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PERFORMANCE EVALUATION OF AIRCRAFT MAINTENANCE STAFF USING A FUZZY MCDM APPROACH

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Abstract. *Airline companies today face formidable competitive pressure. To confront these problems and sustain competitive advantages, many companies have resorted to downsizing; this method, however, often results in the overworking of a small number of workers, especially in the case of aircraft maintenance staff, who are largely responsible for aviation safety. At the same time, during the staff annual appraisal reviews, which employ evaluation criteria that are considered equally important by most airlines, most staff members perceive themselves as underappreciated and question the fairness of the evaluation criteria. This fact influences morale and work quality, and such attitudes may possibly threaten flight safety. The aim of this research is to propose a performance evaluation model for aircraft maintenance staff, overcoming such problems by exploring the relative weights of various evaluation criteria to reflect the actual performance of workers as precisely as possible. This research takes the aircraft maintenance staff of C Airline as its case study object. A hybrid MCDM model, based on the fuzzy analytic hierarchy process (FAHP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), is utilized to analyze the data collected from the database of C Airline. Based on the research findings, it can be concluded that for C Airline, compared with conventional evaluation criteria with equal weights, the proposed performance evaluation model for the aircraft maintenance staff not only can better assess the staff's real performance and reward them in a more worthwhile manner but can also decrease complaints of unjust appraisals. Furthermore, according to the VIKOR analyses, taking the weights of different evaluation criteria into account can help each staff member locate the aspects of his or her work that most need improvement.*
Keywords: Performance evaluation, MCDM, Airline, Fuzzy analytic hierarchy process (FAHP), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

1. **Introduction.** Setting aside the unique characteristics of operation capital and the skilled nature of the air transportation industry, one might say that each airline has the simple aim of providing its customers with a comfortable and safe experience while ensuring that they arrive at their desired destination on time. Of the different types of workers employed by any airline, the aircraft maintenance staff plays a critical role in helping to fulfill these aims; importantly, performance in this capacity will directly influence the

prestige and market share of a given airline in today's global air transportation industry. Hence, methods of strengthening performance development for aircraft maintenance staff have recently become a critical issue around the world, not only for each airline but also for governments.

Nonetheless, on the heels of negative phenomena that have emerged, such as low railway prices, high-speed rail development, continuous increases in petroleum prices, and the current financial crisis, downsizing has been widely adopted as a means of ensuring survival among the airlines. Consequently, a great number of workers have become overworked, especially aircraft maintenance staff, who are largely responsible for aviation safety. Furthermore, due to performance evaluation criteria being widely weighted equally, some staff members' performances may therefore be underestimated over the course of evaluations. This fact makes the staff question the justice of the performance evaluation standards, leading to decreased motivation and work quality and, thus, increased potential risks to flight safety.

Taiwan, as an island with frequent interaction and trade with foreign countries, is highly dependent on marine transit and air travel [1]; in addition, in comparison with that of marine transit, the influence of air travel is critical in determining the efficiency of interactions with foreign countries; thus, to improve the Taiwanese economy, the operational performance and market share of each airline have become key factors. In this regard, how to regain market share and improve the operation performance have become urgent issues for airlines that need to be handled quickly in such a fiercely competitive global air transportation environment.

Based on the above considerations, the aim of this study is to overcome such difficulties by exploring the relative weights of evaluation criteria and, furthermore, by measuring the performance of workers as precisely as possible. The aircraft maintenance staff of a case airline (C Airline) in Taiwan is taken as an example. Because a number of evaluation dimensions and criteria are taken into account, this research proposes a hybrid multiple-criteria decision-making (MCDM) evaluation model using the fuzzy analytic hierarchy process (FAHP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR). The FAHP method is widely used for MCDM [2-6]; the practical applications reported in the literature have indicated a comparatively strong performance in handling unquantifiable/qualitative criteria and have obtained decidedly reliable results [7]. In addition, the VIKOR method was developed as an MCDM method for use in solving discrete decision problems with non-commensurable and conflicting criteria [8,9]. Unlike the overly subjective nature of the simple average weighted (SAW) method, the VIKOR method emphasizes ranking and selecting from a set of alternatives and determining compromise solutions to problems involving conflicting criteria, thus helping the decision-makers reach their final decisions [9]. Therefore, in the current study, FAHP is first used to calculate the relative weights of the evaluation criteria, and then VIKOR is adopted to rank the performance of each aircraft maintenance staff member with respect to the relative weight of each criterion.

The rest of this paper is organized as follows. Performance evaluation from the employee perspective is discussed in Section 2. The problems of the case airline (C Airline) are described in Section 3. The fuzzy analytic hierarchy process (fuzzy AHP) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) are introduced in Sections 4 and 5. An empirical study is described in Section 6. Conclusions are discussed in the last section.

2. **Performance Evaluation from the Employees' Perspective.** Performance evaluation has recently become an important issue for both practitioners and researchers

[10-13] due to today's globalization resulting from international competition. The performance evaluation is conceptualized as a system for confirming whether an organization is operating well and in accordance with organizational goals. Generally, methods to evaluate employee performance can be categorized as quantifiable or unquantifiable. The former includes absence rates, rates of late arrival and teamwork performance [14]; the ratio of promotion each year [15]; and unit employee cost, profit and productivity [16]. The latter includes the degree of activity [17], employee motivation [15], personal commitment and innovation ability [16]; communications (e.g., oral and written communication and listening comprehension); and self-motivation ability, interpersonal skills, and self-decision–making ability [18]. Second, there is the question of in-role versus extra-role action [19]. The former represents one's action insofar as they satisfy formal and basic requirements; the latter represents one's action outside of what needs to be done, as in the case of organizational citizen behavior [20].

