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Article

Evaluating critical success factors and their causal relationships in ocean freight forwarding using service quality assessment

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Abstract: Given its insular geographic location, Taiwan inherently benefits from a natural advantage in developing its shipping industry, positioning it as a critical sector for the nation's economic advancement. The shipping industry operates within a highly competitive maritime market, wherein ocean freight forwarders provide services on a global scale, thus classifying them within the international transportation and logistics industry. The global competition from logistics peers renders the services highly substitutable. This study breaks new ground by integrating the SERVQUAL scale with advanced methodologies such as the Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) to assess and enhance service quality in the shipping industry. By segmenting the five dimensions of SERVQUAL, the study delineates 19 specific evaluation indicators. The expert questionnaires developed and analyzed through AHP and DEMATEL reveal a previously unidentified link between specific service quality dimensions and customer satisfaction. The findings from this analysis offer crucial insights into the critical success factors (CSFs) of service quality and their causal interrelationships, thereby establishing a model for service standards. By leveraging the identified CSFs and understanding the causal relationships among these key factors, ocean freight forwarders can enhance and optimize their value propositions and resources. This proactive approach is expected to significantly improve service quality, fortify core competitiveness, and elevate customer support and satisfaction levels, ultimately leading to an increased market share and ensuring sustainable business operations.

Keywords: AHP; DEMATEL; SERVQUAL; ocean freight forwarders; critical success factors

1. Introduction

Taiwan is strategically positioned on the edge of the Western Pacific, bridging Northeast Asia to the north and the islands of Southeast Asia to the south. This advantageous geographical location is underscored by data from UNCTAD, which indicates that, in terms of deadweight tonnage, the Taiwanese fleet accounts for 2.48% of the global total, ranking 12th worldwide. Consequently, foreign trade constitutes a vital lifeline for Taiwan's economy, with the maritime industry serving as a cornerstone of its economic development (Hsu et al., 2023). Over 90% of Taiwan's international trade is conducted via maritime transport, with ships being the primary mode of transportation. Ocean freight forwarders (OFFs), due to their ability to offer flexible, convenient, and customized services to small and medium-sized shippers, occupy a significant position in the liner shipping industry.

However, the maritime market is an intensely competitive business environment. OFFs, as part of the global transportation logistics industry, face substantial competition from counterparts worldwide, making their services highly substitutable.

In the current post-pandemic era, the shipping industry encounters heightened market stimuli and uncertainties. By improving service quality, shipping companies can enhance customer loyalty and satisfaction, thereby securing sustained support from shippers. This can, in turn, boost the operational performance of OFFs and ensure their sustainable business operations.

Recent studies, such as those by Pantouvakis et al. (2024) and Ighomereho et al. (2023), have highlighted the increasing importance of service quality in the maritime industry, particularly in the context of digital transformation and environmental sustainability. Despite these advances, there remains a significant gap between theoretical frameworks and their practical applications in enhancing service quality.

The primary issue addressed by this research is the identification and analysis of key success factors (KSFs) in the service quality of OFFs, focusing on how these factors can be utilized to improve competitiveness and customer satisfaction in a highly competitive and uncertain market environment.

To address the research questions arising from the aforementioned motivations, the primary objective of this study is to explore the key success factors in the service quality of OFFs and their causal relationships, identifying determinants that can enhance and improve their competitiveness. The Analytic Hierarchy Process (AHP) method, developed by Saaty (1980), provides a systematic hierarchical structure that effectively captures the consensus of most experts and decision-makers, highlighting key factors with specific weight values in terms of their relative importance. Therefore, this study employs AHP to evaluate and analyze service quality using the SERVQUAL scale as the framework for the questionnaire. The questionnaire is designed to assess the fundamental characteristics and service quality of OFFs, further subdividing these into 19 suitable evaluation indicators and creating an expert questionnaire.

Given the potential correlations among various relatively important key factors, this study explores and analyzes causal relationships, transforming these relationships into a clearer structural model. In constructing and analyzing this model, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique is employed as an effective method for dealing with multi-criteria evaluation problems with interdependent factors. Through the DEMATEL technique, we can quantitatively assess the relationships among multi-criteria factors in complex problems, developing a structural model from these complexities and analyzing the causal relationships among these factors. In this context, this study constructs the DEMATEL technique (Ding et al., 2019) as a causal relationship model to evaluate the key factors of service quality in OFFs, aiming to explore a service quality standard model that serves as a reference for building competitive advantages and making sustainable business decisions.

The structure of this paper is divided into five sections. Besides this introduction, Section 2 reviews the relevant literature. Section 3 presents the research methodology and survey. Section 4 conducts an empirical analysis. Finally, Section 5 provides conclusions and recommendations.

2. Literature review

2.1. Ocean freight forwarding

Taiwan's top three container shipping companies—Evergreen Marine, Yang Ming Marine, and Wan Hai Lines—are ranked among the top 20 globally, highlighting the success achieved through the synergy of government resources and private enterprise collaboration. Foreign trade is a crucial lifeline for Taiwan's economy, and the shipping industry serves as a pivotal axis of economic development (Yu and Zhou, 2016). The management and modernization of ports are also key developmental priorities for both the government and the shipping industry. OFFs primarily coordinate the transportation services for shippers, consolidating fragmented cargo from various consignors into full container loads before entrusting them to carriers for secure and efficient delivery to the destination.

