

Article

Evaluating Competitiveness of Container Shipping Operators in the Sustainability and Digitalization Era

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Abstract: This study aims to comprehensively analyze the operational status and international competitiveness of global container shipping enterprises in the era of sustainability and digitalization within the field of international container transportation. Utilizing the entropy method, this study quantitatively evaluates the direct operational strength of 14 leading container shipping enterprises while considering multiple factors including environmental protection, service quality, company scale, customer satisfaction, research and development level, and brand influence. The contributions of this study to the existing knowledge are primarily manifested in several aspects: firstly, by constructing a comprehensive evaluation framework, it offers a new perspective for assessing the international competitiveness of container shipping enterprises, facilitating a more comprehensive understanding of their strengths and weaknesses. Secondly, this study emphasizes the crucial roles of environmental protection and customer service in the competitiveness of shipping enterprises, providing new strategic directions for the industry's sustainable development and digital transformation. Lastly, through detailed analysis of the operational performance of different companies, this study provides specific improvement suggestions for shipping enterprises, aiding them in achieving more precise management and more efficient development. The research findings demonstrate that companies exhibit varied performance in different aspects, showcasing their respective strengths and challenges. Particularly, this study identifies leading enterprises that have made significant progress in environmental technology innovation and customer service, while also highlighting deficiencies in some companies regarding scale expansion and brand building. These findings not only offer valuable insights for the development of the shipping industry but also serve as a window for policymakers, investors, and consumers to gain a deeper understanding of the shipping market. Through the thorough analysis conducted in this study, we aim to contribute to the sustainable development and digital transformation of the global container shipping industry.

Keywords: container shipping enterprises; operation situation; entropy method; comparative analysis



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1. Introduction

According to the United Nations Conference on Trade and Development, the shipping industry accounts for 80% of international cargo transportation, with container transportation representing approximately 17% of global maritime trade. Specifically, in 2019, global maritime trade volume reached 11.08 billion tons, and ports worldwide handled over 800 million TEUs (Twenty-foot Equivalent Units) [1]. From the perspective of trade volume, container

transportation accounts for about 17% of global trade [1]. Although container transportation does not account for a high proportion of trade volume, it accounts for more than 80% of maritime trade value, demonstrating its dominant position in transporting high-value goods and serving as an important carrier for international trade [1].

In recent years, ocean-going vessels have played a pivotal role in the global transportation network, especially in Europe, the United States, and China. These ships are responsible for transporting containers, which account for a large portion of the total tonnage kilometers of cargo. In the United States, McLean shows that containers transported by ocean-going vessels account for 22–24% of the total tonnage kilometers of cargo. This significant contribution highlights the importance of maritime transport in the economic activities of the country. Efficient and cost-effective capacity to transport goods by sea has been a key factor in sustaining economic growth and development. Similarly, Europe is heavily dependent on its maritime transport system. According to the European Commission, nearly 41% of the European freight industry is carried by offshore shipping [2]. This huge dependence on maritime transport highlights the indispensability of maritime transport in European economic and trade activities. An extensive network of ports and shipping routes has enabled Europe to connect with the rest of the world, facilitating trade and economic integration. Liner container transport has played a crucial role in China's development. In the list of the top 10 container throughput in 2023 published by Alphaliner, an international shipping consulting and analysis agency, 6 Chinese ports were among the top 10, accounting for more than 50% of the throughput of the world's top 30 container ports, compared with 49% in 2022 [3].

Despite the decrease in maritime trade volume in 2020 due to the COVID-19 pandemic, maritime trade continues to play a crucial role in the global economy. The pandemic has undoubtedly had a significant impact on the shipping industry, leading to a decrease in trade volumes and disruptions in supply chains. Maritime trade volume decreased by approximately 4% in 2020, but maritime trade is expected to recover and expand again in 2021 [1]. One of the key factors enabling maritime trade to remain resilient is its flexibility and scalability. Shipping companies have been able to adjust their operations to meet the changing demands of the market, such as by reducing vessel capacity, optimizing routes, and implementing new safety measures. Moreover, maritime trade remains an essential component of the global supply chain. It provides the means to transport bulk commodities such as oil, gas, and minerals, as well as finished goods and consumer products. The ability to transport these goods efficiently and cost-effectively is crucial for maintaining the smooth functioning of the global economy.

Sustainable container shipping is crucial for the future development of maritime transportation. Shipping companies must consider not only the economic prospects related to serving existing and new customers and achieving target profit margins but also environmental factors. The emissions from ocean-going vessels are still rated as "high" by the International Maritime Organization (IMO) and other relevant agencies [4]. Various measures have been taken to reduce greenhouse gas emissions (mainly CO₂, CH₄, and N₂O) and non-greenhouse gas emissions (mainly NO_x, SO_x, and PM) in maritime transportation. To reduce non-greenhouse gas emissions, the IMO has established multiple Emission Control Areas (ECAs) in specific geographic regions, including the English Channel, the Baltic Sea, the North Sea, and the North American coastline [5–7]. Furthermore, the Chinese government has announced the designation of certain areas along China's coastline as ECAs, namely, the Pearl River Delta, Yangtze River Delta, and Bohai Bay. Given China's 14th Five-Year Plan, Marine Power Strategy, and the 21st Century Maritime Silk Road Strategy [8], the shipping industry is facing unprecedented opportunities and challenges.

In the context of economic globalization and low carbon emission reduction, container shipping companies must evaluate their operational advantages and disadvantages. This assessment is crucial for the formulation of future development strategies. At present, the research of domestic and foreign scholars on shipping enterprises covers a wide range of topics, such as shipping competitiveness, status quo of shipping enterprises, and strategy of shipping enterprises. A relatively complete evaluation index system has been formed, and

rich conclusions have been drawn, which are of great significance to the future development of shipping enterprises. This paper presents an innovative approach to ensemble research. Combining the entropy method, verification method, and comparative analysis method, this method not only relies on quantitative indicators and empirical analysis, but also integrates qualitative soft power indicators such as customer satisfaction, technical proficiency, and brand influence, so as to comprehensively and reliably understand the operating status of marine container transportation enterprises. This method can evaluate enterprises from multiple dimensions, thus improving the persuadability and credibility of the research results. In addition, several well-known maritime enterprises, such as CMA CGM, OOCL, and EVERGREEN, are analyzed in depth to reveal their actual operation. Overall, this comprehensive research framework not only provides valuable insights for assessing the operational performance of shipping companies, but also provides an important reference basis for their future development strategies.

2. Literature Review

In recent years, research on container shipping companies has predominantly focused on assessing competitiveness, analyzing transportation networks, investigating current conditions, and devising strategic plans. Researchers have employed various methodologies, such as the analytic hierarchy process (AHP), principal component analysis, case analysis, factor analysis, and entropy method, to quantitatively evaluate the strengths and weaknesses of different enterprises in assessing their competitiveness.

In shipping enterprise competitiveness research, for instance, Shen conducted an analysis of the international competitiveness of Oriental Overseas Limited using comparative analysis and the analytic hierarchy process (AHP), contrasting it with typical shipping enterprises like Maersk [9]. Chai used factor analysis to primarily expound on the actual competitiveness of China COSCO Shipping Group Co., Ltd. (Shanghai, China) among twelve shipping enterprises and eleven specific indicators. The study found issues such as the lack of prominent strength in the main business and low operational efficiency within China COSCO Shipping Group Co., Ltd., and provided recommendations to enhance operational efficiency and strengthen core business capabilities [10]. Vu et al. successfully evaluated the international competitiveness of the wood processing industry in Vietnam by integrating the coefficient of variation and entropy, indicating that this approach is more precise than relying solely on a single indicator, thus warranting consideration in the study of container shipping company competitiveness [11]. Additionally, scholars have underscored the significant influence of factors like strategic deployment, core business expansion, cost control, and corporate governance on the variations in competitiveness among enterprises [12]. Common internal weaknesses of enterprises may encompass inadequate core business strength and low operational efficiency. Strategies for enhancing enterprise competitiveness, particularly amid shipping market uncertainty, have been deliberated by Kim et al. [13]. Adam Kaliszewski et al. developed a questionnaire comprising 20 indicators such as service level and operational smoothness. This questionnaire was distributed to employees of globally renowned shipping companies, yielding the primary influencing factors on the international competitiveness of ports from the perspective of shipping enterprises [14]. Constantinos Chlomoudis et al. concluded that enhancing innovation capabilities, as evidenced by patents and other innovative strengths of liner shipping companies, is a crucial pathway to improving corporate competitiveness [15].

In the study of corporate shipping networks, researchers have used complex networks, spatial analysis, and comparative analysis to carefully examine their hierarchical characteristics, topologies, clusters, stability, and fixed patterns. Ye used complex network and GIS spatial technology to describe the pattern characteristics of the global shipping network, and obtained the conclusion that the global port system has obvious hierarchical characteristics. The shipping network topology of 18 major shipping companies is constructed, and the spatial pattern characteristics of the shipping network of each shipping company are sorted out by comprehensively using various network indicators and spatial measurement methods. It is concluded that the route network of large shipping companies has a high level of agglomera-

tion, and special hub ports play a leading role in the transportation network [16]. Liang et al. outlined the basic situation, advantages, and disadvantages of COSCO and Maersk, and used the comparative analysis method to analyze the selection of ship types, routes, and ports of specific routes in the same shipping area of COSCO and Maersk [17]. Rousset and Ducruet surveyed the shipping networks of major container shipping enterprises, utilizing various complex network indicators and spatial analysis methods to determine their hierarchical characteristics. They concluded that the transportation networks of large-scale container shipping enterprises exhibit a high level of agglomeration, with specific hub ports playing pivotal roles [18]. Additionally, Wang and Jin scrutinized the transportation networks of major container shipping enterprises from the perspectives of market competition, network topology, and shipping line organization, providing valuable insights for port managers in their decision-making processes [19]. Pablo Kaluza et al. studied the navigation trajectories of tens of thousands of ships and analyzed that the transportation network characteristics of dry bulk carriers, container ships, and oil tankers are different. The container ships have fixed rules in time and space, while the transportation routes of dry bulk carriers and oil tankers are more flexible [20].