A large amount of literature has pointed out that performance evaluation is critical for an employee's self-definition regarding his or her work [21], short-term goal screening, and long-term goal planning [22,23]. That is, a positive performance evaluation leads an employee to pursue higher performance [24,25] through ambitious intentions with regard to work [26-33], and thus, evaluations need to be effective and fair. Nevertheless, mainstream studies have found that the evaluation systems for many companies today are ineffective or even unfair, making employees feel that they are just wasting time on administrative matters in the long run, which results in employee dissatisfaction, apathy, pessimism, turnover and even lawsuits [34]. To overcome these problems, recent studies have claimed that it is necessary to develop a system for effective performance evaluation that includes a series of evaluation dimensions and criteria, in accordance with an organization's characteristics [35]. For fair evaluation processes, it is necessary to consider the different level of importance of each evaluation dimension and criterion [36].

3. Problems of the Case Airline (C Airline).

Based on an anonymous manager's indications, it would seem that salary adjustments for workers each year are theoretically in accordance with performance evaluations from the previous year. On average, the degree of adjustment is 3% and the upper and lower bounds are 6% to 0%, respectively. However, in practice, the baseline adjustment is often set at 2.5%, with an extra 0.5% used to reward those employees who exhibit higher performance.

Nevertheless, as stated previously, with unfavorable conditions, including the cheaper price of railways, the development of high-speed railways, the increasing price of petroleum, and the economic depression, and although the top managers of C Airline claim that operational revenue still continues to climb each year, the real profit does not truly reflect this claim, and thus, the rewards for workers are not as generous as in the past. Furthermore, due to downsizing, which has resulted in drastic increases in employee workloads, a majority of workers (and especially aircraft maintenance staff) have revealed that their rewards do not correspond to what they have accomplished. Despite rising requests for increasing rewards, improvement is still limited; specifically, a number of aircraft maintenance staff members have found that the increase ranges only from 1% to 2.5%; that is, few of them can obtain an increase of 3% or higher. The insufficiency of their rewards has led them to start questioning the justice of performance evaluation standards and has thus resulted in decreases in motivation and work quality. Overall, this pattern represents a potential risk to flight safety, which is not good news for the future survival of C Airline. To properly address the above dilemma, C Airline must recognize the urgent need to develop a precise and just performance evaluation standard, not only to decrease the qualms of workers but also to eliminate future risks to flight safety. This study aims to resolve such difficulties by taking the aircraft maintenance staff of C Airline as an example and exploring the relative weights of the evaluation criteria at play, as well as the actual performance of C Airline's employees, as precisely as possible.

4. **Fuzzy Analytic Hierarchy Process (FAHP).**

4.1. **Fuzzy set theory.** Fuzzy set theory was first developed in 1965, when Professor L. A. Zadeh [6] was trying to solve fuzzy phenomenon problems that exist in the real world, such as uncertain, incomplete, unspecific and fuzzy situations. Fuzzy set theory has more advantages in describing set concepts in human language than traditional set theory. It demonstrates the unspecific and fuzzy characteristics of language through evaluation and uses a membership function concept to represent the field in which a fuzzy set can permit situations such as "incompletely belonging to" and "incompletely not belonging to". Currently, the practical applications reported in the literature have indicated the advantages of fuzzy set theory for acquiring more precise and subjective results [37-41]. For this reason, to avoid possible objective scoring by senior sample experts, fuzzy set theory has been incorporated into the expert questionnaire.

4.2. **Fuzzy number.** We order the Universe of Discourse such that U is a whole target that we discuss, and each target in the Universe of Discourse is called an element. We have fuzzy $\tilde{A}$, which on U states that random $x \to U$, appointing a real number $\mu_{\tilde{A}}(x) \to [0,1]$. We call anything above that level of x *under* A.

The universe of real number R is a triangular fuzzy number (TFN): $\tilde{A}$, which means $x \in R$, appointing $\mu_{\tilde{A}}(x) \in [0,1]$, and

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-L)/(M-L), & L \le x \le M, \\ (U-x)/(U-M), & M \le x \le U, \\ 0, & \text{otherwise}, \end{cases} \tag{1}$$

The triangular fuzzy number above can be shown as $\tilde{A} = (L, M, U)$, where L and U represent fuzzy probabilities between the lower and upper boundaries of evaluation information, as shown in Figure 1. Assume two fuzzy numbers, $\tilde{A}_1 = (L_1, M_1, U_1)$ and $\tilde{A}_2 = (L_2, M_2, U_2)$; then

$$\tilde{A}_1 \oplus \tilde{A}_2 = (L_1, M_1, U_1) \oplus (L_2, M_2, U_2) = (L_1 + L_2, M_1 + M_2, U_1 + U_2) \tag{2}$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (L_1, M_1, U_1) \otimes (L_2, M_2, U_2) = (L_1 L_2, M_1 M_2, U_1 U_2), \quad L_i > 0, M_i > 0, U_i > 0 \tag{3}$$

$$\tilde{A}_1 - \tilde{A}_2 = (L_1, M_1, U_1) - (L_2, M_2, U_2) = (L_1 - U_2, M_1 - M_2, U_1 - L_2) \tag{4}$$

$$\tilde{A}_1 \div \tilde{A}_2 = (L_1, M_1, U_1) \div (L_2, M_2, U_2) = (L_1/U_2, M_1/M_2, U_1/L_2), \quad L_i > 0, M_i > 0, U_i > 0 \tag{5}$$

$$\tilde{A}_1^{-1} = (L_1, M_1, U_1)^{-1} = (1/U_1, 1/M_1, 1/L_1), L_i > 0, M_i > 0, U_i > 0 \tag{6}$$