Globally, OFFs provide comprehensive logistics services, with cargo consolidation being their core business. Their integrative capabilities ensure seamless transportation services from the point of export to the point of import. They assist shippers in negotiating space with shipping lines, arranging inland transportation to export ports, leasing containers, consolidating cargo, arranging loading operations, handling customs clearance, managing import port customs declarations, and providing final delivery to the destination after unloading, thus offering end-to-end transportation solutions. Consequently, OFFs play an increasingly critical role in modern trade by meeting customer needs, offering logistical solutions, and reducing delivery times.

With the evolution of transportation methods and international trade demands, OFFs have transitioned beyond basic transportation services to become experts in multimodal transportation. The increasing demand for value-added logistics services in international transport has positioned OFFs as integrated logistics providers capable of delivering superior consolidated transportation services (Ding et al., 2021).

Despite the low entry barriers leading to a proliferation of OFF companies and intense competition, the current era emphasizes service quality over mere cost considerations. Modern consumers seek not just competitive freight rates but also professional and diversified services to attract and retain customers and maintain competitiveness. Hence, OFFs must possess robust internal and external technical support. To achieve shippers' service objectives, OFFs must provide optimized comprehensive transportation services, such as preliminary inland transportation and customs services, selecting maritime carriers, and post-delivery inland transport services. These essential services rely heavily on the expertise provided by OFFs.

2.2. Service quality

Parasuraman et al. (1985) define service quality as "an attitude reflecting the discrepancy between consumers' expected service (ES) and perceived service (PS)." In their seminal work, they conducted a comprehensive behavioral survey of consumers, resulting in the development of the PZB model. This model comprises ten dimensions: tangibles, reliability, responsiveness, communication, credibility, security, competence, courtesy, understanding customers, and accessibility. These

dimensions collectively determine the factors influencing service quality, captured through 97 questionnaire items that shape the perceptual system of customer service quality. Following an in-depth analysis of five selected service industries and utilizing factor analysis, they refined these dimensions into five key factors:

- Tangibles: Refers to the physical facilities, equipment, and appearance of personnel.
- Reliability: The ability to perform the promised service dependably and accurately.
- Responsiveness: The willingness to help customers and provide prompt service.
- Assurance: The knowledge and courtesy of employees and their ability to convey trust and confidence.
- Empathy: The provision of caring, individualized attention to customers.

This model for measuring service quality, known as the SERVQUAL scale, is pivotal in the current era, where service quality is paramount. The era not only values the best product outcomes but also the optimal provision of services (Sasser et al., 1978). Unlike in the past, today's consumers consider factors beyond the price of freight, necessitating professional and diversified services to attract and retain customers.

2.3. Related research on service quality in ocean freight forwarding

In constructing a comprehensive evaluation framework, this research integrates relevant literature on service quality in ocean and air freight services, logistics services in the supply chain, and analogous industries. The study references the SERVQUAL scale developed by Parasuraman et al. (1988) for measuring service quality. Through an extensive review of the literature on service quality elements in the ocean freight forwarding industry, combined with expert interviews, the study preliminarily identifies five essential dimensions: tangibles, reliability, responsiveness, assurance, and empathy. These dimensions form the foundational basis for this research. Detailed explanations of each indicator are provided to enhance the study's perspective. The synthesized evaluation dimensions, indicators, descriptions, and reference literature for service quality in the ocean freight forwarding industry are summarized in **Table 1**.

Table 1. Assessment of the quality-of-service impacts in the ocean freight forwarding and references.

Dimensions	Definitions of service quality dimensions	Key Indicators	References
Tangibles	Services provided directly and indirectly by ocean freight forwarders are equipment, field, and personnel	A1 A great number of physical channels and branches	Parasuraman et al. (1985), Liang et al. (2010), Huang and Hsiao (2014), Subhashini et al. (2018), Hu and Cai (2019), Ding et al. (2021)
		A2 Convenient web services and online inquiry systems	Parasuraman et al. (1985), Liang et al. (2010), Chang and Liao (2012), Liu (2013), Chang and Yang (2015), Chuang and Liu (2022), Subhashini et al. (2018), Yeh et al., (2020)
		A3 Containers with good cargo worthiness	Parasuraman et al. (1985), Meng et al. (2010), Liu (2013), Li and Yang (2014), Subhashini et al. (2018) Hsu et al. (2023).
		A4 Many routes and a wide range of services	Parasuraman et al. (1985), Chang and Liao (2012), Liu (2013), Subhashini et al. (2018) Ding et al. (2021)

Table 1. (*Continued*).

