Research Article

Selection of In-Flight Duty-Free Product Suppliers Using a Combination Fuzzy AHP, Fuzzy ARAS, and MSGP Methods

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Over a billion people travel by air all over the world every year, and there are many in-flight retailing opportunities for the airline industry. This paper proposes a novel integration fuzzy analytical hierarchy process (FAHP), fuzzy additive ratio assessment (FARAS), and multisegment goal programming (MSGP) methods to select the best supplier for in-flight duty-free product in airline industry. The advantage of this proposed method is that it allows decision makers (DMs) to set multisegment aspiration vague levels considering both the qualitative and quantitative criteria for supplier selection simultaneously. To the best of our knowledge, a simultaneous consideration of qualitative and quantitative criteria for supplier selection of in-flight duty-free product has never been applied under the airline retail industry context. This research will fill into the gaps of supplier selection in in-flight duty-free product for airline industry. The integrated model is illustrated by an example in an airline company in Taiwan.

1. Introduction

Each day, millions of people travel by air. Thus, the air tour has expanded into a large market and is no longer a wealth only for the rich [1]. For instance, in Taiwan, according to the annual report of the Civil Aeronautics Administration (CAA) [2], from 2008, the number of passengers entering and leaving the 17 airports (including inbound, outbound, and transit passengers) was 3,524 (10000 persons). By 2017, the number of passengers entering and leaving these airports increased to 6,598 (10000 persons). From 2008 to 2017, the number of visitors to the three major international airports in Taiwan increased significantly. The growth rate of Taiwan Taoyuan International Airport (TITA) was 51%, the growth rate of Taiwan Kaohsiung International Airport (TKIA) was 36%, and the growth rate of Taiwan Taipei International Airport (TTIA) was 48%. The average growth rate of the three major airports was 45% in Taiwan (see Table 1).

In other words, air tourism has many passengers and business opportunities. As a result, in-flight retailing offers a critical growth area for the airlines industry and many multiple channel retailers in Taiwan. Therefore, in-flight retail product revenue has become an essential key to the competitiveness and long-term survival of the airline industry. Besides, consumer satisfaction is one index used to evaluate product quality/variety and service performance. Based on the in-flight shopper's experience reviews and considering the unique nature of retailing at flight, a consumer satisfaction category is established and divided into five extrinsic values: quality, product variety, price, information, and services sold in the sky. The quality and variety of services sold in the sky are essential factors to passengers looking for an enjoyable and satisfying experience during flight [3, 4]. However, considering the importance of quality, airlines must consider in-flight duty-free product supply resources, such as supplier selection.

TABLE 1: Number and growth rate of passengers entering and leaving in the top three airports in 2008 to 2017 in Taiwan (unit: persons).

Year	Airports		
	TITA	TKIA	TTIA
2008	21936083	4160515	3101854
2016	44878703	6479183	5943153
Growth rate	51%	36%	48%

Resource: Civil Aeronautics Administration (CAA) Annual Report (2017).

The importance of supplier selection has been increasingly recognized in supply chain management (SCM). SCM has identified suppliers as significant based on consumers' purchase decisions. In recent years, determining the best supplier in the supply chain has overwhelmingly become an essential strategy for business [5]. The supplier selection process is a multicriteria decision-making (MCDM) problem, due to the involvement of many conflicts in business resources based on qualitative and quantitative criteria [6–8]. Therefore, supplier selection is one of the sophisticated and many measures in the supply chain that has a significant effect on the excellent capability of a business [9]. However, selecting the fittest supplier from many latent suppliers is often a daunting work. The sustainable supplier selection problem can be defined as the classical supplier selection issue that considers economic, social, and environmental criteria to select and monitor suppliers' performances [10–12]. For any manufacturer, selecting the right supplier is crucial to success; at the right, supplier will significantly increase customer satisfaction, reduce purchasing costs, and improve competitive ability.

These years, a large number of methodologies have been used to decide the supplier evaluation problem. The methods include goal programming (GP), linear programming (LP), statistical and probabilistic methods, mathematical programming models, multiple objective programming, analytic hierarchy process (AHP), analytic network process (ANP), techniques for order preference by similarity to ideal solution (TOPSIS), additive ratio assessment (ARAS), data envelopment analysis (DEA), cost-based methods (CBMs), decision-making trial and evaluation laboratory (DEMATEL), and neural networks (NNs) [13]. Recently, the integration of different techniques within the supplier selection process has received considerable attention in the SCM literature; for example, Fu [14] focused on the performance of AHP, ARAS, and MCGP approach in supplier selection issues. Additionally, Memari et al. [15] presented an intuitive fuzzy TOPSIS approach to select the right fit provider that considers nine criteria and thirty subcriteria for an automotive spare parts manufacturer in relation to airline companies. Awasthi et al. [16] used a fuzzy AHP-VIKOR-based approach for multi-tier sustainable global supplier selection. Fallahpour et al. [17] used the DEA decision support model for sustainable supplier selection in sustainable supply chain management. Liao et al. [18] presented a hybrid model for the selection of optimal online travel agencies (OTAs) using the fuzzy Delphi method (FDM)-DEMATEL-ANP. Chaharsooghi and Ashrafi [11]

introduced a fuzzy MCDM approach using a neofuzzy TOPSIS method to find the best solution for sustainable supplier selection based on the triple bottom line (TBL) approach in a supply chain. Wang Chen [12] proposed a comprehensive fuzzy MCDM method for green supplier evaluation using fuzzy AHP and TOPSIS in the luminance enhancement film (LEF) industry.