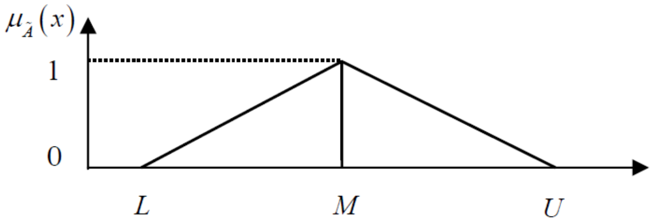

FIGURE 1. Triangular fuzzy number

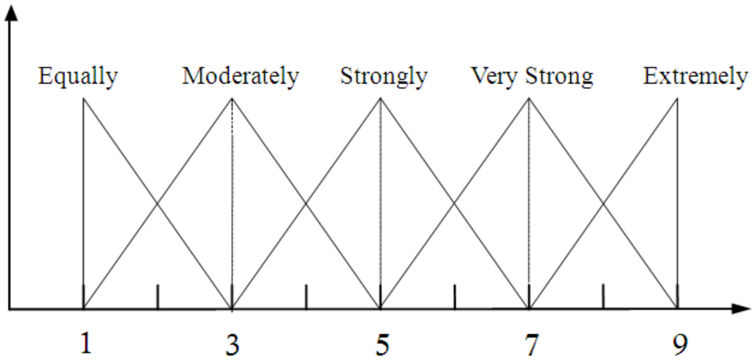

FIGURE 2. Fuzzy membership function for linguistic values for attributes

TABLE 1. Definition and membership function of fuzzy number

Fuzzy Number	Linguistic Variable	Triangular Fuzzy Number
$\tilde{9}$	Extremely important/preferred	(7,9,9)
$\tilde{7}$	Very strongly important/preferred	(5,7,9)
$\tilde{5}$	Strongly important/preferred	(3,5,7)
$\tilde{3}$	Moderately important/preferred	(1,3,5)
$\tilde{1}$	Equally important/preferred	(1,1,3)

4.3. **Fuzzy linguistic variable.** The fuzzy linguistic variable is a variable that reflects the different levels of human language. Its value represents the range from natural to artificial language. When one precisely reflects the value or meaning of a linguistic variable, there must be an appropriate way to change. Variables for a human word or sentence can be divided into numerous linguistic criteria, such as equally important, moderately important, strongly important, very strongly important, and extremely important, as shown in Figure 2, with definitions and descriptions as shown in Table 1. For the purpose of the present study, the 5-point scale (i.e., equally important, moderately important, strongly important, very strongly important and extremely important) is used.

4.4. **Calculation steps of FAHP.** The 4-step procedure of this approach is given as follows:

Step 1: Comparing the performance score

Assuming K experts, we proceed to decision-making on P alternatives with n criteria.

Step 2: Construct fuzzy comparison matrix

We use a triangular fuzzy number to represent the meaning of questionnaires, and we construct positive reciprocal matrices.

Step 3: Exam consistency of fuzzy matrix $\tilde{A}_i$

Assume that $A = [a_{ij}]$ is a positive reciprocal matrix and $\tilde{A} = [\tilde{a}_{ij}]$ is a fuzzy positive reciprocal matrix. If $A = [a_{ij}]$ is consistent, then $\tilde{A} = [\tilde{a}_{ij}]$ will be consistent also.

Step 4: Calculate fuzzy evaluation of number $\tilde{r}_i$

$$\tilde{r}_i = [\tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{in}]^{1/n} \tag{7}$$

Step 5: Calculate fuzzy weight $\tilde{W}_i$

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_i \oplus \cdots \oplus \tilde{r}_m)^{-1} \tag{8}$$

Step 6: Defuzzy

The study finds the best crisp value, or nonfuzzy value, in accordance with the Center of Area (COA) or Center Index (CI) concept, which was developed by Teng and Tzeng [42]. The concept means that we calculate clear weights for each index. The calculation method is as follows:

$$BNP_i = [(U_i - L_i) + (M_i - L_i)]/3 + L_i, \forall i \tag{9}$$

5. **VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR).** The VIKOR method was developed by Opricovic and Tzeng [8]. This method is based on compromise programming for MCDM. We assume that each alternative is evaluated according to a separate criterion function; the compromise ranking can be utilized by comparing the measure of closeness to the ideal alternative [43]. The multi-criteria measure for compromise ranking is developed from the L_p*-metric*, used as an aggregating function in a compromise programming method [44]. The numerous J alternatives are represented as $a_1, a_2, \ldots, a_J$. For alternative a_j, the rating of the ith aspect is denoted as f_{ij}; i.e., f_{ij} is the value of the ith criterion function for the alternative a_j, and n is the number of criteria [43]. VIKOR method development started with the form L_p*-metric*, shown as follows [8]:

$$L_{P,j} = \left\{ \sum_{i=1}^{n} \left(w_i \frac{|f_i^* - f_{ij}|}{|f_i^* - f_i^-|} \right)^p \right\}^{1/p}, \quad j = 1, 2, \ldots, m \quad 1 \le p \le \infty \tag{10}$$

In the VIKOR method, $L_{1,j}$ (representing S_j as follows) and $L_{\infty,j}$ (representing R_j as follows) are used to formulate ranking measures. The solution gained via $\min_j S_j$ has the maximum group utility, and the solution gained by $\min_j R_j$ has a mix of the individual regret of the "opponent". The compromise solution F^c is the solution that is the closest to the ideal F^*, with an agreement established by mutual concessions, as shown in Figure 3 by $\Delta f_1 = f_1^* - f_1^c$ and $\Delta f_2 = f_2^* - f_2^c$ [8].

