processes

Article

Logistics Service Provider Evaluation and Selection: Hybrid SERVQUAL–FAHP–TOPSIS Model

Le Anh Luyen [1] and Nguyen Van Thanh [2,*]

[1] Department of Business Administration, FPT University, Da Nang City 50509, Vietnam; luyenla@fe.edu.vn
[2] Faculty of Commerce, Van Lang University, Ho Chi Minh City 70000, Vietnam
* Correspondence: thanh.nguyenvan@vlu.edu.vn

Abstract: Production and business enterprises are aiming to improve their logistics activities in order to increase competitiveness. Therefore, the criteria and decision support models for selecting logistics service providers are significant to businesses. Fuzzy theory has been applied to almost all industrial engineering fields, such as decision making, operations research, quality control, project scheduling and many more. In this research, the authors combined fuzzy theory and a Multicriteria Decision Making (MCDM) model for the evaluation and selection of potential third-party logistics (3PL) providers. The goal is to take the advantages of these approaches and allow for more accurate and balanced (symmetric) decision making through their integration. The main contribution of this study is that it develops a complete approach to assessing the quality of the logistics service industry. The combined method of the SERVQUAL and FAHP–TOPSIS models not only provides reasonable results, but it also allows decision makers to visualize the impact of different criteria on the final outcome. Furthermore, this integrated model can provide valuable insights and methods for other areas to define service quality.

Keywords: fuzzy theory; MCDM; logistics services provider; optimization

Citation: Luyen, L.A.; Thanh, N.V. Logistics Service Provider Evaluation and Selection: Hybrid SERVQUAL–FAHP–TOPSIS Model. *Processes* **2022**, *10*, 1024. https://doi.org/10.3390/pr10051024

Academic Editor: Jasna Čanadanović-Brunet

Received: 3 May 2022
Accepted: 19 May 2022
Published: 20 May 2022

1. Introduction

The logistics services industry, in which companies compete in order to deliver products and goods as fast as possible to customers in order to satisfy customer needs, has been competitive in modern times Popular logistics service companies such as FedEx deliver up to 6.6 million packages daily, serving all across the world, as shown in Figure 1 [1]. Not only is FedEx competitive, but other companies such as DHL also strive to be great logistics companies worldwide, providing logistical services from small packages to huge commercial shipments from other businesses. The proof for this is DHL having delivered over 1.3 billion shipments worldwide per year [2]. However, FedEx and DHL provide logistical services on a global scale, resolving international shipments from country to country, and do not focus tightly on domestic and internal shipments. This created opportunities for smaller logistical companies to start developing where they can provide the same services but starting on a smaller scale.

With such a wide range of small, medium and corporate levels of different services globally and domestically, deriving a suitable logistics service based on criteria and decision-making processes will ensure that businesses choose the most suitable option. However, initially determining suitable criteria and a set of standards in order to help companies determine what is the best for them is difficult. With further research from Parmata et al. [3], the Service Quality (SERVQUAL) model has shown a suitable application to determining a set number of criteria in determining a suitable logistics supplier. The SERVQUAL model introduces a suitable questionnaire that businesses can use in order to develop an applicable set of weighted criteria that would assist them in surveying experts.

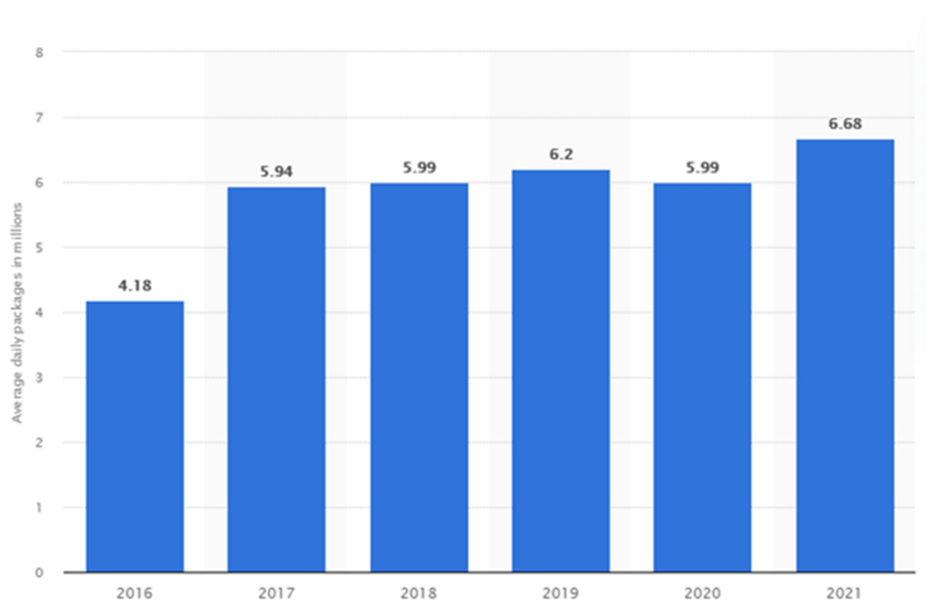

Figure 1. Number of daily packages delivered from FedEx [1].

After the criteria set has been determined, the experts will have different opinions as to which criteria they believe are more important than others. In order to solve this, Multicriteria Decision Making (MCDM) models have been developed in order calibrate and solve suitable problems for decision makers. In this study, SERVQUAL, the Fuzzy Analytical Hierarchy Process (FAHP) and The Technique for Order of Preference by Similarity to Ideal Solution Model (TOPSIS) are applied in order to solve the weightings of the criteria and determine the best logistics service supplier out of a number of alternatives provided. To develop the proposed approach, SERVQUAL is used to develop the evaluation criteria. Then, FAHP is applied to calculate the criteria weights. Finally, TOPSIS is applied to rank the potential suppliers. In the remaining sections of the paper, a comprehensive literature review is provided in Section 2, Section 3 presents the details of the applied methods, Section 4 introduces a real-world case study to demonstrate the feasibility of the proposed approach, and the conclusions are presented in Section 5.

