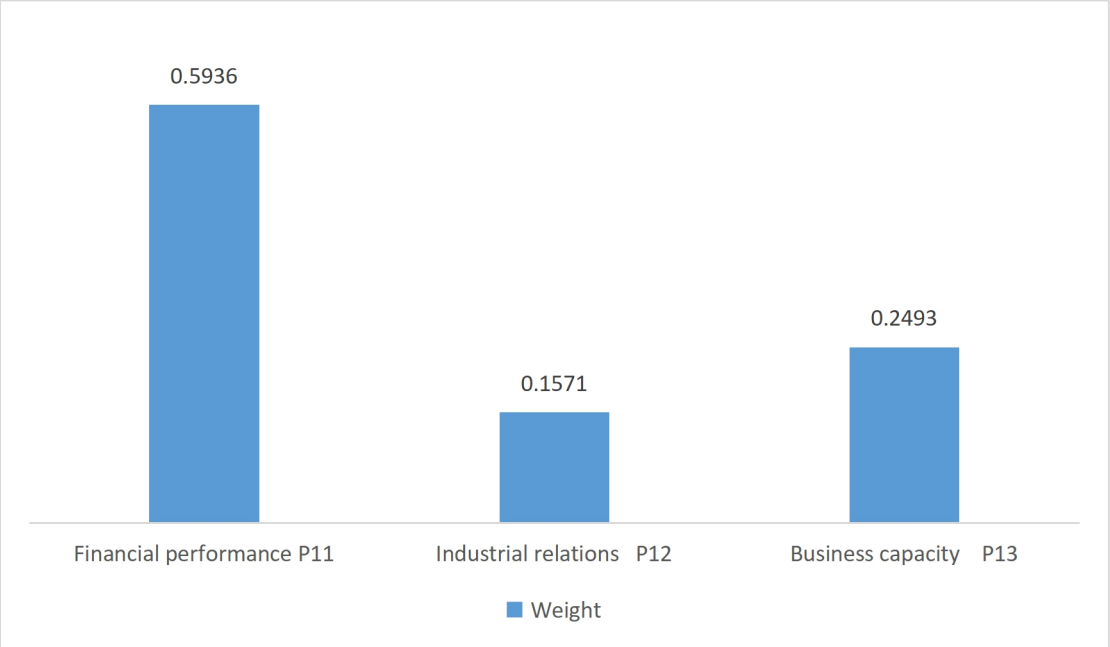
The weight vector of index factors in the criterion layer W= (0.5396,0.297.0.164), CR=0.008<0.1, which is in accordance with consistency test

(2) Build judgment matrix for Governance criterion layer

Table 5 Judgment matrix of governance factors on B1

B1	P11	P12	P13	W	Consistency test
P11	1	3	3	0.5936	CR=0.0515
P12	1/3	1	1/2	0.1571	λ max = 3.0636
P13	1/3	2	1	0.2493	

Figure 3 Weight histogram of governance factors



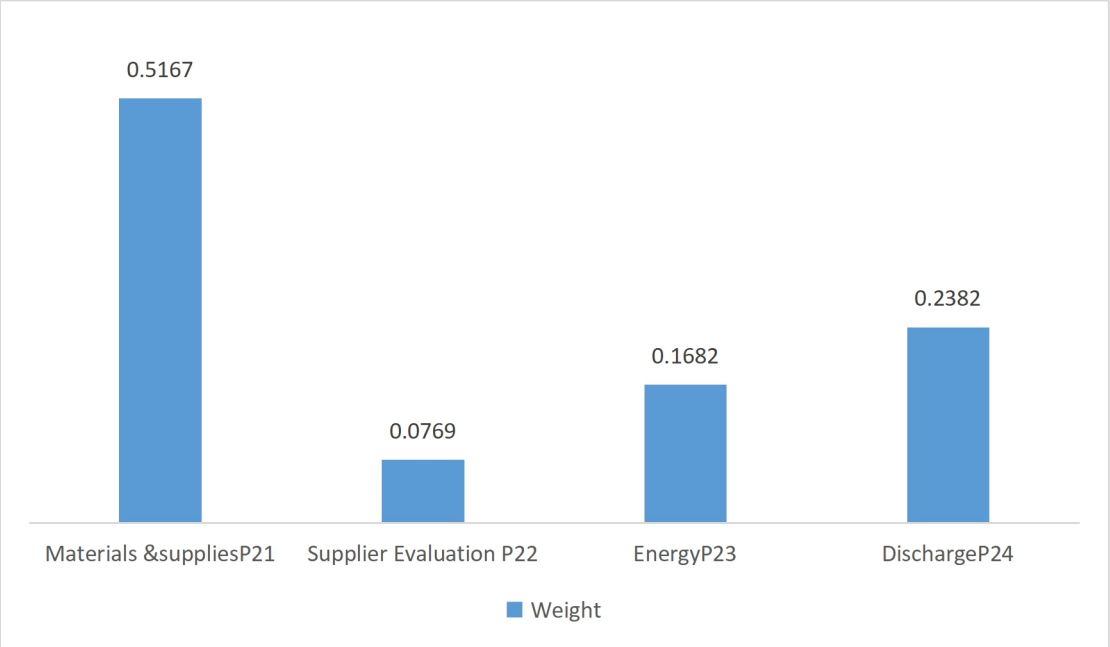
As depicted in Fig. 3， the weight vector of governance factors in the index layer W = (0.5936,0.2493.0.1571), CR = 0.05 < 0.1, which is in accordance with consistency test

(3) Build judgment matrix for environmental criteria layer

Table 6 Judgment matrix of environment factors on B2

B2	P21	P22	P23	P24	W	Consistency test
P21	1	5	3	3	0.5167	CR=0.039
P22	1/5	1	1/3	1/3	0.0769	λmax = 4.1041
P23	1/3	3	1	1/2	0.1682	
P24	1/3	3	2	1	0.2382	

Figure 4 Weight histogram of environment factors



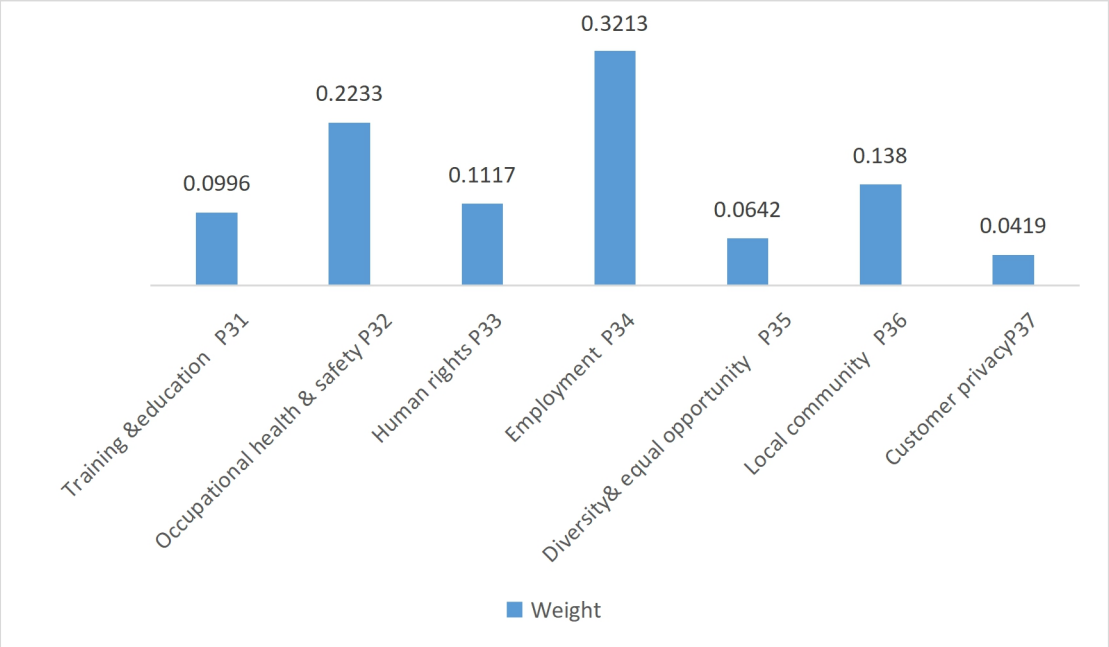
As depicted in Fig. 4, the weight vector of environment factors in the index layer W = (0.5167,0.0769.0.1682,0.2382), CR = 0.039 < 0.1, which is consistent with consistency test