There are five VIKOR calculation steps, shown as follows [8,9,43]:

Step 1: Decide the best f_i^* and worst f_i^- values of all criterion functions $i = 1, 2, \ldots, n$. If the ith function represents a benefit, then:

$$f_i^* = \max_j f_{ij}, \quad f_i^- = \min_j f_{ij} \tag{11}$$

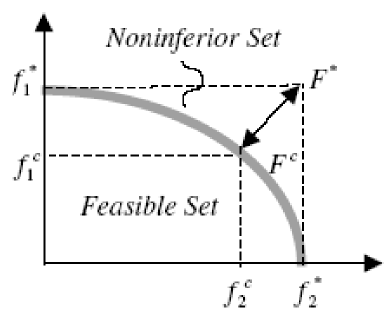

Figure 3. Ideal and compromise solutions [8]

Step 2: Calculate the values S_j and R_j; $i = 1, 2, \ldots, J$ using the equations

$$S_j = \sum_{i=1}^{n} w_i(f_i^* - f_{ij})/(f_i^* - f_i^-) \tag{12}$$

$$R_j = \max_i \left[w_i(f_i^* - f_{ij})/(f_i^* - f_i^-)\right] \tag{13}$$

where w_i are the weights of the criteria, expressing their relative importance.

Step 3: Calculate the values Q_j, $j = 1, 2, \ldots, J$, by the relation

$$\begin{aligned} &Q_j = v(S_j - S^*)/(S^- - S^*) + (1 - v)(R_j - R^*)/(R^- - R^*), \\ &S^* = \min_j S_j,\ S^- = \max_j S_j \\ &R^* = \min_j R_j,\ R^- = \max_j R_j \end{aligned} \tag{14}$$

and v is introduced as the weight of the strategy in terms of the maximum group utility, here $v = 0.5$.

Step 4: Alternatives ranking, sorted by the values S, R and Q, in decreasing order. The results are three ranking lists.

Step 5: We propose as a compromise solution the alternative (d), which is ranked best by the measure Q (min) if it satisfies the following two conditions:

1. $Q(a'') - Q(a') \geqslant DQ$, which is called acceptable advantage, where a'' is the alternative in second place in the ranking list according to $DQ = 1/(J-1)$ and J is the number of alternatives.
2. Acceptable stability in decision-making: Alternative d must also be the best ranked by S or/and R. This solution is stable in a decision-making process, which could be as follows: "voting by majority rule" (when $v > 0.5$ is needed), "by consensus" ($v \approx 0.5$), or "with veto" ($v < 0.5$). Here, v is the weight of the decision-making strategy based on the maximum group utility.

If the conditions cannot be fully satisfied, then a set of compromise solutions is proposed, which is shown as the following:

1. Alternatives a' and a'' if only Condition 2 is not satisfied, or
2. Alternatives $a', a'', \ldots, a^{(M)}$ if Condition 1 is not satisfied, and $a^{(M)}$ is determined by the relation $Q(a^{(M)} - Q(a') < DQ$ for Max M.

The best alternative ranked by Q is the one with the minimum value of Q. The main ranking result is the compromise ranking list of alternatives, along with the compromise solution with the advantage rate [45].

Ranking by utilizing the VIKOR method means the performance of different values of criterion weights and an analysis of the impact of criterion weights on the proposed compromise solution. This method determines weight stability intervals by using the methodology cited in Opricovic [46]. The compromise solution gained with the initial weights (w_i, $i = 1, \ldots, n$) will be replaced if the value of a weight is not in the stability interval. The analysis of weight stability intervals for a single criterion is utilized for all criterion functions, with the given initial values of weights; in this way, the preference stability of a gained compromise solution may be analyzed using the VIKOR program [8].

VIKOR is a tool that benefits MCDM in situations in which the decision-maker is unstable at the beginning of the system design; in addition, decision-makers accept the compromise solution obtained because it provides maximum group utility, as represented by Min Q, and a minimum of individual regret, as represented by Min R [45].

6. **An Empirical Study.**

6.1. **The construction of the hierarchical structure for performance evaluation.** Constructing the hierarchical structure for performance evaluation is complicated because of the various operation styles of the airlines. To acquire precise results, in this study, the formal performance evaluation standards (four dimensions and 11 criteria) of the aircraft maintenance staff for the case airline (C Airline) are thus adopted. The definitions of the performance evaluation criteria are listed in Table 2. There are four evaluation dimensions: Professional (P), Innovation (I), Team (T) and Discipline (D). Each dimension includes two or three evaluation criteria. The Professional (P) dimension contains three criteria: Basic Knowledge (P1), Aircraft Maintenance Workload (P2) and Other Workload (P3). Innovation (I) also comprises three criteria: Self-Development (I1), Problem-Solving Skill (I2) and Problem-Solving Attitude (I3). Two criteria, Responsibility (T1) and Teamwork (T2), are under the Team (T) dimension. Additionally, three criteria, Work Quality (D1), Reliability (D2) and Attendance Rate (D3), belong to the Discipline (D) dimension. In addition, because there are 51 aircraft maintenance staff members working for C Airline, all of them are therefore involved in this study of performance evaluations. The hierarchical structure of performance evaluation is illustrated in Figure 4. To solicit expert opinions on the importance of these evaluation dimensions and criteria, a questionnaire was sent to a total of 12 domain experts; each expert has at least 10 years of related background working at C Airline. Their weightings utilized the 5-point scale shown in Table 1 with respect to the importance of evaluation dimensions and criteria. Additionally, with respect to the 51 aircraft maintenance staff members' performance evaluations, scoring within a range of 5 (the best) to 1 (the worst) was adopted, in accordance with the experts' professional experiences.