In the scrutiny of the current status and strategies of container shipping enterprises, methodologies such as the SWOT method, development indicators, entropy value, cooperation agreements, and comparative analysis have been employed. For example, Lv utilized the SWOT method to analyze the development of Evergreen Group, exploring its adaptability under relevant national policies and demonstrating its ability to make timely decisions in response to global economic changes [21]. Liu used the case study method to analyze the case of COSCO Maritime Holding's merger and acquisition of OOCL and obtained that the motivation was to play a synergistic effect and pave the way for the future strategic development of the enterprise, and to increase the financial competitiveness [22]. Photis M. Panayides et al., through an analysis of cooperation agreements among the top 20 liner shipping companies globally, concluded that the service characteristics of liner alliances vary slightly, including factors such as port call frequency and average deployed vessel numbers. They further determined that shipping alliances cannot be regarded as closed corporate entities; instead, alliance members primarily form relationships based on service agreements [23]. Liu put forward strategic suggestions on the development of Chinese shipping enterprises under the background of the great era of the shipping alliance and joined the shipping alliance to keep up with market development, so as to increase China's competition level in the world shipping market [24]. In addressing the impact of the pandemic on the shipping industry, Md Rajib Kamal et al. conducted a study on the short-term effects of the COVID-19 pandemic on the shipping stock market. They employed an event study methodology to analyze the daily data collected from publicly listed shipping companies [25]. Arda Toygar et al. have also conducted research on the impact of the COVID-19 pandemic on the shipping industry. They argue that the spread of COVID-19, akin to the 2008 financial crisis, has exerted significant disruptions on the shipping industry. Their study delves into the strategic formulations by container shipping companies and evaluates the resultant effects of these strategies [26]. Gao has proposed several recommendations for bulk cargo shipping enterprises based on the economic and trade environment characteristics during China's "14th Five-Year Plan" period, including integrating into the entire supply chain, enhancing asset operation and cost control, strengthening digital transformation, and cultivating talent with market-oriented skills [27]. Similarly, Li et al. evaluated the development indicators of the Greater Bay Area and port logistics system using the entropy value method, concluding the interrelation between transportation development and economic and trade development under the plan of the Guangdong–Hong Kong–Macao Greater Bay Area [28].

However, most of these studies stay at the country or overall market level, ignoring the differences in actual operation, routes, ports, fleets, and main business of different shipping enterprises, which limits the practical application of research results in specific enterprises. In terms of research methods, although the current shipping market environment and national strategic policies are combined, and methods such as the analytic hierarchy process are used,

they still need to be improved. In view of the shortcomings found in the existing research, this paper establishes a non-financial indicator system to evaluate the operational performance of maritime container shipping enterprises. A combination of quantitative and qualitative methods was used, and confirmatory factor analysis was used to verify the quantitative index system. Then, the comparative analysis method and entropy method were used to study and analyze the established evaluation index system. In this paper, three main indicators are proposed: scale factor, environmental protection factor, and service factor. This paper analyzes the direct management strength and indirect management strength of the enterprise, so as to scientifically and reasonably realize the comparative analysis of the management status of maritime container shipping enterprises. This paper analyzes the advantages and disadvantages of the current operating situation of maritime container transportation enterprises and provides valuable insights for their future development direction.

3. Methodology

This section outlines the quantitative analysis of the operation situation of Maritime Shipping Enterprise, the whole analysis program, as shown in Figure 1. The proposed comprehensive analysis methodology combines the entropy value method [29], validation, and comparative analysis [30]. It explains the principle of evaluation indicator selection, establishes the current operating status evaluation for container shipping enterprises, and further carries out the validation and comparative analysis. The entropy method was used to quantitatively rank and select the indicators for analyzing the operating status of container shipping enterprises. The experimental operational status analysis based on the collected database for different container shipping enterprises was conducted to figure out their advantages and showcases.

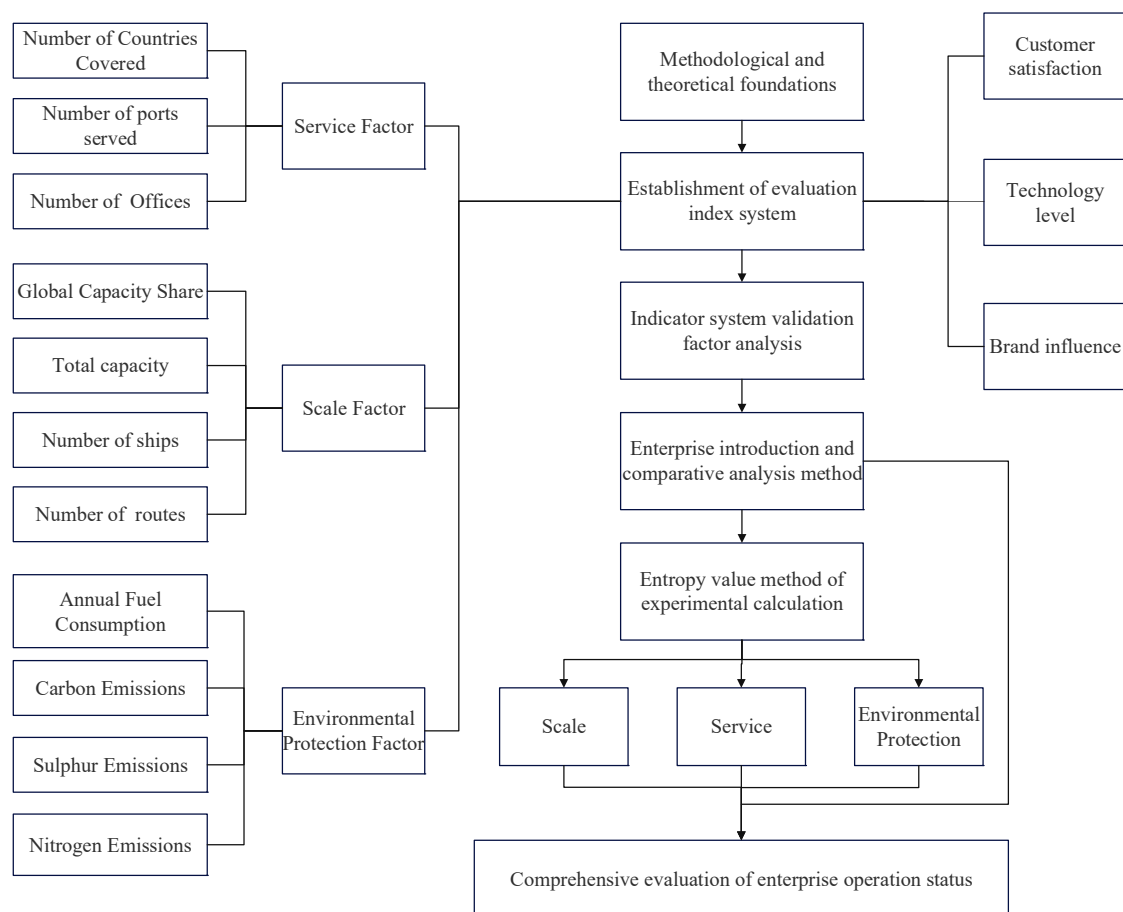


Figure 1. Methodological framework.

3.1. Principles for Selecting Evaluation Indicators

The selection of evaluation indicators is the basis of subsequent experiments for revealing the operating status of container shipping enterprises. The selected indexes should be scientific, logical, and rigorous.

- Science: considering the existing studies that mostly favor financial indicators, non-financial indexes cannot be ignored that can objectively and comprehensively reflect the characteristics of container shipping enterprises.
- Representativeness: the indicators for evaluating the operational status of container shipping enterprises are various and diverse, which implies that the selected indicators should be representative and concise.
- Comprehensive: Meanwhile, it can encompass the majority characteristics of the shipping enterprise, reflecting their strength and status in all aspects. In particular, the non-quantifiable but equally important indicators should not be ignored to establish a more scientific evaluation methodology.

3.2. Determination of Evaluation Indicators

According to the principle of evaluating index selection, a series of indicators that can reflect the operational status of container shipping enterprises more comprehensively have been determined. For the indicators that can be quantified and analyzed by the entropy value method, they can be named as the direct operational strength indicators; for the indicators that cannot be directly quantified but can influence the operation of the enterprise, they can be named as the indirect business strength indicators.

3.2.1. Direct Operational Strength

The present study, building upon the indicators selected by scholars such as Shen [9] and Fu [31], in their research on the transportation network and competitiveness of container shipping enterprises, has expanded and enriched the evaluation criteria for the operational status. It forms 3 primary indicators, namely service factors, scale factors, and environmental protection factors, with 11 secondary indicators represented by factors such as the number of serviced ports, global capacity share, vessel quantity, and annual fuel consumption, as shown in Table 1.

Table 1. Direct operational strength indicators.

	First-Level Indicators	Second-Level Indicators	Serial Number
Direct operational strength indicators	Scale factor	Number of ships	1
		Total capacity	2
		Number of routes	3
		Global capacity share	4
	Service factor	Number of ports served	5
		Number of offices	6
		Number of countries covered	7
	Environmental protection factor	Carbon footprint	8
		Nitrogen emissions	9
		Sulfur emissions	10
		Annual fuel consumption	11

- (1) Scale factor: Enterprise scale can directly reflect the strength of container shipping enterprises and their operational status. Large-scale container shipping enterprises have a high market share and strong industry resources and are naturally in a leading position in terms of their hard power, industry influence, and economic benefits. This paper selects the number of ships, the total capacity, the number of routes, and the share of global capacity, to reflect the scale of container shipping enterprises.

- (2) Service factor: As a service-oriented industry, the global service capability of a shipping company is an important factor in judging its operational status and performance. This paper selects the numbers of covered countries, served ports, and offices to reflect the business coverage and global service capability of container shipping enterprises.
- (3) Environmental protection factor: Green transportation has also become a new reality for the future development of the shipping industry. According to the IMO's new emission reduction rules for 2023 [4], the major container shipping enterprises have committed to reduce carbon emissions by 40% by 2030 against the 2008 baseline. Indicators such as carbon emissions, sulfur emissions, nitrogen emissions, and fuel oil volume can undoubtedly reflect the current status of environmental protection and green shipping efforts of the enterprise, which are crucial for zero-emission shipping services.

3.2.2. Indirect Business Strength

The indirect operational strength of a shipping company is also important for evaluating its operational status. Based on the qualitative analysis by current researchers, this paper employs three indexes including customer satisfaction, enterprise science and technology level, and brand influence to evaluate the indirect business strength of container shipping enterprises [10], as shown in Table 2.

Table 2. Indirect business strength indicators.

	Indicator Name
Indirect business strength indicators	Customer satisfaction
	Technological level
	Brand impact

Customer satisfaction is important business feedback, which directly reflects the business reputation of the shipping company and its position in the industry. More importantly, customer satisfaction is important for the future development of the enterprise because it is closely related to whether the cooperation between existing customers and the enterprise will continue and the possibility of new customers joining the service of the enterprise.

The level of science and technology is another crucial factor that directly influences the future development of enterprises. The technological level of container shipping enterprises encompasses both ship-based and shore-based technologies, as well as their level of digital transformation. It includes various aspects such as the handling of customer orders, fleet composition, efficiency of maritime communications, navigation systems, cargo handling and services, and technological innovations throughout the entire transportation service process. Due to limitations in the data collected, this study only reflects the scientific and technological level of container shipping enterprises based on shore-based technologies and the level of digital transformation.

