Neutrosophic Combinative Distance-based Assessment (CODAS) Method for Evaluating the Financial and Operational Performance of Shipping Companies

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Abstract

Stakeholders must evaluate the efficiency, profitability, risk management, and overall operational effectiveness of shipping businesses by analyzing their financial and operational performance. Revenue, expenses, fleet utilization, accident rates, market share, and competitive advantage are only a few of the parameters that must be analyzed in this procedure. Stakeholders may use this information to make better choices, spot weak spots, and measure up to competitors. An overview of the criteria used to evaluate the financial and operational performance of shipping businesses is provided in this paper, together with an emphasis on the importance of such assessments in enabling strategic decision-making and long-term development within the shipping sector. This paper used the neutrosophic set framework to overcome the uncertain data. The neutrosophic set combined with the combinative distance-based assessment (CODAS) method to evaluate the financial and operational performance of shipping companies. There are ten criteria and eight companies are used in this study. The application shows the results of the proposed method.

Keywords: Neutrosophic Set; CODAS Method; Shipping Companies; Evaluation Problem

1. Introduction

It is critical for stakeholders, investors, and industry experts to assess the financial and operational success of shipping enterprises. The shipping business is crucial to international commerce because it provides a means for the transportation of products across international waters. The efficiency, profitability, risk management practices, and overall operational efficacy of shipping businesses may be gained by evaluating their performance[1], [2].

Considerations such as income creation, cost management, fleet utilization, safety records, market position, and competitive advantage are part of the appraisal process for shipping businesses[1], [2]. Stakeholders may use this data to make educated choices, gauge potential threats, pinpoint problem spots, and compare results to those of competitors[3], [4].

Analyzing the company's income statement, balance sheet, and statement of cash flows is a key part of any financial review[1], [5]. To learn about the company's revenue generation, profitability, liquidity, and financial stability, we look at revenue patterns, profit margins, cost structures, and debt levels[6], [7].

Efficiency and utilization of fleets, safety records, regulatory compliance, and technology advancement are all evaluated as part of the operational assessment. These metrics are useful for evaluating a company's fleet optimization, risk management, international standard compliance, sustainable practice adoption, and technology innovation leveraging efforts[8], [9].

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Stakeholders may gauge a maritime firm's resilience in the face of market uncertainty, geopolitical threats, economic downturns, and environmental requirements by analyzing its financial and operational performance. It also aids in spotting potential trouble spots, investment avenues, and development initiatives[5], [10], [11].

Smarandache established a neutrosophic set by discovering the phrase degree of indeterminacy as a logically independent component for dealing with uncertain data in practical settings. Truth, indeterminacy, and false membership functions for neutrosophic sets all have values in the real standard interval[12], [13]. In a neutrosophic context, we may understand the concept of abstract value. The vast amount of data provides only hazy, partial practical applications. Fuzzy theories and probability theories are only two examples of the many methods developed specifically for managing this kind of data[14], [15]. The measure, however, serves as an example of the unprejudiced or overtone effects that might be controlled as continuous, discontinuous, or blended in a neutrosophic setting[16], [17]. The Viterbi algorithm, for instance, works well in a fuzzy setting but achieves indeterminacy (neutral) qualities in a neutrosophic one that aren't relevant to fuzzy sets[18], [19]. The neutrosophic set used in this paper with the CODAS method to evaluate the operational and financial performance of shipping companies.

Stakeholders may have a more complete knowledge of a shipping company's strengths, shortcomings, and long-term survival by conducting an in-depth analysis of the company's financial and operational performance. This analysis is helpful for making strategic decisions, assessing risks, and seeking sustainable development in the complex shipping business.

2. Risks Factors Face the shipping companies

Numerous threats threaten the security, profitability, and viability of the shipping industry as a whole. Some typical dangers faced by shipping firms are listed below.

Shipping firms are vulnerable to market variations such as changes in freight prices, imbalances in the supply and demand for vessels, and shifts in global trade patterns. Revenue, profitability, and utilization of fleets may all be impacted by market volatility[20], [21].

Shipping firms are vulnerable to geopolitical risks such as war, terrorism, trade disputes, sanctions, and changes in government policy. Disruptions in shipping lanes, the closing of ports, new regulations, and higher operating expenses are all possible results of geopolitical instability.

Recessions and downturns in the economy may have a negative impact on shipping firms by lowering global trade volumes, freight rates, and demand for shipping services. When the economy is struggling, it might be difficult to make ends meet, leaving ships idle and increasing the level of competition[22], [23].