6.2. **Weighting evaluation dimensions and criteria by using FAHP.** Upon completing the construction of the hierarchical structure, we can see that the weights of each evaluation dimension and criterion are obtained using the FAHP. The global weights of the evaluation dimensions and local weights of the evaluation criteria were acquired first, with each fuzzy measuring matrix formed in the same manner. All pairwise comparisons

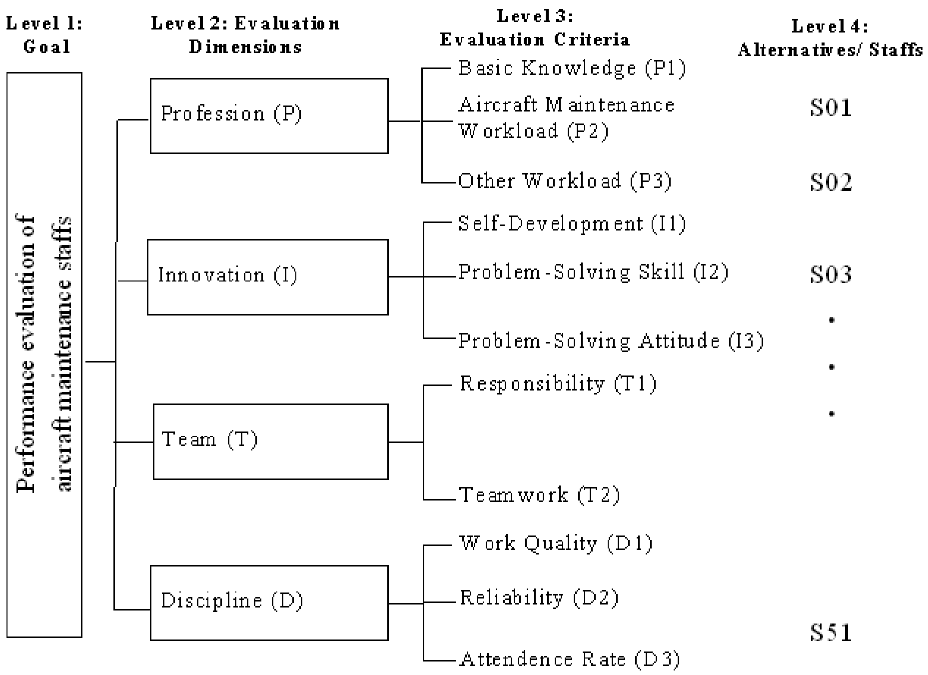

FIGURE 4. The hierarchical structure of performance evaluation

TABLE 2. The definitions of performance evaluation criteria

Evaluation Dimensions	Evaluation Criteria	Definitions
Professional (P)	Basic Knowledge (P1)	How much general education / specialized training in aircraft maintenance the staff member has
	Aircraft Maintenance Workload (P2)	How many work hours the staff member spends on aircraft maintenance work
	Other Workload (P3)	How many work hours the staff member spends on aircraft maintenance, excluding aircraft maintenance jobs
Innovation (I)	Self-Development (I1)	How the staff member can plan for his/her future (career)
	Problem-Solving Skill (I2)	How well the staff member can apply tools/techniques to solving problems
	Problem-Solving Attitude (I3)	What attitude the staff member takes toward solving problems
Team (T)	Responsibility (T1)	If the staff member is accountable with regard to his/her tasks
	Teamwork (T2)	How the staff member can coordinate his/her efforts with others (i.e., spirit of cooperation)
Discipline (D)	Work Quality (D1)	The quality of the results of the staff member's work
	Reliability (D2)	If the staff member is trustworthy (i.e., can he/she achieve what's been promised?)
	Attendance Rate (D3)	How often the staff is present at the workplace on workdays

Source: Internal data obtained from the personnel office of C Airline

TABLE 3. Pairwise comparison matrix and global weights of evaluation dimension

Evaluation Dimension	Profession (P)			Innovation (I)			Team (T)			Discipline (D)			BNP	Global Weight*
Profession (P)	1.000	1.000	3.000	1.649	2.415	4.333	0.850	1.353	2.962	0.702	1.089	2.608	0.528	0.347
Innovation (I)	0.231	0.414	0.606	1.000	1.000	3.000	0.262	0.432	0.952	0.195	0.315	0.693	0.177	0.116
Team (T)	0.338	0.739	1.176	1.050	2.314	3.820	1.000	1.000	3.000	0.958	1.227	3.066	0.430	0.282
Discipline (D)	0.383	0.918	1.424	1.442	3.178	5.137	0.326	0.815	1.043	1.000	1.000	3.000	0.386	0.254

Note: * is standardized BNP

are based on Saaty's 9-point (see Table 1) scale, ranging from 1 (equally important) to 9 (extremely important). Obtained using the above six steps of the FAHP analysis process, the results for the global weights of the four evaluation dimensions and the local weights of the eleven evaluation criteria are given in Tables 3 to 7.

Then, using global weights for each dimension with six steps of fuzzy AHP, global weights for the evaluation criteria were analyzed. The results for the global weight of each evaluation criterion are given in the last column of Tables 4 to 7. Table 8 summarizes the results of the FAHP analyses. Based on the results, the most critical evaluation criterion is Basic Knowledge (P1) (0.201). The results reflect a phenomenon that the basic knowledge of aircraft maintenance staff is currently below the required standard, which could seriously impact the safety of the airline and further threaten the operation

Table 4. Pairwise comparison matrix and global weights of evaluation criteria (P1-P3)

Profession (P)	P1			P2			P3			BNP	Local Weight[a]	Global Weight[b]
P1	1.000	1.000	3.000	1.940	3.483	5.666	1.261	2.204	4.126	0.820	0.568	0.201
P2	0.177	0.287	0.516	1.000	1.000	3.000	2.024	3.926	5.509	0.414	0.287	0.100
P3	0.242	0.454	0.793	0.182	0.255	0.494	1.000	1.000	3.000	0.209	0.145	0.051

Note: 1. [a] is standardized BNP.
2. [b] is obtained by multiplying the local weight of the criterion and the global weight of its dimension.

Table 5. Pairwise comparison matrix and global weights of evaluation criteria (I1-I3)

Innovation (I)	I1			I2			I3			BNP	Local Weight[a]	Global Weight[b]
I1	1.000	1.000	3.000	0.623	0.979	2.218	0.417	0.610	1.176	0.444	0.305	0.037
I2	0.451	1.021	1.605	1.000	1.000	3.000	0.512	0.733	1.505	0.442	0.303	0.036
I3	0.850	1.639	2.397	0.664	1.308	1.953	1.000	1.000	3.000	0.572	0.392	0.046

Note: 1. [a] is standardized BNP.
2. [b] is obtained by multiplying the local weight of the criterion and the global weight of its dimension.