The brand impact is one of the key factors that influence the choice of customers who tend to have a natural trust in the popular brands. Therefore, it is also an important indicator to analyze the current situation of container shipping enterprises. The feedback on the industry's current state is crucial, serving as a holistic external representation of the enterprise's heritage, quality, and strength.

3.3. Evaluation and Comparative Analysis

The details for the concepts, principles, and steps of the entropy value method factor analysis and comparative analysis will be explained in the following subsections.

3.3.1. Entropy Method

The entropy method is a comprehensive evaluation method with objective weight assignment according to the variability of data information. The entropy value is negatively correlated with the indicator variability [32]. Its basic steps are shown in Figure 2.

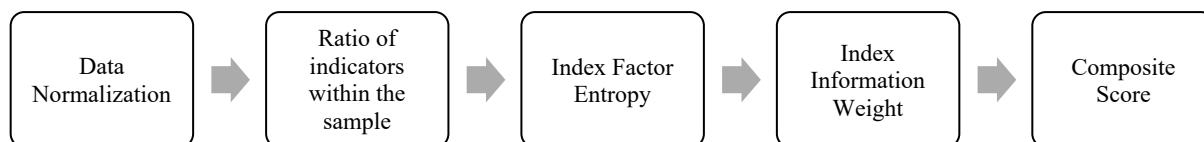


Figure 2. Basic steps of entropy method.

- (1) Data normalization: Data normalization processing was carried out using the maximum value method with the following formula:

$$X'_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \quad (1)$$

where X_{ij} denotes the j th indicator of the i th shipping enterprise, and X'_{ij} is the normalized value of X_{ij} . $\min(X_{ij})$ is the minimum value of X_{ij} and $\max(X_{ij})$ is the maximum value of X_{ij} .

- (2) Weight calculation: the weight of the j -th indicator of the i -th shipping enterprise is calculated by the following formula:

$$q_{ij} = \frac{X'_{ij}}{\sum_{i=1}^n X'_{ij}}, \quad (i = 1, 2, \dots, n; j = 1, 2, \dots, m) \quad (2)$$

where n is the number of container shipping enterprises covered in this paper, and m is the number of evaluation indicators; q_{ij} is the weight of the j -th indicator of the i -th shipping enterprise. $\sum_{i=1}^n X'_{ij}$ is the sum of the j -th indicator for all container shipping enterprises.

- (3) Entropy value calculation: the formula for calculating the entropy value is as follows:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^n q_{ij} \ln q_{ij}, \quad (j = 1, 2, \dots, m) \quad (3)$$

where $e_j \geq 0$, is the entropy value of the j th indicator. Then, the indicator information weight can be determined as formulation (4).

$$z_j = \frac{1 - e_j}{\sum_{j=1}^m 1 - e_j}, \quad (j = 1, 2, \dots, m) \quad (4)$$

where $1 - e_j$ is called the variation coefficient. The larger the value of $1 - e_j$ indicates the smaller the entropy.

- (4) Comprehensive score calculation: comprehensive score is calculated as follows:

$$s_j = \sum_{j=1}^m z_j \times q_{ij} \quad (5)$$

A comprehensive score for the operational status of the container shipping enterprises can be calculated based on the weights and entropy value.

3.3.2. Factor Analysis Methods

Factor analysis is a multivariate statistical analysis method that utilizes the idea of dimension reduction. It starts from the dependency relationship within the correlation matrix of the original variables and summarizes several complex variables with intricate relationships into a few comprehensive indicators. It is divided into exploratory factor analysis and confirmatory factor analysis [33].

Confirmatory factor analysis is a method used to judge the quality of an established system. Firstly, a factor analysis model (i.e., the evaluation indicator system in this paper) is proposed based on relevant studies, experiences, etc. Then, modeling is conducted using appropriate software, and experiments of confirmatory factor analysis are performed to obtain fit indices, which are used to determine the scientific and rational nature of the model [34]. The quality of the established indicator system can be judged based on the output fit indices. This paper mainly assesses the rationality of the evaluation indicator system based on the convergence effect and discriminant effect of the established indicator system.

- (1) Assessing the convergence effect. The convergence effect is determined by examining the aggregation of secondary indicators related to the primary indicators. This is calculated using the Average Variance Extracted (AVE) and the Composite Reliability (CR) as described below:

$$AVE = \frac{\sum \lambda^2}{n} \quad (6)$$

$$CR = \frac{(\sum \lambda)^2}{(\sum \lambda)^2 + \sum e} \quad (7)$$

where $\sum \lambda^2$ is the sum of the squares of the loading values of second-level indicators, and n is the number of second-level indicators. The standardized residual loading coefficient is denoted as 'e'. For validity, the Average Variance Extracted (AVE) should exceed 0.5, and the Composite Reliability (CR) value should be above 0.7 [29].

- (2) Distinguishing effect. The distinguishing effect is negatively related to the correlation coefficient between first-level indicators. The smaller the correlation coefficient, the more effective the distinction, the better. To assess this differentiation effect, Pearson's correlation coefficient and the square root of the Average Variance Extracted (AVE) are commonly employed. The square root of the AVE for each primary indicator must exceed its correlation coefficient with any other primary indicator.

3.3.3. Comparative Analysis

Comparative analysis is a common analytical method for qualitative analysis. In terms of the status or competitiveness of enterprises, it can be used to evaluate the soft power of container shipping enterprises based on the advantages and disadvantages identified [35,36]. The comparison analysis can not only be applied to different soft power indicators but also to the same indicator changes along the time and place. The results can be represented using text and graphs.

In this paper, the customer satisfaction, technological level, and brand impact of container shipping enterprises will be comparatively analyzed. Comparative analysis of these soft power indicators that are not easy to quantify improves the operating status evaluation of container shipping enterprises. It can analyze the container shipping enterprises from more perspectives and make the results more complete and convincing.

4. Results

Considering the impact of the number of samples on the rigor of statistical methods, among the enterprises with similar levels, we chose the enterprises with easy data acquisition as the research sample. Doing so increases the credibility and reliability of the study, while also helping to reduce the likelihood of bias.

It should be pointed out in particular that we mainly selected container shipping enterprises as the sample objects. This is because container transportation business occupies an important position in the global shipping field. Based on the above considerations, this paper selected the top 14 container shipping enterprises in the world for the sample analysis according to the Alphaliner top 100 ranking [3]. The index of their direct combat intensity was analyzed using entropy, comprehensive score, and ranking. The experimental

results were further verified by factor analysis. Comparative analysis was also used to evaluate the indirect operating strength.

4.1. Convergence Analysis of Indicators

The standardized loading coefficient is usually used to quantify the correlation between the first-level and the second-level indicators, as shown in Table 3. When the loading coefficient is higher than 0.7, it indicates that there are close correlations between the second-level indicators with the corresponding first-level indicator [35]. It can be seen that the standardized loading coefficient of each second-level indicator meets the requirements.

Table 3. Loading coefficients of indicators.

Factor	Measurement Term	Non-Standardized Loading Coefficient	Standardized Loading Coefficient
Scale factor	Number of ships (NS)	1.000	0.992
	Number of routes (NR)	0.767	0.943
	Global capacity share (GCS)	0.923	1.000
	Total capacity (TC)	0.921	1.000
Service factor	Number of offices (NO)	1.000	0.947
	Number of ports served (NPS)	1.191	0.950
	Number of countries covered (NCC)	1.167	0.964
Environmental protection factor	Carbon footprint (CF)	1.000	0.974
	Annual fuel consumption (AFC)	1.120	0.973
	Sulfur emissions (SE)	1.155	0.983
	Nitrogen emissions (NE)	1.274	0.980

The AVE and CR values have been computed based on the standardized loading coefficient calculations, and the results are presented in Table 4. Notably, all AVE values associated with the three first-level factors surpass the threshold of 0.5, and all CR values exceed 0.7. These findings indicate that the sample data used in this study exhibit strong convergent validity.

Table 4. AVE and CR calculation.

Factor	AVE	CR
Scale Factor	0.968	0.992
Service Factor	0.909	0.968
Environmental Protection Factor	0.956	0.989

4.2. Differentiation Analysis of Indicators

Figure 3 displays the Pearson correlation coefficients among the second-level indicators. Notably, the second-level scale factors exhibit positive correlations with the second-level service factors, while they show negative correlations with the second-level environmental protection factors. To assess the differentiation between the first-level indicators, both Pearson correlation coefficients and AVE values have been employed, and the results are summarized in Table 5. The AVE values for the first-level indicators are higher than the absolute values of the correlation coefficients between them, underscoring the clear distinctions among the first-level indicators.

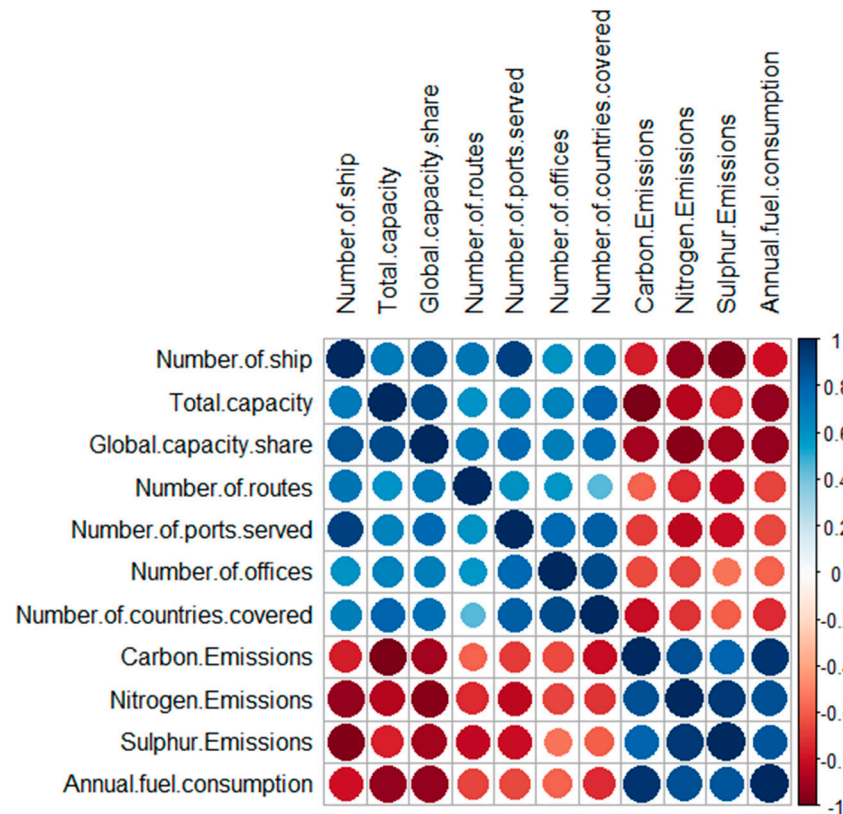


Figure 3. Pearson correlations for the considered indicators.