Dimensions	Definitions of service quality dimensions	Key Indicators	References
Reliability	Ocean freight forwarders can provide promised services and make them fulfilled	B1 Large enterprise scale, sound financial conditions, and good reputation	Parasuraman et al. (1985), Liang et al. (2010), Liu. (2013), Subhashini et al. (2018) Ding et al. (2021)
		B2 High-accuracy documents (bills of lading and bills)	Parasuraman et al. (1985), Lu and Wu (2010), Chang and Liao (2012), Li and Yang (2014), Subhashini et al. (2018), Ding et al. (2021)
		B3 Highly flexible and punctual scheduled freighters	Parasuraman et al. (1985), Liang et al. (2010), Liu (2013), Li and Yang (2014), Chang and Yang (2015), Subhashini et al. (2018), Hu and Cai (2019), Yeh et al. (2020), Hsu et al. (2023).
		B4 Companies can grasp the market information at any time to provide customers with emergency response and reduce risks	Parasuraman et al. (1985), Liao and Chang (2004), Chang et al. (2013), Liu (2013), Li and Yang (2014), Subhashini et al. (2018), Yeh et al. (2020)
Assurance	The business and transportation personnel of ocean freight forwarders are professional, and their abilities to arrange cargos can be trusted by shippers	C1 The business and transportation personnel have rich professional knowledge on shipping and laws	Parasuraman et al. (1985), Liang et al. (2010), Lu and Wu. (2010), Liu (2013), Li and Yang. (2014), Chang and Yang. (2015), Hu and Cai. (2019), Yeh et al. (2020), Lin and Chang (2021) Ding et al. (2021)
		C2 Integrated and consistent compound shipping services	Parasuraman et al. (1985), Chang and Liao (2012), Liu (2013), Li and Yang (2014), Hsu et al. (2023).
		C3 Ability to track cargos	Parasuraman et al. (1985), Liang et al. (2010), Li and Yang (2014), Subhashini et al. (2018), Lin and Chang (2021)
		C4 The business and transportation personnel have good communication skills and are trustworthy	Parasuraman et al. (1985), Murphy et al. (1992), Liang et al. (2004), Li and Yang (2014), Subhashini et al. (2018), Hu and Cai (2019), Lin and Chang (2021) Ding et al. (2021)
Responsiveness	The business and transportation personnel of ocean freight forwarders can quickly respond to customer needs	D1 Flexible freight adjustment	Parasuraman et al. (1985), Liang et al. (2010), Meng et al. (2010), Chang (2012), Subhashini et al. (2018) Ding et al. (2021)
		D2 The ability of the business and transportation personnel to deal with emergencies	Parasuraman et al. (1985), Murphy et al. (1992), Wu (2009), Chang (2012), Liang et al. (2010), Liu (2013), Li and Yang (2014), Yeh et al. (2020)
		D3 Speed to correct documents such as bills of lading and shipping bills	Parasuraman et al. (1985), Murphy et al. (1992), Hsu (2009), Lu and Wu (2010), Lan (2011), Chang (2012), Li and Yang (2014), Subhashini et al. (2018)
		D4 The business and transportation personnel deal with cargo damage and loss	Parasuraman et al. (1985), Wu (2009), Chang (2012), Liu (2013), Chang and Yang (2015) Ding et al. (2021)
Empathy	The business and transportation personnel of ocean freight forwarders meet shippers' special needs	E1 Customized services	Parasuraman et al. (1985), Lu and Wu (2010), Liang et al. (2010), Yeh et al. (2020), Lin and Chang (2021)
		E2 Significance of customer interest	Parasuraman et al. (1985), Lu and Wu (2010), Hsu. (2011), Huang and Hsiao (2014), Li and Yang (2014)
		E3 The business personnel's response to customer complaints	Parasuraman et al. (1985), Li and Yang (2014), Chang and Yang. (2015), Subhashini et al. (2018), Hu and Cai (2019), Yeh et al. (2020), Lin and Chang (2021)

3. Materials and methods

In this section, the AHP method and DEMATEL technique are briefly introduced.

3.1. AHP method

This study employs the Analytic Hierarchy Process (AHP) as its primary methodological framework. AHP, developed by Professor Thomas L. Saaty at the University of Pittsburgh in 1971, is a Multiple Criteria Decision Making (MCDM) method that integrates both qualitative and quantitative approaches. In AHP, the topmost layer typically contains a single element representing the overall objective of the analysis, known as the goal layer. The intermediate layers, known as the criteria layers, include various interrelated elements necessary to achieve the objective and may consist of multiple levels. The bottom layer, referred to as the alternative layer, encompasses the different decision options available for achieving the goal. The purpose of AHP is to systematize complex problems by hierarchically structuring the various evaluation aspects, facilitating pairwise comparisons at different levels.

In this study, AHP is applied to determine the relative weights of key success factors in evaluating service quality for Ocean Freight Forwarders (OFFs). The computational steps of AHP are outlined as follows (Leung et al., 2010):

Step 1: Establishing Pairwise Comparison Matrices.

Based on the evaluation scale presented in **Table 2**, pairwise comparison matrices are constructed to assess the relative importance of factors influencing the key success factors of OFFs in terms of service quality. The matrix structure is illustrated below:

$$A = \begin{bmatrix} 1 & a12 & \cdots & a1n \\ 1/a12 & 1 & \cdots & a2n \\ \vdots & \vdots & \ddots & \vdots \\ 1/a1n & 1/a2n & \cdots & 1 \end{bmatrix} \quad (1)$$

where, $a_{ij} = {}^{1}/_{a_{ji}}$, $a_{ij} > 0$, $\forall i, j$, $i,j = 1,\ 2,\ \ldots,\ n$ represents the importance of element i to element j. The pairwise comparison matrix A is called a positive reciprocal matrix. If all comparison measurements are in accordance with the transitivity, that is, $a_{ik} = a_{ij} \times a_{jk}$ holds true for all $i,\ j,\ k$, so A is a consistency matrix. However, the matrix A is consistent obviously because of $a_{ij} = w_i/w_j, i = 1,\ 2,\ \ldots,\ n;\ j = 1,\ 2,\ \ldots,\ n$. In the equation, $w_1, w_2, \ldots, w_n$ mean the weights of evaluation elements of an element in the layer $i-1$ under the layer i.