In addition, Shi et al. [19] deployed a new integrated model based on interval-valued intuitionistic uncertain linguistic sets (IVIULSs) and a grey relational analysis (GRA)-TOPSIS method for the selection of green suppliers. Tsui and Wen [20] proposed a hybrid, multiple criteria group decision-making (MCGDM) method by using AHP; entropy, elimination, and selection expressing the reality III (ELECTRE III); and the linear assignment method (LAM) to assist a thin film transistor liquid crystal display (TFT-LCD) manufacturer in choosing green suppliers. Ulutas et al. [21] develop a novel fuzzy multiattribute decision-making model consisting of a fuzzy extension of preference selection index (FPSI) and fuzzy extension of the range of value (FROV) to determine the best supplier for a Turkish textile company. Jauhar and Pant [22] integrated the DEA with DE and MODE for sustainable supplier selection problems. Yu and Wong [23] developed an agent-based CBM model for supplier selection of multiple products with a synergistic effect. Rezaei et al. [6] investigated supplier selection in the airline retail industry by using a conjunctive screening method and fuzzy AHP. Hsu et al. [24] utilized the DEMATEL approach with an example in the green supply chain to improve the overall performance of supplier selection management. Liao and Kao [25] integrated the AHP and MCGP model to solve the supplier selection issue. The integrated model uses source data provided for the airline industry to discuss the real world in supplier selection. However, these techniques are not perfect for in-flight duty-free supplier evaluation and selection because the available information in the airline context is inherently ambiguous, inaccurate, imprecise, and uncertain by nature. The novel integration fuzzy AHP, fuzzy ARAS, and MSGP method may be useful for various MCDM problems. This is a crucial contribution to the paper.

The remainder of this paper is structured as follows. In the next section, a detailed review of the criteria for supplier selection-related literature is presented. Section 3 explains the proposed combined FAHP, FARAS, and MSGP methods. Section 4 used the integrated method to the supplier selection for in-flight duty-free product with a numerical example to the airline firm. In Section 5, the paper finishes with concluding suggestions for future research.

2. Literature Review

Many researchers have proposed different criteria to evaluate the sustainability of supplier selection. There are various important factors to consider when selecting suppliers, including price discounts, delivery time, service level, a quantity discount, transportation cost, carbon emission tax, currency exchange rate, supplier capacity, and lead time [26, 27]. Rao and Zhang [28] summarized the supplier

selection problems and proposed that the most important criteria are quality, price, cost, and delivery performance. Kannan et al. [29] applied fuzzy AHP and TOPSIS to select the best suppliers. They applied quality, cost, delivery, technology capability, and environmental competency criteria for supplier selection. Bankian-Tabrizi et al. [30] proposed five primary evaluation criteria for suppliers: service, financial competencies, and organization skills. Gheidar Kheljani et al. [31] considered the costs of both the buyer and the suppliers to minimize the overall costs of the supply chain. Furthermore, Zimmer et al. [32] reviewed the literature concerning supplier selection issues. They examined 143 peer-reviewed papers from 1997 to 2014 to summarize relationship research areas. Based on their survey, the top 10 economic, environmental, and social criteria are shown in Table 2 [15].

Also, many elements affect an airline's decision to select a cooperation supplier. For example, Fu [14] used criteria including product quality, service, delivery time, business image, and food safety for catering supplier selection. Chiappa et al. [33] used fuzzy theory and the TOPSIS approach and applied criteria including price, quality of products, location and internal atmosphere, proximity, friendliness of staff, and speed of service to evaluate airport retailers. Rezaei et al. [6] considered cost/price, service/product quality, delivery, financial patience, and corporate social responsibility (CSR) and applied an assortment of supplier selection methodologies to airline retail. Hsu and Liou [34] applied the DANP (DEMATEL-based ANP) approach to select the suppliers in the airline industry, including on-time rate, cost/price, service quality, skills, customer relationship, client satisfaction, flexibility, and information partake. Vijayvargy [35] applied cost, service, delivery performance, relationship, business reputation, meal hygiene, and safety to evaluate providers in the airline retail industry. Chang and Lee [36] examined a multiple object goal programming method to select the airport supplier by using price, product quality, service quality, experience, reputation, and consumer satisfaction in order to obtain the best overall optimal performance.

In previous studies, many researchers have discussed airline supplier selection problems. However, most of the literature on the supplier selection method considers only the qualitative criteria. To the best of researcher's knowledge, qualitative and quantitative criteria for supplier selection, the in-flight duty-free product, have never been applied simultaneously in the airline retail industry case. The main aim of this paper is based on the airline's context to suggest a new integrated method using the combined FAHP, FARAS, and MSGP methods to fill this gap in the airline retail trade literature.

3. Proposed Supplier Selection Method

3.1. Fuzzy Analytical Hierarchy Process. Peng et al. [37] used a fuzzy AHP method to solve MCDM in management issues. The problem of MCDM is to decide the best selections using a fuzzy set of complete alternatives that are assessed in conflicting criteria. Determining the relative importance of

different criteria in MCDM problems involves a high degree of personal preference judgment from DMs [38]. However, the linguistic measure of people's judgments is often vague; in other words, it is in interval value rather than that stable value judgment. Therefore, FAHP theory can deal with information that is usually uncertain, imprecise, and vague in decision-making problems [39].

FTNs are popular in fuzzy AHP applications. A fuzzy number A is described as a fuzzy subset of the real line X with a member function, such as u_A , which represents uncertainty. This membership function is defined in a universe of discourse of $[0, 1]$. Thus, a fuzzy triangular number (Figure 1) can be defined as a triplet (a, b, c) , where $a \leq b \leq c$; the membership function of the fuzzy number A can be shown in Figure 1 and equation (1) denotation for algebraic operations on fuzzy numbers [40]:

$$u_A = \begin{cases} \frac{(x-a)}{(b-a)}, & x \in [a, b], \\ \frac{(c-x)}{(c-b)}, & x \in [b, c], \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