(4) Build judgment matrix for society criteria layer

Table 7 Judgment matrix of society factors on B3

B3	P31	P32	P33	P34	P35	P36	P37	Wi	Consistency test
P31	1	1/3	1	1/3	3	1/3	3	0.0996	CR=0.0334
P32	3	1	3	1/3	3	3	3	0.2233	λ max = 7.5992
P33	1	1/3	1	1/3	3	1	3	0.1117	
P34	3	3	3	1	3	3	5	0.3213	
P35	1/3	1/3	1/3	1/3	1	1/3	3	0.0642	
P36	3	1/3	1	1/3	3	1	3	0.138	
P37	1/3	1/3	1/3	1/5	1/3	1/3	1	0.0419	

Figure 5 Weight histogram of society factors



As depicted in Fig. 5, the weight vector of society factors in the index layer W = (0. 0.0996, 0.2233, 0.1117, 0.3213, 0.0642, 0.138, 0.0419), ， CR = 0.0334 < 0.1, which is in accordance with consistency test

Through the test, the weight coefficients of the above secondary criteria layer can pass the consistency test. Use Yaahp software to get the weight of each level to the upper level, and get the weight coefficient of shipping enterprise social responsibility index system (Table 8).

Table 8 Weight of performance evaluation system of shipping enterprises under "Double Carbon" strategy

Target layer	Criterion layer (Primary index)		Index layer			
Performance evaluation index of shipping enterprises	Criteria layer evaluation indicators	Criteria layer index weight	Index layer evaluation indicators	Weight of index layer relative to criterion layer	Weight of indicator layer relative to target layer	Index ranking
	Governance B1	0.5396	Financial performance P11	0.5936	0.3203	1

			Industrial relations P12	0.1571	0.0847	4
			Business capacity P13	0.2493	0. 1345	3
	Environment B2	0.297	Materials &supplies P21	0.5167	0.1534	2
			Supplier evaluation P22	0.0769	0.0228	9
			Energy P23	0.1682	0.0499	7
			Discharge P24	0.2382	0.0707	5
	Society B3	0.1634	Training &education P31	0.0996	0.0163	12
			Occupational health & safety P32	0.2233	0.0365	8
			Human rights P33	0.1117	0.0183	11
			Employment P34	0.3213	0.0525	6
			Diversity& equal opportunity P35	0.0642	0.0105	13
			Local community P36	0.0225	0.0225	10
			Customer privacyP37	0.0419	0.0068	14

The model solution is completed with the help of Yaahp software (Figure 6). The weight of each judgment matrix is calculated, in which CI represents the consistency index and the maximum characteristic root (Figure 6). The analysis and calculation results show that the consistency ratio CR of each judgment matrix and

each level is less than 0.1. It can be seen that the consistency of each judgment matrix is acceptable, and the calculation results of hierarchical total ranking have satisfactory consistency.

The ranking result of the weight of the performance evaluation system of China's shipping enterprises is: 0.5396;0.297;0.1063, corresponding indicators are governance indicators, environmental indicators and social indicators.

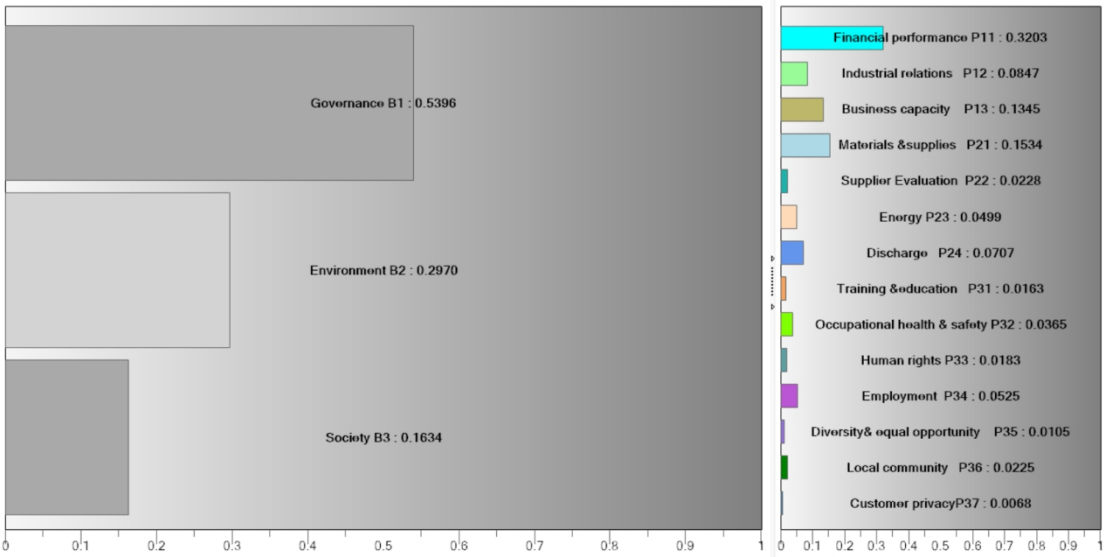
In the performance evaluation system of shipping enterprises, the ranking result of governance index weight is: 0.3203; 0.1345;0.0847, the corresponding indicators are financial performance, labor relations and business capacity.

In the performance evaluation system of shipping enterprises, the ranking result of environmental index weight is: 0.499; 0.1534;0.0228, the corresponding indicators are materials&supplies, discharge, energy, supplier and environmental evaluation.

In the performance evaluation system of shipping enterprises, the ranking result of social index weight is: 0.0525; 0.0365; 0.0225; 0.0183; 0.0163; 0.0105; 0.0068, corresponding indicators are employment, occupational health& safety, training & education, local community, human rights, diversity & equal opportunities, and customer privacy.

The weights of the top three indicators are 0.3203, 0.1534 and 0.1345 respectively. The corresponding indicators are financial performance, materials and business strength.

Figure 6 Interactive analysis histogram of shipping enterprise performance evaluation system



It should be highlighted that the use of analytic hierarchy process modeling also has some limitations. First, the judgment, comparison and calculation process of this

method is relatively rough and the accuracy is not high, so it is not suitable to solve the problem of strict requirements on accuracy; Second, it cannot provide a new scheme for decision-making. The function of analytic hierarchy process is to select the best scheme from the alternatives.

6.Case analysis of COSCO SHIPPING Energy Transportation Co., Ltd

6.1Overview of COSCO SHIPPING Energy

COSCO SHIPPING Energy Transportation Co., Ltd(,“COSCO SHIPPING Energy” or the “Enterprise”, together with its subsidiaries, the “Group”) operating under COSCO SHIPPING Corporation Limited (COSCO SHIPPING), is a specialized enterprise in shipping oil, LNG and chemicals. The enterprise was established in Shanghai on June 6, 2016 by merging the energy transportation business units of China Ocean Shipping (Group) enterprise (COSCO) and China Shipping (Group) enterprise (China Shipping). The enterprise has two core businesses: oil shipping and LNG shipping. It is committed to becoming a prominent leader in global energy transportation. COSCO SHIPPING Energy owns and controls 160 tankers with total capacity of over 23 million DWT, including all major types of tankers in the world. The enterprise leverages the scale of tonnage to offer whole-process energy transportation solutions to clients. The enterprise is also a leader in China's LNG shipping industry and competes in the global LNG shipping market. COSCO SHIPPING LNG Investment (Shanghai) Co., Ltd. (Shanghai LNG), a wholly-owned subsidiary of the enterprise, and China LNG Shipping (Holdings) Co., Ltd. (CLNG) in which the enterprise holds a 50% stake, are top owners of LNG shipping fleets in China. The enterprise is working with global partners in the energy industry for win-win collaborations and development.