Price fluctuations in fuels, especially marine fuel (bunker fuel), may have a serious effect on the bottom lines of shipping firms. Profitability is impacted by fluctuations in gasoline costs, which may need fuel surcharges or fuel hedging techniques.

Hurricanes, typhoons, and tsunamis, together with other natural catastrophes, and bad weather, such as storms and fog, pose a threat to shipping operations. These occurrences may jeopardize shipping schedules, damage vessels, and cargo, and even endanger lives.

Rapid technical progress and the advent of digitalization may offer the maritime industry both possibilities and threats. Cyber assaults, system failures, or antiquated technology may all create operational interruptions and put sensitive information at risk, offsetting the benefits of technical advancements in terms of efficiency and competitiveness[24], [25].

Safety, security, environmental protection, and labor standards are just some of the many areas in which shipping businesses must comply with a tangled web of international, national, and municipal requirements. The consequences of breaking these rules include fines, lost credibility, halted operations, and higher expenses.

Stricter environmental rules are being pushed upon shipping businesses as society becomes more concerned with environmental sustainability and reducing emissions. Investing heavily in cleaner technology and alternative fuels

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may be necessary to comply with restrictions such as the International Maritime Organization's (IMO) sulfur and greenhouse gas emissions requirements.

Insurance premiums might go up, lives on board can be put in danger, and goods can be stolen if a ship is operating in an area with a high risk of piracy. Security measures and industry best practices must be implemented by shipping businesses to reduce vulnerability[24], [26].

Shipping operations may be impacted by problems in the supply chain, such as port congestion, labor strikes, or the closure of vital trade routes. Delays, higher expenses, and unhappy customers are the result of supply chain disruptions.

The financial stability, operational resilience, and long-term performance of shipping businesses depend on their ability to manage and mitigate these risks. Shipping firms may mitigate these dangers by taking precautions including conducting risk analyses, making backup plans, purchasing insurance, implementing thorough compliance programs, and expanding their reach into new markets and trade corridors[27], [28].