$\tilde{a} = (a_1, b_2, c_3)$ and $\tilde{b} = (a_1, b_2, c_3)$ are two fuzzy triangular numbers (FTNs); then, the basic calculation of FTNs $\tilde{a}$ and $\tilde{b}$ can be defined as follows [41]:

$$\text{addition : } \tilde{a} + \tilde{b} = (a_1 + a_2, b_1 + b_2, c_1 + c_2),$$

$$\text{subtraction : } \tilde{a} - \tilde{b} = (a_1 - c_2, b_1 - b_2, c_1 - a_2),$$

$$\text{multiplication : } \tilde{a} \times \tilde{b} = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2),$$

$$\text{division : } \tilde{a} \div \tilde{b} = (a_1 \div c_2, b_1 \div b_2, c_1 \div a_2),$$

$$\text{multiplication by constant : } k\tilde{a} = (ka_1, kb_2, kc_3),$$

$$\text{inverse : } (\tilde{a})^{-1} = \left(\frac{1}{c_1}, \frac{1}{b_1}, \frac{1}{a_1} \right). \quad (2)$$

If a decision group has k DMs and the fuzzy ratings (FRs) of all DM preferences are the FTNs $\tilde{R}_k(a_k, b_k, c_k)$, next the aggregated FRs will be obtained from $\tilde{R}(a, b, c)$, where $a = \min a_k$, $b = \sqrt[k]{\prod_{k=1}^K b_k}$, and $c = \max c_k$, with $k = 1, 2, \dots, K$.

The FRs and importance weight of the k th ($k = 1, 2, \dots, K$) and the DMs are $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $\tilde{w}_{jk} = (\tilde{w}_{jk1}, \tilde{w}_{jk2}, \tilde{w}_{jk3})$, respectively, where $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$. Therefore, the fuzzy group ratings $\tilde{x}_{ij}$ of i th alternatives with pertaining to j th criterion will be obtained from $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$, where $a_{ij} = \min a_{ijk}$, $b_{ij} = \sqrt[k]{\prod_{k=1}^K b_{ijk}}$, and $c_{ij} = \max c_{ijk}$, and the fuzzy group weights $\tilde{w}_j$ of each criterion will be obtained from $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$, where $w_{j1} = \min w_{jk1}$, $w_{j2} = \sqrt[k]{\prod_{k=1}^K w_{jk2}}$, and $w_{j3} = \max w_{jk3}$.

TABLE 2: Suppliers' selection criteria by Zimmer et al. (2016).

Category	Criteria
Economic	Quality, price/cost*, lead time*, flexibility, relationship, technical capability, reverse logistics, logistics costs*, rejection ratio*
Environmental	Environmental management system, resource consumption, recycling, reuses, ecodesign, controlling of ecological impacts, wastewater, energy consumption, air emissions, and environmental code of conduct
Social	Involvement of stakeholders, social management commitment, health and safety, stakeholder relations, the rights of stakeholders, staff training, social code of conduct, donations for sustainable projects, safety practices, annual number of accidents

* indicates quantitative criteria, and all others are qualitative criteria.

FIGURE 1: Triangular membership function fuzzy number.

In addition, the consistency index (CI) and consistency ratio (CR) are calculated as $CI = (\lambda_{\max} - n)/(n - 1)$; $\lambda_{\max}$ is the maximum given eigenvector of the comparative matrix, and n is the number of criteria in the matrix. The consistency ratio (CR) is used to estimate directly the consistency of pairwise comparisons. The CR is computed by dividing the CI by a value obtained from a table of Random Consistency Index (RI); $CR = CI/RI$. If the CR is less than 0.10, the comparisons are acceptable, otherwise not. RI is the average index for randomly generated weights.

3.2. Fuzzy Additive Ratio Assessment. A new fuzzy ARAS technique was put forward by Zavadskas et al. [42]. The steps of the fuzzy ARAS approach can be precisely described as follows [40, 43, 44].

The first stage is establishing a fuzzy decision-making matrix for each criterion. The typical form of the fuzzy MCDM discrete issue, which contains m alternatives and n criteria ($i = 0, 1, \dots, m$ and $j = 1, 2, \dots, n$), can be shown in a fuzzy decision-making matrix as

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{01} & \cdots & \tilde{x}_{0j} & \cdots & \tilde{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{x}_{i1} & \cdots & \tilde{x}_{ij} & \cdots & \tilde{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mj} & \cdots & \tilde{x}_{mn} \end{bmatrix}, \quad (3)$$

where $\tilde{x}_{0j}$ denotes the optimal value of j criterion and $\tilde{x}_{ij}$ denotes a fuzzy value indicating the performance value of the

alternative in terms of the j criterion, in which m is items of alternatives and n is the item of criteria picture each alternative. When the DMs do not have preferences, the optimal performance ratings are obtained by $x_{0j} = \max x_{ij}$, $j \in \Omega_{\max}$, and $x_{0j} = \min x_{ij}$, $j \in \Omega_{\min}$, where x_{0j} denotes the optimal performance rating to the j th criterion, $x_{0j} = \max x_{ij}$ indicates benefit criteria for optimization direction are maximization, and $x_{0j} = \min x_{ij}$ represents cost criteria for optimization direction are minimized.

In the second stage, the decision of a fuzzy normalized matrix for the initial value is computed. The initial values of all criteria are normalized, and the initial values $\tilde{\tilde{x}}_{ij}$ of normalized decision-making matrix $\tilde{\tilde{X}}$ are as

$$\tilde{\tilde{X}} = \begin{bmatrix} \tilde{\tilde{x}}_{01} & \cdots & \tilde{\tilde{x}}_{0j} & \cdots & \tilde{\tilde{x}}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{\tilde{x}}_{i1} & \cdots & \tilde{\tilde{x}}_{ij} & \cdots & \tilde{\tilde{x}}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{\tilde{x}}_{m1} & \cdots & \tilde{\tilde{x}}_{mj} & \cdots & \tilde{\tilde{x}}_{mn} \end{bmatrix}, \quad i = 0, 1, \dots, m, j = 1, 2, \dots, n. \quad (4)$$