2. Literature Review

MCDM models are developed to support decision making problems which involve multiple criteria. These models are frequently applied to solve problems in supply chain management such as supplier evaluation and selection [4–7], facility location selection [8–10], inventory management [11–13], etc. However, MDCM models are also utilized in other disciplines such as health science [14,15], banking and finance [16,17]. These models are also used for service quality evaluation in many industries.

There have been multiple studies about service quality evaluation in various industries and sectors throughout the years [18–22]. Among the various methods applied in these studies, Multicriteria Decision Making (MCDM) models are frequently used. Akdag et al. [23] introduced a MCDM model based on FAHP and TOPSIS to evaluate hospital service quality. The proposed model is applied to evaluate the performance of four class B hospitals in Istanbul, Turkey. The TOPSIS method's performance is also compared with three other MCDM methods: OWA, compensatory AND operators and the min-max approach. The results are consistent across the four different methods. Tsaur et al. [24] proposed a fuzzy MCDM model to support the service quality evaluation process in the airline industry based on the SERVQUAL model introduced by Parasuraman et al. [25]. The proposed model applied the FAHP method to calculate the weightings of the evaluation criteria and the TOPSIS method in ranking the service quality of different airlines. The results suggest that the most important aspect of service quality is "tangible", while the least important one is "empathy". Chou and Ding [26] introduced an integrated decision support model using MCDM and Importance-Performance Analysis (IPA) to evaluate the service quality of transshipment ports. The proposed model is applied to evaluate and rank the service quality of three international ports in Asia. The results show that these ports need improvement in the service quality of services such as container availability, ship call frequency and port charges. Bakir et al. [27] proposed an MCDM-based solution to the low-cost carriers service quality performance evaluation problem. The authors utilized the Entropy method to determine the evaluation criteria and the WASPAS method to calculate the service quality ranking of the airlines. The model was then applied to rank 13 low-cost carriers across Europe. A sensitivity analysis was performed to test the stability and validity of the results. The results suggest that the most important criterion is "legroom" and the least important one is "cleanliness". Chen [28] developed a combined MCDM model to support the selection of airline quality improvement criteria. The model is based on the DEMATEL and ANP methods. The proposed model is then applied to a real-world case study in the Taiwanese airline industry. The results suggest that the top five most important criteria are "customer relationship management improvement", "service differentiation", "top manager support for front-line services" and "service negligence and compensation information access". Zoraghi et al. [29] introduced a novel Fuzzy MCDM mode to support the service quality assessment process of hotels. The proposed model utilized a combination of subjective and objective approaches to the calculation of criteria weights, which allowed the model to reflect both the subjective considerations of the decision makers as well as the objective information. The proposed model was applied to a real-world case study where the service qualities of five hotels in Tehran, Iran were evaluated. A comparative study was also performed, and the results from the proposed model were compared with those of two other methods introduced by Chang and Lee [30] and Cheng [31].

There have been several studies that studied the application of the MCDM model in the service quality evaluation process of logistics services. Tsai et al. [32] introduced a hybrid MCDM model to evaluate the key aspects influencing the service quality of port logistics centers. The proposed model was based on the AHP, ANP and DEMATEL techniques. The model was then applied to a hypothetical case study to demonstrate the feasibility of the model. Stević et al. [33] developed a SERVQUAL–MCDM model to support the reverse logistics service quality assessment process. The authors utilized the Delphi and Full Consistency Method (FUCOM) to calculate the weighting of the quality dimensions and a modified version of the SERVQUAL model to measure the service quality of reverse logistics services. The proposed model was then applied to a real-world case study to demonstrate its feasibility. Kuo and Liang [34] introduced a combined MCDM model based on the VIKOR and GRA techniques to support the service quality evaluation process of airports under fuzzy decision-making environments. The proposed model was applied to evaluate the performance of seven airport in Northeast Asia. The results of the model were verified by a sensitivity analysis and comparative study by which they were compared with the results from two other MCDM models: Fuzzy SAW and Fuzzy TOPSIS. The results from the three models differ slightly, which suggests that the results of the proposed model are reliable. Pamucar et al. [35] developed a novel BWM–WASPAS–MABAC model to support the third-party logistics service provider evaluation process. A computational study was performed to demonstrate the calculation steps of the proposed approach. The authors also performed a sensitivity analysis and a comparative study to validate the results from the model.

While there have been some studies about the application of MCDM techniques in solving the logistics service supplier selection problem, few have considered the use of the SERVQUAL model, especially under fuzzy decision-making environments. In this study, the Fuzzy Analytical Hierarchy Process (FAHP) and The Technique for Order of Preference by Similarity to Ideal Solution Model (TOPSIS) are applied to solve the weightings of the criteria and to determine the best logistics service supplier out of a number of alternatives provided under fuzzy decision-making environments.

3. Methodology

The SERVQUAL model was selected to be the basis of the development of the proposed MCDM approach's criteria, as it is a comprehensive research instrument in measuring service quality. While it has been applied in various studies on service quality evaluation [35–38], it has not been applied in the case of logistics service quality evaluation. FAHP and TOPSIS were selected to develop the proposed approach, as these methods are easy to understand and calculate and are widely available in numerous software, helping to improve the applicability of the approach. The model development process includes three stages, as follows:

Step 1: Examine and assess the current procedures (logistics service provider evaluation and selection) using the SERVQUAL Model and industry expertise to gather more criteria for each challenge.