6.2 Reasons for selection

COSCO SHIPPING Energy Transportation Co., Ltd. is representative in China’s shipping logistics industry. The reasons for choosing COSCO SHIPPING Energy for analysis are as follows:

First, COSCO SHIPPING Energy is an enterprise with strong strength in China's shipping industry. Since its establishment in 2016, the enterprise complies with the vision of building a world-class shipping enterprise with global competitiveness, firmly adheres to the strategic aim of “four global leaders”, earnestly undertakes the mission and responsibility of national energy transportation, expedites the transformation of low-carbon shipping”, and strives to build a brand image of “leader of sustainable development”. It has been leaping forward over the past years. Accordingly, COSCO SHIPPING Energy Transportation Co., Ltd as a typical case for research.

Second, data are easy to obtain. There are public annual reports, ESG indicator disclosure, financial information, CSR report, product report and other information disclosures in accordance with the regulations, and the data are easy to obtain. The reliability of analysis basis and the accuracy of analysis results are enhanced based on the analysis of public data.

Third, the Group plays an exemplary role in responding to the "double carbon" plan in the low-carbon development. The Group actively sets carbon emission reduction targets in accordance with the requirements of EU ship emission and fuel consumption monitoring requirements, IMO’s data collection system for ship fuel consumption and other international conventions or standards. It sets goals based on long-term energy efficiency statistics to increase energy efficiency and facilitate greenhouse gas emission reduction. It vigorously develops clean energy, grasps the opportunity of accelerating energy transformation and promoting the development of clean energy industry, actively explores LNG transportation, and leads the development direction of green energy transportation.

6.3 Data source

According to the screening, the influential indicators of the industry should be considered comprehensively. The data in this study mainly comes from COSCO SHIPPING Energy Transportation’s public enterprise annual report, social responsibility report, Business Research Report and national Yearbook. Among them, the indicators of financial performance and operating strength mainly come from the enterprise's financial annual report and Industry Research Report. Other data such as labor relations, shipping, energy, employment, labor relations, diversification and equal opportunities mainly come from the enterprise's public sustainable development report, ESG report, industry news and the research results of other

scholars.

6.4 Performance status of the enterprise

The performance indicators of the Group in 2019, 2020 and 2021 are investigated from three aspects, including environmental dimension, social dimension and governance dimension based on the previous analysis of the performance evaluation system of shipping enterprises under the “double carbon” strategy, in combination with the collection of relevant data of COSCO SHIPPING Energy Transportation.

6.5.1 Environmental dimension performance evaluation

The environmental dimension social responsibility indicator consists of four secondary indicators: materials & supplies, energy, discharge and supplier evaluation.

1) Materials & supplies

Materials & supplies refer to equipment that can be converted into products and services and equipment usage. The indicators consist of the quantity of self-owned ships, the quantity of LNG ships put into operation, LNG ship capacity, average age of vessel, gross tonnage (million dwt or million cubic meters) and oil tank capacity introduced into operation (million DWT)

COSCO SHIPPING Energy Transportation has owned and controlled 166 oil tanker fleets with a total of nearly 25.24 million deadweight tons and controlled 6 joint venture LNG carriers by the end of 2021. To be specific, it has 154 transportation capacity, 21.86 million deadweight tons; 12 ships with a capacity of 3.38 million deadweight tons were chartered. Moreover, the order capacity reaches 2, with 369000 deadweight tons. COSCO SHIPPING Energy Transportation serves as the leader of China’s LNG transportation business and a vital participant in the world LNG transportation market. Shanghai LNG, a wholly-owned subsidiary of the Group, and LNG, holding 50% of the equity, are recognized as the only two large LNG transportation enterprises in China. In the LNG transportation business, the landing progress of LNG project is boosted, and the anti-cycle ability is further demonstrated.

The average age of vessel will progressively increase from 2019 to 2021, with an average age of 9.40 years in 2019, 9.55 years in 2020, and 10.47 years in 2021,

marking a year-on-year increase of 9%. The global VLCC fleet is seriously aging, accounting for nearly 24% of the VLCC fleet over 15 years old, which covers nearly 60 VLCCs aged more than 20 years.

(2) Emission performance

Discharge indicators largely refer to greenhouse gas emissions and oil pollution emissions. The emission indicators comprise sulfur dioxide emission performance, nitrogen oxide emission performance, as well as sulfur oxide emission performance.

In 2021, the enterprise’s hazardous waste discharge target is to decrease by 3% per year. The enterprise's ships discharged 10767.16 tons of hazardous waste in 2021, 22.75% lower than that in 2020. 607.40 tons of harmless wastes (garbage) were discharged. A total of 202 ships were arranged to discharge domestic sewage, with a total discharge of 1895.81 cubic meters. The enterprise's per unit turnover emission of carbon dioxide reached 7.27 kg / kiloton nautical mile in 2021, 3.58% lower than that in 2020. The unit turnover emission of NOx is 0.17 kg / kiloton nautical mile, 5.56% lower than that in 2020. The unit turnover emission of sulfur oxide reached 0.02 kg / kiloton nautical mile.

In 2021, the enterprise would give a strong boost to the establishment and improvement of carbon data collection, verification, monitoring and management mechanisms, and complete the submission of ship carbon emission data to IMO and EU. For the deployment on carbon inventory data collection, COSCO Shipping Group regularly fills in energy consumption and other data, and completes the 2020 carbon emission status report, the emission detection plan of water transport enterprises and the energy utilization status report of key energy users of Shanghai Water passenger and freight transport.

(3) Energy performance

In general, energy indicators are reflected in the content of renewable and nonrenewable energy produced and consumed by enterprises. Energy indicators include total energy consumption (electricity, gas, and oil), unit turbine of fuel consumption (kW • h in’ 000s /1000 tone miles), sulfur oxides emissions, unit turbine emission of sulfur oxides (kg/1000 tone miles), hazardous waste emissions (tone), as well as nonhazardous waste emissions (tone)

In 2021, COSCO SHIPPING Energy Transportation successfully built the world’s

first LNG dual fuel VLCC “Yuanruiyang”, which is powered by LNG and marine fuel. For energy efficiency management, the ship's energy efficiency design index (EEDI) is 36% lower than that of the baseline value, the carbon dioxide emission reduction complies with the requirements of EEDI phase III, the nitrogen oxide emission satisfies the most stringent tier III requirements of IMO, the structural design abides by the harmonized common structure rules, and the list of hazardous substances is provided in accordance with EU regulations, satisfying the requirements of the intelligent energy efficiency symbol i-ship (E) of China Classification Society. It has made important breakthroughs in the application of green, environmental protection and energy-saving technologies for VLCC. Moreover, “Yuanruiyang”, as a green ship manufacturing project, has been approved as a double carbon green environmental protection loan in accordance with the green industry guidance catalogue (2019 version) of the national development and Reform Commission, and the green action of energy efficiency management was supported by green finance.

(4) Supplier evaluation

Supplier environmental evaluation refers to the proportion of qualified suppliers assessed by environmental indicators. Supplier environmental evaluation is the proportion of qualified suppliers assessed using environmental indicators.

The enterprise formulates and implements management systems (e.g., procurement management measures and supplier management measures) to develop a comprehensive and standardized management system. Under the supplier access conditions, suppliers are required to submit “relevant quality, safety, environmental protection, industry and other third-party qualification certificates” before warehousing. The supplier inspection coverage has been kept at 100% from 2019 to 2021.

The above analysis is summarized using the corresponding indicators, as listed in Table 9.