When the criteria whose preferable values are maxima (e.g., benefit criteria), they are normalized as shown in the following formula:

$$\tilde{\tilde{x}}_{ij} = \frac{\tilde{x}_{ij}}{\sum_{i=0}^m \tilde{x}_{ij}}, \quad (5)$$

where $j \in \Omega_{\max}$; when the criteria whose preferable values are minima (e.g., cost criteria), the normalized are shown as follows:

$$\tilde{\tilde{x}}_{ij} = \frac{1/\tilde{x}_{ij}}{\sum_{i=0}^m 1/\tilde{x}_{ij}}, \quad j \in \Omega_{\min}. \quad (6)$$

The third stage is to obtain the weight of fuzzy normalized decision matrix as follows:

$$\tilde{\tilde{X}} = \begin{bmatrix} \tilde{\tilde{x}}_{01} & \cdots & \tilde{\tilde{x}}_{0j} & \cdots & \tilde{\tilde{x}}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{\tilde{x}}_{i1} & \cdots & \tilde{\tilde{x}}_{ij} & \cdots & \tilde{\tilde{x}}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \tilde{\tilde{x}}_{m1} & \cdots & \tilde{\tilde{x}}_{mj} & \cdots & \tilde{\tilde{x}}_{mn} \end{bmatrix}, \quad i = 0, 1, \dots, m, j = 1, 2, \dots, n. \quad (7)$$

The following formula obtains the fuzzy values of normalized weighted in all the criteria:

$$\tilde{x}_{ij} = \tilde{\tilde{x}}_{ij} \times \tilde{w}_j, \quad i = 0, 1, \dots, m, j = 1, 2, \dots, n, \quad (8)$$

where $\tilde{\tilde{x}}_{ij}$ is the weighted normalized performance rating of the i th alternative in relation to the j th criterion and $\tilde{w}_j$ is the weight (importance) of the j criterion.

The following task is to compute the overall performance index for each alternative. The overall performance index $\tilde{S}_i$ of each alternative can be obtained as the sum of weighted normalized performance ratings, using the following formula:

$$\tilde{S}_i = \sum_{j=1}^n \tilde{\tilde{x}}_{ij}, \quad i = 0, 1, \dots, m, \quad (9)$$

where $\tilde{S}_i$ is the value of the optimality function of the i th alternative; then, the highest value is the best, and the last one is the worst. In addition, the center-of-area method is the most practical and simple to use:

$$\tilde{S}_i = \frac{1}{3}(\tilde{S}_{i\alpha} + \tilde{S}_{i\beta} + \tilde{S}_{i\gamma}), \quad i = 0, 1, \dots, m. \quad (10)$$

The final step is to calculate the utility degree to each alternative. The utility degree of an alternative A_i will be obtained using the following model:

$$Q_i = \frac{S_i}{S_0}, \quad i = 0, 1, \dots, m, \quad (11)$$

where S_0 and S_i are the optimal criterion values and obtained from equation (10), Q_i is the degree of utility of the i th alternative, and the largest value of Q_i is the best value.

3.3. Multisegment Goal Programming. Goal programming (GP) is the most powerful techniques that have been applied to solve various decision-making issues in which targets have been assigned to all attributes, and the DMs are the preference in minimizing the not achievement of the relevant goal [45]. However, GP cannot solve some multi-aspiration levels of management and economic problems. Liao [46] put forward a multisegment goal programming (MSGP) method to solve multisegment aspiration level (MSAL) problems, and then, the DMs can set multiple aspiration levels to each segment goal levels.

The MSGP model has been formulated under no penalty weight as the following achievement function [40, 46].

MSGP model:

$$\begin{aligned} \text{Min } Z &= \sum_{i=1}^n (d_i^+ + d_i^-), \\ \text{s.t., } f_i(x) + d_i^+ - d_i^- &= g_i, \\ f_i(x) &= \sum_{j=1}^m s_{ij} B_{ij}(b) \times x_i, \\ s_{ij} &= s_{i1} \text{ or } s_{i2} \text{ or } \dots \text{ or } s_{im}, \\ s_{ij} B_{ij}(b) &\in R_i(x), \quad i = 0, 1, \dots, n, j = 1, 2, \dots, m, \\ d_i^+, d_i^- &\geq 0, \quad i = 0, 1, \dots, n, \\ X &\in F \text{ (} F \text{ is a feasible set)}, \end{aligned} \quad (12)$$

where d_i^+ and d_i^- represent positive and negative deviations, respectively, attached to the i th goal $|f_i(x) - g_i|$, and s_{ij} is a decision variable coefficient, which represents the multisegment aspiration levels of the j th segment of the i th goal. In addition, $B_{ij}(b)$ represents a function of a binary serial number and $R_i(x)$ is the function of resource limitations.

Following Chang's [47] fuzzy GP idea, the MSGP model can be reformulated as follows:

$$\text{Min } Z = \sum_{i=1}^n (d_i^+ + d_i^-) + (e_i^+ + e_i^-), \quad (13)$$

$$\text{s.t., } \sum_{j=1}^m s_{ij} B_{ij}(b) \times x_i + d_i^+ - d_i^- = g_i, \quad (14)$$

$$\begin{aligned} &\frac{1}{L_i} (b_i s_{ij}^{\max} + (1 - b_i) s_{ij}^{\min}) - e_i^+ + e_i^-, \\ &= \frac{1}{L_i} (s_{ij}^{\max} \text{ or } s_{ij}^{\min}), \end{aligned} \quad (15)$$

$$\begin{aligned} L_i &= (s_{ij}^{\max} - s_{ij}^{\min}), \\ s_{ij} B_{ij}(b) &\in R_i(x), b_i \in \{0, 1\}, d_i^+, d_i^-, e_i^+, e_i^- \geq 0, \\ X &\in F \text{ (} F \text{ is a feasible set)}, \end{aligned} \quad (16)$$

where e_i^+ and e_i^- are the positive and negative deviations, respectively, attached to the i th goal $|y_i - s_{ij}^{\max}|$ or $|y_i - s_{ij}^{\min}|$; α_i represents the weights attached to the sum of the deviations ($e_i^+ + e_i^-$); and $s_{ij}^{\max}$ and $s_{ij}^{\min}$ are the lower and upper bounds of the i th goal, respectively. All other variables are determined in the MSGP model.