Step 2: For each challenge, create MCDM models.

The defined criteria weights are initially generated using FAHP for the logistics service provider evaluation and selection problem. The ranking of probable places is then calculated using TOPSIS.

Step 3: Discussion of real-world case studies.

3.1. SERVQUAL Model

The SERVQUAL model looks specifically into five dimensions, which are:

- Tangibles: physical facilities, equipment, human resources, overall appearance to the customers
- Reliability: ability to perform the required service accordingly and dependably
- Responsiveness: ability to respond and willingness to assist customers in need of assistance
- Empathy: showing care and understanding customers' feelings accordingly
- Assurance: employees' knowledge, courtesy and ability to show confidence to the customers.

In order to assess logistics services, a questionnaire will initially be created in order to ask experts their opinions about logistical services based on the five dimensions of service quality. A list of criteria is developed based on the SERVQUAL model's dimensions.

3.2. Process of Fuzzy Analytic Hierarchy

The fuzzy set was created to demonstrate the ambiguity and haziness of subjective assertions. The set enabled a mathematical system to function in a fuzzy environment. A fuzzy set might be defined as a criterion class with continuous membership values that is characterized by its beginning function. The initial function, which may be set between 0 and 1, specifies the beginning level for each criterion in the SERVQUAL model.

While there are other fuzzy number transformations, triangular fuzzy numbers are used in this study. Figure 2 shows how it is defined [39].

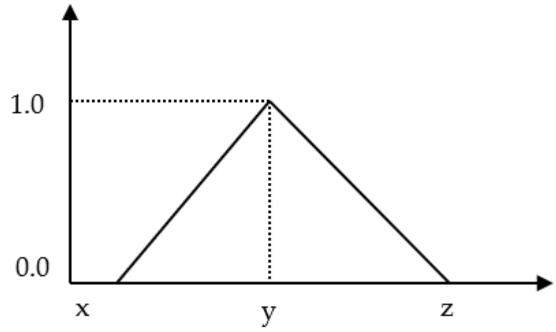

Figure 2. Triangular Fuzzy Number.

$$(n) = \begin{cases} \frac{n-x}{y-x}, & x \le n \le y \\ \frac{z-n}{z-y}, & y \le x \le z \\ 0, & otherwise \end{cases} \quad (1)$$

The fuzzy number $\widetilde{A}$ is defined as an unfuzzied number with no variation if $x = y = z$. As a result, unfuzzified numbers are regarded as special fuzzy numbers.

According to Buckley, the implementation of the FAHP model consists of four stages:

Step 1: Constructing the FAHP model

Based on the framework of the AHP model, the decision maker compares the criteria and alternatives.

Step 2: Generating the pairwise comparison matrix

Fuzzy numbers are used to generate a pairwise comparison matrix. The matrix is defined as follows:

$$\widetilde{A^k} = \begin{bmatrix} \widetilde{a_{11}^k} & \widetilde{a_{12}^k} & \cdots & \widetilde{a_{1n}^k} \\ \widetilde{a_{21}^k} & \widetilde{a_{22}^k} & \cdots & \widetilde{a_{2n}^k} \\ \cdots & \cdots & \cdots & \cdots \\ \widetilde{a_{n1}^k} & \widetilde{a_{n2}^k} & \cdots & \widetilde{a_{nn}^k} \end{bmatrix} \quad (2)$$

where: $\widetilde{A^k}$ is the fuzzy elements′ pairwise comparison matrix; $\widetilde{a_{nn}^k}$ is the value of the triangle fuzzy mean.

If there is more than one decision maker, the preferences of each expert $(\widetilde{a_{nn}^k})$ are averaged, and $(\widetilde{a}_{ij})$ is calculated as in Equation (3).

$$\widetilde{a}_{ij} = \frac{\sum_{k=1}^{K} \widetilde{a_{nn}^k}}{K} \quad (3)$$

Step 3: The pair-wise contribution matrix will then be updated based on the average preferences, as shown in Equation (4).

$$\widetilde{A} = \begin{bmatrix} \widetilde{a_{11}} & \cdots & \widetilde{a_{1n}} \\ \vdots & \ddots & \vdots \\ \widetilde{a_{n1}} & \cdots & \widetilde{a_{nn}} \end{bmatrix} \quad (4)$$

Step 4: Equation (5) calculates the geometric mean of the fuzzified comparison results for each criterion. The values $\widetilde{g}_i$ are triangular.

$$\widetilde{g}_i = \left(\prod_{j=1}^{n} \widetilde{a}_{ij} \right)^{1/n}, \ i = 1, \ 2, \ \ldots, \ n \quad (5)$$

Step 5: Equation (5) calculates the geometric mean of the fuzzified comparison results for each criterion. The values $\widetilde{g}_i$ are triangular.

Step 6: Equation (5) may be used to obtain the fuzzified weights for each criterion by combining the three minor phases listed below.

Step 6a: Determine the vector sum for each $\widetilde{g}_i$.

Step 6b: Determine the inverse power of the summation vector. Fill in the fuzzified triangle as needed and arrange in ascending order.