This paper introduces a framework for assessing direct business strength, as indicated in Figure 4. This framework is both effective and appropriate for factor analysis, characterized by its notable convergence and distinctiveness. The subsequent sections will present an experimental analysis utilizing this newly proposed framework.

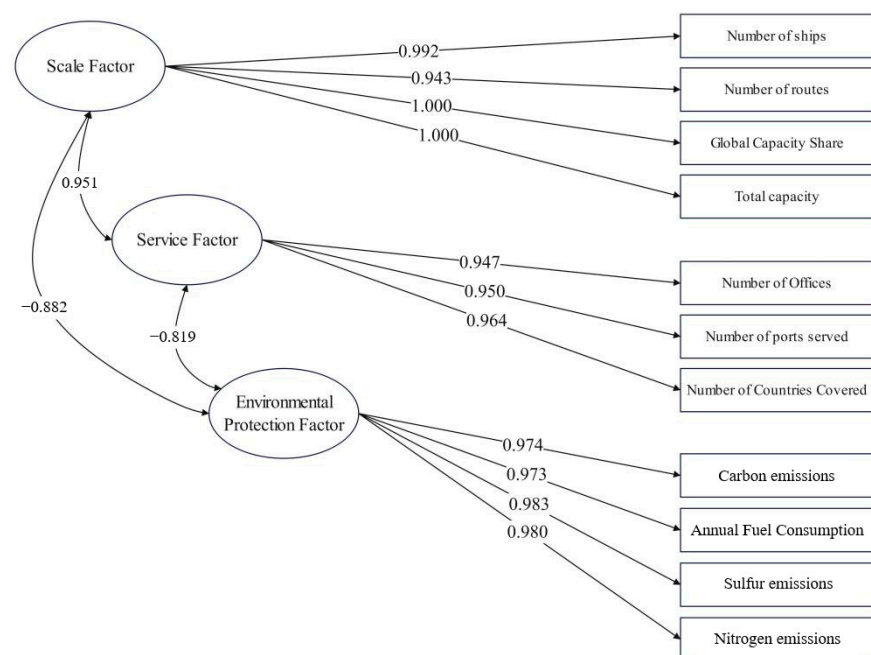


Figure 4. The established direct business strength evaluation framework.

Table 5. Pearson correlation values.

	Scale Factor	Service Factor	Environmental Protection Factor
Scale factor	1		
Service factor	0.821	1	
Environmental protection factor	−0.779	−0.562	1

4.3. Direct Operational Strength Analysis

The data used in the experiment were collected from the official websites of container shipping enterprises, including annual reports, sustainable development plans, etc. [37–50]. Table 3 presents these data, which constitute the three categories of indicators: scale, service, and environmental protection. It is worth noting that for some companies, the annual fuel consumption is provided in the form of the total heat generated by fuel. By cross-referencing with other fully documented data from comparable enterprises, the annual fuel consumption can be estimated.

- (1) Data normalization processing: The data on the second-level indicators for container shipping enterprises including MSK, MSC, CMA, OOCL, HPL, Evergreen, YangMing, ZIM, ONE, HMM, WanHai, PIL, SITC, and KMTC are calculated and normalized, as shown in Table 6. MSK and MSC show obvious advantages in scale and service, followed by CMA, and WanHai, PIL, SITC, and KMT fall behind. Correspondingly, WanHai, PIL, SITC, and KMTC cause less emissions.

Table 6. Data normalization processing.

Company	NS	TC	GCS	NR	NPS	NO	NCC	CF	NE	SE	AFC
MSK	0.935	0.865	0.869	1.000	0.809	0.412	0.790	1.000	0.778	1.000	1.000
MSC	1.000	1.000	1.000	0.609	0.847	1.000	0.965	0.803	1.000	0.538	0.943
CMA	0.795	0.698	0.698	0.847	0.685	0.538	1.000	0.440	0.759	0.737	0.775
OOCL	0.070	0.129	0.142	0.401	0.294	0.605	0.601	0.049	0.147	0.134	0.137
HPL	0.270	0.355	0.357	0.150	1.000	0.538	0.825	0.182	0.371	0.297	0.377
Evergreen	0.220	0.326	0.329	0.355	0.319	0.395	0.678	0.146	0.139	0.162	0.334
YangMing	0.042	0.120	0.125	0.091	0.135	0.249	0.371	0.030	0.113	0.078	0.088
ZIM	0.110	0.090	0.090	0.072	0.427	0.202	0.580	0.036	0.121	0.098	0.107
ONE	0.209	0.298	0.301	0.362	0.523	0.267	0.720	0.120	0.314	0.276	0.299
HMM	0.015	0.143	0.147	0.010	0.011	0.032	0.336	0.049	0.080	0.056	0.123
WanHai	0.101	0.063	0.068	0.244	0.237	0.076	0.231	0.041	0.090	0.102	0.121
PIL	0.036	0.031	0.034	0.000	0.116	0.193	0.580	0.048	0.027	0.034	0.035
SITE	0.068	0.005	0.005	0.007	0.000	0.017	0.000	0.000	0.029	0.018	0.018
KMTC	0.000	0.000	0.000	0.062	0.055	0.000	0.056	0.013	0.000	0.000	0.000

Entropy and weight calculations have been performed for the second-level indicators, and the results are presented in Table 7 and Figure 5. Notably, the weights assigned to NS, TC, GCS, NR, NPS, NCC, CF, NE, SE, AFC, and NO are 0.178, 0.147, 0.148, 0.142, 0.103, 0.055, 0.023, 0.044, 0.029, 0.031, and 0.101, respectively. These weight values exhibit variations among the second-level indicators, with NS having the highest weight of 0.178 and CF having the lowest weight of 0.023.

Comprehensive score calculation: The entropy scores and rankings of scale, environmental protection, and service factors for the container shipping enterprises are shown in Table 8. MSC, CMA CGM, and other top-ranking comprehensive score companies have lower environmental protection factor scores due to their large trade volumes and huge number of voyages. It results in larger emissions for the large-scale enterprises. These companies have an annual fuel consumption of around 10 million tons, which leads to increased carbon emissions and harmful gas emissions, despite using measures such as clean energy updating [51]. On the contrary, the companies appear at the bottom ranking

in terms of global capacity, with relatively higher environmental protection factor scores. The comprehensive score ranking ultimately is impacted by the scale, environmental protection, and service factor scores that can be used to evaluate the operational performance of container shipping enterprises.

Table 7. Summary of weight calculation results by entropy method.

Items	Information Entropy	Information Utility	Weight
NS	0.749	0.251	17%
TC	0.792	0.208	14%
GCS	0.793	0.207	14%
NR	0.199	0.201	13%
NPS	0.856	0.144	10%
NO	0.858	0.142	9%
CF	0.909	0.091	6%
NCC	0.925	0.075	5%
SE	0.925	0.075	5%
AFC	0.941	0.059	4%
NE	0.952	0.048	3%

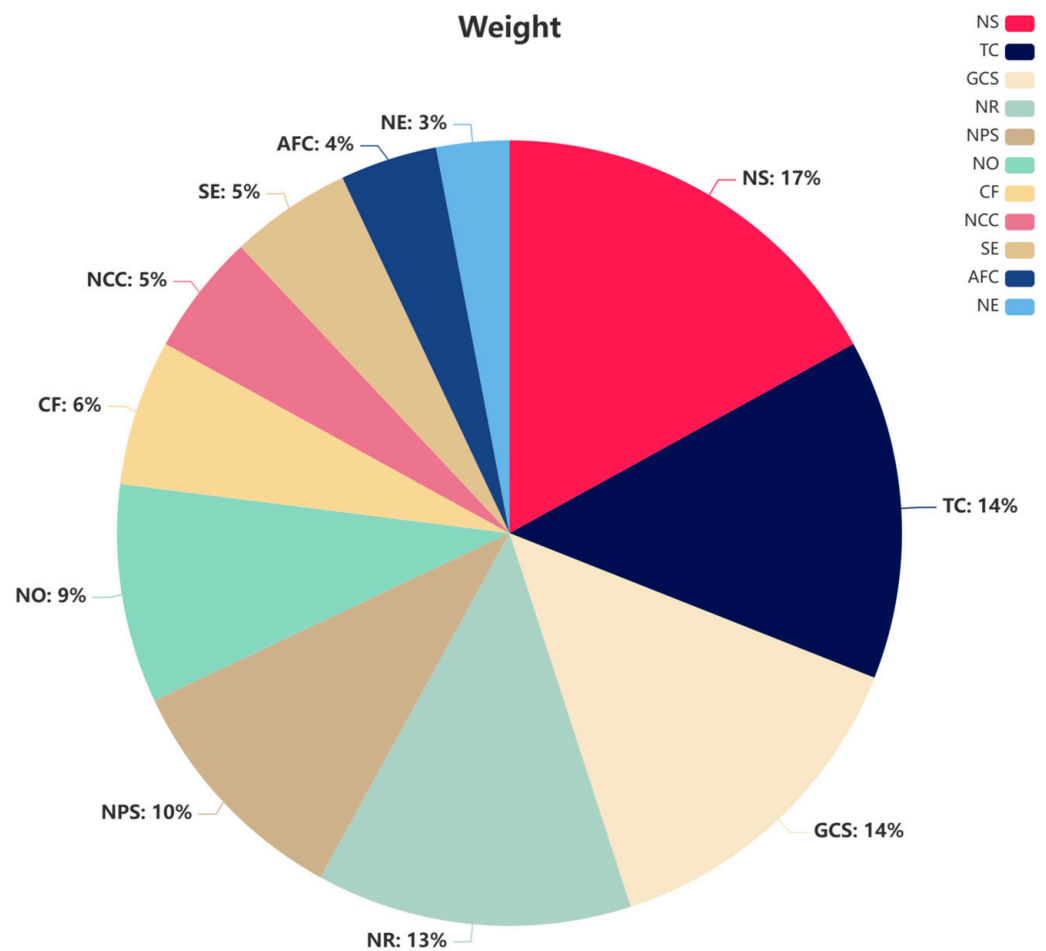


Figure 5. The weights of the second-level indicators.

Table 8. Summary of first-level rankings and comprehensive score.