Table 9 Environmental indicators of COSCO SHIPPING Energy

Criterion layer	Secondary index	Tertiary indicators	2021	2020	2019	Optimal index
Environment	Materials &	Self-owned ships	166	156	153	166

	supplies	LNG ships put into operation	6	6	38	38
		LNG ship capacity (million m3)	105	105	105	105
		Average age of vessel(year)	10.47	9.55	9.40	9.40
		Gross tonnage(million DWT or million cubic meters)	2,524/105	2,524/105	2,524/105	2,524/105
		Oil tankers in operation	154	150	145	166
Environment		Oil tanker capacity put into operation (million DWT)	2186	2097	1926	2524
	Discharge	Nitrogen oxides emissions (tonne)	87,780.92	88,261.50	84,816.30	84,816.30
		Unit turnover emission of nitrogen oxides (kg/1,000 tonne-miles)	0.17	0.18	0.19	0.17
		Sulfur	9,585.27	9,637.75	58,494.00	58,494.00

		oxides emissions (tonne)				
		Unit turnover emission of sulfur oxides (kg/1,000 tonne-miles)	0.02	0.02	0.13	0.02
		Carbon dioxide emissions (tonne)	3,690,721.49	3,663,025.34	3,530,998.00	3,530,998.00
Environment	Discharge	Unit turnover emission of carbon dioxide (kg/1,000 tonne-miles)	7.27	7.54	6.88	6.88
		Oily water discharged (tonne)	75,666.06	100,118.21	68,148.00	68,148.00
		Hazardous waste emissions (tonne)	10,767.16	13,939.12	8,374.78	8,374.78
		Non-hazardous waste emissions (tonne)	607.40	413.00	404.39	404.39
	Energy	Total energy consumption (electricity,	11,735,179.63	11,797,778.68	11,341,741.25	11,341,741.25

		gas, and oil) (kW • h in' 000s)				
		Unit turnover of fuel consumption (kW • h in' 000s /1,000 tonne-miles	0.02	0.02	0.03	0.02
		Gross fuel consumption (thousand tonne)	100.90	101.45	97.49	97.49
		Unit fuel consumption (kg/1,000 tonne-miles)	1.99	2.09	2.21	1.99
		Total water consumption (m3)	505,032.50	383,746.00	373,607.00	373,607.00
Environment		Water consumption density (m3 /1,000 tonne-miles)	0.000995	0.000790	/	0.000790
	Supplier evaluation	Supplier inspection coverage (%)	100	100	100	100
		Passing rate of zero defect annotation (%)	74	87.88	74.58	87.88

6.5.2 Social dimension performance evaluation

The social dimension performance indicators comprise five secondary indicators: employment, charity, product responsibility, training & education, as well as occupational health and safety.

(1) Employment performance

Employment indicator is an indicator indicating the internal relationship of the supply chain. Employment indicators consist of the total number of employees, employee satisfaction, number of employed people, as well as employee membership rate.

COSCO SHIPPING Energy Transportation strictly abides by national laws and regulations. It insists on equal employment, optimizes the employment system and salary and welfare system, unblocks internal communication, strives to create a fair, just and healthy career development environment, respects and protects the basic rights and interests of employees to the greatest extent, and gives a strong boost to their decent work and all-round development. In 2021, there were 764 employees, 71 new employees, 0 new overseas employee, and 1 disabled employee. Besides, the labor contract coverage rate was 100%, the social insurance coverage rate was 100%, the physical examination coverage rate reaches 100%, the rate of returning to work after child rearing was 80%, and the average paid leave days were 11.12 days.

(2) Public and charity performance

Public welfare and charity refer to undertakings relating to social public welfare and interests. Public welfare and charity comprise total donations, employee volunteer services, and employee volunteers. COSCO SHIPPING Energy Transportation is committed to developing the coordinate system of economic and social development, complies with the idea that enterprises and communities complement each other, plays a role in the cause of rural revitalization, deepens the management of public welfare investment, launches social responsibility practice with unique corporate characteristics under the regulations of the measures for the management of external donations, and facilitates the integration of business ecology and social ecology through public welfare undertakings.

Help rural revitalization. In 2021, the enterprise has invested 20million yuan in rural revitalization, implemented six projects, and benefited 76000 people.

(3) Product responsibility

In accordance with the customer-centered principle, COSCO SHIPPING Energy Transportation constantly optimizes the customer service management system, places stress on customer needs, improves service processes and methods, and offers high-quality service experience to customers. In 2021, the enterprise received three customer complaints, with a complaint handling rate of 100% and customer satisfaction of 100%. Moreover, while enhancing its ability to perform its responsibilities, the enterprise has been integrating the concept of responsibility into supply chain management, inspecting suppliers' behavior in fulfilling their social responsibilities, guiding suppliers to establish a sense of responsibility, enhancing the ability to perform their responsibilities and the anti-risk ability of the supply chain, and jointly boosting the development of the resilience of the supply chain.

(4) Training &education

Training and education refers to the annual training coverage and frequency of employees. Training &education means total investment in training, per capital training time, as well as employee training coverage. The enterprise places stress on the growth and development of employees, unblocks the career promotion channel, launches various forms of training and vocational skill competitions for management talents, young cadres, new employees, sailors and other employees of different levels and types, comprehensively upgrades the "5+n" training system, increases the selection range, appointment and training of cadres and talents, and significantly facilitates the growth and development of employees.

(5) Occupational health & safety

Occupational health and safety refers to the number, quantity or percentage of products and services that assess the health and safety of their personnel. Occupational health & safety includes anti-typhoon success rate, anti-traction success rate, number of work-related deaths, work related death rate and physical examination coverage. From 2019 to 2021, the enterprise has maintained an anti-typhoon success rate of 100% and an anti-piracy success rate of 100%, and there have been no major and serious production safety accidents. In 2021, 10 ship shore joint emergency drills were conducted, involving a total of 236 participants. Special awards of 11million yuan have been given to the crew members who have extended their service on board, condolences have been given to the crew members, and

economic subsidies of 39000 yuan have been given.

The above analysis is summarized using the corresponding indicators, as listed in Table 10.

Table 10 Society indicators of COSCO SHIPPING Energy

Criterion layer	Secondary index	Tertiary indicators	2021	2020	2019	Optimal index
Society	Employment	Total number of employees	764	719	775	775
		Number of new employees	71	25	26	71
		Number of disabled employees	1	1	0	1
		Employee turnover rate(%)	2	4.75	3.2	2
	Charity	Investment in Rural Revitalization (targeted poverty alleviation)	2,000.00	848.96	760.00	2,000.00
	Product Responsibility	Customer satisfaction (%)	100	100	82	100
		Number of customer complaints	3	6	18	3
		Complaint handling rate (%)	100	100	100	100
	Training &education	Total investment in trainings (RMB	322.97	94.59	216.64	322.97

		thousand)				
		Per capita training time (hours)	31.21	39.28	23.85	39.28
		Employee training coverage (%)	97.22	97	96.5	97.22
	Occupational health & safety	Anti-typhoon success rate (%)	100	100	100	100
		Anti-piracy success rate (%)	100	100	100	100
		Number of work-related deaths	0	1	2	0
		Lost days due to work injury	0	2	25	0
		Work related death rate (%)	0	0.01	0.03	0
		Physical examination coverage (%)	100	100	99.87	100

6.5.3 Governance dimension performance

(1) Financial performance

Financial performance refers to the contribution made by the enterprise strategy and its implementation and execution to the final operating performance. It falls into growth capacity indicators, profitability indicators, financial risk indicators, as well as operational capacity indicators

Indicators of growth capacity comprise net profit, freight volume (million tons), crude oil transportation volume, as well as transportation volume of refined oil. In 2020, the net profit was 2.373 billion, and the net profit of the enterprise was -4.975

billion in 2021, marking a year-on-year decrease of% since it was affected by the global COVID-19 pandemic in 2021. For operating income, the international tanker transportation market is extremely depressed, and the enterprise's foreign trade oil transportation income has decreased significantly. In terms of operating costs, fuel costs increased compared with those of the previous period due to the rise of international oil prices. In 2019, the freight volume reached 150 million tons. In 2020, the freight volume climbed to 160 million tons. In 2021, it reached 167 million tons, marking a year-on-year increase of 4.35%. In 2020, the crude oil transportation volume was obtained as 127.88 million tons, and it reached 130.94 million tons in 2021, marking a year-on-year increase of 2.3%. The transportation volume of refined oil has increased in three years, reaching 31.03million tons in 2019, 32.58 million tons in 2021, as well as 36.34 million tons in 2021. For foreign trade oil transportation business, COSCO SHIPPING Energy has boosted the development of new customers and continued to develop novel routes. In general, VLCC's economical and fuel-efficient transport capacity is introduced into the Atlantic market to obtain better benefits, and the rest of the ship positions are primarily arranged on the Middle East Far East route.