In this case, a new approach combining FAHP, FARAS, and MSGP is integrated to solve the problem of supplier selection for in-flight duty-free product. First, fuzzy AHP is used to compute the relative weight for each criterion based on the subjective determination from DMs from the airline company (e.g., EVA Air). Second, FARAS technology calculates a closeness coefficient (CC) for the capability of each alternative supplier with respect to each criterion. Finally, quantitative constraints (i.e., those related to benefit, cost, or business strategic demand criteria) are merged into the MSGP pattern to identify the optimality supplier. The integration method steps are as follows:

FAHP step

- (1) Identify criteria of supplier selection and pairwise comparison of criteria for each supplier
- (2) Determine criteria weights for each candidate

FARAS step: using the weights obtained from FAHP step into FARAS to calculate closeness coefficient for each alternative with respect to each criterion.

Integration step: formulate the main goals of supplier selection into FAHP, FARAS, and MSGP models. Also, the process of this integration is shown in Figure 2.

FIGURE 2: An integrated FAHP-FARAS-MSGP procedure for supplier selection.

4. Supplier Selection for In-Flight Duty-Free Product Application

The proposed method is applied to the largest and well-known airline in Taiwan, EVA Air (BR). This airline seeks the best supplier for their in-flight duty-free product in order to achieve a competitive advantage and increase the number of passengers satisfied with the aviation industry market. An EVA Air project decision committee comprised five members such as CEO, top marketing manager, and top purchase, say (D_1 , D_2 , and D_3), respectively, and two in-flight retail experts (D_4 and D_5). The two experts were invited to participate in this committee and provide their valuable opinions.

The following criteria used to evaluate the suppliers had to be set up for the project decision committee. Based on a literature review from the committee and retail experts using the nominal group technique (NGT) method, the supplier's evaluation qualitative criteria have been decided as follows:

- (i) $\tilde{c}_1$: product quality.
- (ii) $\tilde{c}_2$: delivery performance.
- (iii) $\tilde{c}_3$: brand image.
- (iv) $\tilde{c}_4$: price/cost level.
- (v) $\tilde{c}_5$: financial stability.

Meanwhile, the market survey has five suppliers, S1, S2, S3, S4, and S5, remaining for further evaluation and selection. The FAHP hierarchical structure of the supplier's selection decision-making problem is shown in Figure 3.

In general, airlines have provided in-flight duty-free product for the customer to purchase pending their flight. Many airlines offer the customer the opportunity to purchase from a wider goods range and place orders prior to departure [6]. The general airline retail products category can be divided into different items of related goods; for example, EVA Air offers in-flight duty-free products, as shown in Table 3, and EVA Air's sales share in revenue generation 2018 is presented in Figure 4.

In the first stage, by applying formula in Section 3.1, $CI = (\lambda_{\max} - n)/(n - 1)$ and $CR = CI/RI$. The consistency property of each DM's comparison results is examined by calculating the CR. From consistency ratio $CR = 0.083$, it shows that the judgment matrix processes consistency. Furthermore, the DMs use the fuzzy membership function (FMF) for linguistic values, as shown in Figure 5, and the corresponding linguistic term for the supplier's evaluation is displayed in Table 4 to evaluate the importance of the criteria. In addition, the importance of fuzzy weights of the criteria decided by DMs is displayed in Table 5.

FIGURE 3: FAHP hierarchy structure of supplier selection problem.

TABLE 3: Airline retail product categories by Eva Air (BR).

Product category	In-flight retail products items
Skincare products	84
Necklace jewelry	30
Watches	21
Perfume	18
Liquor	14
Wallet/belt/leather bag	12
Beauty products	12
Health food	7
Others (scarves and travel gadgets)	6
Pen	5
Sunglasses	4
3C products	4

Resource: Eva Air (BR) internal document, 2018.

FIGURE 4: Eva Air's sales share in revenue generation 2018.

FIGURE 5: Fuzzy membership function for linguistic values.

TABLE 4: Corresponding linguistic term for supplier's evaluation.

Linguistic terms (abbreviation)	Fuzzy preference
None (N)	(0, 0, 0.1)
Very low (VL)	(0, 0.1, 0.2)
Low (L)	(0.1, 0.2, 0.3)
Fairly low (FL)	(0.2, 0.3, 0.4)
More or less low (ML)	(0.3, 0.4, 0.5)
Medium (M)	(0.4, 0.5, 0.6)
More or less good (MG)	(0.5, 0.6, 0.7)
Fairly good (FG)	(0.6, 0.7, 0.8)
Good (G)	(0.7, 0.8, 0.9)
Very good (VG)	(0.8, 0.9, 1)
Excellent (E)	(0.9, 1, 1)

In the second stage, the DMs use the corresponding linguistic term for the supplier's evaluation shown in Table 4 to assess the rating of each candidate about each criterion, and then the ratings are shown in Table 6.

In the third stage, a fuzzy weighted decision matrix is created using the weights of each criterion (w_i) in Table 5, and the linguistic evaluations are shown in Table 6, which are presented in Table 7, displaying the decision values of fuzzy weighted.

TABLE 5: Aggregated fuzzy weight of criteria by decision makers (DMs).