Company Name	Scale Factor	Ranking	Environmental Protection Factor	Ranking	Service Factor	Ranking	Comprehensive Score	Ranking
MSC	0.920	2	0.725	4	0.942	1	0.881	1
Maersk	0.927	1	0.303	11	0.661	4	0.741	2
CMA CGM	0.770	3	0.519	9	0.705	3	0.700	3
Hapag-Lloyd	0.293	6	0.628	6	0.793	2	0.466	4
Evergreen	0.312	4	0.831	2	0.435	7	0.428	5
ONE	0.297	5	0.653	5	0.475	6	0.396	6
OOCL	0.186	7	0.879	7	0.490	5	0.325	7
Yang Ming	0.101	9	0.783	3	0.239	10	0.249	8
ZIM	0.100	10	0.531	8	0.382	8	0.238	9
HMM	0.085	11	0.857	1	0.098	12	0.221	10
Wan Hai	0.126	8	0.266	13	0.183	11	0.157	11
PIL	0.035	12	0.311	10	0.255	9	0.130	12
KMTC	0.024	14	0.288	12	0.044	13	0.069	13
SITC	0.032	13	0.243	14	0.017	14	0.059	14

4.3.1. Environmental Protection Factor

The carbon emissions, sulfur and nitrogen emissions, and fuel consumption for the selected container shipping enterprises are shown in Figure 6. The figure employs units of hundreds of thousands of tons for carbon emissions, thousands of tons for sulfur and nitrogen emissions, and tons for fuel consumption. Maersk, MSC, and CMA CGM have higher fuel consumption and emissions compared with other container shipping enterprises. Always, the container shipping enterprises with a higher fuel consumption lead to higher emissions, including all aspects of carbon, sulfur, and nitrogen. However, Evergreen has relatively high fuel consumption, but its emissions are low compared with ONE and OOCL. This may be related to efforts to modernize and update their ships, for example, having enough funds to upgrade their fleet or retrofit older ships with desulfurization devices and other relevant equipment for reducing excessive emissions resulting in a significant reduction in sulfur emissions from 83,945 metric tons to 19,184 metric tons in recent years. The environmental protection challenges the container shipping enterprises face will grow under the increasing fleets and voyages.

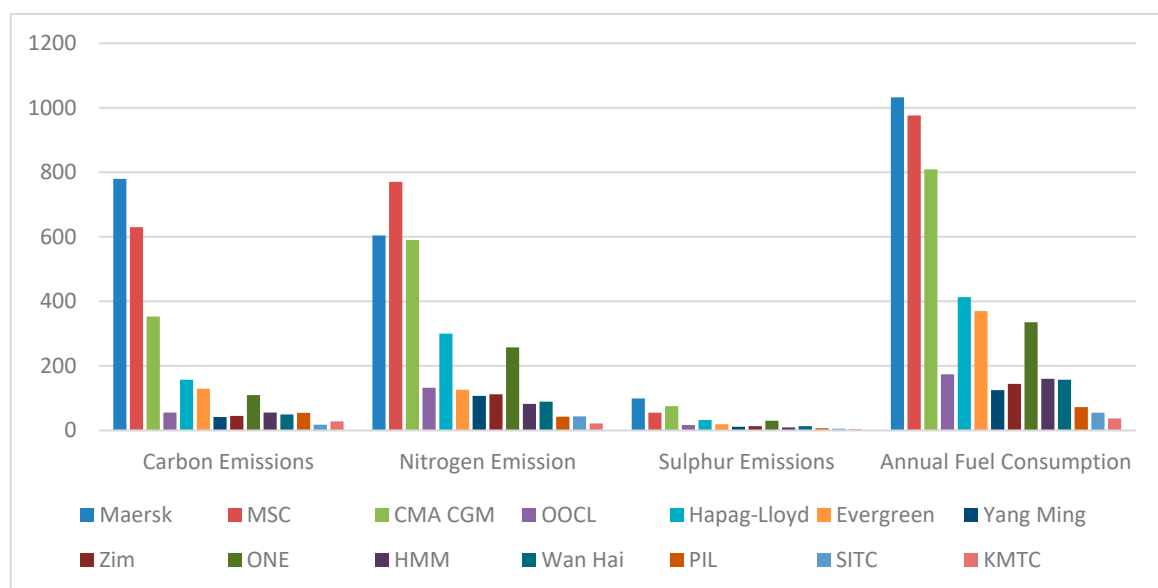


Figure 6. Annual fuel consumption and emissions.

4.3.2. Scale Factor

The container transportation industry is dominated by MSC, Maersk, and CMA CGM. MSC, Maersk, and CMA CGM are the top three ranking companies that all have nearly 600 vessels in operation, with a capacity of about 4,000,000 TEUs and a global capacity share of about 15%. Hapag-Lloyd, Evergreen, and One are the following companies, with 200 vessels serving 1,929,726, 1,649,763, and 1,701,887 TEUs with a global capacity share of 6.9%, 5.9%, and 6.1%, respectively [3]. OOCL operates a total of 112 vessels with a capacity of 804,946 TEUs, about a 3% share of global capacity; however, it serves more routes per vessel compared with Hapag-Lloyd, Evergreen, and One. This indicates the utilization rate of ships varies in different companies and does not follow the pattern of larger companies with higher usage rates (Figure 7).

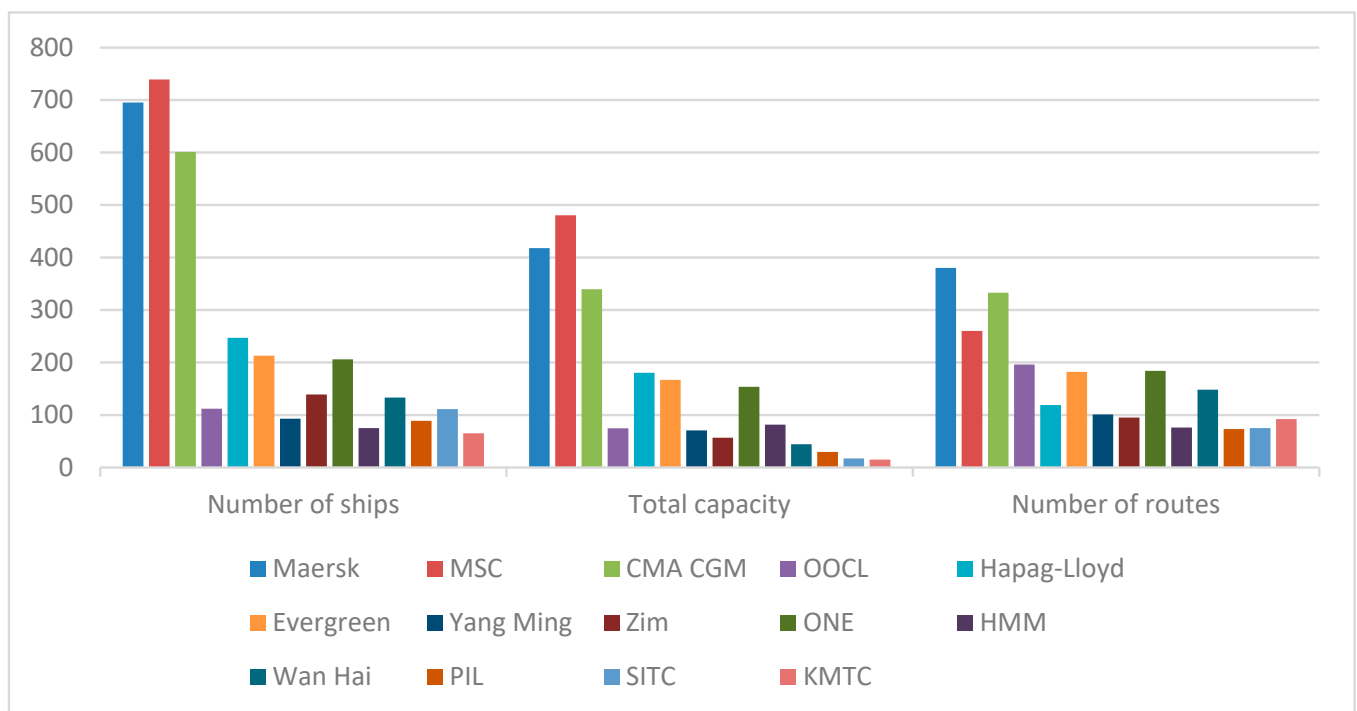


Figure 7. Number of ships, total capacity, and number of routes for container shipping enterprises.

4.3.3. Service Factor

The four major container shipping enterprises have leading positions in the global shipping service, including Maersk, MSC, CMA CGM, and Hapag-Lloyd. According to the open-source data of the relevant companies, the number of countries covered by the service network of Maersk, MSC, CMA CGM, and Hapag-Lloyd is over 130 and the number of ports served is over 500, except for CMA CGM, which has 435 ports, as shown in Figure 8. They also have a large number of offices around the world to support international shipping operations. Evergreen and OOCL are in the middle of the rankings, in the seventh and fifth places, respectively. The number of countries and ports covered by Evergreen is slightly higher than that of OOCL, while the number of offices is the opposite. The service network should be appropriately increased to improve competitiveness in the global shipping market, and the functions of the offices should be more fully utilized around the world.

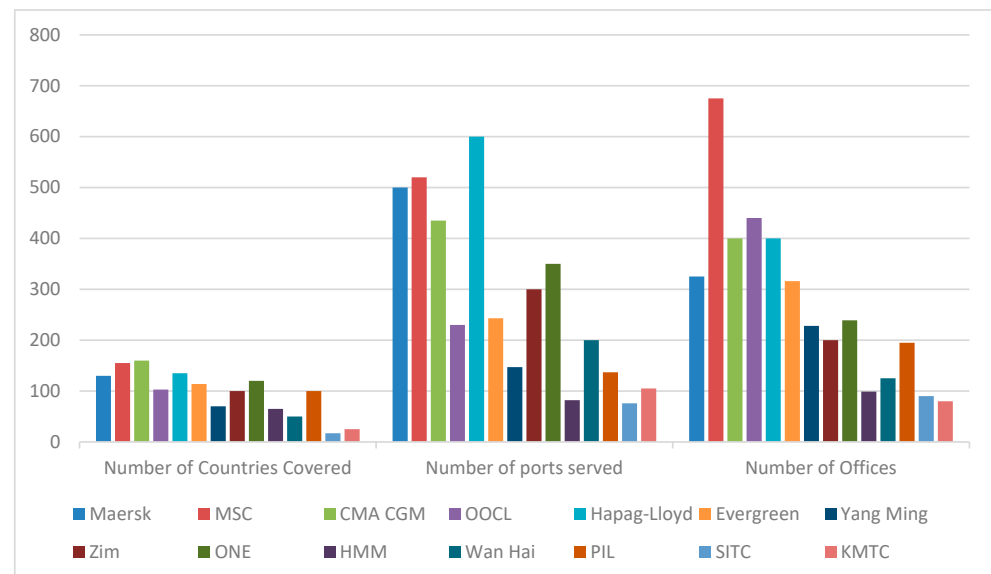


Figure 8. Service indicator data.