Once the hierarchical structure is established, each level must be evaluated based on the criteria or objectives of the preceding level through pairwise comparisons. If there are multiple elements, numerous pairwise comparisons are required. In the context of the post-pandemic era, this study divides the key success factors influencing service quality in the ocean freight forwarding industry into two layers: the dimension layer and the factor layer. Pairwise comparisons are made using a scale from 1 to 9 to establish pairwise comparison matrices.

Step 2: Calculation of eigenvalues and eigenvectors.

The matrix A is multiplied by the weight vector of each element to get

$$Aw = \begin{bmatrix} 1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & 1 & \cdots & w_2/w_n \\ \vdots & \vdots & 1 & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = nw \quad (2)$$

Since a_{ij} is subjectively rated by the decision-maker in making the pairwise comparison to evaluate the importance of elements and is different from the real

w_i/w_j to some extent, $Aw = nw$ is impossible. Hence, Saaty suggested replacing n with the maximum eigenvalue λ_{max} of the relative matrix A, namely, $Aw = \lambda_{max}$.

Step 3: Consistency test.

The consistency test can be used to evaluate the decision maker's judgment and the overall hierarchical structure. The consistency test covers two aspects. One aspect examines whether the pairwise comparison matrix constructed by the decision-maker (or subject) when answering questions during the evaluation (i.e., to examine whether the comparative factors) are consistent when the surveyed experts answer questionnaires. Meanwhile, the other verifies whether the overall hierarchical structure is consistent and calculates its eigenvalue and eigenvector. Finally, the maximum eigenvalue λmax is calculated for the consistency test of consistency ratio (C.R.) and consistency index (C.I.) to get the relative weights of all evaluation criteria. The parameter used to evaluate consistency is the consistency ratio between consistency index and random index (R.I.), namely C.R. $= \frac{\text{C.I.}}{\text{R.I.}}$, where C.I. $= \frac{\lambda_{max}}{n-1}$, and R.I. is known from **Table 2**.

In evaluating the decision maker's judgment or measuring the overall hierarchical structure, Saaty suggested that the consistency ratio shall not be greater than 0.1 to ensure consistency.

Table 2. Random index (R.I.).

n	1	2	3	4	5	6	7	8	9	10
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980).

3.2. DEMATEL technique

The DEMATEL technique is utilized to evaluate the causal relationships among key determinants of Ocean Freight Forwarders. The steps of the DEMATEL technique (Ding, 2019; Hsu, 2023) are outlined as follows:

Step 1: Defining Key Determinants of Ocean Freight Forwarders and Establishing a Quantitative Scale for Each Determinant.

A commonly used scale to measure the varying degrees of influence among factors include: "No Influence (0)", "Low Influence (1)", "Moderate Influence (2)", "High Influence (3)", and "Very High Influence (4)".

Step 2: Establishing Direct-Relation Matrix.

A direct-relation matrix can be created by integrating the results of all respondents.

The integration of the pairwise comparison of the magnitudes of influence between n factors by m respondents is represented by Y, and the direct-relation matrix of the rating results can be expressed as:

$$Y = [y_{ij}]_{n \times n}$$

Specifically,

$$y_{ij} = \sum_{t=1}^{m} a_{ij}^{t}/m, \ \forall i \neq j,$$

$$y_{ii} = 0, \ \forall i = j$$

where, a_{ij}^{t} represents the results of the tth respondent's rating of the magnitude of the influence of the ith factor on the jth factor.

Step 3: Normalize the direct-relation matrix.

The standardized direct-relation matrix of the direct-relation matrix is represented as Y. Then:

$$X = \lambda \times Y,$$

Specifically,

$$\lambda = 1 \Big/ max\{ \max_{i}\{\sum_{j=1}^{n} y_{ij}\},\ \max_{j}\{\sum_{i=1}^{n} y_{ij}\}\}$$

Step 4: Derive the total relation matrix.

The total relation matrix is represented as T. Then:

$$T = [t_{ij}]_{n\times n} = \lim_{k\to\infty}(X + X^2 + \cdots + X^k) = X(I - X)^{-1}$$

Specifically, I is the unit matrix.

Step 5: Calculate the sums of the rows and the sums of the columns.

Definition:

$$D_i = \sum_{j=1}^{n} t_{ij},\ i = 1,\ 2,\ \ldots,\ n,$$

$$R_j = \sum_{i=1}^{n} t_{ij},\ j = 1,\ 2,\ \ldots,\ n.$$

$\mathrm{D_i}$ represents the sum of the magnitudes of the influences of factor C_i as a cause on other factors, while R_j represents the sum of the magnitudes of the influences of other factors on factor C_j as an effect.

Step 6: Find the prominence and relation.

Calculate the $D + R$ value and the $D - R$ value of each factor respectively based on the D value and the R value of each factor obtained in step 5.

Step 7: Draw the cause-effect diagram

Use the obtained $D + R$ and $D - R$ values of all the factors, plot the distribution of each factor on a two-dimensional coordinate system. Utilize appropriate thresholds to draw causal maps between factors and conduct an analysis of the causal relationships among factors.