Table 6. Pairwise comparison matrix and global weights of evaluation criteria (T1-T2)

Team (T)	T1			T2			BNP	Local Weight[a]	Global Weight[b]
T1	1.000	1.000	3.000	0.744	0.856	2.280	0.788	0.542	0.160
T2	0.439	1.168	1.345	1.000	1.000	3.000	0.666	0.458	0.128

Note: 1. [a] is standardized BNP.
2. [b] is obtained by multiplying the local weight of the criterion and the global weight of its dimension.

Table 7. Pairwise comparison matrix and global weights of evaluation criteria (D1-D3)

Discipline (D)	D1			D2			D3			BNP	Local Weight[a]	Global Weight[b]
D1	1.000	1.000	3.000	1.000	1.000	3.000	2.280	4.401	6.435	0.704	0.501	0.123
D2	0.333	1.000	1.000	1.000	1.000	3.000	2.943	5.207	7.297	0.560	0.398	0.093
D3	0.155	0.227	0.439	0.137	0.192	0.340	1.000	1.000	3.000	0.142	0.101	0.025

Note: 1. [a] is standardized BNP.
2. [b] is obtained by multiplying the local weight of the criterion and the global weight of its dimension.

performance of C Airline. Therefore, to effectively improve the performance of the aircraft maintenance staff, enhancing basic knowledge, including general education/specialized training in aircraft maintenance, should be highly advocated. The other evaluation criteria within the top five are Responsibility (T1) (0.160), Teamwork (T2) (0.128), Work Quality (D1) (0.123) and Aircraft Maintenance Workload (P2) (0.100). In other words, considering the limited resources and the 80/20 principle, based on the resulting findings, it is proposed that rather than focusing on all evaluation criteria, C Airline should put more emphasis on the vital few criteria as follows: (1) whether the staff member is accountable with regard to his/her tasks, (2) how the staff member can coordinate his/her efforts with others (i.e., spirit of cooperation), (3) the quality of the results of the staff member's work and (4) how many work hours the staff member spends on aircraft maintenance.

6.3. **Ranking the performance of aircraft maintenance staff by using VIKOR.** Next, in this section, the VIKOR method for ranking the performance of the 51 aircraft

Table 8. The summarized results of FAHP analyses

Evaluation Dimensions/Criteria	BNP	Local Weight[a]	Global Weight[b]	Global Ranking[c]
Professional (P)	**0.528**	**0.347**		**1**
Basic Knowledge (P1)	0.820	0.568 (3)	0.201	1
Aircraft Maintenance Workload (P2)	0.414	0.287 (2)	0.100	5
Other Workload (P3)	0.209	0.145 (1)	0.051	7
Innovation (I)	**0.177**	**0.116**		**4**
Self-Development (I1)	0.444	0.305 (2)	0.037	9
Problem-Solving Skill (I2)	0.442	0.303 (3)	0.036	10
Problem-Solving Attitude (I3)	0.572	0.392 (1)	0.046	8
Team (T)	**0.430**	**0.282**		**2**
Responsibility (T1)	0.788	0.542 (1)	0.160	2
Teamwork (T2)	0.666	0.458 (2)	0.128	3
Discipline (D)	**0.386**	**0.254**		**3**
Work Quality (D1)	0.704	0.501 (1)	0.123	4
Reliability (D2)	0.560	0.398 (2)	0.093	6
Attendance Rate (D3)	0.142	0.101 (3)	0.025	11

Note: 1. [a] is standardized BNP.
2. [b] is obtained by multiplying both the local weight of the criterion and its dimension.
3. [c] is ranked by global weights.
4. ( ) indicates the local ranking within each dimension.

maintenance staff members is used, based on the global weights of the evaluation criteria (See Table 8). Because some of the evaluation criteria are non-quantifiable, to make the results consistent and precise, a range from 1 (the worst) to 5 (the best) is used, in accordance with the perception of senior experts with professional experience in scoring. First, the original values shown in Table 9 are obtained by averaging all the experts' scores. To achieve the highest possible level [47], f_i^* should be set to 5 (the best) and f_i^- to 1 (the worst), instead of using Equation (11). From Equations (12) and (13), S_j and R_j are then calculated, respectively. After that step, the value of Q is obtained by using Equation (14), where $v = 0.5$, which stands for voting by consensus. Last, according to the Q values, the rankings of the 51 aircraft maintenance staff members are finally acquired. The results for the VIKOR evaluation values and the rankings of the aircraft maintenance staff at C Airline are summarized in Tables 10 and 11.

To validate the differences between un-weighted and weighted performance, the Spearman rank order correlation coefficient is also adopted. The results are provided in Table 12. Consistent with the results, it appears that there is no significant relationship between the two ($r_s = 0.967$, $p = 0.077$); that is, the ranking result based on the proposed evaluation model indeed differs from that achieved using the current model. Also, consistent with the results for the staff performance adjustment rate, nearly half (43%) of the staff's performance was overrated and 39% of the staff's performance was underrated; that is, only 18% of the overall staff had their performance evaluated fairly. Performance evaluation using equal weights for all criteria is proved to be inequitable. However, it seems that performance evaluation with weighted criteria can justly demonstrate the differences in performance among staff members. In other words, the ranking by the weighted evaluation model can appropriately reflect the real performance of the aircraft maintenance staff of C Airline because of its distinguishing performance regarding the different importance of tasks (evaluation criteria). As referred to previously, for the aircraft maintenance staff of C Airline, their current performance evaluation system has not been deemed "fair". As indicated in Table 12, it was found that 82% of the aircraft maintenance staff's rankings were changed, and nearly half of the staff was unjustly rated, which can explain why the current unweighted performance evaluation system of C Airline is unable to satisfy the aircraft maintenance staff. Therefore, these research results verify the real practice of the performance evaluation of the aircraft maintenance staff of C Airline through a comparison of empirical data.