Fuzzy criterion	Decision makers (DMs)					Fuzzy group weight $\bar{w}_i$
	D_1	D_2	D_3	D_4	D_5	
	Ratings					
$\bar{c}_1$	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.8, 0.9, 1)	(0.8, 0.9, 1)	(0.8, 0.9, 1)	(0.4, 0.71, 1)
$\bar{c}_2$	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.7, 0.8, 0.9)	(0.4, 0.61, 0.9)
$\bar{c}_3$	(0.8, 0.9, 1)	(0.7, 0.8, 0.9)	(0.6, 0.7, 0.8)	(0.5, 0.6, 0.7)	(0.6, 0.7, 0.8)	(0.5, 0.73, 1)
$\bar{c}_4$	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.5, 0.6, 0.7)	(0.3, 0.4, 0.5)	(0.4, 0.5, 0.6)	(0.3, 0.52, 0.9)
$\bar{c}_5$	(0.5, 0.6, 0.7)	(0.2, 0.3, 0.4)	(0.9, 1, 1)	(0.8, 0.9, 1)	(0.5, 0.6, 0.7)	(0.2, 0.63, 1)

TABLE 6: The rating of five criteria by DMs.

Fuzzy criterion	Decision makers (DMs)	Alternatives				
		S_1	S_2	S_3	S_4	S_5
		Ratings				
$\tilde{c}_1$	D_1	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)
	D_2	(0.4, 0.5, 0.6)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.9, 1, 1)
	D_3	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)	(0.5, 0.6, 0.7)
	D_4	(0.5, 0.6, 0.7)	(0.5, 0.6, 0.7)	(0.3, 0.4, 0.5)	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)
	D_5	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)
$\tilde{c}_2$	D_1	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.6, 0.7, 0.8)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)
	D_2	(0.3, 0.4, 0.5)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.5, 0.6, 0.7)
	D_3	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)
	D_4	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.9, 1, 1)	(0.8, 0.9, 1)	(0.4, 0.5, 0.6)
	D_5	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)
$\tilde{c}_3$	D_1	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.5, 0.6, 0.7)	(0.7, 0.8, 0.9)	(0.5, 0.6, 0.7)
	D_2	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.9, 1, 1)	(0.7, 0.8, 0.9)
	D_3	(0.5, 0.6, 0.7)	(0.6, 0.7, 0.8)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)
	D_4	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)
	D_5	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)
$\tilde{c}_4$	D_1	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.7)
	D_2	(0.3, 0.4, 0.5)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)
	D_3	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.8, 0.9, 1)
	D_4	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)	(0.3, 0.4, 0.5)	(0.6, 0.7, 0.8)	(0.7, 0.8, 0.9)
	D_5	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)
$\tilde{c}_5$	D_1	(0.4, 0.5, 0.6)	(0.5, 0.6, 0.7)	(0.6, 0.7, 0.8)	(0.3, 0.4, 0.5)	(0.5, 0.6, 0.7)
	D_2	(0.9, 1, 1)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.9, 1, 1)	(0.4, 0.5, 0.6)
	D_3	(0.6, 0.7, 0.8)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)
	D_4	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)
	D_5	(0.7, 0.8, 0.9)	(0.5, 0.6, 0.7)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.9, 1, 1)

TABLE 7: The fuzzy decision matrix of five alternatives.

Fuzzy criterion	Alternatives				
	S_1	S_2	S_3	S_4	S_5
	Ratings				
$\tilde{c}_1$	(0.3, 0.54, 1)	(0.3, 0.56, 0.9)	(0.3, 0.52, 0.8)	(0.4, 0.59, 0.9)	(0.5, 0.77, 1)
$\tilde{c}_2$	(0.3, 0.58, 0.9)	(0.3, 0.49, 0.8)	(0.5, 0.7, 1)	(0.4, 0.64, 1)	(0.4, 0.63, 0.9)
$\tilde{c}_3$	(0.4, 0.63, 0.9)	(0.4, 0.63, 0.8)	(0.3, 0.54, 0.9)	(0.3, 0.73, 1)	(0.3, 0.6, 0.9)
$\tilde{c}_4$	(0.3, 0.49, 0.8)	(0.4, 0.59, 0.98)	(0.3, 0.34, 0.9)	(0.4, 0.63, 0.9)	(0.4, 0.64, 1)
$\tilde{c}_5$	(0.4, 0.67, 1)	(0.4, 0.59, 0.9)	(0.4, 0.59, 0.9)	(0.3, 0.58, 1)	(0.4, 0.63, 1)

In the fourth stage, by using equations (3) and (4), the fuzzy decision matrix of five alternatives is derived and shown in Table 8.

In the fifth stage, using equations (5) and (6) and Table 8, the decision-making of the normalized fuzzy matrix is constructed and displayed in Table 9.

In the following stage, by using equations (7)–(11), the fuzzy decision-making matrix of normalized weighted and solution results are derived and displayed in Table 10.

The final stage, in line with the normalized weights (Q_i , $i = 1, 2, \dots, 5$) obtained for each supplier in Table 10, is used as a priority value to set up the integrated fuzzy

TABLE 8: The change in fuzzy decision matrix of five alternatives.

Fuzzy criterion	Alternatives						Total
	S_0	S_1	S_2	S_3	S_4	S_5	
	Ratings						
$\tilde{c}_1$	1.00	(0.3, 0.54, 1)	(0.3, 0.56, 0.9)	(0.3, 0.52, 0.8)	(0.4, 0.59, 0.9)	(0.5, 0.77, 1)	(2.8, 3.98, 5.6)
$\tilde{c}_2$	1.00	(0.3, 0.58, 0.9)	(0.3, 0.49, 0.8)	(0.5, 0.7, 1)	(0.4, 0.64, 1)	(0.4, 0.63, 0.9)	(2.9, 4.03, 5.6)
$\tilde{c}_3$	1.00	(0.4, 0.63, 0.9)	(0.4, 0.63, 0.8)	(0.3, 0.54, 0.9)	(0.3, 0.73, 1)	(0.3, 0.6, 0.9)	(2.7, 4.13, 5.5)
$\tilde{c}_4$	1.00	(0.3, 0.49, 0.8)	(0.4, 0.59, 0.98)	(0.3, 0.34, 0.9)	(0.4, 0.63, 0.9)	(0.4, 0.64, 1)	(2.8, 3.89, 5.5)
$\tilde{c}_5$	1.00	(0.4, 0.67, 1)	(0.4, 0.59, 0.9)	(0.4, 0.59, 0.9)	(0.3, 0.58, 1)	(0.4, 0.63, 1)	(2.9, 4.06, 5.8)

TABLE 9: The normalized fuzzy decision-making matrix.