4. Empirical analysis

4.1. Research design and questionnaire survey

In this study, the hierarchical structure was constructed using the Analytic Hierarchy Process (AHP), and a questionnaire titled "Application of Service Quality to Evaluate Key Success Factors of Ocean Freight Forwarders" was designed. A pairwise comparison matrix was employed to analyze hierarchical factors such as effects and evaluation indicators, utilizing a quantitative evaluation scale ranging from 1 to 9. The weights of evaluation criteria were compared pairwise on a scale from 1 to 9. Given that pairwise comparison is one of the most effective methods for making judgments, this study established a pairwise comparison matrix and calculated the eigenvalues and eigenvectors. Finally, the consistency test was performed using the

maximum eigenvalue to obtain the relative weights of the evaluation criteria.

After collecting the questionnaires, "Expert Choice 11" software was used to calculate the weights and the relationships of layers and indicators. A consistency test was conducted to select valid samples with a Consistency Ratio (CR) ≤ 0.1. Subsequently, the weights of valid samples were sorted and analyzed. Consistency tests were necessary for the weights of indicators to ensure that respondents' thinking remained consistent before and after the pairwise comparison. According to Saaty, a Consistency Index (CI) ≤ 0.1 is ideal. After calculation with the Random Index (RI), if the Consistency Ratio (CR) ≤ 0.1, the conditions for the consistency test are satisfied. The weights of indicators within layers were then calculated based on the results to identify the key success factors affecting the service quality of OFFs.

Initially, based on the five evaluation dimensions and 19 service quality factors listed in **Table 1**, this study constructed a hierarchical structure and designed an AHP expert questionnaire to determine the relative weights of dimensions and service quality factors. Data were collected through a questionnaire survey. Therefore, the expert questionnaire and the AHP model constructed in Section 3 were employed to confirm the weight ranking of evaluation dimensions and elements. The questionnaire was pre-tested and revised by experts, ensuring good content validity. The questionnaires were sent to decision-makers and managers in the ocean freight forwarding industry, who were asked to complete and return them for data collection. The AHP questionnaire consisted of three parts: the first part collected basic information about the respondents, including title, job seniority, and company department; the second part provided answer examples and descriptions of dimensions and criteria; the third part evaluated the relative importance of the key success factors affecting the service quality of OFFs.

The survey targeted managers with decision-making authority from top companies in the ocean freight forwarding industry, as identified by Common Wealth Magazine's ranking of Taiwan's top 500 service companies. This approach aimed to explore the key success factors affecting service quality from the perspective of major OFFs in Taiwan. A total of 25 questionnaires were distributed, with 20 returned and 18 valid responses, all meeting the standard consistency ratio of ≤ 0.1. Among the 18 valid respondents, 10 were assistant managers (55.5%), 4 were general managers (22.25%), and 4 were managers (22.25%). All respondents had at least 15 years of experience in the shipping industry, with most having over 20 years of experience. According to Robbins (1994), the optimal number of experts for group decision-making problems ranges from 5 to 7. Therefore, the AHP responses in this study are representative.

After analyzing these valid responses and incorporating expert opinions, this study used the AHP procedure to measure and evaluate the relative weights of dimensions and factors, as shown in **Table 3**.

4.2. Discussions of the AHP results

This study identified the weight of factors through the Analytic Hierarchy Process (AHP). Based on these significant weighted factors, the key success factors impacting service quality in the ocean freight forwarding industry were constructed. According

to the service quality dimensions in the order of 1. Reliability, 2. Assurance, 3. Responsiveness, 4. Tangibles, and 5. Empathy, the most crucial strategies are identified as follows: "Reliability" with a weight of 0.251, "Assurance" with a weight of 0.241, "Responsiveness" with a weight of 0.235, and "Tangibles" with a weight of 0.184. The explanations for the factors within these four dimensions are as follows:

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Table 3. Weighting table of all measurement factors.

Dimensions	Weight	Definition of service quality dimensions	Sequence	Key Indicators	The integrated weight	Sequence
A: Tangibles	0.184	Services provided directly and indirectly by ocean freight forwarders are equipment, field, and personnel	4	A1 A great number of physical channels and branches	0.016	18
				A2 Convenient web services and online inquiry systems	0.024	16
				A3 Containers with good cargo worthiness	0.078	5
				A4 Many routes and a wide range of services	0.025	14
B: Reliability	0.251	Ocean freight forwarders can provide promised services and make them fulfilled	1	B1 Large enterprise scale, sound financial conditions, and good reputation	0.065	6
				B2 High-accuracy documents (bills of lading and bills)	0.064	7
				B3 Highly flexible and punctual scheduled freighters	0.102	2
				B4 Companies can grasp the market information at any time to provide customers with emergency response and reduce risks	0.107	1
C: Assurance	0.241	The business and transportation personnel of ocean freight forwarders are professional, and their abilities to arrange cargos can be trusted by shippers	2	C1 The business and transportation personnel have rich professional knowledge on shipping and laws	0.042	10
				C2 Integrated and consistent compound shipping services	0.055	8
				C3 Ability to track cargos	0.042	11
				C4 The business and transportation personnel have good communication skills and are trustworthy	0.102	3
D: Responsiveness	0.235	The business and transportation personnel of ocean freight forwarders can quickly respond to customer needs	3	D1 Flexible freight adjustment	0.043	9
				D2 The ability of the business and transportation personnel to deal with emergencies	0.100	4
				D3 Speed to correct documents such as bills of lading and shipping bills	0.032	13
				D4 The business and transportation personnel deal with cargo damage and loss	0.024	17
E: Empathy	0.890	The business and transportation personnel of ocean freight forwarders meet shippers' special needs	5	E1 Customized services	0.016	19
				E2 Significance of customer interest	0.025	15
				E3 The business personnel's response to customer complaints	0.038	12

