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Fuzzy AHP for Prioritizing Factors in the Selection of Shipping Lines within the Maritime Transport Market in Vietnam

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Abstract

INTRODUCTION: Selecting suitable shipping lines is crucial for supply chain efficiency, particularly in Vietnam's maritime sector.
OBJECTIVES: This study seeks to identify and prioritise key criteria affecting shipping line selection from the perspective of freight forwarders.
METHODS: The Fuzzy Analytic Hierarchy Process (FAHP) was applied to evaluate multiple decision-making factors.
RESULTS: Competitive freight rates, container availability, and special cargo capabilities were ranked as the most influential criteria.
CONCLUSION: Findings highlight the need for carriers to enhance service reliability and cost-efficiency to meet the demands of developing markets.

Keywords: Shipping line selection; Freight forwarders; Fuzzy AHP

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1. Introduction

The shipping industry has been a fascinating business since goods were first transported by sea over 5,000 years ago, and it has played a key role in driving globalisation [1]. Even in the modern era, the shipping industry remains highly profitable and continues to be a driving force behind globalisation. This is particularly evident in the distribution of goods worldwide, with an estimated 80–90% of global trade by volume transported across the oceans [2]. Moreover, it facilitates international trade, with goods worth billions of dollars shipped daily [2]. Globally, it is estimated that over 10 billion tonnes of dry and liquid bulk cargo are transported via maritime routes each year [3]. This demonstrates that maritime transport remains the dominant force in international trade, enabling imports and exports for nations of all sizes while serving as the backbone of regional trading systems [2].

Vietnam is recognised for its extensive coastline and strategic maritime advantages, with three of its ports, including those in Ho Chi Minh City, ranking among the world's top 50 busiest container ports. As a result, the country's maritime transport sector has experienced significant growth. As of now, nearly 40 major international shipping lines operate in Vietnamese seaports [4]. In particular, with the increasing growth of globalisation, the import and export of goods worldwide is gradually becoming a prevailing trend. In the first three quarters of 2022, Vietnam's total import-export turnover surpassed the $500 billion mark, reflecting a 15.1% increase compared to the same period last year. This sector has emerged as one of the key pillars of the economy in the post-pandemic era [5].

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Given this remarkable growth, there is significant potential for developing Vietnam's international shipping fleet.

Nevertheless, current trends in maritime transport indicate a shift in the movement of goods between developing and developed economies. In emerging economies such as Vietnam, the Transport Work Intensity (TWI) index is nearly twice as high as that of developed nations [6], which means to transport the same trade value, developing countries need to move a larger volume of goods or cover greater distances compared to developed economies. Presently, developing countries continue to focus their maritime trade on heavy and bulky raw materials, such as dry bulk commodities (iron ore, grain) and liquid bulk goods (crude oil, refined petroleum). These goods generally have lower value compared to high-value, low-volume containerised cargo [6].

As a result, developing countries like Vietnam require a fleet with the capacity to transport large volumes at low costs to remain competitive. However, Vietnam's current fleet consists predominantly of small-capacity vessels, with the infrastructure and technology lacking automation. This setup is not aligned with global maritime transport trends, where developing economies need large-capacity ships to optimise costs and compete in the international market [5]. Consequently, Vietnam's shipping fleet struggles to compete with foreign operators, and over 90% of the country's import and export cargo is still primarily handled by foreign vessels, particularly on long-haul routes to the America and Europe. Meanwhile, the domestic fleet remains largely confined to shorter regional routes within Asia [5]. This heavy reliance presents significant challenges for domestic shipping companies, as they lack the necessary infrastructure and scale to compete effectively. For instance, in the first and second quarters of 2024, freight rates to the European Union doubled compared to December 2023, while shipping costs to the US West Coast rose sharply from approximately USD 1,000 to nearly USD 3,000 per container. Additionally, in February of the same year, service charges increased by around 10%, including terminal handling charges (THC) and stevedoring fees. Moreover, foreign shipping lines unilaterally imposed a range of surcharges - such as documentation handling fees, fuel surcharges, and container cleaning fees - without prior agreement with customers. These developments were largely driven by political instability around the Suez Canal and the Red Sea, which has forced shipping lines to reroute maritime journeys between Asia and Europe, leading to additional surcharges being imposed by carriers. The heavy reliance on foreign carriers, who dominate the freight market, has significantly undermined Vietnamese firms' ability to negotiate favourable terms [7].