Step 6c: The fuzzified weight is calculated by multiplying each one by its inverse vector.

$$\widetilde{w}_i = \widetilde{g}_i \otimes (\widetilde{g}_1 \oplus \widetilde{g}_2 \oplus \ldots \oplus \widetilde{g}_n)^{-1} = (lw_i, mw_i, uw_i) \quad (6)$$

Step 7: Because $\widetilde{w}_i$ are still fuzzified triangular numbers, the defuzzification procedure must employ the Center of Area approach, which is indicated in Equation (7).

$$Y_i = \frac{lw_i + mw_i + uw_i}{3} \quad (7)$$

Step 8: Even if Y_i is a normal number, it must be normalized using Equation (8).

$$Z_i = \frac{Y_i}{\sum_{i=1}^{n} Y_i} \quad (8)$$

The eight aforementioned steps are used to calculate the normalized weights for both criteria and alternatives, which are then used to determine the weights of each criterion and the scores of each alternative. As a consequence, the highest score option is provided to the decision maker as the best choice the decision maker should select.

3.3. The Order of Preference by Similarity to the Ideal Solution Model Technique (TOPSIS)

TOPSIS is a multi-criteria decision analysis approach developed by Ching-Lai Hwang and Yoon in 1981 [40], with additional refinements by Yoon in 1987 [41] and by Hwang, Lai and Liu in 1993 [42]. The TOPSIS procedure is followed as follows:

Step 1: Create an evaluation matrix with m choices and n criteria, with the intersection of each alternative and criterion denoted by x_{ij}, yielding a matrix $(x_{ij})_{mxn}$.

Step 2: The matrix will undergo normalization $(x_{ij})_{mxn}$ to generate the matrix $R = (r_{ij})_{mxn}$ using the normalization method defined in Equation (9):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}}, \; i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n \quad (9)$$

Step 3: Make the following weighted normalized choice matrix:

$$t_{ij} = r_{ij}.w_j, \; \mathrm{i} = 1, 2, \ldots, m; \; \mathrm{j} = 1, 2, \ldots, n \quad (10)$$

where $w_j = \frac{W_j}{\sum_{k=1}^{n} W_k}$, j = 1, 2, ..., n such that $\sum_{i=1}^{n} w_j = 1$, and W_j is the initial weight assigned to the indicator v_j, j = 1, 2, ..., n.

Step 4: Identify the worst alternative (A_w) and the best alternative (A_b):

$$A_w = \{\langle \max(t_{ij} | i = 1, 2, \ldots, m | j \in J_- \rangle, \langle \min(t_{ij} | i = 1, 2, \ldots, m | j \in J_+ \rangle\} = \{t_{wj} | j = 1, 2, \ldots, n\} \quad (11)$$

$$A_b = \{\langle \min(t_{ij} | i = 1, 2, \ldots, m | j \in J_- \rangle, \langle \max(t_{ij} | i = 1, 2, \ldots, m | j \in J_+ \rangle\} = \{t_{wj} | j = 1, 2, \ldots, n\} \quad (12)$$

Step 5: Determine the L^2-distance between the desired alternative i and the worst-case scenario A_w:

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}, i = 1, 2, \ldots, m \quad (13)$$

In addition, determine the distance between the goal alternative i and the worst case scenario A_b:

$$d_b = \sqrt{\sum_{j=1}^{n} \left(t_{ij} - t_{bj}\right)^2}, i = 1, 2, \ldots, m \quad (14)$$

Step 6: Determine the degree of resemblance to the worst case scenario:

$$s_{iw} = \frac{d_{ib}}{(d_{iw} + d_{ib})} i = 1, 2, \ldots, m \quad (15)$$

$s_{iw} = 1$ if and only if the options' solution is in the best case scenario; and
$s_{iw} = 0$ if and only if the options' solution is in the worst case scenario

Step 7: Rank the options using s_{iw} $(i = 1, 2, \ldots, m)$.

4. Case Study

Most businesses today prioritize focusing their resources on their core business. As a matter of fact, activities related to warehousing, freight, import and export procedures will be outsourced. Choosing a reputable logistics service provider will help your business cut costs, improve business efficiency and increase competitiveness in the market. In this study, the SERVQUAL model, the Fuzzy Analytical Hierarchy Process (FAHP) and The Technique for Order of Preference by Similarity to Ideal Solution Model (TOPSIS) are applied to solve the weightings of the criteria and to determine the best logistics service supplier out of a number of alternatives provided. To demonstrate the feasibility of the proposed approached, a real-world case study is presented in this section, in which a garment manufacturer in Vietnam evaluates and selects an optimal outbound logistics service provider among several potential candidates.

Table 1 shows 15 important criteria that businesses need to pay attention to when choosing a logistics service provider based on the SERVQUAL model:

Table 1. The criteria list.

Dimension	Criteria	Specific Meaning
Tangibility (D1)	PL1	Modernized facilities
	PL2	Attractive facilities
	PL3	Suitable facilities
Reliability (D2)	PL4	Able to deal with the required order
	PL5	Reliable staff
	PL6	Reliable and trustworthy brand
	PL7	Timely service
	PL8	Data confidentiality
Responsiveness (D3)	PL9	Precise time-span of service
	PL10	Timely service providers
Assurance (D4)	PL11	Experienced staff
	PL12	Good service experience
	PL13	Reliable support
Empathy (D5)	PL14	Can provide customized service
	PL15	Understands customer demand

As a proposed fuzzy MCDM model, the Fuzzy Analytical Hierarchy Process (FAHP) is applied to determine the weightings of 15 criteria. The structure of the FAHP model is shown in Figure 3 and the weight of criteria is shown in Table 2.