4.4. Indirect Operating Strength Analysis

4.4.1. Customer Satisfaction

For container shipping enterprises, on-time performance stands as a vital benchmark indicating the stability and reliability of their transportation services. In customer satisfaction, it is evident that MSK, being a heavyweight in the maritime industry, develops a robust customer service assurance system. The schedule reliabilities for the study enterprises are shown in Figure 9. The preeminence of MSK is obvious, with a 71.3% on-time performance rate [52]. Members of THE Alliance, including ONE, HMM, and Yang Ming, have lower on-time performance rates compared with MSK and have ranked at the bottom in on-time performance, which indicates the union cannot ensure timely service. KMTC and SITC have the worst performance in on-time transportation. On-time transportation can provide a good customer service experience, which can greatly accelerate cargo pickup and improve trade efficiency, as well as minimize the loss of customers. Customer satisfaction is also connected with complaints handling and feedback on time, convenient online reservations, and making up deficiencies and weaknesses to improve the quality of service.

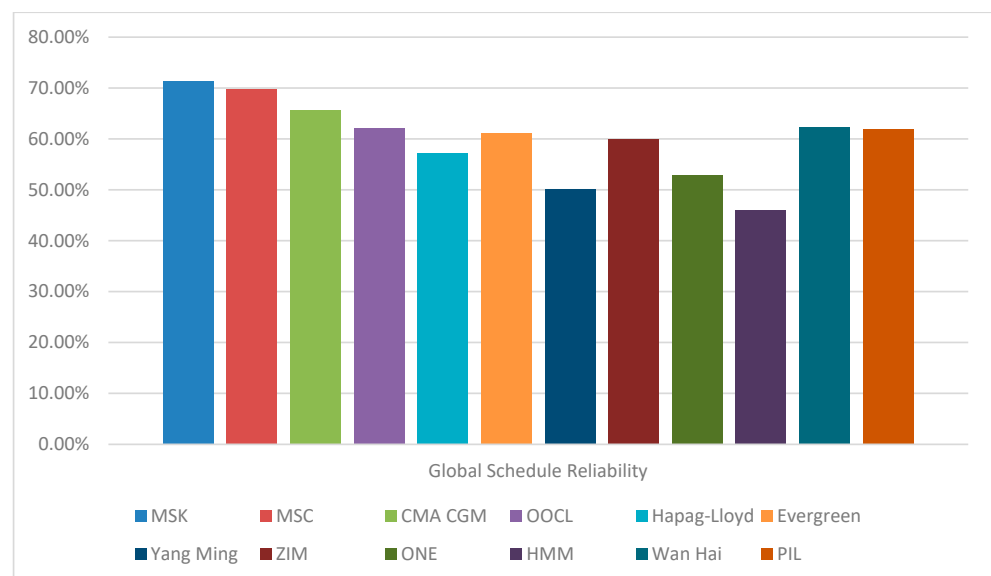


Figure 9. Customer satisfaction score.

4.4.2. The Level of Digital Transformation

Maersk is actively driving digital transformation in its port operations, aiming to enhance operational efficiency and port performance. Maersk is currently undertaking a systematic digitization of its port operations. Maersk is actively working on integrating all cranes, straddle carriers, and terminal trucks into the Internet of Things (IoT) network to enable the evaluation of their performance, efficiency, and maintenance through digitalized data. This initiative is being implemented at the Port of Los Angeles, which happens to be the largest container terminal in North America. The primary objective is to enhance operational efficiency and safety and reduce emissions. Furthermore, in 2020, Maersk successfully conducted trials of an AI-assisted container packing system. This system swiftly identifies the optimal packing configuration, resulting in a remarkable 9% increase in efficiency. As a result of these advancements, AI-assisted container packing is expected to become the standard practice, with approximately 95% of containers being packed using this approach. In addition to these technological innovations, Maersk is planning to leverage digitized data to generate Key Performance Indicator (KPI) reports for its shipping network, which spans 78 ports worldwide [42].

Evergreen has made significant progress in container yard electrification, environmentally friendly vessels, and digital platforms through advanced technological means, fully demonstrating its leading position in environmental sustainability, operational efficiency, and customer experience. Evergreen strives to promote the electrification level by abandoning old cranes in favor of new ones such as automated gantry starters and electric bridge cranes. The ship is equipped with desulfurization to eliminate oil spillage and pollution. The Shipmentlink and Green X e-commerce platforms are mainly used for online booking and ordering free from time and geographical restrictions. The use of Evergreen's online platforms is growing year after year, which indicates the maturity of the technology is achieved [40].

OOCL, with its continuous technological innovation and leadership in information technology within the industry, consistently introduces advanced digital solutions and platforms. Its online service platform and applications cover almost all the operational business, and its information development level is at the forefront of the industry. OOCL has always adhered to sustainable development closely connected with technological innovation. To comply with the Verified Gross Container Weight regulation in Container SOLAS (SOLAS VGM regulation), OOCL has launched the Box Snap free mobile application to help customers with the real-time sharing of container weight information. The developed MyOOCL Reefer combined with the latest technological means, such as artificial intelligence, Internet of Things (IoT), mobile and shipment information processing devices, etc., can more accurately predict the arrival time and monitor the progress of cargo transportation, to allow customers to grasp the cargo transportation chain more efficiently. Apart from the above-mentioned online platforms, OOCL has also launched various IT platforms such as OOCL Lite and ISCMS-Lite for logistics services, and Freight Smart for e-commerce. To ensure the security of IT platforms, OOCL has set up a Security Threat Monitoring Center (STMC) and a Global IT Infrastructure and Security Center (GISC) to provide round-the-clock monitoring and security services. OOCL has invested in a weather routing system that avoids bad weather and chooses the shortest route to the destination, greatly improving voyage safety [39].

Digitization has emerged as a crucial trend in the global shipping industry, prompting major container shipping enterprises to actively respond and take measures to drive digital transformation. In this digital wave, the Digital Container Shipping Association (DCSA) has played a pivotal role, with prominent container shipping enterprises such as the Mediterranean Shipping Company (MSC), CMA CGM, and Yang Ming Line. These companies have established their e-commerce platforms and Internet of Things (IoT) applications to achieve global digital supply chain collaboration and full traceability of goods. This digital transformation not only enhances transportation efficiency and reduces time costs but also lowers labor costs, bringing about novel operational models and competitive

advantages to the shipping industry. MSC, as a member of the Digital Container Shipping Association (DCSA), is also proactive to digitalization in the shipping industry. MSC has taken part in establishing an e-commerce platform that fully complies with DCSA standards for collaboration in the global digital supply chain. CMA has developed Traxens to record the movement and status of cargo during transport based on Internet of Things (IoT) technology. It provides customers with maximum visibility and full traceability of their goods. They will receive immediate notifications and can take prompt action in the event of accidents. CMA can assess the efficiency of their logistics chain and quickly improve operations. In June 2020, Yang Ming introduced e-B/L (electronic bill of lading) services to assist customers in improving transportation efficiency and reducing time costs between payment and cargo picking-up. It can also reduce labor costs and accelerate order procedures by replacing physical counter operations [43].

Revolutionizing the maritime industry through cutting-edge technologies, ZIM's ZIMonitor, ONE's eBL service, and Wan Hai's smart terminal automation showcase the transformative power of digital solutions in enhancing cargo tracking, trade document management, and port operations. ZIMonitor allows customers to track and monitor their cargo from start to finish of the voyage. This system can respond immediately to technical faults, helps mitigate risks to reduce insurance claims, enhance cargo security, and prevent environmental pollution [46]. ONE offers an electronic bill of lading (eBL) system designed to facilitate swift and secure issuance, transfer, and electronic signing of bills of lading and various trade documents among supply chain partners. This platform harnesses blockchain technology to uphold advanced transmission and security measures, guaranteeing the safeguarding of all documents and transactions against fraudulent activities, theft, and potential loss [47]. To enhance operational efficiency and safety, as well as reduce manpower requirements for portside cargo handling, Wan Hai has introduced an intelligent gantry system at the Taichung and Kaohsiung ports. This system features trailer guidance capabilities, guiding portside vehicles to precise container locations. The intelligent system operates reliably with an impressive accuracy rate of 98% under post-testing. It can also reduce the risk for personnel working beneath lifting equipment and prevent operational errors caused by human misjudgment [49].

In August 2021, PIL launched an eService platform called myPIL, which aims to provide customers with faster and more convenient access to all the necessary services. Customers have better shipment visibility and benefit from improved accuracy as well as fewer repetitive checks on documents [50]. Due to the relatively smaller scale and the absence of significant technological development for other container shipping enterprises, such as KMTC and SITC, it is worth exploring further discussion on these entities soon.

4.4.3. Brand Influence

After reviewing the existing data on various indicators of container shipping enterprises, the brand influence of container shipping enterprises can be evaluated through expansive fleets, powerful shipping networks, efficient and reliable services, environmental shipping development, and the full spectrum of logistics solutions, as shown in Table 9. Maersk, MSC, Evergreen, CMA CGM, and Hapag-Lloyd occupy significant roles in the worldwide shipping industry. Among them, Maersk stands out as one of the largest container shipping enterprises globally, playing an indispensable role in the global supply chain, owing to its vast fleet and a worldwide service network. MSC and Evergreen also play key roles in the global shipping market, relying on extensive shipping networks and specialized services. Companies like CMA CGM and APL have earned a favorable reputation for their service quality. Hapag-Lloyd, as one of the largest container shipping enterprises in Germany, holds a significant position in the European shipping market.

Table 9. Brand influence of container shipping enterprises.

Shipping Company	Expansive Fleets	Powerful Shipping Networks	Efficient and Reliable Services	Environmentally Friendly Shipping Development	Innovation	A Full Spectrum of Logistics Solutions	Score
MSK	•	•	•		•	•	5
MSC	•	•	•		•	•	5
CMA CGM		•	•		•	•	4
OOCL			•		•	•	3
HPL		•		•			2
Evergreen			•	•	•	•	4
Yang Ming				•	•		2
ZIM		•	•		•		3
ONE		•	•		•		3
HMM		•		•			2
Wan Hai			•	•	•	•	4
PIL		•	•				2
SITE				•			1
KMTC		•					1

MSK, a globally renowned container shipping and logistics powerhouse established in 1904, stands out for its exceptional global service network and expansive fleet. Offering comprehensive logistics solutions across industries such as petroleum, port operations, and retail, MSK is committed to environmental sustainability through the adoption of green shipping technologies. Their continuous technological innovation, particularly in information technology and artificial intelligence, enhances operational efficiency and ensures an unparalleled customer experience. As a leader in the global freight transportation sector, MSK enjoys an outstanding reputation and trust worldwide, making it one of the most influential and reliable container shipping enterprises in the contemporary landscape.

MSC, established in 1970 and headquartered in Geneva, Switzerland, stands as one of the largest privately owned global container shipping enterprises. Renowned for its vast fleet and global service network, MSC, as a leading container transportation company, offers extensive shipping routes and logistics services worldwide, covering industries such as manufacturing, retail, and energy. Prioritizing environmental sustainability, MSC adopts advanced maritime technologies and fuel efficiency measures, actively participating in sustainable shipping development. The company is esteemed for its flexibility, innovation, and customer-centric services. Leveraging digital technologies and information systems, MSC continually enhances operational efficiency, providing customers with efficient and reliable logistics solutions. Its global influence and leadership position make MSC an indispensable key player in global trade.