Fuzzy criterion	Alternatives					
	S_0	S_1	S_2	S_3	S_4	S_5
	Ratings					
$\tilde{c}_1$	(0.18, 0.25, 0.36)	(0.05, 0.14, 0.36)	(0.05, 0.14, 0.32)	(0.05, 0.13, 0.29)	(0.07, 0.15, 0.32)	(0.09, 0.19, 0.36)
$\tilde{c}_2$	(0.18, 0.25, 0.34)	(0.05, 0.14, 0.31)	(0.05, 0.12, 0.28)	(0.09, 0.17, 0.34)	(0.07, 0.16, 0.34)	(0.07, 0.16, 0.31)
$\tilde{c}_3$	(0.18, 0.24, 0.37)	(0.07, 0.15, 0.33)	(0.07, 0.15, 0.30)	(0.05, 0.13, 0.33)	(0.05, 0.18, 0.37)	(0.05, 0.14, 0.33)
$\tilde{c}_4$	(0.18, 0.26, 0.36)	(0.05, 0.13, 0.29)	(0.07, 0.15, 0.32)	(0.05, 0.14, 0.32)	(0.07, 0.16, 0.32)	(0.07, 0.16, 0.36)
$\tilde{c}_5$	(0.17, 0.25, 0.34)	(0.07, 0.17, 0.34)	(0.07, 0.15, 0.31)	(0.07, 0.14, 0.31)	(0.05, 0.14, 0.34)	(0.07, 0.16, 0.34)

TABLE 10: The normalized weights fuzzy decision-making matrix and FARAS solution results as figures.

Fuzzy criterion	Alternatives					
	S_0	S_1	S_2	S_3	S_4	S_5
	Ratings					
$\tilde{c}_1$	(0.07, 0.19, 0.36)	(0.02, 0.1, 0.36)	(0.02, 0.1, 0.32)	(0.02, 0.1, 0.29)	(0.03, 0.11, 0.32)	(0.04, 0.14, 0.36)
$\tilde{c}_2$	(0.07, 0.15, 0.31)	(0.02, 0.09, 0.28)	(0.02, 0.07, 0.25)	(0.04, 0.11, 0.31)	(0.03, 0.10, 0.31)	(0.03, 0.09, 0.28)
$\tilde{c}_3$	(0, 0.18, 0.37)	(0.04, 0.1, 0.33)	(0.04, 0.11, 0.3)	(0.03, 0.10, 0.33)	(0.03, 0.13, 0.37)	(0.03, 0.11, 0.33)
$\tilde{c}_4$	(0.05, 0.13, 0.32)	(0.02, 0.07, 0.26)	(0.02, 0.08, 0.29)	(0.02, 0.07, 0.29)	(0.02, 0.08, 0.29)	(0.02, 0.09, 0.32)
$\tilde{c}_5$	(0.03, 0.15, 0.34)	(0.01, 0.1, 0.34)	(0.01, 0.09, 0.31)	(0.01, 0.09, 0.31)	(0.01, 0.09, 0.34)	(0.01, 0.1, 0.34)
$\tilde{S}_i$	(0.32, 0.8, 1.7)	(0.11, 0.47, 1.57)	(0.11, 0.46, 1.47)	(0.11, 0.46, 1.53)	(0.12, 0.51, 1.64)	(0.13, 0.53, 1.64)

S_i	0.943	0.717	0.680	0.702	0.754	0.763
Q_i	1	0.76	0.72	0.74	0.80	0.81

TABLE 11: Five supplier's data from Eva Air's outsource research.

Suppliers	Average purchase cost (NT\$1000/month)	Quantitative criteria	
		Service capability items	Operation experience (years)
S_1	4500–5200	4–7	14
S_2	4620	3–5	10
S_3	3450–3800	5	8
S_4	4200	2–6	11
S_5	5350	4	9

MSGP method to get the best supplier selection procedure.

Furthermore, following the business strategy by EVA Air, the top managers of EVA Air established other goals to determine the supplier selection criteria as follows:

G_1 : minimizes average purchase cost, such as $f_1(x) \leq 5300$ (NT\$ 1000/month).

G_2 : more services capability items, such as $f_2(x) \geq 5$ items.

G_3 : more operation experience, such as $f_3(x) \geq 12$ years.

G_4 : the highest weighted of supplier, such as $f_4(x) = 1$.

To select the best in-flight duty-free product supplier, EVA Air outsources market research of the suppliers' sales

records from the last five years. The relation coefficients of variables in the supplier profiles are displayed in Table 11, which indicates the data set and ranges for all suppliers.