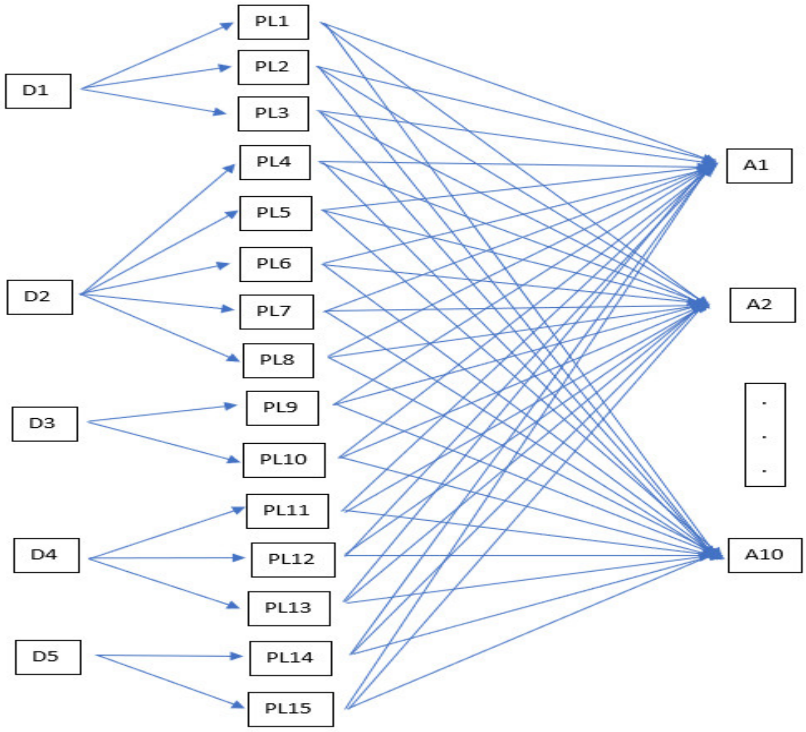

Figure 3. The FAHP model's structure.

Table 2. Weight of criteria.

No.	Criteria	Fuzzy Geometric Mean of Each Row			Fuzzy Weights			BNP	Weight
1	PL01	0.8116	1.1200	1.5201	0.0383	0.0729	0.1372	0.0828	0.0723
2	PL02	0.8173	1.1560	1.5768	0.0386	0.0752	0.1424	0.0854	0.0746
3	PL03	0.9274	1.2817	1.7240	0.0438	0.0834	0.1556	0.0943	0.0823
4	PL04	0.8354	1.1967	1.6521	0.0394	0.0779	0.1492	0.0888	0.0776
5	PL05	1.0371	1.4940	2.0668	0.0490	0.0972	0.1866	0.1109	0.0969
6	PL06	0.6783	0.9230	1.2584	0.0320	0.0601	0.1136	0.0686	0.0599
7	PL07	0.6064	0.8421	1.1819	0.0286	0.0548	0.1067	0.0634	0.0554
8	PL08	0.7451	1.0543	1.4472	0.0352	0.0686	0.1307	0.0782	0.0683
9	PL09	0.7875	1.1047	1.5076	0.0372	0.0719	0.1361	0.0817	0.0714
10	PL10	0.6650	0.9298	1.3039	0.0314	0.0605	0.1177	0.0699	0.0610
11	PL11	0.5740	0.7671	1.0652	0.0271	0.0499	0.0962	0.0577	0.0504
12	PL12	0.9120	1.2467	1.6947	0.0431	0.0811	0.1530	0.0924	0.0807
13	PL13	0.5741	0.7595	1.0524	0.0271	0.0494	0.0950	0.0572	0.0499
14	PL14	0.5216	0.6983	1.0025	0.0246	0.0455	0.0905	0.0535	0.0468
15	PL15	0.5835	0.7895	1.1236	0.0276	0.0514	0.1014	0.0601	0.0525

Choosing a logistics service provider to make them responsible for critical cargo is a challenging decision for many managers. Partner logistics service providers have a significant impact on business operations. It is important for managers to have criteria to evaluate and choose the most suitable partner for the operation process. In this research, the author applied The Technique for Order of Preference by Similarity to Ideal Solution Model (TOPSIS) model to rank 10 potential logistics providers in the final stage. Normalized matrix and normalized weight matrix of TOPSIS model are shown in Tables 3 and 4. As shown in Table 5 and Figure 4, Alternative A9 is the optimal logistics provider.

Table 3. Normalized matrix.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
PL01	0.3143	0.2750	0.3536	0.3536	0.2750	0.3143	0.3536	0.3536	0.2750	0.2750
PL02	0.3451	0.2684	0.3451	0.3451	0.3068	0.3451	0.3068	0.3451	0.2684	0.2684
PL03	0.3536	0.3143	0.3143	0.3143	0.2750	0.3143	0.2357	0.3536	0.3536	0.3143
PL04	0.2935	0.3354	0.2935	0.3354	0.3773	0.2515	0.2935	0.2935	0.3354	0.3354
PL05	0.3451	0.2684	0.3068	0.3068	0.3451	0.2684	0.3451	0.2684	0.3451	0.3451
PL06	0.3333	0.2593	0.2963	0.3333	0.3333	0.3333	0.3333	0.2593	0.3333	0.3333
PL07	0.2971	0.3343	0.3343	0.3343	0.2971	0.3343	0.2971	0.3343	0.2971	0.2971
PL08	0.2750	0.3536	0.3536	0.3143	0.2750	0.3143	0.2750	0.3536	0.3536	0.2750
PL09	0.3414	0.3035	0.3035	0.2655	0.3414	0.2655	0.3414	0.3035	0.3414	0.3414
PL10	0.2825	0.2825	0.2825	0.3229	0.3632	0.3229	0.3632	0.2825	0.3229	0.3229
PL11	0.2655	0.3414	0.3035	0.3414	0.3414	0.3035	0.3035	0.3414	0.2655	0.3414
PL12	0.2593	0.3333	0.3333	0.3333	0.2963	0.3333	0.2593	0.3333	0.3333	0.3333
PL13	0.2754	0.3148	0.3541	0.3148	0.2754	0.3541	0.2754	0.3148	0.3541	0.3148
PL14	0.2940	0.2940	0.3360	0.2940	0.3780	0.3360	0.2940	0.2940	0.3360	0.2940
PL15	0.2820	0.3626	0.2820	0.2820	0.3223	0.2820	0.3626	0.3626	0.2820	0.3223