CMA CGM, headquartered in Marseille, France, has been a world-leading provider of container shipping and logistics services since its establishment in 1978. Ranking as the fourth-largest global container shipping company, CMA CGM is distinguished by its expansive fleet and a comprehensive operational network covering major ports worldwide. Recognized for innovation and operational efficiency, the company is committed to delivering reliable and flexible logistics solutions to its clientele. Beyond shipping services, CMA CGM offers a full spectrum of logistics solutions, including land transportation, freight forwarding, and supply chain management. Embracing advanced technologies like digitization and information systems, the company strives to enhance operational efficiency and elevate customer experiences. Furthermore, CMA CGM actively contributes

to sustainable development by adopting environmentally friendly maritime technologies and fuels, aiming to reduce carbon emissions and actively participating in global initiatives to decrease greenhouse gas emissions.

OOCL originally belonged to the Hong Kong Tung. Hong Kong is an important pivot point of the Chinese “One Belt, One Road” strategy. As one of the most well-known maritime container shipping enterprises in Hong Kong, OOCL provides comprehensive logistics and transportation services for its customers. According to statistics, more than 60% of the existing shipping capacity for OOCL is deployed along the “One Belt, One Road” countries [53], which also shows a rising trend. After OOCL was acquired by COSCO, it developed rapidly and ranked No. 3 in the global container liner rankings of COSCO Maritime Container Lines plus OOCL Cargo.

EVERGREEN has a shipping service network covering more than 100 countries around the world. Its own terminals and logistics facilities are located in many major cities. It is always ranked among the top 10 global container shipping enterprises and has become the most representative private shipping enterprise in Asia. Its brand influence is mainly concentrated in the Asian region and enjoys a good reputation in Europe, North America, Latin America, and other regions.

Hapag-Lloyd not only enjoys a widespread reputation in the international shipping domain but also demonstrates profound characteristics in customer trust, digital innovation, social responsibility, and industry leadership. Customers hold strong trust in its efficient and reliable services. Simultaneously, Hapag-Lloyd is committed to sustainable development and actively engaged in environmental initiatives.

YangMing operations on major routes such as Asia–Europe, Asia–Pacific, and Trans-Pacific demonstrate the diversified service capabilities in the era of globalization. Yang-Ming also actively takes part in environmentally friendly shipping development and technology innovation.

ZIM has risen to a prominent international shipping giant through its efficient and innovative operations. The company primarily focuses on routes from Asia to the Mediterranean and the East and West coasts of the United States and can also support shipping trade between other regions. Acclaimed for its excellent service quality and flexible logistics solutions, ZIM has emerged as a trusted partner in the global supply chain. With its ongoing commitment to sustainability and the continual innovation of digital platforms, ZIM showcases robust competitiveness in the worldwide maritime industry.

ONE, formed in 2018 through the merger of Japanese Kawasaki Kisen Kaisha, Mitsui O.S.K. Lines, and NYK Line, operates a diverse global shipping network covering Asia, Europe, the Americas, and the Middle East. ONE provides reliable and secure transportation services through efficient fleets, advanced shipping technology, and digital logistics platforms. It has a commitment to sustainable development for green transportation practices.

Hyundai Merchant Marine (HMM) stands as one of the foremost international container shipping enterprises in South Korea. HMM provides an extensive range of maritime transport services encompassing containers, bulk cargo, and liquefied natural gas between different continents with a robust fleet. HMM supports the global supply chain through its efficient shipping network. It actively implements digital transformation and innovative technologies to enhance transport efficiency while emphasizing sustainable development by trying its best to reduce carbon emissions.

WanHai, belonging to China Ocean Shipping Group, stands as one of the largest comprehensive container shipping enterprises in China supported by an extensive and formidable fleet. With a strategic focus on digitization and green shipping, WanHai can offer comprehensive and sustainable logistics for global trade.

PIL, headquartered in Singapore, stands as a leading shipping company renowned for its diversified fleet and extensive route network. Holding a prominent position among the largest container shipping enterprises in Asia, the company emphasizes sustainable development by adopting advanced technologies and implementing green shipping practices to reduce emissions.

SITC, headquartered in Hong Kong, China, is an international shipping company that specializes in container transportation services. The company, with its extensive route network, particularly on major trade routes in Asia, Europe, and North America, provides efficient and reliable transportation services fully considering customer-oriented demands.

KMTC, a major shipping company in South Korea established in 1954, focuses on container and bulk transportation. Distinguished by its advanced fleet and extensive global shipping network, the company is committed to enhancing transportation efficiency and service quality. KMTC pays more attention to digital technology and sustainable development to meet the evolving demands of the global supply chain.

These enterprises continually strengthen and expand their brand influence in the international shipping market through sustained innovation, service improvement, and shipping network development. Their contributions are pivotal to the sustainable development of global trade and supply chains.

5. Discussion

5.1. Analysis of the Strengths of Container Shipping Enterprises

The strengths of Evergreen are as follows:

- (1) **Emphasizing corporate reputation and brand effects.** Evergreen Shipping has established a positive industry reputation over 50 years and values customer feedback to continually improve service quality. The company has also expanded its global shipping service network based on its good reputation.
- (2) **Emphasizing the advancement of environmentally friendly shipping,** Evergreen is dedicated to the promotion of green shipping through retrofitting older ships and utilizing cleaner fuels. Based on the annual report of Evergreen, the bunker fuel usage in 2021 amounted to 3,703,747 metric tons, with 47% of desulfurization fuel, and desulfurization devices installed on older vessels at a rate of 61%.

The advantages of OOCL are as follows:

- (1) **Internet technologies proficiency:** OOCL has achieved a remarkable level of Internet technologies proficiency to maximize efficiencies in global shipping. For instance, its subsidiary Cargo Smart(Zhuhai, China), which concentrates on developing global freight forwarding software, uses big data and cloud-based platforms to offer shipping information and operates as the data processing center of Ocean Alliance.
- (2) **Youthful staff structure:** In recent years, OOCL has held a variety of recruitment activities around the world, constantly recruiting a variety of young talent. The number of young employees under the age of 30 has exceeded 34% and is still increasing. OOCL attaches great importance to staff training to maintain an innovative ability and youthful thinking for long-term development.
- (3) **High coverage service network:** Its fleet size and total capacity are only about 50% of Evergreen. However, its service network covers a similar number of countries and ports as that of Evergreen. OOCL is closely following the strategy of “One Belt, One Road” and expanding the shipping market.

The strengths of MSC are as follows:

- (1) **Large capacity share:** The enterprise has the highest capacity share in the global shipping market. On 6 January 2022, MSC surpassed Maersk to become the No. 1 liner shipping company in the top 100 global container shipping enterprises and now accounts for 19% of the global capacity. MSC is expected to be able to further increase its capacity to 6 million TEUs by mid-2024.
- (2) **Actively deploying net-zero decarbonization:** Although MSC boasts a vast fleet size, its environmental protection factor ranks fourth, demonstrating the company’s commitment to green shipping. MSC is actively exploring the deployment of low-carbon and zero-carbon fuels, as well as energy-efficiency technologies. It plays a leadership role in the Oceanic Natural Gas Association. In 2022, its first LNG-powered

vessel joined the fleet, while ammonia vessels will join the fleet in 2025. MSC is committed to having its first zero-carbon fuel vessel in service by 2030.

The advantages of Maersk are as follows:

- (1) **Good internal governance framework:** Maersk has a safe and secure whistleblowing mechanism to safeguard business operations, which is designed to create a safe and secure environment for anyone to speak up and report violations without fear of retaliation.
- (2) **Huge fleet size and a high share of global capacity:** Maersk, which ranks at the second-highest global capacity, accounted for 15.2% in 2022 and ranked first before 2022. Even though it has been surpassed by MSC, it is still the benchmark of container shipping enterprises in terms of fleet strength.

The advantages of the CMA CGM are as follows:

The extensive service network and shipping routes: CMA CGM, as the third-largest carrier in the world, has routes covering 160 countries. Its total capacity is equal to 70% of MSC. Moreover, CMA CGM has reached a cooperation program with the countries along the “One belt, one road”, which is conducive to strengthening brand influence.

The advantages of ONE are as follows:

Large fleet size: By 2023, ONE will have a total of 217 vessels, with a capacity of 1,681,897 TEUs, accounting for 6.1% of the global capacity share. Its global offices and accessible ports are among the highest in the same level of enterprises.

The advantages of Hapag-Lloyd are as follows:

- (1) **The shipping routes covering numerous ports:** Hapag-Lloyd only occupies the fifth-largest share of global capacity, but the number of accessible ports along its routes has reached 600, which shows it provides a wide service network. According to the result of the entropy method, the Hapag-Lloyd Service Factor ranked in second place.
- (2) **Good brand reputation:** As a German shipping enterprise established in the last century, Hapag-Lloyd has a good brand reputation and a bright prospect for future development.

The advantages of Yang Ming are as follows:

Strong environmental protection awareness: Yang Ming has a remarkable capacity scale and also achieves excellent environmental protection ability, according to its sustainable development report. The carbon emission intensity of the enterprise has been reduced by 56.91% from the baseline year of 2008 to 2020, and the average energy consumption per unit of transportation operation has been improved by 57.27%, which fully demonstrates its environmental protection responsibility [45].

The advantage of Wan Hai is as follows:

Intelligent shore-based technology: Wan Hai has implemented intelligent gantry systems at the Taichung and Kaohsiung ports. These systems feature trailer guidance capabilities, accurately positioning vehicles to container locations with precision. Operating reliably, the intelligent systems boast a testing accuracy rate of up to 98%. Furthermore, they reduce risks for personnel working under lifting equipment and prevent operational errors stemming from human misjudgment. This underscores the company’s emphasis on employee safety and substantial investment in shore-based technology [52].

The advantages of HMM are as follows:

Vigorously promoting green shipping: According to the data in Table 8, HMM ranks first in the environmental protection factor, which fully demonstrates HMM’s emphasis on green shipping and energy-saving emission reduction. HMM will continue to adopt low-carbon and zero-carbon vessels by 2025, increasing the proportion of alternative-fuel-propelled vessels by 12% [48].

The advantage of ZIM is as follows:

A good staff structure with a large number of experienced employees can support better coping with the risks and challenges of ship voyages. At the same time, ZIM also emphasizes the training of employees, which lays a good foundation for the stable development of the enterprise.

The advantages of SITC are as follows:

The age composition of employees is favorable: The data indicate that 97.6% of SITC employees are under the age of 50, with 35.9% of them being under 30 years old. SITC not only has a significant number of experienced middle-aged employees but also numerous young employees, indicating that its team is experienced and possesses innovative vitality.