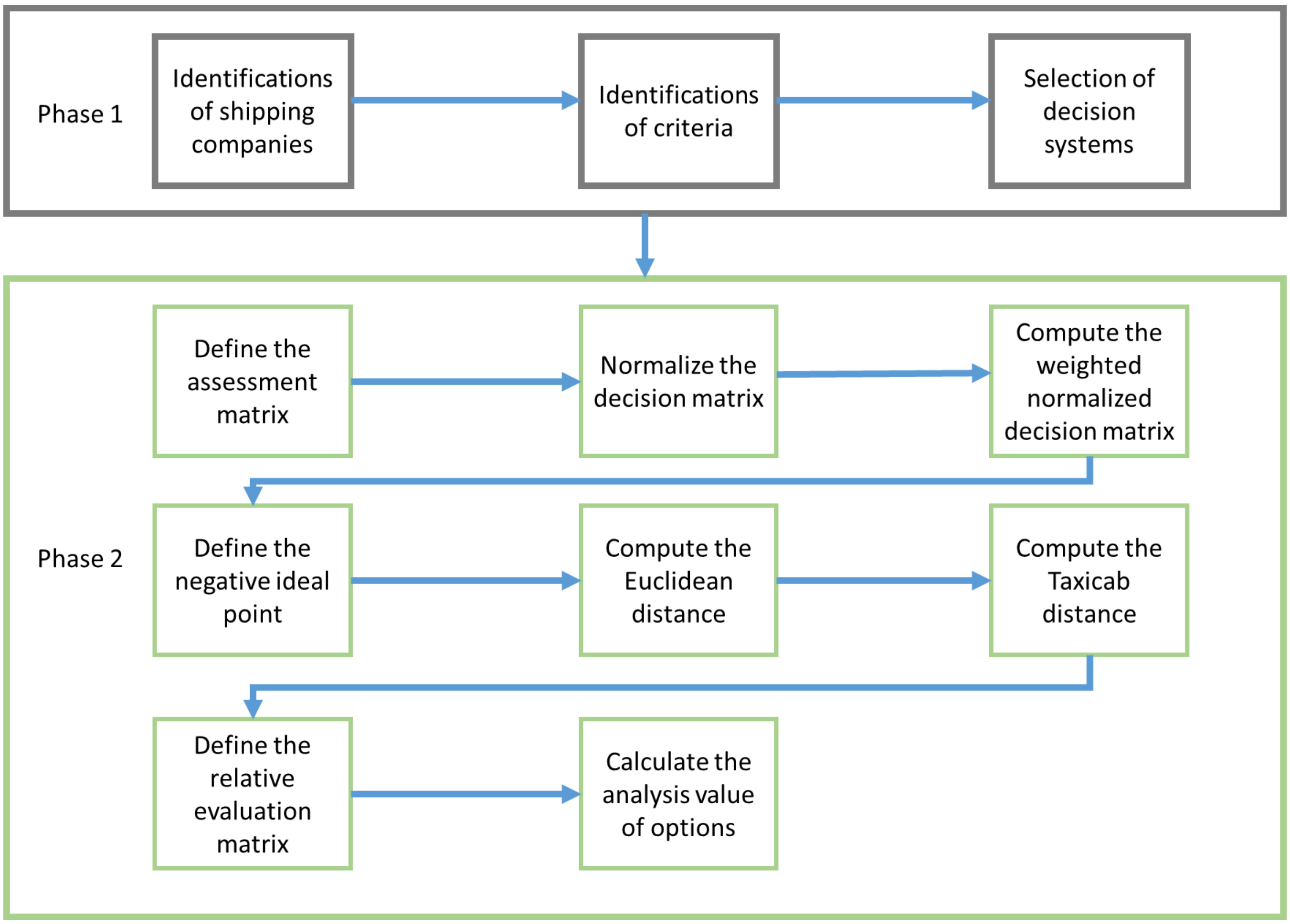

Figure 1: The stages of the CODAS method with neutrosophic set.

3. Evaluation Approach

This part has covered the topic of the mathematical illustration of CODAS. Combinative Distance-based Assessment (CODAS) evaluates the criterion/option according to both the Euclidean and Taxicab distances from the negative ideal demonstrated. The methodology relies on an initial evaluation based on Euclidean distance. Nonetheless, the method uses Taxicab distance for comparison if the resulting distance between two options is too little. The cutoff is established for the level of proximity. Think of an MCDM issue with n possible solutions and m measures of quality[29]–[31]. The stages of the CODAS method are outlined below and Figure 1:

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A) Define the assessment matrix

B) Normalize the decision matrix

$$D_{ij} = \begin{cases} \frac{a_{ij}}{\max_i a_{ij}} \\ \frac{\max_i a_{ij}}{a_{ij}} \end{cases} \quad (1)$$

C) Compute the weighted normalized decision matrix

$$n_{ij} = w_j * D_{ij} \quad (2)$$

D) Define the negative ideal point

$$Id_j = \min_i n_{ij} \quad (3)$$

E) Compute the Euclidean distance

$$EL_i = \sqrt{\sum_{j=1}^{m}(n_{ij} - Id_j)^2} \quad (4)$$

F) Compute the Taxicab distance

$$TX_i = \sum_{j=1}^{m}|n_{ij} - Id_j| \quad (5)$$

G) Define the relative evaluation matrix

$$[EV_{ik}]_{n\times n} = (EL_i - EL_k) + (\beta(EL_i - EL_k) * (TX_i - TX_k)) \quad (6)$$

H) Calculate the analysis value of options

$$AV_i = \sum_{k=1}^{n} EV_{ik} \quad (7)$$

4. Results

Several important factors should be taken into account when assessing the financial and operational success of shipping enterprises. Considerations along these lines provide light on how well a business operates in terms of efficiency, profitability, risk management, and general efficacy. Some crucial factors to think about are as follows:

Revenue and Profitability: Analyze the company's financial documents (income statement, balance sheet, and cash flow statement) to get a sense of how much money it brings in and how profitable it is. Analyze the firm's revenue generation capabilities and whether or not they are expanding and stable.

Examine the effectiveness and efficiency of the company's cost management procedures. Estimate ongoing expenditures such as fuel, upkeep, crew, port fees, and management salaries. Profitability and competitiveness may be boosted by using cost control methods.

Determine the company's operational efficiency and effectiveness by analyzing its fleet efficiency and utilization. Turnaround time, average speed, port wait times, and capacity utilization are all important variables to think about. Better operational results are indicative of greater fleet efficiency and utilization.

Assess the company's safety procedures and their adherence to relevant requirements. Evaluate safety KPIs including accident rates, incidents, and compliance with global safety standards. Managing pollutants and garbage in accordance with applicable laws is also crucial.

Position in the Industry and Competitive Advantage Analyze the Company's Place in the Shipping Industry and its Competitive Advantage. Think about things like your service's market share, client base, geographic reach, service

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options, and tactics for standing out from the competition. Long-term success is boosted by the firm's dominant market share and competitive edge.