4.2.1. Reliability

a) "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks"

If a company fails to monitor market fluctuations that may affect shipping rates, shippers might end up shipping their goods at peak rates. Ignoring international shipping news, such as port congestion due to dockworker strikes or pandemic-induced delays and labor shortages, could result in additional costs for shippers, like demurrage charges. Such operational errors would severely impact the company's professionalism. Therefore, it is recommended that companies establish a specialized information and training team to monitor relevant shipping websites, provide timely market updates, and equip employees and shippers to mitigate potential impacts.

b) "B3: Highly flexible and punctual scheduled freighters"

Shippers expect their goods to arrive on time to meet delivery deadlines. Offering comprehensive route planning and diverse shipping options not only ensures timely delivery but also reduces storage costs for shippers. In the post-pandemic era, with increased demand and limited shipping capacity, a freight forwarder capable of providing a flexible and extensive global shipping network will be highly valuable to shippers. Additionally, proactively informing shippers of schedule changes and arranging alternative routes to ensure timely deliveries enhances trust and reliability.

4.2.2. Assurance

"C4: The business and transportation personnel have good communication skills and are trustworthy": Freight forwarders rely on sales personnel to promote services and operational staff to handle logistics. These frontline employees frequently interact directly with shippers. Sales personnel may make promises to secure orders, and the fulfillment of these promises significantly affects shippers' perceptions. Shippers value the commitment and professional competence of sales and operational staff in providing reliable communication and service. Training in communication and service skills is crucial, ensuring that promises made to shippers are kept, thereby maintaining trust and satisfaction.

4.2.3. Responsiveness

"D2: The ability of the business and transportation personnel to deal with emergencies": Shippers often contact freight forwarders before accepting orders or shipping goods to inquire about rates, schedules, and capacity. The speed and accuracy of responses to such inquiries are critical, especially when dealing with capacity shortages, port strikes, or pandemic-related disruptions. Quick and effective communication and problem-solving capabilities can prevent missed opportunities and ensure shippers prefer the most responsive forwarders.

4.2.4. Tangibles

"A3: Containers with good cargo worthiness": Freight forwarders maintain strong relationships with shipping lines to secure capacity, which is particularly attractive during peak seasons. The ability to offer a variety of specialized containers (e.g., flat racks, refrigerated containers, open-top containers) and ensure adequate availability is crucial. Inadequate container availability can delay shipments, affecting service quality. Large shippers, in particular, prioritize reliable capacity guarantees and diverse container options, as missing a shipment schedule on long-haul routes can significantly impact delivery timelines. Ensuring priority access to containers enhances shippers' confidence and loyalty.

4.3. Results of the DEMATEL technique

In Section 4.1, the AHP method was utilized to evaluate the five critical factors of service quality in the ocean freight forwarding industry. This section employs the DEMATEL technique to design and conduct an expert survey, assessing the relationships and causalities among these five key factors. The DEMATEL survey was also conducted using expert questionnaires, distributed similarly to those in Section 4.1, targeting relevant stakeholders (mid-to-senior management). Consequently, the effective response rate of the DEMATEL survey holds a significant degree of representativeness. From the completed surveys, we followed the steps of the DEMATEL technique to obtain empirical results, as shown in **Table 4** and **Figure 1**.

Table 4. The DEMATEL results.

	D_i	R_j	$D_i + R_j$	$D_i - R_j$	Quadrant
B_4	4.3047	2.9523	7.2571	1.3524	I
B_3	3.4619	3.7648	7.2267	-0.3030	IV
C_4	3.5820	3.7105	7.2924	-0.1285	IV
D_2	3.0799	3.3982	6.4781	-0.3183	III
A_3	3.1014	3.7040	6.8053	-0.6026	III

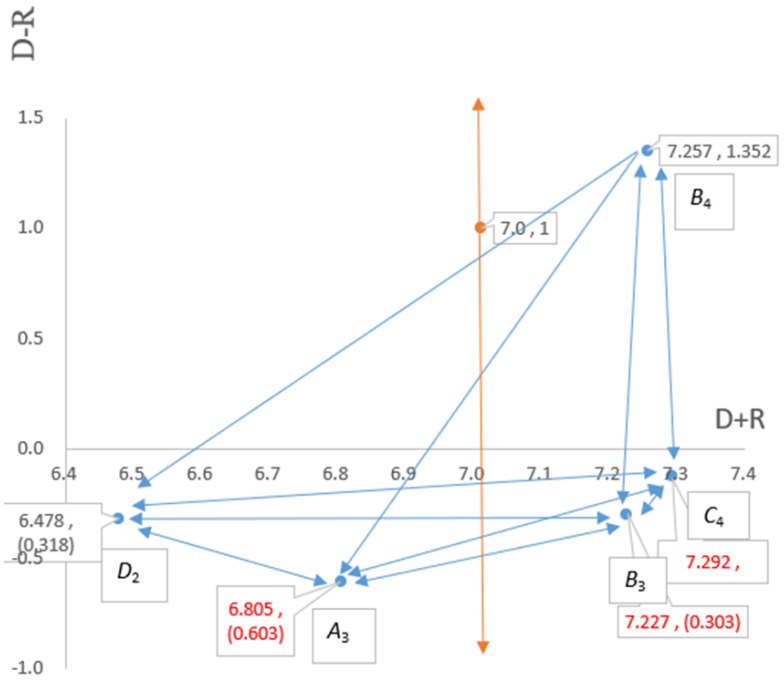

Figure 1. Causal relationship diagram of the five key development factors.