Profitability indicators comprise ROE (return on net assets) and gross profit margin (%) Roe index indicates the income level of shareholders' equity while measuring the efficiency of the enterprise in using its own capital. The higher the index value, the higher the return of investment will be. The above indicator can reflect the ability of self-owned capital to obtain net income. ROE was obtained as 1.52% in 2019, increased to 7.27% in 2020, and decreased significantly in 2021. The index ratio reached -15.51%, marking a year-on-year decrease of 165,1%. In 2019, the gross profit margin accounted for 18.97%, the index increased to 29.03% in 2020, and the ratio decreased significantly to 7.32% in 2021.

For total asset turnover rate and turnover rate of accounts receivable, the enterprise's total asset turnover rate was 0.215 in 2019, 0.249 in 2020, and 0.203 in 2021, marking a year-on-year decrease of 7.9%. The turnover rate of accounts receivable of the enterprise has been rising for three years, which is considered a good trend. It was 16.43 in 2019, and 20.40 in 2020, as well as 24.47 in 2021

(2) Business capacity

Business capacity refers to the sum of an enterprise's decision-making ability for business strategies and plans, which comprises its internal conditions and development potential, as well as the management ability for a wide variety of production and business activities. Operating strength consists of basic discoveries

per share (RMB), EBITDA total debt ratio, EBITDA interest cover, current ratio, quick ratio, cash interest cover, as well as loan repayment rate (%). The enterprise's operating strength index decreased in 2021, compared with that of the previous period. Basic discoveries per share in 2019. It was 0.5180 in 2020 and -1.0447 in 2021, a significant decrease of 301.67% compared with the previous period. The EBITDA total debt ratio in 2020 reached 0.23 and -0.03 in 2021, marking a decrease of 112.81% over the previous period.

The cash interest cover in 2020 reached 8.88 and 6.04 in 2021, indicating a year-on-year decrease of -32.01%. Moreover, the quick ratio of the enterprise showed a year-on-year decrease of 32.01% in 2021 at the end of the previous period, and the current ratio (%) showed a year-on-year decrease of 38.94%. The enterprise's debt ratio increased, whereas remained within a moderate range. In 2021, the international oil transportation market underwent a continuous downturn rarely seen in history. The average time charter equivalent (TCE) of the VLCC ship type td3c (Middle East China) route was only -518 USD per day, the lowest annual average in the history of the route. In 2020, it was 48179 USD per day. TCE of representative routes of other major ship types showed a year-on-year decrease of nearly 70%-100%. From the perspective of transportation demand, despite repeated global epidemics, the global economy will be further recovered in 2021 with the continued popularization of vaccines and the introduction of more financial support policies, thus boosting the continuous improvement of oil consumption. Furthermore, the overall upward trend of fuel prices in 2021 puts pressure on the cost side of international tanker owners, thus posing a certain challenge to the operating environment of the international oil transportation market throughout the year.

(3) Industrial relations

Industrial relationship refers to an employment relationship formed between enterprise workers. Labor relations indicators primarily consist of labor contract signing rate and social insurance coverage rate.

For industrial relations, the indicators of COSCO SHIPPING Energy Transportation’s labor contract signing rate and social insurance coverage rate are selected. The signing rate of labor contracts refers to the rate at which employees of the enterprise signed labor contracts in the report period. From 2019 to 2022, the signing rate of labor contracts of the enterprise has remained stable at 100%. COSCO SHIPPING Energy Transportation strictly abides by the labor contract law and other national labor laws and regulations, responds to international labor conventions, signs labor contracts with all employees in accordance with law, ensures equal

employment of employees, and respects the rights and interests of employees. Social insurance coverage represents the coverage ratio of "five insurances and one fund" among the regular employees of the enterprise.

The enterprise has fully covered the social insurance coverage from 2019 to 2021, and the signing rate has reached 100%.

The above analysis is summarized using the corresponding indicators, as listed in Table 11.

Table 11 Governance indicators of COSCO SHIPPING Energy

Criterion layer	Secondary index	Tertiary indicators	2021	2020	2019	Optimal index
Governance	Financial performance	ROE(Return on net assets %)	-15.51	7.27	1.52	7.27
		Gross profit margin (%)	7.32	29.03	18.97	29.03
		Asset liability ratio (%)	49.62	46.02	55.70	55.70
		Net profit(billion)	-4.975	2.373	0,4316	2.373
		Total asset turnover rate (Times)	0.203	0.249	0.215	0.249
		Turnover rate of accounts receivable (Times)	24.47	20.40	16.43	24.47
		Cash flow ratio	0.255	0.715	0.433	0.715
		Freight volume (million tons)	167	160	150	167
		Freight turnover (million tons and nautical	507,736	486,062	440,785	507,736

		miles)				
Governance	Financial performance	Crude oil transportation volume (million tons)）	130.94	127.88	118.96	130.94
		Transportation volume of refined oil (million tons)	36.34.	32.58	31.03	36.34
	Business capacity	Basic earnings per share (RMB)	-1.0447	0.5180	0.1070	0.5180
		Current ratio (%)	0.486	0.796	0.561	0.796
		Quick ratio (%)	0.410	0.710	0.498	0.710
		EBITDA total debt ratio	-0.03	0.23	0.15	0.23
		EBITDA interest cover	-1.07	6.41	3.65	6.41
		Cash interest cover	6.04	8.88	5.19	8.88
		Loan repayment rate (%)	100.00	100.00	118.70	118.70
	Industrial relations	Labor contract coverage (%)	100	100	100	100
		Social insurance coverage (%)	100	100	100	100

6.5 Model analysis

On the basis of the index system established in Chapter 5, the re-screened indexes are weighted, and then the judgment matrix of each layer of indexes is constructed and calculated. The calculation process is as follows

6.51 Establishment of judgment matrix for environmental indicators

(1) Calculation of the weight of the first layer of indicators to environmental indicators

Table 12 First level index weight of environmental indicators

Environment	Materials&supply	Discharge	Energy	Supplier evaluation	Wi	Consistency test
Materials&supply	1	1	2	2	0.3333	CR=0.00
Discharge	1	1	2	2	0.3333	
Energy	1/2	1/2	1	1	0.1667	
Supplier evaluation	1/2	1/2	1	1	0.1667	

It can be seen from Table 12 that the weight of the first level indicators to environment indicators w = (0.333,0.333,0.1667,0.1667), CR = 0 < 0.1, thus suggesting that the weight division is reasonable.