Table 4. Normalized weight matrix.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
PL01	0.0227	0.0199	0.0256	0.0256	0.0199	0.0227	0.0256	0.0256	0.0199	0.0199
PL02	0.0257	0.0200	0.0257	0.0257	0.0229	0.0257	0.0229	0.0257	0.0200	0.0200
PL03	0.0291	0.0259	0.0259	0.0259	0.0226	0.0259	0.0194	0.0291	0.0291	0.0259
PL04	0.0228	0.0260	0.0228	0.0260	0.0293	0.0195	0.0228	0.0228	0.0260	0.0260
PL05	0.0334	0.0260	0.0297	0.0297	0.0334	0.0260	0.0334	0.0260	0.0334	0.0334
PL06	0.0200	0.0155	0.0177	0.0200	0.0200	0.0200	0.0200	0.0155	0.0200	0.0200
PL07	0.0164	0.0185	0.0185	0.0185	0.0164	0.0185	0.0164	0.0185	0.0164	0.0164
PL08	0.0188	0.0241	0.0241	0.0215	0.0188	0.0215	0.0188	0.0241	0.0241	0.0188
PL09	0.0244	0.0217	0.0217	0.0190	0.0244	0.0190	0.0244	0.0217	0.0244	0.0244
PL10	0.0172	0.0172	0.0172	0.0197	0.0222	0.0197	0.0222	0.0172	0.0197	0.0197
PL11	0.0134	0.0172	0.0153	0.0172	0.0172	0.0153	0.0153	0.0172	0.0134	0.0172
PL12	0.0209	0.0269	0.0269	0.0269	0.0239	0.0269	0.0209	0.0269	0.0269	0.0269
PL13	0.0138	0.0157	0.0177	0.0157	0.0138	0.0177	0.0138	0.0157	0.0177	0.0157
PL14	0.0137	0.0137	0.0157	0.0137	0.0177	0.0157	0.0137	0.0137	0.0157	0.0137
PL15	0.0148	0.0190	0.0148	0.0148	0.0169	0.0148	0.0190	0.0190	0.0148	0.0169

Table 5. Ranking value from the TOPSIS model.

Alternatives	Si+	Si−	Ci	Ranking
A1	0.0144	0.0158	0.5236	7
A2	0.0146	0.0140	0.4907	8
A3	0.0113	0.0153	0.5750	4
A4	0.0107	0.0159	0.5984	2
A5	0.0120	0.0169	0.5847	3
A6	0.0154	0.0134	0.4646	10
A7	0.0157	0.0142	0.4739	9
A8	0.0130	0.0168	0.5644	6
A9	0.0111	0.0182	0.6218	1
A10	0.0122	0.0159	0.5660	5

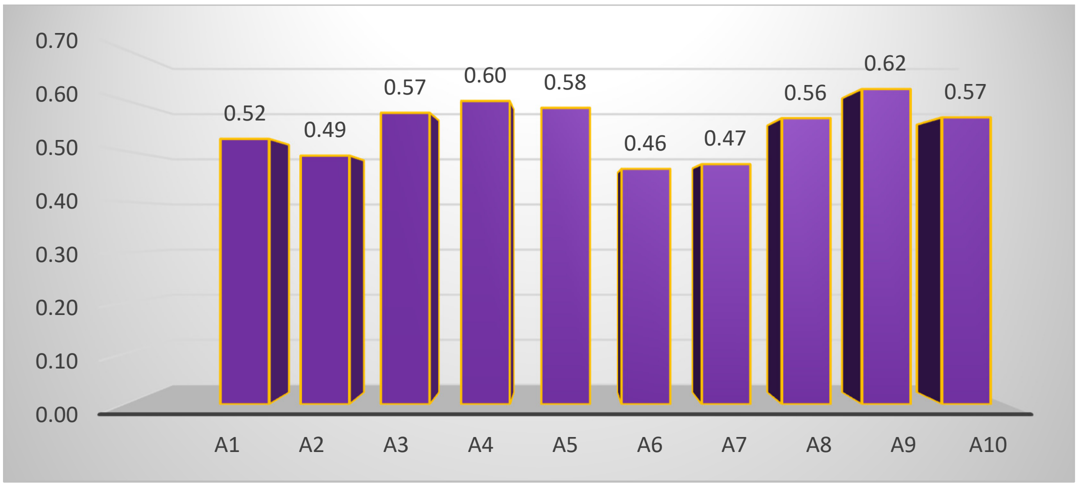

Figure 4. Final ranking of the alternatives.

This research provides both scientific and practical contributions to the domestic logistics industry by providing some theoretical contributions and practical implications regarding logistics service provider selection.

5. Conclusions

Service quality is a research direction that has received a lot of attention in recent years not only from scientists but also from businesses, among whom the demand for quality of customers is increasing. Various techniques have been applied, but there are few studies using the combination of the SERVQUAL and FAHP–TOPSIS models. The SERVQUAL model is very commonly used to evaluate the service quality in different industries. The combination of applying the SERVQUAL model and the FAHP–TOPSIS model is a possible method to assess the quality of the logistics service industry. The results of the model provide opportunities for these service businesses to plan policies to improve service quality.