TABLE 9. The average of original performance value given by experts

Alternatives (Staff)	Profession (P)			Innovation (I)			Team (T)		Discipline (D)			Total*	Ranking
	P1	P2	P3	I1	I2	I3	T1	T2	D1	D2	D3		
S 01	2.800	3.000	2.900	2.900	3.300	2.800	2.900	3.100	3.000	3.100	3.300	33.100	47
S 02	3.375	3.625	3.500	3.375	3.750	3.500	3.500	3.500	3.500	3.875	4.000	39.500	11
S 03	2.750	3.000	2.875	3.250	2.750	3.375	3.000	3.000	3.000	3.125	3.625	33.750	46
S 04	3.125	3.125	3.500	3.375	3.500	3.250	3.250	3.500	3.500	3.500	3.750	37.375	25
S 05	3.375	3.125	3.250	3.125	3.500	3.500	3.125	3.500	3.375	3.375	3.625	36.875	29
S 06	3.375	3.000	3.000	3.125	2.875	3.500	3.125	3.250	3.000	3.375	3.625	35.250	39
S 07	3.625	3.500	3.250	3.875	3.625	3.625	3.250	3.375	3.625	3.750	3.875	39.375	12
S 08	2.500	2.750	2.750	3.000	2.500	3.000	2.875	2.750	3.000	2.625	2.875	30.625	50
S 09	3.125	3.500	3.375	3.125	3.625	3.125	3.500	3.375	3.375	3.375	3.625	37.125	28
S 10	3.375	3.125	3.125	2.875	3.375	2.875	3.125	3.625	3.500	3.375	3.875	36.250	33
S 11	2.875	3.375	3.250	3.500	3.500	3.500	3.375	3.625	3.375	3.500	3.750	37.625	23
S 12	2.875	3.250	3.250	3.625	3.625	3.625	3.250	3.500	3.500	3.750	3.500	37.750	21
S 13	3.250	3.500	3.375	3.750	4.000	3.500	3.750	3.750	3.625	4.000	3.875	40.375	7
S 14	2.875	3.125	3.125	3.250	3.625	3.125	3.125	3.375	3.375	3.375	3.625	36.000	34
S 15	3.125	3.125	3.250	3.250	3.875	3.125	3.250	3.500	3.250	3.375	3.625	36.750	30
S 16	3.125	3.500	3.000	3.625	3.625	3.375	3.375	3.500	3.500	3.500	3.500	37.625	23
S 17	3.000	3.375	3.375	3.750	3.625	3.500	3.375	3.625	3.500	4.000	3.625	38.750	15
S 18	3.000	3.125	3.125	3.000	3.375	2.875	3.250	3.375	3.375	3.125	3.375	35.000	40
S 19	3.625	3.875	3.750	3.750	3.875	3.500	3.500	4.000	4.125	3.875	4.375	42.250	3
S 20	3.500	3.625	3.500	3.750	3.875	3.750	3.625	3.750	3.625	3.875	4.125	41.000	4
S 21	3.125	3.250	3.125	3.500	3.500	3.500	3.250	3.625	3.250	3.500	3.750	37.375	25
S 22	2.750	3.125	2.875	3.125	3.250	3.000	3.250	3.125	3.000	3.250	3.250	34.000	45
S 23	3.125	3.125	3.000	3.625	3.625	3.625	3.500	3.500	3.750	3.750	3.750	38.375	17
S 24	3.750	4.000	3.750	4.000	4.125	3.875	4.000	4.000	3.750	4.500	4.375	44.125	1
S 25	3.875	3.625	3.500	3.875	4.000	4.375	3.750	3.750	3.750	4.000	3.875	42.375	2
S 26	3.250	3.375	2.750	3.625	3.375	3.625	3.500	3.375	3.125	3.625	3.625	37.250	27
S 27	3.500	3.750	3.500	3.375	3.750	3.750	3.750	3.750	3.750	3.875	3.750	40.500	6
S 28	3.375	3.500	3.500	3.125	3.625	3.375	3.500	3.625	3.750	3.375	3.750	38.500	16
S 29	3.125	3.750	3.875	3.375	3.875	3.625	3.500	3.750	3.875	3.750	3.875	40.375	7
S 30	3.125	3.375	3.250	3.625	3.375	3.500	3.625	3.500	3.375	3.625	3.875	38.250	18
S 31	3.375	3.875	3.250	3.750	4.000	3.875	3.875	3.625	3.625	3.750	3.875	40.875	5
S 32	3.000	3.375	2.875	3.375	3.500	3.375	3.375	3.375	3.250	3.750	3.500	36.750	30
S 33	3.375	3.625	3.375	3.500	3.875	3.500	3.500	3.625	3.625	3.875	3.875	39.750	10
S 34	2.250	2.750	2.500	3.000	3.000	2.875	2.750	2.875	3.125	2.875	3.500	31.500	48
S 35	3.000	3.125	3.000	3.125	3.125	3.500	3.250	3.250	3.125	3.375	3.875	35.750	36
S 36	3.625	3.125	3.000	3.000	3.125	3.375	2.875	3.000	3.125	3.125	3.625	35.000	40
S 37	2.875	3.000	2.875	3.250	3.125	3.500	3.375	2.875	3.000	3.500	3.375	34.750	42
S 38	3.750	3.000	2.875	2.875	3.375	3.000	3.250	3.250	3.500	3.250	3.625	35.750	36
S 39	3.125	3.500	3.125	3.625	3.625	3.625	3.625	3.375	3.250	3.750	3.375	38.000	19
S 40	3.375	3.500	3.125	3.625	3.625	3.750	3.375	3.500	3.750	3.750	3.750	39.125	14
S 41	3.000	3.125	3.000	3.375	3.500	3.250	3.375	3.375	3.625	3.500	3.500	36.625	32
S 42	3.250	3.750	3.125	3.750	3.750	3.500	3.750	3.500	3.500	3.750	3.625	39.250	13
S 43	3.500	3.500	3.625	3.750	3.625	3.625	3.625	3.750	3.625	3.875	3.875	40.375	7
S 44	2.625	2.750	2.500	3.000	2.750	3.250	3.250	2.750	2.750	2.875	2.875	31.375	49
S 45	3.250	3.250	3.750	3.125	3.625	3.250	3.250	3.500	3.500	3.375	4.000	37.875	20
S 46	3.125	3.250	2.750	3.000	2.875	3.375	3.250	3.125	2.750	3.375	3.750	34.625	43
S 47	2.750	2.625	2.500	3.125	2.750	3.000	2.875	2.750	2.750	3.000	2.375	30.500	51
S 48	2.750	3.000	3.625	2.875	3.125	3.250	3.000	3.250	3.000	3.000	3.500	34.375	44
S 49	3.125	3.500	3.250	3.250	3.750	3.375	3.500	3.375	3.500	3.500	3.625	37.750	21
S 50	3.250	3.125	3.250	2.750	3.500	3.125	3.125	3.250	3.375	3.375	3.875	36.000	34
S 51	3.750	3.375	2.625	3.375	3.125	3.375	3.125	3.125	3.000	3.250	3.500	35.625	38