As shown in **Table 1**, most existing research on shipping line selection has focused on the perspective of shippers, with criteria typically reflecting their direct concerns such as cost, reliability, transit time, and port connectivity. However, freight forwarders now play a central role as intermediaries and are often the actual decision-makers in choosing carriers. This shift is clearly reflected in Agility's 2021 Emerging Markets Logistics Index, where Viet Nam ranked 8th out of 50 economies, highlighting the country's growing appeal to logistics service providers—particularly freight forwarders [8]. Among nearly one million enterprises in Viet Nam, only around 82,000–83,000 operate in the logistics sector, with the majority being forwarding companies [9]. This indicates that many small and medium-sized enterprises in Viet Nam heavily rely on outsourced logistics services, especially for export activities. Nevertheless, there remains a notable lack of research exploring the decision-making criteria of freight forwarders, representing a significant gap that needs to be addressed in order to better inform shipping lines, port authorities, and policymakers in serving this vital customer segment. This represents a research gap that warrants further exploration.

Beyond this, geographical constraints are also an important consideration, particularly in the context of developing economies. Garg & Kashav [10], for example, primarily examined global supply chains, whereas Kannan et al. [17] focused on carrier selection among Indian enterprises. Similarly, Pham et al. [11] analysed container port selection in Vietnam from the perspective of shipping lines, yet there remains a scarcity of research investigating carrier selection from a forwarders's viewpoint. Moreover, there is a limited body of research examining the factors influencing the choice of shipping lines in the context of developing countries. As such, this study will centre on the Vietnamese market, producing findings that are contextually relevant and valuable for shipping lines or policymakers seeking to understand the needs of shipping line selectors in Vietnam.

Table 1. Research Perspectives in Previous Studies

Ref	Perspective	Limitation
[10]	Shipping Lines	Emphasises environmental factors and value creation.
[11]	Shipping Lines	Conducted solely in Viet Nam
[12]	Firms	Limited to Bahrain.
[13]	Enterprise	Survey limited to five internal experts within a single company.
[14]	Enterprises from three sectors	Restricted to Turkey and three specific industries.
[15]	Freight Forwarder	Based on only 30 experts from 15 Taiwanese OFFs.
[16]	Shipping Line	Focuses on port attractiveness criteria.
[17]	Enterprise	Focused solely on the Indian market.
[18]	Not clearly stated	Survey unit not specified.

Consequently, this research contributes to bridging the identified gaps by focusing on Vietnam. More specifically, it directly enhances the body of knowledge concerning maritime transport within developing economies, a field that Kannan et al. [17] highlighted as under-researched and which Pham et al. [11] identified as a research gap within the Vietnamese context. Additionally, the application of the Fuzzy Analytic Hierarchy Process (FAHP) provides a

structured and systematic approach to evaluating carrier selection criteria. The incorporation of fuzzy methods also helps account for the inherent uncertainty and subjectivity in decision-making, a common challenge in this domain.

This study seeks to enhance businesses' understanding of customer preferences, offering valuable insights into customer behaviour. Furthermore, it provides several strategic suggestions aimed at improving service quality and strengthen the competitiveness of shipping lines. In line with research by Kannan et al [17], it supports carriers in developing effective strategies. By highlighting key factors influencing customer decisions in Viet Nam, the study offers practical insights for the local maritime transport sector.

2. Related Work and Methodology

2.1. Related Work

The research on selecting shipping lines for container transportation has gained considerable attention globally, with studies exploring various criteria influencing decision-making from diverse perspectives. Earlier research primarily focused on shippers' viewpoints, emphasizing key factors like cost, reliability, and service quality. For instance, Abshire and Premeaux [19] identified key factors influencing shipping line selection from the perspective of shippers, highlighting on-time delivery reliability, timely cargo collection, and total transit time as critical considerations. Similarly, Lambert et al. [20] conducted a survey and found that punctuality in delivery and collection, along with the integrity of service personnel, were significant determinants for shippers when choosing a carrier. However, other studies have emphasised cost as a primary factor. For instance, Ben-Akiva et al. [21] analysed shipping line selection and identified total logistics costs and service quality as the most influential criteria. Evidently, there is no clear consensus among researchers regarding which factor holds the greatest importance. While shippers are usually thought to make these decisions, in reality, freight forwarders often choose shipping lines on behalf of shippers [22].

Marketing theories explain that shippers and freight forwarders have different priorities. Shippers care more about service quality, while freight forwarders focus on minimizing costs [23]. This means that the criteria for choosing a shipping line can vary depending on the perspective and market context. In this study, the analysis focuses on the perspective of freight forwarders, using recent studies to ensure the findings are current and relevant. All relevant related works and their key aspects are summarised in **Table 2**.

Permata [13] investigated transport route selection using Fuzzy AHP and MOLP, identifying reliability, transit time, and space availability as the most critical factors, while transportation costs were found to be of lower priority. Similarly, the decision-making processes of freight forwarding companies were analysed using the DEMATEL approach [15], which revealed that integrated logistics services and on-time delivery significantly influenced their choices. The attractiveness of container ports has also been evaluated through Fuzzy AHP-TOPSIS [16], highlighting port efficiency, inland connectivity, and service quality as key determining criteria.