The use of the FAHP model allows for the identification of the most important and least important aspects that logistics service providers focus on. Meanwhile, the TOPSIS model shows the best and worst performing aspects.

The main contribution of this study is to develop a complete approach to assess the quality of the logistics service industry. The combined method of the SERVQUAL and FAHP–TOPSIS models not only provides sufficient answers but also allows decision makers to visualize the impact of different criteria on the outcome. Furthermore, these mixed models can provide valuable information and methodologies for other industries that require service quality evaluation.

Future studies can look deeper into the hesitancy or personal semantics of experts to improve the accuracy of the proposed approach in cases of incomplete hesitant fuzzy preference relations [40,41]. While the proposed approach was developed for the evaluation and selection of logistics service providers, it can be modified and applied to different cases of service supplier selection.

Author Contributions: Conceptualization, N.V.T. and L.A.L.; Data curation, N.V.T. and L.A.L.; Formal analysis, N.V.T. and L.A.L.; Funding acquisition, N.V.T. and L.A.L.; Investigation, L.A.L. Methodology, N.V.T.; Project administration, N.V.T.; Resources, L.A.L.; Supervision, N.V.T.; Validation, L.A.L.; Writing—original draft, N.V.T.; Writing—review and editing, L.A.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Van Lang University and FPT University.

Acknowledgments: The authors wish to express their gratitude to Van Lang University, Vietnam for the financial support of this research. The authors also wish to express their gratitude to FPT University for supporting this work.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. FedEx Express: Total Average Daily Packages 2021 | Statista, Statista. 2021. Available online: https://www.statista.com/statistics/878354/fedex-express-total-average-daily-packages/ (accessed on 5 January 2022).
2. James, J.; Felix, R. DHL vs. FedEx vs. UPS: Comparing the Three Behemoths. Available online: https://www.lateshipment.com/blog/overview-of-fedex-ups-and-dhl/ (accessed on 5 January 2022).
3. Parmata, U.M.D.; Rajashekhar, B. Measuring service quality in pharmaceutical supply chain—Distributor's perspective. *Int. J. Pharm. Healthc. Mark.* **2016**, *10*, 258–284. [CrossRef]
4. Rezaeisaray, M.; Ebrahimnejad, S.; Khalili-Damghani, K. A novel hybrid MCDM approach for outsourcing supplier selection. *J. Model. Manag.* **2016**, *11*, 536–559. [CrossRef]
5. Fung, R.; Wong, C. Supplier Environmental Performance Evaluation Using AHP. In Proceedings of the 6th ISAHP 2001, Berne, Switzerland, 2–4 August 2021; pp. 111–118.
6. Dweiri, F.; Kumar, S.; Khan, S.; Jain, V. Designing an integrated AHP based decision support system for supplier selection in automotive industry. *Expert Syst. Appl.* **2016**, *62*, 273–283. [CrossRef]
7. Wang, C.; Nguyen, V.; Kao, J.; Chen, C.; Nguyen, V. Multi-criteria decision-making methods in fuzzy decision problems: A case study in the frozen shrimp industry. *Symmetry* **2021**, *13*, 370. [CrossRef]
8. Kieu, P.; Nguyen, V.; Nguyen, V.; Ho, T. A spherical fuzzy analytic hierarchy process (SF-AHP) and combined compromise solution (CoCoSo) algorithm in distribution center location selection: A case study in agricultural supply chain. *Axioms* **2021**, *10*, 53. [CrossRef]
9. Tadić, S.; Krstić, M.; Roso, V.; Brnjac, N. Dry port terminal location selection by applying the hybrid grey MCDM model. *Sustainability* **2020**, *12*, 6983. [CrossRef]
10. Budak, A.; Kaya, İ.; Karaşan, A.; Erdoğan, M. Real-time location systems selection by using a fuzzy MCDM approach: An application in humanitarian relief logistics. *Appl. Soft Comput.* **2020**, *92*, 106322. [CrossRef]
11. Vukasović, D.; Gligović, D.; Terzić, S.; Stević, Ž.; Macura, P. A novel fuzzy MCDM model for inventory management in order to increase business efficiency. *Technol. Econ. Dev. Econ.* **2021**, *27*, 386–401. [CrossRef]
12. Negi, L.; Kharde, Y. Identifying the root causes for inventory accumulation and prioritizing them using an MCDM-based TOPSIS approach. *Mod. Supply Chain Res. Appl.* **2021**, *3*, 145–154. [CrossRef]
13. Kartal, H.; Oztekin, A.; Gunasekaran, A.; Cebi, F. An integrated decision analytic framework of machine learning with multi-criteria decision making for multi-attribute inventory classification. *Comput. Ind. Eng.* **2016**, *101*, 599–613. [CrossRef]
14. Aydin, N.; Seker, S. Determining the location of isolation hospitals for COVID-19 via Delphi-based MCDM method. *Int. J. Intell. Syst.* **2021**, *36*, 3011–3034. [CrossRef]
15. Liou, J.; Lu, M.; Hu, S.; Cheng, C.; Chuang, Y. A hybrid MCDM model for improving the electronic health record to better serve client needs. *Sustainability* **2017**, *9*, 1819. [CrossRef]
16. Wanke, P.; Azad, M.K.; Barros, C.; Hadi-Vencheh, A. Predicting performance in ASEAN banks: An integrated fuzzy MCDM-neural network approach. *Expert Syst.* **2015**, *33*, 213–229. [CrossRef]
17. Daiy, A.; Shen, K.; Huang, J.; Lin, T. A hybrid MCDM model for evaluating open banking business partners. *Mathematics* **2021**, *9*, 587. [CrossRef]
18. Fraihi, K.; Famco, D.; Famco, F.; Latif, S. Evaluation of outpatient service quality in Eastern Saudi Arabia. *Saudi Med. J.* **2016**, *37*, 420–428. [CrossRef]
19. Najafi, S.; Saati, S.; Tavana, M. Data envelopment analysis in service quality evaluation: An empirical study. *J. Ind. Eng. Int.* **2014**, *11*, 319–330. [CrossRef]
20. Jayawardhena, C. The impact of service encounter quality in service evaluation: Evidence from a business-to-business context. *J. Bus. Ind. Mark.* **2010**, *25*, 338–348. [CrossRef]
21. Hsu, T.; Hung, L.; Tang, J. The multiple criteria and sub-criteria for electronic service quality evaluation. *Online Inf. Rev.* **2012**, *36*, 241–260. [CrossRef]
22. Hung, Y.; Huang, M.; Chen, K. Service quality evaluation by service quality performance matrix. *Total Qual. Manag. Bus. Excell.* **2003**, *14*, 79–89. [CrossRef]
23. Akdag, H.; Kalaycı, T.; Karagöz, S.; Zülfikar, H.; Giz, D. The evaluation of hospital service quality by fuzzy MCDM. *Appl. SoftComput.* **2014**, *23*, 239–248. [CrossRef]
24. Tsaur, S.; Chang, T.; Yen, C. The evaluation of airline service quality by fuzzy MCDM. *Tour. Manag.* **2002**, *23*, 107–115. [CrossRef]
25. Parasuraman, A.; Leonard, L.; Valarie, A. SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *J. Retail.* **1988**, *64*, 12–40.
26. Chou, C.; Ding, J. Application of an integrated model with MCDM and IPA to evaluate the service quality of transshipment port. *Math. Probl. Eng.* **2013**, *2013*, 656757. [CrossRef]