(2) Calculation of materials & supplies weight by the second level indicator

Table 13 Weight of second- level indicators of materials & supplies

Materials&supply	Self-owned ships	Gross tonnage	Average age of vessel(year)	LNG ships put into operation	LNG ship capacity (million m3)	Oil tankers in operation	Oil tanker capacity put into operation (million DWT)	Wi	Consistency test
Self-owned ships	1	1/2	2	2	2	2	2	0.1879	CR=0.333
Gross tonnage	2	1	3	3	3	3	3	0.3054	
Average age of vessel(year)	1/2	1/3	1	1/2	1/2	1/2	1/2	0.067	
LNG ships put into operation	1/2	1/3	2	1	1	2	2	0.1313	
LNG ship capacity (million m3)	1/2	1/3	2	1	1	2	2	0.1313	
Oil tankers in operation	1/2	1/3	2	1/2	1/2	1	1	0.0885	
Oil tanker capacity put into operation (million DWT)	1/2	1/3	2	1/2	1/2	1	1	0.0885	

It can be seen from Table 13 that the weight of the second layer index to the material index w = (0.1879, 0.3054, 0.067, 0.1313, 0.1313,0.0885, 0.0885), CR = 0.0333 < 0.1, thus suggesting that the weight division is reasonable.

(3) Calculation of discharge weight of the second level indicators

Table 14 Weight of second- level indicators of discharge

Discharge	Sulfur oxide emission performance	Carbon dioxide emission performance	NOx emission performance	Oil pollution emission performance	Hazardous waste discharge performance	Harmless waste discharge performance	Wi	Consistency test
Sulfur oxide emission performance	1	1/3	2	2	2	3	0.2039	CR=0.333
Carbon dioxide emission performance	3	1	3	3	3	3	0.3619	
NOx emission performance	1/2	1/3	1	1/2	1/2	1/2	0.0759	
Oil pollution emission performance	1/2	1/3	2	1	2	2	0.1497	
Hazardous waste discharge performance	1/2	1/3	2	1/2	1	2	0.1189	
Harmless waste discharge performance	1/3	1/3	2	1/2	1/2	1	0.0897	

It can be seen from Table 14 that the weight of the second layer of indicators on discharge w = (0.2039,0.3619,0.0759,0.1497,0.1189,0.0897), CR = 0.0000 < 0.1, thus suggesting that the weight division is reasonable.

（4）Calculation of energy weight of the second level indicators

Table 15 Weight of second- level indicators of energy

Energy	Water consumption density	Unit turnover of energy consumption	Unit fuel consumption	Total electricity consumption	Wi	Consistency test
Water consumption density	1	1/3	1/3	1/2	0.1059	CR=0.1667
Unit turnover of energy consumption	3	1	2	3	0.4476	
Unit fuel consumption	3	1/2	1	2	0.2829	
Total electricity consumption	2	1/3	1/2	1	0.1636	

It can be seen from Table 15 that the weight of the second layer of indicators on energy ,w = (0.1059,0.4476,0.2829,0.1636), Cr = 0.0000 < 0.1, thus suggesting that the weight division is reasonable.

（5）Calculation of supplier evaluation weights for the second level indicators

Table 16 Weight of second- level indicators of supplier evaluation

Supplier evaluation	Supplier inspection coverage (%)	Passing rate of zero defect annotation (%)	Wi	Consistency test
Supplier inspection coverage (%)	1	1	0.5	CR=0
Passing rate of zero defect annotation (%)	1	1	0.5	

It can be seen from Table 16 that the weight of the second layer of indicators on supplier evaluation ,w = (0.1059,0.4476,0.2829,0.1636), Cr = 0.0000 < 0.1, thus suggesting that the weight division is reasonable.

6.52 Establish judgment matrix for social indicators

(1) Calculation of the weight of the first level indicators on social indicators:

Table 17 First level index weight of society indicators

Society	Employment	Charity	Product Responsibility	Development and Training	Occupational health & safety	Wi	Consistency test
Employment	1	3	3	2	2	0.3665	CR = 0.0175
Charity	1/3	1	1/2	1/2	1/3	0.0867	
Product Responsibility	1/3	2	1	1	1/2	0.141	
Development and Training	1/2	2	1	1	1/2	0.153	
Occupational health & safety	1/2	3	2	2	1	0.2529	

It can be seen from this that the weight of the second layer of indicators on supplier evaluation , w = (0.1059,0.4476,0.2829,0.1636), Cr = 0.0175 < 0.1, thus suggesting that the weight division is reasonable.

(2) Calculation of employment weight of the second level indicators

Table 18 Weight of second- level indicators of employment

Employment	Total number of employees	Employee turnover rate(%)	Number of new employees	Number of disabled employee	Wi	Consistency test

				s		
Total number of employees	1	3	3	4	0.508	CR = 0.0328
Employee turnover rate(%)	1/3	1	2	3	0.2449	
Number of new employees	1/3	1/2	1	2	0.1545	
Number of disabled employees	1/4	1/3	1/2	1	0.0926	

It can be seen from Table 18 that the weight of the second layer of indicators on employment ,w = (0.508， 0.2449， 0.1545， 0.0926), CR = 0.0328 < 0.1, thus suggesting that the weight division is reasonable.

(3) Calculation of the weight of the second level index to charity

Table 19 Weight of second- level indicators of charity

Charity	Investment in Rural Revitalization (targeted poverty alleviation)	Employee volunteer activities	Wi	Consistency test
Investment in Rural Revitalization (targeted poverty alleviation)	1	2	0.6667	CR=0.00
Employee volunteer activities	1/2	1	0.3333	

It can be seen from Table 19 that the weight of the second layer of indicators on charity, w = (0.6667,0.3333), CR = 0.00 < 0.1, thus suggesting that the weight division is reasonable.

(4) Calculation of the weight of the second level indicators on training & education

Table 20 Weight of second- level indicators of training & education

Training &education	Employee training coverage (%)	Total investment in trainings (RMB)	Per capita training time (hours)	Wi	Consistency test
Employee training coverage (%)	1	2	3	0.5499	CR=0.0176
Total investment in trainings (RMB)	1/2	1	1	0.2402	
Per capita training time (hours)	1/3	1	1	0.2098	

It can be seen from Table 20 that the weight of the second layer of indicators on training & education, w = (0.5499,0.2402,0.2098), CR = 0.0176 < 0.1, thus suggesting that the weight division is reasonable.

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(5) Calculation of the weight of secondary indicators on occupational health & safety

Table 21 Weight of second- level indicators of occupational health & safety

Occupational health & safety	Anti-piracy success rate (%)	Anti-typhoon success rate (%)	Number of work-related deaths	Lost days due to work injury	Physical examination coverage (%)	Wi	Consistency test
Anti-piracy success rate (%)	1	1	2	4	3	0.3168	CR=0.0208
Anti-typhoon success rate (%)	1	1	2	4	3	0.3168	
Number of work-related deaths	1/2	1/2	1	3	2	0.1827	
Lost days due to work injury	1/4	1/4	1/3	1	1/3	0.0634	
Physical examination coverage (%)	1/3	1/3	1/2	3	1	0.1204	

It can be seen from Table 21 that the weight of the second layer of indicators on occupational health & safety, w = (0.5499,0.2402,0.2098), CR = 0.0208 < 0.1, thus suggesting that the weight division is reasonable.

6.53 Establish judgment matrix for governance indicators

(1) Calculation of the weight of the first level indicators on the governance indicators:

Table 22 First level index weight of governance indicators

Governance	Financial performance	Business capacity	Industrial relations	Wi	Consistency test
Financial performance	1	3	5	0.6483	CR=0.0036
Business capacity	1/3	1	2	0.2297	
Industrial relations	1/5	1/2	1	0.122	

It can be seen from Table 22 that the weight of the first level indicators to governance indicators w = (0.6483,0.2297,0.122), CR = 0.0036 < 0.1, thus suggesting that the weight division is reasonable .