From a regional perspective, container port selection in Vietnam [11] integrated Cumulative Prospect Theory (CPT) into Multi-Criteria Decision Making (MCDM), emphasising the role of operational efficiency in port selection, with Cat Lai Port emerging as the most suitable choice. Similarly, [12] examined freight transport mode selection in Bahrain using Fuzzy AHP from a senior management perspective, concluding that safety, CO_2 emissions, and reliability were more significant than cost considerations, with rail transport being preferred for longer distances.

In the field of maritime carrier selection, various decision-making frameworks have been employed. (Ergin, 2023) [14] utilised Analytic Network Process (ANP) instead of the traditional Analytic Hierarchy Process (AHP) to account for interdependencies among criteria, demonstrating that reliability, cost, and service frequency were the most influential factors. Meanwhile, Kannan [17] assessed the selection criteria of Indian carriers using AHP, revealing that low freight rates and pricing flexibility were prioritised over additional services such as online booking and trade notifications. Similarly, Shen [18] studied the Chinese market and identified cargo damage, on-time reliability, and multimodal capability as the top priorities when selecting shipping carriers.

Sustainability considerations in maritime logistics have also gained increasing attention. Garg [10] examined value creation in greening global maritime supply chains (GMSC) through Fuzzy AHP, assessing factors such as CO_2 reduction, energy efficiency, and supply chain integration. However, integrating environmental, economic, and operational factors into a unified decision-making framework remains an area requiring further research.

There is a limited body of research focusing on the operational efficiency and carrier selection criteria specific to Vietnam, with most existing studies centred on developed countries. The role of freight forwarders, though influential, has also been understudied. This paper applies the Fuzzy Analytic Hierarchy Process (FAHP) to systematically evaluate and rank the key factors influencing shipping line selection, offering practical insights to improve service quality and enhance the competitiveness of Vietnam's maritime sector.

2.2. Fuzzy set

In many practical problems, human judgment and perception are often uncertain and inaccurate. Therefore, the fuzzy set theory was proposed by Zadeh [24] to deal with the uncertainty in human judgment [25]. A fuzzy set is defined by a membership function, it assigns values between 0 and 1 to indicate the degree of belonging, where a higher value signifies stronger membership [24]. A common fuzzy value used in many studies is the triangular fuzzy number (TFN).

The notation for a TFN is $\tilde{A} = (l, m, u)$, where the fuzzy set of real numbers has a membership function defined as follows [25].

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-l}{m-l}, & l \le x \le m \\ \dfrac{u-x}{u-m}, & m \le x \le u \\ 0, & otherwise \end{cases} \quad (1)$$

In which, *l, m, u* represent the lower, middle, and upper bounds of the fuzzy number A, respectively. The membership function of a TFN describes the degree of belonging of values within the range *[l, u]*.

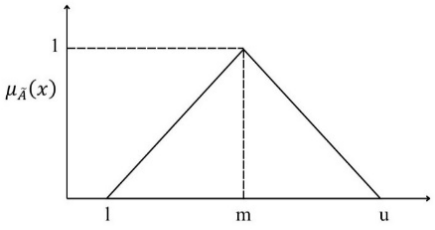

Figure 1. A triangular fuzzy number

Table 2. Summary related work

Ref	Study Type	Object	Model	Country	Number	Evaluation Measure
[10]	Theoretical & empirical	Value creation strategies in sustainable maritime supply chains	FAHP	Global	TFNs	Ranking and prioritizing value creating factors and sub-factors based on criticality and impact.
[11]	Empirical	Container terminal choice from the perspective of shipping lines. Competitiveness of six terminals.	AHP & F-TOPSIS, and CPT	Vietnam	TFNs	Ranking of the six container terminals by competitiveness. Identification of crucial criteria.
[12]	Empirical	Selection of freight transport mode for cargo movement.	FAHP	Bahrain	TFNs	Weights of criteria influencing mode choice. Consistency ratio for judgment testing.
[13]	Empirical	Shipping line selection	FAHP & MOLP	Indonesia	TFNs	Reliability in on-time delivery, total transit time, and space availability ranked highest
[14]	Empirical	Selection of ocean container carriers across different industries	ANP	Türkiye	Crisp numbers	Importance weights of criteria for each industry. Carrier satisfaction ratings.
[15]	Empirical	Decision-making factors for freight forwarders in choosing container shipping lines	Revised DEMATEL, Modified Delphi Method	Taiwan	Revised DEMATEL (0-4 scale)	Relevance and correlation of influence factors.
[16]	Empirical	Selection of the most attractive container port	FAHP-TOPSIS	Taiwan	TFN	Limited to a case study with three hypothetical ports
[17]	Empirical	Evaluating service quality and operational performance of ocean container carriers	AHP	India	Crisp values	Weights and ranking of criteria influencing carrier selection.
[18]	Empirical	Key factors influencing shipping carrier selection in the Chinese market	AHP	China	Crisp values	Ranking of criteria based on expert opinions. Local and global weights of criteria.
This study	Empirical	Shipping line selection criteria	FAHP	Vietnam	TFNs	Ranking of six main criteria and 17 sub-criteria of shipping lines selection.