Consider the quantitative criteria in Table 10 and the integration of fuzzy MSGP method for supplier selection decision issue adapted from equation (13) to allow one-sided deviations as follows:

$$\text{Min } Z = d_1^+ + d_2^- + d_3^- + d_4^+ + d_4^- + e_1^+ + e_2^+ + e_3^- + e_4^- + e_5^-. \quad (17)$$

Satisfy all obligatory goals:

$$\text{s.t., } (4500b_1 + 5200(1 - b_1))x_1 + 4620x_2 + (3450b_2 + 3800(1 - b_2))x_3 + 4200x_4 + 5350x_5 - d_1^+ + d_1^- = 5300. \quad (18)$$

For purchase cost minimization goal:

$$\frac{1}{700(4500b_1 + 5200(1 - b_1))} - e_1^+ + e_1^- = 7.43. \quad (19)$$

Minimization of purchase cost for S_1 :

$$\frac{1}{350(3450b_2 + 3800(1 - b_2))} - e_2^+ + e_2^- = 10.85. \quad (20)$$

Minimization of purchase cost for S_3 :

$$(4b_3 + 7(1 - b_3))x_1 + (3b_4 + 5(1 - b_4))x_2 + 5x_3 + (2b_5 + 6(1 - b_5))x_4 + 5x_5 - d_2^+ + d_2^- = 5. \quad (21)$$

Maximization of service capability items:

$$\frac{1}{3(4b_3 + 7(1 - b_3))} - e_3^+ + e_3^- = 3.33. \quad (22)$$

Maximization of service capability items for S_1 :

$$\frac{1}{2(3b_4 + 5(1 - b_4))} - e_4^+ + e_4^- = 3.50. \quad (23)$$

Maximization of service capability items for S_2 :

$$\frac{1}{4(2b_5 + 6(1 - b_5))} - e_5^+ + e_5^- = 2.50. \quad (24)$$

Maximization of service capability items for S_4 :

$$14x_1 + 10x_2 + 8x_3 + 11x_4 + 9x_5 - d_3^+ + d_3^- = 12. \quad (25)$$

Maximization of operation experience:

$$0.76x_1 + 0.72x_2 + 0.74x_3 + 0.80x_4 + 0.81x_5 + d_4^- = 1. \quad (26)$$

For weighing supplier goal

$$b_i \in \{0, 1\}, \quad i = 1, 2, 3, \dots, 5. \quad (27)$$

represents the binary number

$$\begin{aligned} d_i^+, d_i^- &\geq 0, \quad i = 1, 2, \dots, 4, \\ e_i^+, e_i^- &\geq 0, \quad i = 1, 2, \dots \end{aligned} \quad (28)$$

represents the deviation from the target.

The integration fuzzy MSGP model was solved using LINGO software [48] on a Pentium (R) 4 CPU 2.00 GHz-based microcomputer in a few seconds of computer processing time. The solutions are as follows:

$$\begin{aligned} x_2 &= 1, \\ x_1 &= 0, \\ x_3 &= 0, \\ x_4 &= 0, \\ x_5 &= 0. \end{aligned} \quad (29)$$

Therefore, according to the results, based on the involvement of quantitative criteria survey in the best supplier to EVA Air, the S_2 should be selected as the in-flight duty-free product supplier. This result differs from the previous results since the integration fuzzy MSGP method considers qualitative and quantitative criteria at the same time as the decision supplier.

TABLE 12: Comparison of supplier selection methods.

Methods*	Selection criteria		Multisegment aspiration levels
	Qualitative	Quantitative	
LP/GP	No	Yes	No
AHP/ANP	Yes	No	No
DEA	No	Yes	No
CBE	No	Yes	No
NN	Yes	No	No
DEMATEL	No	Yes	No
TOPSIS	Yes	No	No
AHP (or ANP)+TOPSIS	Yes	No	No
Fuzzy ARAS	Yes	No	No
This proposed method (FAHP + FARAS + MSGP)	Yes	Yes	Yes

*Please see Appendix A for all these abbreviations.

5. Conclusions

The air travel market in Taiwan has witnessed both domestic and international competitions in recent years. Therefore, in-flight retail product revenue has become an essential key to the competitiveness and long-term survival of the airline industry. The appropriate selection of a sustainable supplier is important to ensure the quality of in-flight duty-free products to increase consumer satisfaction. This paper offers a new integration method using a combination of fuzzy AHP, fuzzy ARAS, and MSGP to select the best supplier in the airline industry.

The supplier selection problem comprises many multi-segment aspiration levels that may exist such as supplier's average purchase cost; thus, this integrated approach allows the DMs to set multi-aspiration levels for supplier evaluation. The contribution of this integrated method is it enables simultaneous consideration of both tangible (qualitative) and intangible (quantitative) criteria as well as both "higher is better" (e.g., benefit criteria) and "lower is better" (e.g., cost criteria) in in-flight retailing supplier's selection problem. To the best of our knowledge, no researcher has been performed to solve supplier selection problems using an integrated fuzzy view of AHP, ARAS, and MSGP approaches. Table 12 shows the superiority of this proposed method with others. The main advantage of this paper is to propose an efficient and simple reference method to help airlines in selecting the best in-flight duty-free product supplier. The findings show that when considering qualitative criteria by using FARAS method, the best supplier was identified as S_1 . However, if qualitative and quantitative criteria (e.g., four tangible constraints) were incorporated into the FARAS-MSGP model, the best supplier is calculated as S_2 .

The main limitation of the proposed method is that it may complicate the supplier selection problem because of more complicated vagueness and imprecision of goals, constraints, and parameters in decision-making. Therefore, future work could link the fuzzy MSGP approach in supplier selection problems. Moreover, the proposed approach can be useful for many fuzzy MCDM issues, for example, supplier-related activity selection, supplier segmentation or in-flight shopping marketing, and airline project management when available information is vague, imprecise, and uncertain. In addition, in future, research

can consider combining DEMATEL, MSGP, and TOPSIS methods into the proposed model to reduce the number of criteria comparisons and achieve a more objective direction [49, 50].

Abbreviation

LP/GP:	Linear programming/goal programming
AHP/ANP:	Analytical hierarchy process/analytical network process
DEA:	Data envelopment analysis
CBM:	Cost-based method
NN:	Neural network
DEMATEL:	Decision-making trial and evaluation
TOPSIS:	Techniques for order preference by similarity to ideal solution
FAHP:	Fuzzy analytical hierarchy process (FAHP)
FARAS:	Fuzzy additive ratio assessment
MSGP:	Multisegment goal programming.

Data Availability

The data used to support the findings of this study are included within the article.

Disclosure

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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