(2) Calculation of the weight of the second level indicators on financial performance

Table 23 Weight of second- level indicators of financial performance

Financial performance	ROE(Return on net assets%)	Total asset turnover rate (Times)	Net profit	Cash flow ratio	Asset liability ratio (%))	Gross profit margin (%)	Crude oil transportation volume	Freight volume (million tons)	Transportation volume of refined oil	Wi	Consistency test
ROE(Return on net assets%)	1	3	1/3	1	2	2	2	2	2	0.1382	CR=0.033
Total asset turnover rate (Times)	1/3	1	1/4	1/3	1/2	1/2	2	2	2	0.0685	
Net profit	3	4	1	3	3	4	4	4	4	0.29	
Cash flow ratio	1	3	1/3	1	1	3	3	3	3	0.1503	

Asset liability ratio (%))	1/2	2	1/3	1	1	3	2	2	2	0.1194	
Gross profit margin (%)	1/2	2	1/4	1/3	1/3	1	2	2	2	0.0805	
Crude oil transportation volume	1/2	1/2	1/4	1/3	1/2	1/2	1	1	1	0.051	
Freight volume (million tons)	1/2	1/2	1/4	1/3	1/2	1/2	1	1	1	0.051	
Transportation volume of refined oil	1/2	1/2	1/4	1/3	1/2	1/2	1	1	1	0.051	

It can be seen from Table 23 that the weight of the second level indicators to financial performance indicators w = (0.1382,0.0685,0.29,0.1503,0.1194,0.0805,0.051,0.051,0.051), CR = 0.0033 < 0.1, thus suggesting that the weight division is reasonable.

(4) Calculation of the weight of the second level indicators on the business capacity:

Table 24 Weight of second- level indicators of business capacity

Business capacity	EBITDA total debt ratio	Basic earnings per share (RMB)	Loan repayment rate (%)	Quick ratio (%)	Cash interest cover	Current ratio (%)	EBITDA interest cover	Wi	Consistency test
EBITDA total debt ratio	1	1/3	2	2	1/4	2	2	0.1237	CR=0.0384
Basic earnings per share (RMB)	3	1	4	2	1/3	3	3	0.2175	
Loan repayment rate (%)	1/2	1/4	1	1/2	1/4	1/2	1/2	0.0526	
Quick ratio (%)	1/2	1/2	2	1	1/3	1	2	0.098	
Cash interest cover	4	3	4	3	1	3	4	0.3482	
Current ratio (%)	1/2	1/3	2	1	1/3	1	2	0.0931	

EBITDA interest cover	1/2	1/3	2	1/2	1/4	1/2	1	0.0669	

It can be seen from Table 24 that the weight of the second level indicators to business capacity indicators w = (0.1237,0.2175,0.0526,0.098,0.3482,0.0931,0.0669), CR = 0.00384 < 0.1, thus suggesting that the weight division is reasonable.

(5) Calculation of the weight of the second level indicators on industrial relations

Table 25 Weight of second- level indicators of industrial relations

Industrial relations	Labor contract coverage (%)	Basic earnings per share (RMB)	Wi	Consistency test
Labor contract coverage (%)	1	1	0.5	CR=0.00
Basic earnings per share (RMB)	1	1	0.5	

It can be seen from Table 25 that the weight of the second layer of indicators on industrial relations, w = (0.5,0.5), CR = 0.00 < 0.1, thus suggesting that the weight division is reasonable.

6.54 Analysis of evaluation results

After the above calculation, the weights of performance evaluation indicators of COSCO SHIPPING Energy Transportation Co., Ltd are summarized as Table 26

Table 26 Summary of weights of COSCO SHIPPING Energy performance indicators under the “Double Carbon” strategy

Criterion layer	weight	Indicator					
		Secondary index	weight	Composite weight	Tertiary indicators	weight	Composite weight
Environment	0.297	Materials&supply	0.3333	0.0990	Self-owned ships	0.1879	0.0186
					Gross tonnage	0.3054	0.0302
					Average age of vessel(year)	0.067	0.0066
					LNG ships put into operation	0.1313	0.0130
					LNG ship capacity (million m3)	0.1313	0.0130
					Oil tankers in operation	0.0885	0.0088
					Oil tanker capacity put into operation (million DWT)	0.0885	0.0088
Environment	0.297	Discharge	0.3333	0.0990	Sulfur oxide	0.2039	0.0202

					emission performance		
					Carbon dioxide emission performance	0.3619	0.0358
					NOx emission performance	0.0759	0.0075
					Oil pollution emission performance	0.1497	0.0148
					Hazardous waste discharge performance	0.1189	0.0118
					Harmless waste discharge performance	0.0897	0.0089
		Energy	0.1667	0.0495	Water consumption density	0.1059	0.0052
					Unit turnover of energy consumption	0.4476	0.0222
					Unit fuel consumption	0.2829	0.0140
					Total	0.16	0.0081

					electricity consumption	36	
Environment	0.297	Supplier evaluation	0.1667	0.0495	Supplier inspection coverage (%)	0.5	0.0248
					Passing rate of zero defect annotation (%)	0.5	0.0248
Society	0.1634	Employment	0.3665	0.0599	Total number of employees	0.508	0.0304
					Employee turnover rate(%)	0.2449	0.0147
					Number of new employees	0.1545	0.0093
					Number of disabled employees	0.0926	0.0055
		Charity	0.0867	0.0142	Investment in Rural Revitalization (targeted poverty alleviation)	0.6667	0.0094
					Employee volunteer activities	0.3333	0.0047
		Product Responsibility	0.141	0.0230	Complaint handling rate (%)	0.309	0.0071
					Customer satisfaction	0.5816	0.0134

					(%)		
					Number of customer complaints	0.1095	0.0025
		Training &education	0.153	0.0250	Employee training coverage (%)	0.5499	0.0137
Society	0.1634	Training &education	0.153	0.0250	Total investment in trainings (RMB)	0.2402	0.0060
					Per capita training time (hours)	0.2098	0.0052
		Occupational health & safety	0.2529	0.0413	Anti-piracy success rate (%)	0.3168	0.0131
					Anti-typhoon success rate (%)	0.3168	0.0131
					Number of work-related deaths	0.1827	0.0075
					Lost days due to work injury	0.0634	0.0026
					Physical examination coverage (%)	0.1204	0.0050
Governance	0.5396	Financial performance	0.6483	0.3498	ROE(Return on net assets%)	0.1382	0.0483
					Total asset	0.06	0.0240

					turnover rate (Times)	85	
					Net profit	0.29	0.1014
					Cash flow ratio	0.1503	0.0526
					Asset liability ratio (%))	0.1194	0.0418
					Gross profit margin (%)	0.0805	0.0282
					Crude oil transportation volume	0.051	0.0178
					Transportation volume of refined oil	0.051	0.0178
					Freight volume (million tons)	0.051	0.0178
		Business capacity	0.2297	0.1239	EBITDA total debt ratio	0.1237	0.0153
					Basic earnings per share (RMB)	0.2175	0.0270
					Loan repayment rate (%)	0.0526	0.0065
					Quick ratio (%)	0.098	0.0121
					Cash interest cover	0.3482	0.0432

					Current ratio (%)	0.0931	0.0115
					EBITDA interest cover	0.0669	0.0083
		Industrial relations	0.122	0.0658	Labor contract coverage (%)	0.5	0.0329
					Basic earnings per share (RMB)	0.5	0.0329