Note: F – Fuzzy; AHP - Analytic Hierarchy Process; TFN - Triangular Fuzzy Number; CPT - Cumulative Prospect Theory; MOLP - Multi-Objective Linear Programming; ANP - Analytic Network Process

2.3. Fuzzy AHP

The Analytic Hierarchy Process (AHP) was introduced as a multi-criteria decision-making (MCDM) method that compares criteria in pairs and determines their weights. This method simplifies complex problems by breaking them into smaller sub-problems at different hierarchical levels. Each level represents a set of criteria or attributes related to the decision, and the weight of each criterion is determined based on its relative importance [26]. The AHP offers several advantages in decision-making. It provides a structured approach to handle complex problems by

comparing both qualitative and quantitative criteria. AHP enhances consistency through pairwise comparisons, determines the relative importance of factors, supports consensus-building in group decisions, and allows sensitivity analysis to assess decision robustness.

In addition to the advantages of the AHP method, considering ambiguity in the process may enhance its effectiveness, as uncertainty in decision-makers' evaluations is common in practical applications. Although FAHP does not entirely eliminate subjectivity, it provides more reliable input for decision-making, particularly in hierarchical problems that involve assigning weights to multiple criteria. These are steps to perform the FAHP method are as follows:

1. Develop a fuzzy pairwise comparison matrix. In this step, transform the responses of DMs who use linguistic terms to evaluate criteria in the pairwise comparison matrix into fuzzy numbers by applying the nine-point conversion scale of Papadopoulos et al. [27] in **Table 3**.

$$\tilde{A} = [\tilde{a}_{ij}]_{n\times n} \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} \quad (2)$$

Table 3. Assign fuzzy values to any conversational terms

Crisp Scale	Linguistic Terms	TFS Scale
1	Equal	(0.5, 1, 1.5)
3	Moderate	(2, 3, 4)
5	Strong	(3.75, 5, 6.25)
7	Very strong	(5.5, 7, 8.5)
9	Extreme	(7, 9, 9)
2,4,6,8	Intermediate values	(1.25, 2, 2.75), (3, 4, 5), (4.75, 6, 7.25), (6.5, 8, 9)

Source: [27]

2. Aggregate the fuzzy pairwise comparison matrix, by using Eq (3), the judgements of the DMs are combined when decision is made in group:

$$l_{ij} = \left(\prod_{k=1}^{K} l_{ijk}\right)^{\frac{1}{K}}, m_{ij} = \left(\prod_{k=1}^{K} m_{ijk}\right)^{\frac{1}{K}}, u_{ij} = \left(\prod_{k=1}^{K} u_{ijk}\right)^{1/K} \quad (3)$$

In which, $\tilde{A} = (l_{ij}, m_{ij}, u_{ij})$ and K as the number of DMs.

1. Calculate the fuzzy weights matrix. First, the fuzzy comparison values are calculated using Eq:

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{a}_{ij}\right)^{1/n}, i = 1,2,\dots,n \quad (4)$$

After that, the fuzzy weights $\tilde{w}_i$ of criteria are calculated using Eq. (5).

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots \oplus \tilde{r}_n)^{-1} \quad (5)$$

2. Defuzzy fuzzy weights $\tilde{w}_i$ by using Eq

$$w_i = \frac{lw_i + mw_i + uw_i}{3} \quad (6)$$

3. Normalizing Weights. The results from the previous step are normalized using the following method:

$$W_i = \frac{w_1'}{\sum w_i'} \quad (7)$$

2.4 Impact factors for shipping line selection

The selection of ocean carriers is a critical decision for freight forwarding and logistics companies, particularly in highly competitive and dynamic markets such as Vietnam. A considerable body of research within transport logistics and maritime economics has examined the criteria influencing this decision-making process. While earlier studies predominantly emphasised cost-related factors, more recent findings highlight the growing relevance of service quality, operational efficiency, and technological capability. Within this paper, factors constructed from previous studies, including Garg et al. [10], Ergin and Alkan [14], Kannan et al. [17], and Shen et al. [18].

Kannan et al. [17], through an AHP-based study in India, highlighted freight cost and pricing flexibility as the most decisive factors from the shippers' perspective. Shen et al. [18], focusing on the Chinese market, identified service quality and transport reliability as the leading priorities, followed by carrier capacity and speed. Meanwhile, Garg et al. [10] introduced an environmental dimension by evaluating value-creating factors in global maritime supply chains using FAHP, underlining sustainability, competitiveness, and efficiency as central concerns. More recently, Ergin and Alkan [14] assessed the priorities of shippers in three major industries using ANP, concluding that reliability and carrier reputation consistently outweighed cost considerations across all sectors. Despite methodological and contextual differences, these studies collectively converge on several recurring themes. Drawing from this synthesis and in alignment with expert feedback from the Vietnamese maritime context, six key impact factors were identified for this study: (1) reliability, (2) transportation cost, (3) customer service, (4) operations (5) IT orientation and communication, and (6) capacity.