Analyze the firm's debt structure, liquidity, and solvency ratios to determine the firm's financial stability. Analyze the leverage levels, debt repayment plans, credit scores, and availability of cash. A firm with solid financial footing can weather economic storms and take advantage of expansion possibilities.

Assess the company's risk management procedures, including its risk identification, risk assessment, and risk mitigation strategies. Think about potential dangers such as changes in regulations, commodity prices, and the value of ships. The resilience and safety of the business are both increased by a solid risk management system.

Think about the company's efforts to lessen its impact on the environment and its dedication to sustainability. Analyze programs for lowering emissions, adopting greener technology, and meeting environmental standards. The image and long-term success of shipping businesses increasingly depend on their capacity to practice environmental sustainability.

Assess the company's commitment to technology advancement and digitalization. It is possible to increase operational efficiency, route optimization, and decision-making by using automation, data analytics, and digital platforms. The advancement of technology helps businesses gain an edge and perform at a higher level.

Analyze how the firm interacts with its many constituencies, such as its customers, suppliers, workers, and local communities. Think about things like how happy your customers are, how your suppliers feel, how engaged your employees are, and how involved your community is. Long-term success and sustainability may be attributed to solid connections with key stakeholders.

By weighing these factors, interested parties may better comprehend the economic and operational health of a shipping firm. Informed decision-making, risk assessment, and the identification of improvement opportunities are all aided by this analysis. It paves the way for shipping sector strategic planning, resource allocation, and long-term development, and it facilitates comparisons to similar sectors.

A) We define the decision matrix by using the interval valued neutrosophic numbers. We collect the set of experts and decision makers to evaluate the ten criteria and eight firms.

B) Then we normalize the decision matrix by using Eq. (1).

C) Then we compute the weights of criteria. Then we compute the weighted normalized decision matrix by using Eq. (2) as shown in Table 2.

D) Define the negative ideal point by using Eq. (3).

E) Compute the Euclidean distance by using Eq. (4) as shown in Table 1.

Table 1: The Euclidean distance matrix by the CODAS method.

	$CSFC_1$	**$CSFC_2$**	**$CSFC_3$**	**$CSFC_4$**	**$CSFC_5$**	**$CSFC_6$**	**$CSFC_7$**	**$CSFC_8$**	**$CSFC_9$**	**$CSFC_{10}$**
$CSFA_1$	0	0	0	0.031801	0	0.014184	0.008908	0	0.040235	0.055816
$CSFA_2$	0	0.025683	0.010506	0.008639	0.030979	0.014266	0.016167	0.022035	3.66E-05	0.02344
$CSFA_3$	0.046938	0.042117	0.021342	0.031772	0.015097	0.007828	0.039625	0.036911	0.013777	0.039041
$CSFA_4$	0.057145	0.060125	0.001282	0	0.015097	0.014266	0.027645	0	0	0.023306
$CSFA_5$	0.046851	0.058157	0.026217	0.046443	0.057014	0.054067	0.063226	0.022161	0	0.031025
$CSFA_6$	0.015104	0.025772	0.047588	0.008639	0.04665	0	0	0.031859	0.053281	0

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$CSFA_7$	0	0.010234	0.047297	-0.01641	0.040157	0.03507	0.028977	0.073823	0.045477	-0.01974
$CSFA_8$	0.015104	0.068686	0.015167	-0.01654	0.018549	0.014184	0	0.012337	0	0

F) Compute the Taxicab distance by using Eq. (5) as shown in Table 2.

Table 2: The Taxicab distance matrix by the CODAS method.

	$CSFC_1$	**$CSFC_2$**	**$CSFC_3$**	**$CSFC_4$**	**$CSFC_5$**	**$CSFC_6$**	**$CSFC_7$**	**$CSFC_8$**	**$CSFC_9$**	**$CSFC_{10}$**
$CSFA_1$	0	0	0	0.031801	0	0.014184	0.008908	0	0.040235	0.055816
$CSFA_2$	0	0.025683	0.010506	0.008639	0.030979	0.014266	0.016167	0.022035	3.66E-05	0.02344
$CSFA_3$	0.046938	0.042117	0.021342	0.031772	0.015097	0.007828	0.039625	0.036911	0.013777	0.039041
$CSFA_4$	0.057145	0.060125	0.001282	0	0.015097	0.014266	0.027645	0	0	0.023306
$CSFA_5$	0.046851	0.058157	0.026217	0.046443	0.057014	0.054067	0.063226	0.022161	0	0.031025
$CSFA_6$	0.015104	0.025772	0.047588	0.008639	0.04665	0	0	0.031859	0.053281	0
$CSFA_7$	0	0.010234	0.047297	0.016413	0.040157	0.03507	0.028977	0.073823	0.045477	0.019743
$CSFA_8$	0.015104	0.068686	0.015167	0.016545	0.018549	0.014184	0	0.012337	0	0

G) Define the relative evaluation matrix by using Eq. (6)

H) Calculate the analysis value of options by using Eq. (7) as shown in Figure 2.