The advantage of PIL is as follows:

The routes and offices covering more countries: PIL has routes covering 100 countries and has 195 offices worldwide. Among several enterprises at similar capacity levels, the routes of PIL cover most countries. PIL attaches importance to the global customer experience.

The strength of KMTC is as follows:

Promising development prospects: Although KMTC has a relatively small fleet size, this brings about some unique advantages. Firstly, the relatively small scale implies a more streamlined and flexible operational structure for KMTC. This enables them to make decisions more quickly and adjust operational strategies to adapt to rapid changes in the market and customer demands. Lastly, as a company with lower rankings but ambitious aspirations, KMTC may strive even harder to seek innovation and improvements to enhance its competitiveness and expand its market influence. Therefore, despite its lower overall ranking, KMTC still possesses promising development prospects and potential.

5.2. Analysis of Problems in Container Shipping Enterprises

The issues of Evergreen can be improved as follows:

- (1) **Insufficiency of stakeholder participation:** Evergreen is only confined to the suggestions of the shareholders and customers and is not able to absorb the advice of the outside world on the development of the company.
- (2) **Insufficient development of information technology:** The investment of Evergreen is mainly in hardware such as ships and container yards. The investment in information technology can be improved to develop an e-commerce platform further to support important data being updated timely. Evergreen purchases and uses related information technology products from other companies, which can be easily restricted by others due to a shortage of core technology.
- (3) **The aging workforce structure:** the proportion of employees over 50 years is larger than the proportion of young employees under 30 years old, which indicates its employee structure is gradually aging.
- (4) **A slightly limited service network:** its service factor score ranked seventh in the midstream level, indicating that its global service network should be adjusted appropriately to expand service.

The issues of OOCL can be improved as follows:

- (1) **Small fleet size and share of capacity:** OOCL's scale factor ranking in seventh position suggests that there is room for improvement in the company's fleet size and total capacity. Fleet size and total capacity are fundamental aspects of a shipping company, as they directly impact its operational strength and competitiveness in the industry. Enhancing these factors can contribute to improving OOCL's position and capabilities within the market.

- (2) **Slow renewal of fleet structure and old vessels:** OOCL has not invested enough in re-modeling and updating the existing ships, including the installation of desulfurization devices and the addition of shore power systems.
- (3) **High hazardous gas emission:** The total amount of hazardous gas emissions of Evergreen in 2021 were 148.86 kilotons, of which nitrogen emissions were 132.43 kilotons and sulfur emissions were 16.43 kilotons. HMM, which has a similar fleet size, emitted only 82 kilotons of nitrogen and 9 kilotons of sulfur, which shows that OOCL has a certain shortcoming in reducing harmful emissions.

The issues of MSC can be improved as follows:

Improvements are needed in environmental protection: According to Table 8, MSC ranks fourth in terms of the environmental factor, with total nitrogen oxide emissions of 770 kilotons in 2022. In comparison, Maersk, with a similar fleet size, had nitrogen oxide emissions of 604 kilotons. The vast size of MSC's fleet results in significant greenhouse gas emissions. As the largest container shipping company in the global market share, MSC should lead in all aspects, so there is room for better performance in environmental protection.

The issues of Maersk can be improved as follows:

Environmental protection capabilities can be enhanced: As a leading shipping company, Maersk ranks 11th in terms of the environmental protection factor according to the entropy method. Its sulfur and carbon emissions are roughly twice and 1.2 times as high as those of MSC, respectively, indicating a lower usage rate of clean fuels and the need for the active deployment of zero-carbon emission strategies.

Expansion of global offices: Maersk has only 325 offices globally, which is fewer than half the number of MSC's. This hampers the improvement in the global customer experience. Increasing the number of global offices would contribute to enhancing the overall strength of the company.

The issues of CMA CGM can be improved as follows:

- (1) **The increasing emissions need to be reduced:** The CO₂, nitrogen oxide, and sulfide emissions all increased in 2021 compared to the previous years. The Alphaliner TOP 100 shows that CMA CGM currently has 117 vessels with a capacity of 1,213,691 TEUs on order. This means that the capacity of CMA CGM will increase by 34.6% in the future, resulting in more emissions. This implies CMA CGM should pay more attention to environmental protection in the context of carbon neutrality.
- (2) **Aging staff structure:** The total number of CMA CGM employees reached 82,582 in 2021 with 25.8% over 50 years old and 21.2% under 30 years old, which may not be conducive to long-term development considering innovation.

The issues of Hapag-Lloyd can be improved as follows:

Excessive harmful emissions and insufficient environmental protection: The total harmful gas emissions of Hapag-Lloyd from marine activities in 2021 were 332 kilotons, of which 300 kilotons of nitrogen emissions were about 2.4 times those of Evergreen, and 32 kilotons of sulfur emissions were about twice those of Evergreen. The capacity of Hapag-Lloyd is only 1.12 times that of Evergreen, which shows that the control of harmful gas emissions from marine activities for Hapag-Lloyd should be strengthened in the context of advocating carbon neutrality.

The issues of ONE can be improved as follows:

Insufficient environmental protection and high harmful emissions: According to the Alphaliner TOP 100 [3], the capacity share of ONE and Evergreen is almost the same, but there is a big gap between their environmental protection status in marine activities. The nitrogen emission of ONE is 257 kilotons, which is two times that of Evergreen; and the sulfur emission of ONE is 29.95 kilotons, which is 1.6 times that of Evergreen. One needs

to emphasize the use of cleaner fuels and the renovation of old ship equipment to reduce harmful gas emissions.

The issues of Yang Ming can be improved as follows:

Relatively small fleet scale and slow growth in TEUs: Yang Ming is in the third class of container shipping enterprises with HMM and ZIM in terms of capacity size, with the share of global capacity ranging from 2% to 3%. According to the statistics of the Alphaliner TOP 100 [3], Yang Ming has 93 vessels with a capacity of 705,614 TEUs and has ordered 5 vessels with a total capacity of 77,500 TEUs, which is expected to see an 11% growth in its capacity. HMM and ZIM will see a 33.5% and 52.9% growth in capacity, respectively. The capacity of Yang Ming will grow slowly in the future.

The issues of HMM can be improved as follows:

Small coverage of service network and small size of ships: The service factor ranking of HMM is low, with a small size of covered countries and reachable ports as well as global service offices compared with the companies in the same capacity scale. The small coverage of the service network leads to the lowest number of ports of call. It may also relate to the fact that HMM does not have an advantage in ship fleets (ranked 8th in terms of capacity and 13th in terms of the number of ships it owns).

The issues of ZIM can be improved as follows:

- (1) **The limited environmental protection capability:** The environmental protection capability of ZIM is poor among companies with the same level of capacity. It is larger than HMM and Yang Ming in terms of both GHG emissions and hazardous gas emissions. It should improve the consideration of environmental protection in future development.
- (2) **The aging personnel structure:** Employees over 50 years old account for 21.44%, which is larger than the proportion of those under 30 years old. If ZIM wants to occupy the high ground in future competition, innovations of personnel will be very important.

The issues of Wan Hai can be improved as follows:

Fewer countries served and fewer global offices: Wan Hai accounts for 1.7% of the global capacity share, owns 122 vessels of different sizes, and has a high rate (95.6%) of vessel ownership. Wan Hai and ZIM have similar fleet strengths, but the number of countries covered by the routes of ZIM and the number of its global offices are twice as many as those of Wan Hai. It shows that there is still much room for Wan Hai to expand its service network.

The issues of PIL can be improved as follows:

Relative low capacity and small fleet size: The entropy experiment result shows that its scale factor ranks 12th, accounting for 1.1% of the global capacity. The capacity of PIL is 295,331 TEUs, with 89 vessels of different sizes, of which 69 are owned vessels and 20 are chartered vessels, with an ownership rate of 65.3%. Its ship ownership rate is in the middle level. The existing fleet strength and capacity level are low, but the Alphaliner TOP 100 shows that its future capacity scale will increase at a growth rate of 29.8%.

The issues of SITC can be improved as follows:

Insufficient countries covered by routes and low number of accessible ports: the number of countries and ports covered by SITC ranks last among the 14 enterprises, and the number of ships owned by SITC ranks 12th, which indicates that SITC shows low competitiveness in internationalization.

The issues of KMTC can be improved as follows:

Small fleet size and not enough global offices: The scale factor of KMTC ranked 14th with a small fleet size. According to the data of the Alphaliner TOP 100, the total number

of vessels for KMTC up to now is 66 vessels. KMTC has two vessels on order. It will have a 10% growth in capacity in the future, which has still not taken advantage over other companies ranked at the same level. On the other hand, KMTC has a small number of offices worldwide, which is not conducive to serving customers.

6. Conclusions and Future Work

In conclusion, this study sheds light on the imperative role of the shipping industry in facilitating international trade and fostering global economic development. In the contemporary landscape, characterized by the imperative shift towards carbon neutrality in international trade, it becomes increasingly crucial for container shipping enterprises to have a comprehensive understanding of their current business status. Such insights not only enable them to identify existing deficiencies and shortcomings but also provide a roadmap for more effectively aligning their future development strategies.

Our research has contributed by establishing an analysis framework that amalgamates quantitative and qualitative methods, offering a nuanced perspective on the operational strengths and weaknesses of leading global shipping carriers. By employing comparative analysis and the entropy method, we have delved into both direct and indirect operating strength indicators, thereby providing a holistic view of the competitive landscape within the industry.

However, it is essential to acknowledge the limitations of this study. Firstly, the evaluating indicators utilized in our study, while comprehensive, may benefit from further refinement based on more accessible and comprehensive data sources. For instance, the unavailability of annual reports from some companies, such as MSC, necessitated the reliance on data from the secondary literature and websites, which may introduce deviations. Future research endeavors could mitigate this limitation by fostering collaborations with industry stakeholders to access more reliable and comprehensive datasets.

Moreover, while our study offers valuable insights into the operational dynamics of leading container shipping enterprises, it is imperative to recognize that the industry is constantly evolving, influenced by a myriad of internal and external factors. Future research could explore emerging trends and disruptions within the shipping industry, such as technological innovations, regulatory changes, and geopolitical shifts, and their implications on the operational strategies of container shipping enterprises.

Furthermore, as the global push towards sustainability gains momentum, there is a pressing need to delve deeper into the environmental implications of shipping operations and explore strategies for achieving carbon neutrality and mitigating the environmental impact. Additionally, research focusing on the socio-economic implications of shipping, including its role in fostering economic development in emerging markets and addressing social inequalities, would offer valuable insights into the broader impact of the industry.

In conclusion, while this study provides a basic understanding of the operational dynamics of leading container shipping enterprises, there is ample room for further research to address the above limitations and explore new ways to improve the sustainability, efficiency, and inclusion of the shipping industry in pursuit of global prosperity and equitable development.

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