After creating a table of impact factors, in-depth interviews were carried out with five maritime transport experts in Vietnam. These interviews aimed to refine and adjust the indicators in the hierarchical model. The final list of factors is shown in **Figure 2**.

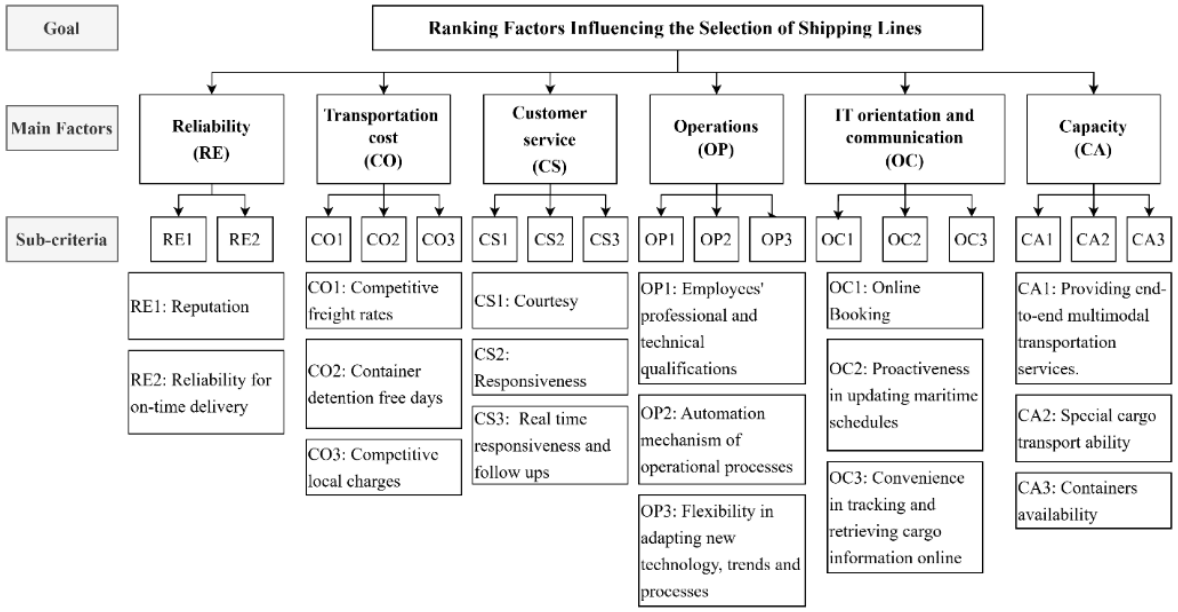

Figure 2. The hierarchical model

3. Methodology

3.1 Research process

This study adopts a quantitative research design, using the Fuzzy Analytic Hierarchy Process (FAHP) to evaluate and rank the critical factors influencing the selection of ocean carriers in the maritime transport market in Vietnam.

The research methodology follows a structured Fuzzy Analytic Hierarchy Process (FAHP), as described in **Figure 3**. The process begins with identifying the research problem, followed by a comprehensive literature review and expert consultation to establish the initial set of criteria. Based on these, a hierarchical model of criteria and sub-criteria is constructed. Subsequently, in-depth interviews are conducted to gather expert judgments, which are then used to calculate fuzzy weights. To ensure the reliability of the responses, the consistency ratio (CR) is checked. If the CR exceeds the acceptable threshold of 10%, the data undergoes revision and further refinement before recalculating. Once consistency is achieved, the final step involves analysing and ranking the factors based on the validated data.