27. Bakir, M.; Akan, Ş.; Durmaz, E. Exploring service quality of low-cost airlines in Europe: An integrated MCDM approach. *Econ. Bus. Rev.* **2019**, *5*, 109–130. [CrossRef]
28. Chen, I. A combined MCDM model based on DEMATEL and ANP for the selection of airline service quality improvement criteria: A study based on the Taiwanese airline industry. *J. Air Transp. Manag.* **2016**, *57*, 7–18. [CrossRef]
29. Zoraghi, N.; Amiri, M.; Talebi, G.; Zowghi, M. A fuzzy MCDM model with objective and subjective weights for evaluating service quality in hotel industries. *J. Ind. Eng. Int.* **2013**, *9*, 38. [CrossRef]
30. Chang, P.; Lee, E. Ranking of fuzzy sets based on the concept of existence. *Comput. Math. Appl.* **1994**, *29*, 1–21. [CrossRef]
31. Cheng, C. A new approach for ranking fuzzy numbers by distance method. *Fuzzy Sets Syst.* **1998**, *95*, 307–317. [CrossRef]
32. Tsai, J.; Ding, J.; Liang, G.; Ye, K. Use of a hybrid MCDM method to evaluate key solutions influencing service quality at a port logistics center in Taiwan. *Brodogradnja* **2017**, *69*, 89–105. [CrossRef]
33. Stević, Ž.; Tanackov, I.; Puška, A.; Jovanov, G.; Vasiljević, J.; Lojaničić, D. Development of modified SERVQUAL–MCDM model for quality determination in reverse logistics. *Sustainability* **2021**, *13*, 5734. [CrossRef]
34. Kuo, M.; Liang, G. Combining VIKOR with GRA techniques to evaluate service quality of airports under fuzzy environment. *Expert Syst. Appl.* **2011**, *38*, 1304–1312. [CrossRef]
35. Abdolvand, M.; Taghipouryan, M. Evaluation of customs service quality by using fuzzy SERVQUAL and fuzzy MCDM. *Am. J. Sci. Res.* **2011**, *35*, 89–103.
36. Ammar, S.; Saleh, Y. Grey relational evaluation of bulk water provision service quality using the SERVQUAL framework. *Int. J. Public Adm.* **2021**, 1–16. [CrossRef]
37. Pamucar, D.; Chatterjee, K.; Zavadskas, E. Assessment of third-party logistics provider using multi-criteria decision-making approach based on interval rough numbers. *Comput. Ind. Eng.* **2019**, *127*, 383–407. [CrossRef]
38. Altuntas, S.; Dereli, T.; Yilmaz, M. Multi-criteria decision-making methods based weighted SERVQUAL scales to measure perceived service quality in hospitals: A case study from Turkey. *Total Qual. Manag. Bus. Excell.* **2012**, *23*, 1379–1395. [CrossRef]
39. Buckley, J.; Eslami, E. *An Introduction to Fuzzy Logic and Fuzzy Sets*; Springer: Berlin/Heidelberg, Germany, 2002.
40. Hwang, C.L.; Yoon, K. *Multiple Attribute Decision Making: Methods and Applications*; Springer: New York, NY, USA, 1981.
41. Yoon, K. A reconciliation among discrete compromise solutions. *J. Oper. Res. Soc.* **1987**, *38*, 277–286. [CrossRef]
42. Hwang, C.; Lai, Y.; Liu, T. A new approach for multiple objective decision making. *Comput. Oper. Res.* **1993**, *20*, 889–899. [CrossRef]