In accordance with the above comparative analysis and weight analysis of indicators, the financial performance and operating strength in the governance indicators of ESG indicators tend to generally decrease, and the industrial relations maintain a stable development. As a shipping enterprise with high-level pollution and high emissions, it has made active responds to the “carbon neutralization and carbon peak” strategy, with prominent environmental performance indicators. LNG ships and transport capacity have remained at the leading level worldwide. The number of ships under construction and ordered ships has increased on a year-to-year basis. The emission reduction effects of sulfur dioxide, sulfur oxide, nitrogen oxide and oil pollution have achieved good results. It has rigorously controlled the quality of suppliers and optimized the green supply chain. The Group, as a large domestic shipping enterprise, actively creates jobs for the society. As an industry with certain high-risk operations, the Group has been actively promoting environmental protection, safety and other training, while strictly controlling the risk of occupational diseases and the number of equipment accidents. The weight analysis of ESG indicators using analytic hierarchy process suggests that governance takes up the highest proportion in governance, environment and society indicators. Among the three-level indicators under financial performance, net profit, cash flow ratio and cash flow ratio rank the top three, and the composite weights reach 0.188, 0.0975 and 0.0896, respectively. Among the three indicators of business strength, cash interest cover and basic earnings per share (RMB) account for high proportions, with the composite weights of 0.0432 and 0.0270, respectively. For the environmental indicators, the three-level indicators (gross tonnage and self-owned ships under the material) rank with the highest weight of 0.0302 and 0.0186. Unit turbine of energy consumption achieves a high weight of 0.0222. Among the emission indicators, carbon dioxide emission performance and sulfur dioxide emission performance achieve higher weights, with the composite

weights of 0.0358 and 0.0202, respectively. The supplier’s environmental evaluation weight is obtained as 0.0495, which is in a high position. The employment index achieves the highest weight under the social index, in which the total number of employees and the employee turnover rate are obtained as 0.0304 and 0.0147, respectively, in accordance with the number of people, ranking the first two. The weight of investment in Rural Revitalization (targeted poverty alleviation) in public charity is obtained as 0.0094. The weight of customer satisfaction in product responsibility is 0.0134 higher than that of complaint handling rate. The employee training coverage weight under the enterprise training & education indicator reaches 0.0137. On the basis of occupational health and safety, the weight of anti-piracy success rate (%) and anti-typhon success rate reaches 0.0131. The analysis of the performance and weight of the enterprise suggests that the governance indicators with a large weight in the performance evaluation indicators of COSCO SHIPPING Energy Transportation Co., Ltd. tend to decrease significantly, and management should be strengthened.

6.6 Development Suggestions

China's shipping enterprises are facing numerous challenges with the acceleration of the green transformation of international energy and the promulgation of the State Council's opinions on carbon neutralization and carbon peaking in 2021. Based on the above research, the following suggestions are proposed.

(1) Accelerate the formulation of carbon emission laws and regulations.

Relevant laws should be modified for shipping enterprises. This study suggests that China lacks the national planning and industry planning for the zero-carbon development of ships, and the emission reduction plan and phased objectives remain unclear. The shipping industry is not covered in the published guidelines for accounting methods and reporting of greenhouse gas emissions. Only Shanghai has issued the accounting and reporting methods for greenhouse gas emissions of Shanghai Water Transport Industry (Trial) for the water transport industry in 2016. The guidelines for the preparation of Provincial Carbon Dioxide Emission Peak Action Plan only requires the provision of emission data in terms of the international ocean shipping industry, and the accounting boundary and method are not clarified. As a result, the shipping industry faces the difficulty in obtaining the total carbon emissions of relevant enterprises, determining the carbon emission reduction time node and planning countermeasures.

(2) Technological innovation and digital transformation:

It is necessary to optimize existing business systems and construct supporting systems more comprehensively, and carry out the digital upgrading of business systems, China pool related systems, customer service, ship intelligent monitoring, and other systems continuously. The Chinese government should expedite the integration of digitalization and business, elevate the level of auxiliary decision-making and scientific decision-making, and improve the overall safe and efficient operation capacity of the whole energy transportation service. It is imperative for China to promote the effective integration of scientific and technological innovation and intelligent ships, and increase the research on new energy power of ships based on artificial intelligence and big data innovation technology.

(3) Adjust the transport capacity structure and reasonably plan the route

China's shipping enterprises should place stress on the intelligent construction of ships and the rational planning of shipping routes. For ship allocation, it is imperative to meet the market demand, accelerate the turnover, timely adjust the ship structure, update the backward ships, make the self-owned ships satisfy the requirements, and lower the ship operation cost by increasing the shipping speed and decreasing the number of ships allocated on the route. Moreover, we should pay close attention to and actively engage in the research and application of ship intelligence at home and abroad, increase the application scenarios of intelligent technology, and manufacture intelligent ships more suitable for the subsequent development of the shipping industry.

In route planning, shipping enterprises should adhere to the globalization strategy, pay attention to the novel pattern of global trade in accordance with following market rules and maintaining existing advantages, reasonably expand the coverage area of navigation areas, and effectively plan route distribution. Besides, enterprises should significantly support the stability of route operation and enhance the anti-cyclical ability of enterprises.

(4) Research on ship emission reduction and green ship combustion

The ship zero-carbon technology has not yet formed a scale, nor has it been applied to large ocean-going ships. Its candidate zero-carbon fuel (e.g., ammonia, hydrogen, and battery) systems should be investigated and development extensively. The International Chamber Of Shipping (ICS) released the report "promoting the fourth system revolution" in November 2020, stressing the urgency of accelerating

technology research and development, which facilitates the revolution of ship power fuel systems and achievement of zero-carbon shipping by the end of the 21st century. Thus, the introduction of zero-carbon energy is the most important step for ships to achieve zero-carbon emissions.

7. Research results and conclusions

7.1 Conclusion

In 2020, China proposed the development goal of “carbon peak in 2030 and carbon neutrality in 2060”, thus providing a direction for China to cope with climate change and achieve green and low-carbon development. The goal provides a direction for China to cope with climate change and achieve green and low-carbon development. The shipping industry, accounting for nearly 90% of the global trade and transportation volume, is a basic industry for the development of the national economy and a pillar industry relating to national security and the lifeline of the national economy. From the perspective of ESG, this study analyzes the performance index system of China’s shipping enterprises, which plays a vital role in the enterprise's carbon emission reduction task and zero-carbon development goal.

(1) A performance evaluation system of shipping enterprises is established based on ESG. The system consists of three dimensions, including environment, society, and governance. The environment dimension comprises four secondary indicators: materials & supply, energy, emissions and supplier evaluation. The social dimension covers five secondary indicators, including employment, public welfare and charity, product responsibility, training & education, as well as occupational health & safety. The governance dimension is composed of three secondary indicators, including financial performance, industrial relations and business capacity. Moreover, the performance evaluation system is further divided into 65 details suitable for the Social Responsibility evaluation System of power generation enterprises, thus further facilitating the improvement of the performance evaluation system of shipping enterprises based on the “Double Carbon” strategy.

(2) The case study of COSCO SHIPPING Energy, a representative shipping enterprise in China, provides insights into the development of performance evaluation of shipping enterprises in China. First, the vertical comparative analysis

suggests that impacted by the current global COVID-19 pandemic, shipping enterprises are facing the risk of financial difficulties and declining business performance. However, China's "Double Carbon" strategy should be urgently implemented, and the carbon emission reduction target proposed by IMO and its implementation time node are imminent.

(3) The weight of the three dimensions (including environment, society and governance) of shipping enterprises is calculated using the analytic hierarchy process model, and the social performance indicators of shipping enterprises are analyzed. The following conclusions are drawn through the model analysis. First, governance indicators account up a high proportion of China's shipping enterprises. Impacted by the economic environment, the profitability indicators are declining significantly. Second, material and energy indicators play a vital role in environmental indicators. Shipping enterprises should vigorously develop zero-carbon fuel, diversified energy technology and ship CCS technology.

7.2 limitations and Prospects

(1) Impacted by the lack of national planning and industry planning for zero-carbon development of ships in China, the emission reduction plan and phased objectives have not been clearly defined, and the shipping industry has not been covered by the published Guidelines. Since no standard disclosure system has been established, plentiful data are non-mandatory disclosure data, which are difficult to obtain. There are different data of the same index in the found data, thus bringing great difficulties to the research.

(2) The empirical analysis part of this study uses AHP analysis method for modeling due to the limitation of the author's academic level. AHP analysis method has strong subjective judgment, and it is generally weighted by the expert scoring method. This study is weighted on the premise of integrating the scoring data of scholars. Due to the different attainments of scholars and the limited data that can be sorted out, the accuracy of weighting is difficult to ensure.

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