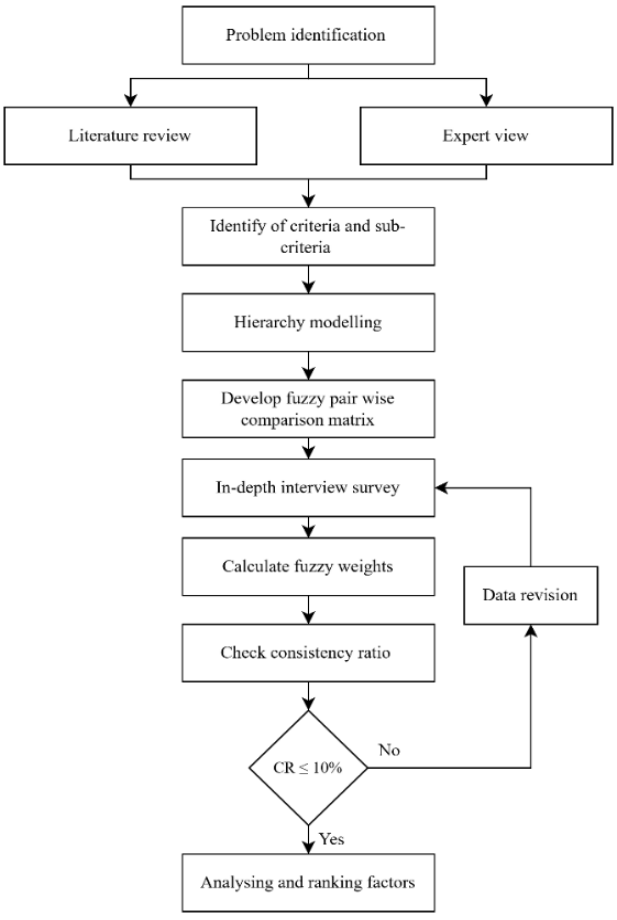

Figure 3. Methodological Framework

3.2 Data Collection

Data were collected from five domain experts through a structured expert survey using pairwise comparison questionnaires. The selection was conducted using purposive sampling to ensure that only participants with substantial maritime logistics experience were included.

The data were collected between October 2024 and January 2025, with all calculations performed using Microsoft Excel to ensure transparency and ease of verification.

4. Research findings

4.1 Data revision

The data were obtained from five logistics and maritime transport experts operating in Vietnam, each possessing more than five years of professional experience in freight forwarding, carrier selection, and shipping operations. These participants were selected using purposive sampling, given their specialised knowledge and direct involvement in decision-making processes relevant to the study. The experts were asked to perform pairwise comparisons across a set of predefined criteria and sub-criteria, structured in accordance with the FAHP hierarchical model. Data validation in this study focused on assessing the internal consistency of expert judgments using the consistency ratio (CR).

Building on this, a two-stage data revision process was implemented to further enhance the reliability of expert evaluations. In the first stage, experts were re-interviewed to clarify specific inconsistencies found in the initial pairwise comparison matrices. Conflicting sub-criteria were identified and redefined where necessary, and the root causes of discrepancies were discussed. Experts were guided through the logic of the FAHP method and the semantic distinctions between fuzzy linguistic terms, ensuring consistent understanding and reducing overly subjective interpretations. They were then asked to reassess selected comparisons based on clearer definitions and logical reasoning.

In the second stage, although CR values from the revised matrices had met the acceptable threshold, an additional round of refinement was conducted to ensure expert consensus. The updated matrices were shared with the experts for feedback, and participants were invited to suggest minor adjustments, particularly for pairs with significant variation. Recommendations included moderating extreme ratings (e.g., revising "Extremely Important" to "Very Strongly Important") and refining evaluations for similar criteria. The final matrices were aggregated and CR values recalculated, ensuring both internal consistency and collective agreement among experts, thereby strengthening the robustness of the FAHP model.

4.2 Data analysis

The analysis started by calculating the geometric responses from decision-makers, then a comparison matrix was created for each criterion. Following the FAHP methodology, the geometric mean of weights was determined, and both fuzzy and normalised weights were evaluated to assess the importance of each criterion, as shown in **Table 4**. To keep the paper concise, the full dataset and results for each step were excluded from the paper.

Table 4. Ranking of Criteria for Selecting Ocean Container Carriers

Criteria	Priority weight	Sub-Criteria		Fuzzy Weight	LW	GW	Rank
RE	0.095	RE1	Reputation	(0.264, 0.344, 0.473)	0.350	0.033	15
		RE2	Reliability for on-time delivery	(0.480, 0.656, 0.870)	0.650	0.062	5
CO	0.317	CO1	Competitive freight rates	(0.443, 0.647, 0.919)	0.639	0.202	1
		CO2	Container detention free days	(0.116, 0.165, 0.248)	0.168	0.053	8
		CO3	Competitive local charges	(0.129, 0.188, 0.287)	0.192	0.061	6
CS	0.118	CS1	Courtesy	(0.090, 0.136, 0.221)	0.139	0.016	16
		CS2	Responsiveness	(0.264, 0.431, 0.672)	0.425	0.050	10
		CS3	Real time responsiveness and follow ups	(0.277, 0.433, 0.692)	0.436	0.052	9
OP	0.145	OP1	Employees' professional and technical qualifications	(0.155, 0.239, 0.370)	0.238	0.034	14
		OP2	Automation mechanism of operational processes	(0.193, 0.299, 0.474)	0.301	0.044	11
		OP3	Flexibility in adapting new technology, trends and processes	(0.290, 0.462, 0.725)	0.461	0.067	4
OC	0.095	OC1	Online Booking	(0.101, 0.154, 0.235)	0.153	0.015	17
		OC2	Proactiveness in updating maritime schedules	(0.262, 0.413, 0.628)	0.407	0.039	13
		OC3	Convenience in tracking and retrieving cargo information online	(0.279, 0.433, 0.695)	0.440	0.042	12
CA	0.231	CA1	Providing end-to-end multimodal transportation services.	(0.158, 0.241, 0.368)	0.241	0.056	7
		CA2	Special cargo transport ability	(0.246, 0.373, 0.572)	0.375	0.086	3
		CA3	Containers availability	(0.253, 0.386, 0.581)	0.384	0.089	2