The service quality in the ocean freight forwarding industry is primarily influenced by one leading factor, identified as "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks." This means D-R > 0, indicating that this causative factor significantly impacts other factors. Positioned in the first quadrant, "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks" is recognized as a core key factor.

The other four determinants of service quality in the ocean freight forwarding industry, namely "B3: Highly flexible and punctual scheduled freighters," "C4: The business and transportation personnel have good communication skills and are trustworthy," "D2: The ability of the business and transportation personnel to deal with emergencies," and "A3: Containers with good cargo worthiness," are classified as influenced factors. This is indicated by D-R < 0, meaning that these four key factors are more affected by other factors.

a) The service quality factors "D2: The ability of the business and transportation personnel to deal with emergencies" and "A3: Containers with good cargo worthiness" fall into the third quadrant. These factors exhibit high independence and are categorized as independent factors, indicating minimal influence from other factors.

b) Conversely, "B3: Highly flexible and punctual scheduled freighters" and "C4: The business and transportation personnel have good communication skills and are trustworthy" are located in the fourth quadrant, highlighting that their service quality is influenced by the core key factor "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks."

The core key factor "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks" interacts with "B3: Highly flexible and punctual scheduled freighters" and "C4: The business and transportation personnel have good communication skills and are trustworthy," influencing each other. Additionally, this core factor affects the other two factors, "D2: The ability of the business and transportation personnel to deal with emergencies" and "A3: Containers with good cargo worthiness."

The key service quality factors "D2: The ability of the business and transportation personnel to deal with emergencies" and "A3: Containers with good cargo worthiness" interact with "B3: Highly flexible and punctual scheduled freighters" and "C4: The business and transportation personnel have good communication skills and are trustworthy," demonstrating interdependence. Furthermore, "A3: Containers with good cargo worthiness" and "D2: The ability of the business and transportation personnel to deal with emergencies" are influenced by the core key factor "B4: Companies can grasp the market information at any time to provide customers with emergency response and reduce risks."

"B3: Highly flexible and punctual scheduled freighters" and the other four key factors exhibit mutual influence. Similarly, "C4: The business and transportation personnel have good communication skills and are trustworthy" also shows mutual influence with the other four key factors.

4.4. Managerial implications

Based on the constraints of limited time and research costs, this study utilizes the Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) techniques. These methodologies were employed to design and conduct expert questionnaires, aiming to evaluate the interrelationships and causal relationships among the five critical factors influencing service quality in the ocean

freight forwarding industry.

In summary, the integration of AHP and DEMATEL methodologies provides a comprehensive evaluation framework. AHP assists in prioritizing the critical factors, while DEMATEL uncovers their causal relationships. This combined approach contributes to more informed decision-making processes, ultimately enhancing service quality in the maritime freight forwarding industry.

The findings, as presented in **Table 4**, indicate that the ocean freight forwarding industry has one predominant causal factor: "B4: The company's ability to grasp market information promptly, provide customer responsiveness, and reduce risks," which falls within the "cause" cluster. This implies that enhancing this factor should be a primary objective, as strengthening the cause cluster can amplify the influence on other dimensions. Conversely, the factors "B3: High flexibility and punctuality of scheduled freighters," "C4: Trustworthy communication skills of business and transportation personnel," "D2: The ability of business and transportation personnel to handle emergencies," and "A3: Containers with good cargo worthiness" are classified within the "effect" cluster, indicating that they are more influenced by other factors, making them a strategic focus for improvement under constrained resources.

Management implications for factors in the first and second quadrants

a) Factors possessing core influence

Factors in the first quadrant are core influencers and should be prioritized for resource allocation. The key factor in this quadrant is "B4: The company's ability to grasp market information promptly, provide customer responsiveness, and reduce risks." This factor has high centrality and causality, signifying its critical role. Improvements in this area can indirectly enhance factors in the fourth quadrant, making it the top priority for enhancement when resources are limited.

b) Factors with the driving characteristic

Factors in the second quadrant are driving influences. This study shows no critical factors in this quadrant.

4.5. Management implications of factors in the third and fourth quadrants

a) Factors with independent factor characteristics

Factors with low centrality and causality fall in the third quadrant. These are considered independent risk factors with minimal interaction with other factors. From a management perspective, these should be controlled individually, making them the third priority for resource allocation. Independent factors include "D2: The ability of business and transportation personnel to handle emergencies" and "A3: Containers with good cargo worthiness."

b) Factors with influenced factor characteristics

Factors in the fourth quadrant are those that are highly central but have low causality. These are dependent key factors, such as "B3: High flexibility and punctuality of scheduled freighters" and "C4: Trustworthy communication skills of business and transportation personnel." Although critical, these factors have limited impact on others. They require management but not direct improvement. Enhancing the core factors in the first and second quadrants can indirectly improve these

dependent factors. When the company's ability to grasp market information and reduce risks improves, it will also enhance the flexibility and punctuality of scheduled freighters, and the communication skills of business and transportation personnel, leading to optimized service quality in the ocean freight forwarding industry.