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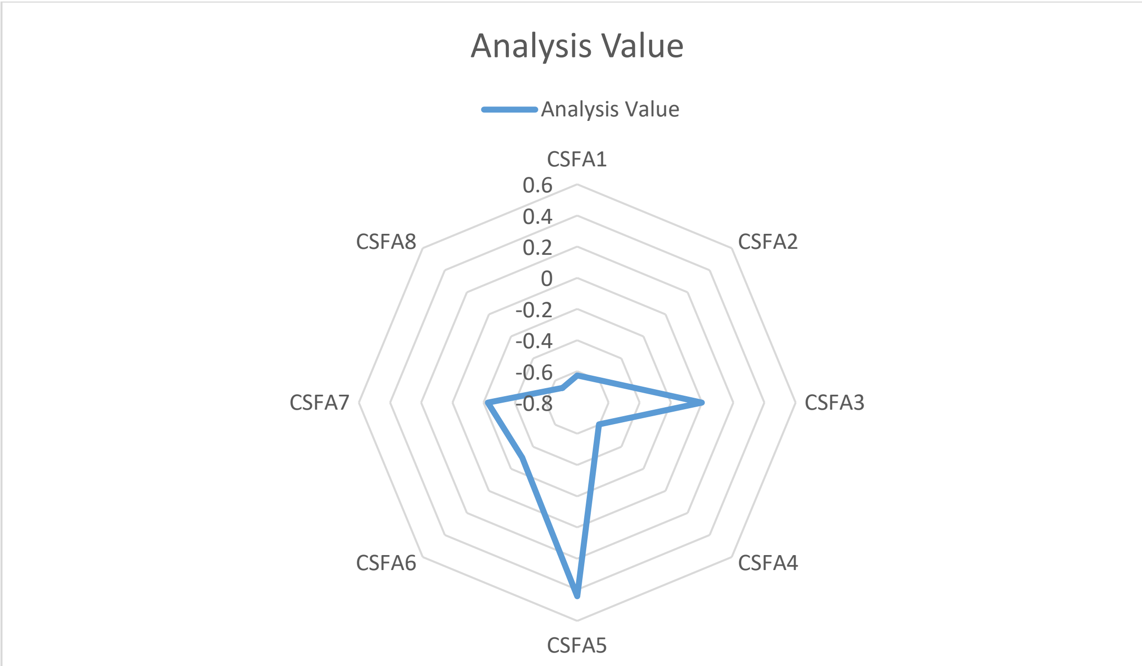

Figure 2: The analysis value of options.

5. Managerial Implications

The management implications of assessing the financial and operational performance of shipping enterprises are many. Managers and decision-makers in the maritime industry may use these ramifications as a road map to better performance, less risk, and sustained expansion.

Managers may get useful insights and information by analyzing the financial and operational performance of shipping enterprises. Managers may use this information to make better choices, reduce risk, enhance resource allocation, stimulate creativity, and instill a spirit of constant improvement. Long-term success, resilience, and competitiveness in a demanding business like shipping are all helped along by the management implications of performance evaluation.

6. Conclusions

Evaluating the health and future prospects of shipping firms is an essential procedure that requires careful attention to their financial and operational performance. Stakeholders may learn a lot about a company's strengths, weaknesses, and opportunities for growth by evaluating important metrics including revenue creation, cost management, fleet utilization, safety records, market position, and competitive advantage. Stakeholders may evaluate risks and possibilities for development and investment using the information gleaned from the assessment process. They may use it to better deal with the challenges of the maritime business, including as market fluctuations, geopolitical threats, economic downturns, and strict environmental requirements. In addition, by comparing their results to those of competitors in the shipping business, establishing strategic objectives, and allocating resources, shipping firms may improve their overall performance.

Strategic decision-making, risk assessment, and the pursuit of sustainable development are all greatly aided by the study of financial and operational performance in shipping enterprises. It enables stakeholders to make educated decisions and helps shipping firms thrive in an ever-changing, competitive market. This paper use the interval valued neutrosophic set to overcome the uncertainty in the evaluation process. This study used the CODAS method to evaluate the performance of operational and financial performance of shipping companies. This paper used ten criteria and eight companies.

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