The results serve as the basis for selecting ocean container carriers, with six main criteria and 17 sub-criteria evaluated and ranked from the perspective of forwarders in Vietnam. The findings indicate that CO1 is the most critical factor, holding the highest weight at more than 20%. Notably, this is the only criterion rated above 10% by forwarding companies. In the context of developing nations, where both logistics service providers and businesses operate in highly competitive environments, cost plays a decisive role in maintaining competitiveness, particularly when products are positioned in lower-priced segments within the global market. A similar study conducted in India, a market comparable to Vietnam, by Kannan et al. [17] also confirmed that businesses in the region regard cost as the most significant factor in strengthening their position in international trade.

The second highest-ranked factor is CA3 – Containers Availability, accounting for 8.9%, as a shipping line's ability to maintain a steady and timely supply of containers plays a crucial role in expediting delivery schedules and ensuring on-time shipments. Similarly, Maloni [28] highlighted that providing high-quality containers with consistent availability not only enhances service efficiency but also creates a significant competitive advantage for shipping lines. Following this, CA2 ranks just below CA3, both of which fall under the broader category of "Capacity". However, these two criteria exhibit substantial overlap, exceeding 95%, due to conflicting perspectives and varying case-specific requirements, as shown in **Figure 4**.

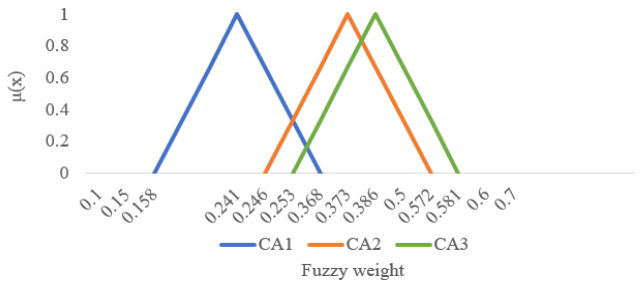

Figure 4. The fuzzy intersection of CA1, CA2, and CA3

Specifically, for forwarders catering to shippers or manufacturers dealing with complex cargo, CA2 is considered more critical. Conversely, for forwarders whose clients prioritise rapid delivery and require readily available containers to ensure timely shipments, CA3 holds greater significance. Within the "Capacity" category, CA1 was also examined in relation to the fuzzy weight of all three criteria. While CA1 is not regarded as essential as CA2 and CA3, a degree of overlap persists. This overlap reflects notable discrepancies in expert opinions. In-depth interviews revealed that these contradictions stem from differing perspectives. One viewpoint suggests that forwarders currently do not prioritise this aspect, as their primary focus remains on cost efficiency. However, other experts argue that a shipping line's ability to integrate multiple transport modes accelerates delivery processes, reduces costs, and enhances customer convenience by enabling seamless door-to-door transportation without excessive procedural complexities.

To achieve an efficient supply chain, both domestically and internationally, businesses increasingly recognise the importance of establishing a robust multimodal transport network. However, the complexity of multimodal operations, stemming from the involvement of multiple stakeholders, poses a significant challenge to its development. A key issue lies in the lack of synchronisation and inefficiencies in information sharing between different transport modes, including maritime, air, road, and rail networks. Nevertheless, Information and Communication Technology (ICT) is regarded as the nervous system of multimodal transport chains, facilitating real-time tracking, seamless data exchange, and enhanced responsiveness to unforeseen disruptions [29].

As a result, indicators such as OP3 and OC3, which relate to the integration of information technology in shipping operations, hold significant importance. In the current era of digitalisation, business interactions and workflows are increasingly conducted online, prompting forwarders to favour streamlined, agile, and technology-driven solutions over traditional manual processes. Additionally, leveraging technology can help optimise the capacity of bottlenecks within the supply chain [6]. With the ongoing digital transformation in maritime logistics, advanced technologies such as AI, IoT, and big data are enhancing vessel operations, while smart ports with automation are improving supply chain efficiency. Furthermore, blockchain technology is emerging as a key tool in increasing transparency and security in maritime transactions, reinforcing trust and efficiency across the industry.