5. Conclusions and recommendations

5.1. Conclusions

This study developed operational methods for evaluating indicators, primarily applying the Analytic Hierarchy Process (AHP) to determine the weights of applicable indicators. Through this process, we formulated five dimensions of service quality (SERVQUAL) to establish key indicators of service quality in the ocean freight forwarding industry. Subsequently, all measurement factors were ranked by their weights, identifying the five most critical factors for service quality in the freight forwarding sector. Using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique, we designed and conducted expert questionnaires to evaluate the relationships and causal links among these five key factors. The study process is summarized as follows:

a) Selection of Measurement Factors: Through a comprehensive literature review and expert interviews, we finalized 19 suitable measurement factors.
b) Applying the AHP method, the results indicated that the top five factors with the highest weights are: 1. Companies can grasp the market information at any time to provide customers with emergency response and reduce risks. 2. Highly flexible and punctual scheduled freighters. 3. The business and transportation personnel have good communication skills and are trustworthy. 4. The ability of the business and transportation personnel to deal with emergencies. 5. Containers with good cargo worthiness.

Among these five decisive factors, the causal relationships were determined. The key core factors influenced are "Highly flexible and punctual scheduled freighters" and "The business and transportation personnel have good communication skills and are trustworthy," both impacted by the factor "Companies can grasp the market information at any time to provide customers with emergency response and reduce risks."

These five critical factors can be used to construct a standard service model to enhance the competitiveness of ocean freight forwarding services. By focusing on these key success factors, companies can develop strategies to build competitive advantages and ensure sustainable operations. The findings serve as a reference for strategic decision-making aimed at fostering competitive advantage and ensuring long-term sustainability in the industry.

Comparison with Previous Studies: Our findings align with those of Yoganandan and Vasan (2024) and Justavino-Castillo et al. (2023), who also highlighted the importance of service quality in the maritime industry, particularly in the context of digital transformation and environmental sustainability. However, this study extends their work by specifically identifying the top five key success factors in the ocean freight forwarding sector and analyzing their causal relationships.

Practical Implications: The research findings can be applied in real-world ocean

freight forwarding settings by helping companies prioritize and focus on the most critical aspects of service quality. This can lead to improved customer satisfaction, enhanced operational performance, and sustainable business practices.

Future Research Directions: Potential areas for further investigation include exploring the impact of digital technologies on service quality in ocean freight forwarding, the role of environmental sustainability in service quality perceptions, and the development of advanced models to predict and manage service quality in dynamic market conditions.

5.2. Recommendations

The service quality in the ocean freight forwarding industry is primarily influenced by two dimensions: "reliability" and "assurance." These dimensions highlight the importance shippers place on the industry's ability to fulfill promised services and arrangements, and the professionalism of the business and transportation personnel in handling shipments. When companies can promptly grasp market information to provide customer responsiveness and reduce risks, it leads to higher flexibility and punctuality in scheduling freighters and enhances the trustworthiness of communication skills among personnel. This optimization in service quality is recommended as an operational benchmark for the industry.

Based on the above recommendations and the results of this study, the following strategic directions are proposed to enhance service quality in the ocean freight forwarding industry:

a) Market Intelligence and Risk Management: The ocean freight forwarding industry should establish professional information departments or training groups to continuously monitor market-related shipping news and professional shipping websites. Upon detecting international shipping incidents or changes in relevant market economic indices, these departments should promptly provide this information to employees and customers. By offering responsive customer service and risk reduction strategies, both customers and the company can preemptively manage potential impacts, minimizing damage. In the face of uncertain supply chain logistics delays and changes, such service quality enables stakeholders to stay informed about current shipping capacity and container status, facilitating timely adjustments and meeting transportation needs. This proactive risk management approach enhances satisfaction and allows stakeholders to mitigate risks before disruptions occur (Hsu, Chou, and Ding, 2023).

b) Enhancing Trust and Reliability with Shippers: OFFs need to strengthen mutual trust with shippers, ensuring they perceive the service as reliable. For shippers, the ease of securing shipping space translates to smooth cargo delivery to destinations. Practically, maintaining good interactions with shipping companies facilitates space acquisition, especially during peak seasons. Strengthening professional relationships and securing guaranteed space through contractual agreements significantly attract shippers. When schedules change, forwarders should proactively inform shippers and flexibly arrange alternative schedules to ensure timely delivery.

c) Strengthening Professional Communication and Operational Competence: Business and transportation personnel in the ocean freight forwarding industry must possess excellent professional communication skills to effectively fulfill customer commitments. When facing increased shipping demand, the industry should provide the most suitable, safe, and efficient loading, unloading, and transportation services. Ensuring cargo safety from ship to land transport and to the final destination is crucial. The core value of OFFs lies in accurate delivery and cargo safety assurance, which builds trust and enhances service quality.

The main contribution of this study is the establishment of a conceptual framework and identification of key factors for service quality, providing OFFs with core management implications for gradual service quality improvement. These frameworks will help the industry reduce costs during economic downturns or pandemics, explore revenue-generating opportunities, and increase organizational resilience. Ocean freight forwarders should focus on optimizing service quality based on these three recommendations, thereby enhancing their value and resources, strengthening service quality, and boosting core competitiveness. This approach will improve customer support and satisfaction, ultimately achieving sustainable business operations.

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