The least important criteria, each with a weight of less than 3.4%, are ranked in descending order as shipping line reputation, customer service attitude, and online booking availability. Firstly, regarding shipping line reputation, this finding aligns with Shen et al. [18], where reputation was ranked relatively low and considered less significant than on-time delivery. This is because forwarders prioritise cost efficiency and reliable delivery over a carrier's reputation, choosing shipping lines that best meet their operational needs rather than selecting based solely on brand recognition. Secondly, for CS1, most forwarders believe that staff politeness is not a decisive factor. Instead, the ability to handle urgent situations and resolve issues professionally and efficiently is deemed far more critical. This aligns with the results for CS2 and CS3, which hold greater significance than CS1, with no notable overlap between these criteria. Lastly, OC1 ranks the lowest. In developing markets, businesses tend to prioritise low costs and reliability over the convenience of digital booking, as these factors directly impact profitability and operational efficiency. Although these three criteria rank relatively low, their importance reflects the trade-offs made by decision-makers, who consistently seek high-quality services at competitive prices and are reluctant to compromise on cost or service reliability Kannan et al. [17].

Although reliability ranks significantly lower than cost and service, this does not imply that it is disregarded in shipping line selection. The importance of this criterion depends on the context and timing of the evaluation. With rapid technological advancements and increasing commercialisation, on-time delivery has become a prerequisite for shipping lines to survive and compete in Vietnam's market. Within the criteria "Reliability", the RE2 sub-criterion is not ranked among the lowest but instead follows OP3, suggesting that decision-makers still value timely delivery. However, political instability and global disruptions, which are beyond the control of forwarders, continue to affect shipping reliability. Events such as the Red Sea crisis or Suez Canal blockages can cause bottlenecks on alternative routes, extend transit times, increase inventory levels, and delay deliveries, ultimately impacting the entire supply chain [30].

As a result, decision-makers are placing greater emphasis on factors they can actively control, with cost efficiency and transport flexibility being top priorities. Despite external disruptions, shipping lines remain primarily responsible for ensuring cargo is transported efficiently. Therefore, Shipping line reliability remains a key concern for shippers. In response, shipping lines should focus on developing more resilient and dependable supply chains, prompting a reconsideration of efficiency-driven models that prioritise cost reduction over system stability and reliability [6].

4. Conclusion

In the case of forwarders operating in Vietnam's market, shipping line selection decisions require a balance between service quality, responsiveness, and competitive pricing. The study's findings highlight that cost, service quality, delivery reliability, and, most notably, shipping capacity are the most critical factors influencing carrier selection. These results align with both developed and developing markets, as reflected in previous studies [17], [18], [13], [15], [12].

However, when comparing findings with studies on developed markets [12], [14], [16], it becomes evident that carrier capability is not always prioritised as highly as other factors. This distinction can be attributed to the fact that developing economies often require large-scale freight capacity, particularly for raw materials and mass-produced goods, to support export-driven growth and price competitiveness. Consequently, shipping capacity plays a vital role in meeting this demand and fostering economic development. In contrast, developed markets tend to place greater emphasis on specialised transport services, high reliability, and seamless integration into complex supply chains.

This study provides valuable insights for shipping lines seeking to enhance their competitiveness in Vietnam's maritime market. By addressing geographical research gaps, incorporating stakeholder-specific perspectives from freight forwarding companies, and applying multi-criteria decision-making techniques, it offers a robust analysis of shipping line selection. However, certain limitations remain. The reliance on the FAHP method introduces subjectivity, as it depends on expert judgment, potentially affecting the objectivity of the results. Additionally, the limited number of expert interviews reduces the generalisability of the findings. While Vietnam's maritime sector continues to evolve amidst regulatory, infrastructural, and global market shifts, these factors have not been extensively explored in this study. Future research should expand the sample size, examine additional markets, and integrate alternative methodologies such as MCDM to enhance analytical rigour. A broader survey encompassing import-export businesses, logistics firms, and end-users would further refine understanding of shipping line selection within an increasingly competitive landscape.

Appendix A. Key CSFs and Sub-Criteria referenced for shipping line selection

A.1. Key CSFs and Sub-Criteria referenced for shipping line selection

Table A.1. Key CSFs and sub-criteria for shipping lines selection

Key criteria	Sub criteria	Ref
Reliability	Reputation	[14], [18]
	Reliability for on-time delivery	[14], [17], [18]
Transportation cost	Competitive freight rates	[17], [18]
	Container detention free days	[14], [17]
	Competitive local charges	[14]
Customer service	Courtesy	[17]
	Responsiveness	[14], [17]
	Real time responsiveness and follow ups	[10], [14]
Operations	Employees' professional and technical qualifications	[17], [18]
	Automation mechanism of operational processes	[10]
	Flexibility in adapting new technology, trends and processes	[10]
IT orientation and communication	Online Booking	[14], [17]
	Proactiveness in updating maritime schedules	[14], [17]
	Convenience in tracking and retrieving cargo information online	[10], [14], [17]
Capacity	Providing end-to-end multimodal transportation services.	[10], [17], [18]
	Special cargo transport ability	[14], [17], [18]
	Containers availability	[10], [17]

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