Note: * is the unweighted total score of performance value.

TABLE 10. VIKOR evaluation value and the ranking of the aircraft maintenance staff of C Airline

Evaluation	Performance Evaluation [b]																									PIS/NIS		Relative Weight
Criteria	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	f_i^*	f_i^-	w_i [a]
P1	0.133	0.062	0.139*	0.093	0.062	0.062	0.031	0.170*	0.093*	0.062	0.123*	0.123*	0.077*	0.123*	0.093	0.093*	0.108*	0.108*	0.031	0.046	0.093	0.139*	0.093*	0.015	0.000	5	1	0.201
P2	0.073	0.028	0.073	0.064	0.064	0.073	0.037	0.091	0.037	0.064	0.046	0.055	0.037	0.064	0.064	0.037	0.046	0.064	0.010	0.028	0.055	0.064	0.064	0.001	0.028	5	1	0.100
P3	0.039	0.015	0.041	0.015	0.025	0.035	0.025	0.046	0.020	0.030	0.025	0.025	0.020	0.030	0.025	0.035	0.020	0.030	0.005	0.015	0.030	0.041	0.035	0.005	0.015	5	1	0.051
I1	0.037	0.021	0.025	0.021	0.029	0.029	0.004	0.033	0.029	0.037	0.016	0.012	0.008	0.025	0.025	0.012	0.008	0.033	0.008	0.008	0.016	0.029	0.012	0.000	0.004	5	1	0.037
I2	0.018	0.008	0.030	0.014	0.014	0.028	0.011	0.036	0.011	0.016	0.014	0.011	0.003	0.011	0.005	0.011	0.011	0.016	0.005	0.005	0.014	0.019	0.011	0.000	0.003	5	1	0.036
I3	0.046	0.025	0.029	0.033	0.025	0.025	0.022	0.040	0.037	0.044	0.025	0.022	0.025	0.037	0.037	0.029	0.025	0.044	0.025	0.018	0.025	0.040	0.022	0.014	0.000	5	1	0.046
T1	0.140*	0.064*	0.128	0.096*	0.112*	0.112*	0.096*	0.144	0.064	0.112*	0.080	0.096	0.032	0.112	0.096*	0.080	0.080	0.096	0.064*	0.048*	0.096*	0.096	0.064	0.000	0.032	5	1	0.160
T2	0.092	0.051	0.102	0.051	0.051	0.076	0.064	0.128	0.064	0.038	0.038	0.051	0.025	0.064	0.051	0.051	0.038	0.064	0.000	0.025	0.038	0.089	0.051	0.000	0.025	5	1	0.128
D1	0.103	0.057	0.103	0.057	0.068	0.103	0.045	0.103	0.068	0.057	0.068	0057	0.045	0.068	0.080	0.057	0.057	0.068	0.000	0.045	0.080	0.103	0.034	0.034*	0.034*	5	1	0.123
D2	0.065	0.029	0.064	0.046	0.052	0.052	0.035	0.087	0.052	0.052	0.046	0.035	0.0023	0.052	0.052	0.046	0.023	0.064	0.029	0.029	0.046	0.058	0.035	0.000	0.023	5	1	0.093
D3	0.018	0.006	0.013	0.011	0.013	0.013	0.009	0.026	0.013	0.009	0.011	0.015	0.009	0.013	0.013	0.015	0.013	0.017	0.000	0.004	0.011	0.019	0.011	0.000	0.009	5	1	0.025
S_j	0.765	0.366	0.746	0.500	0.515	0.609	0.378	0.903	0.487	0.521	0.494	0.502	0.305	0.599	0.540	0.466	0.430	0.605	0.177	0.273	0.505	0.697	0.431	0.069	0.172			
R_j	0.140	0.064	0.139	0.096	0.112	0.112	0.096	0.170	0.093	0.112	0.123	0.123	0.077	0.123	0.096	0.093	0.108	0.108	0.064	0.048	0.096	0.139	0.093	0.034	0.034			
Q_j	0.733	0.267	0.719	0.443	0.500	0.556	0.370	0.905	0.426	0.504	0.520	0.525	0.270	0.583	0.467	0.414	0.437	0.542	0.154	0.164	0.446	0.690	0.393	0.000	0.062			
Rank [c]	47	9	46	25	31	39	15	50	22	32	33	34	10	40	28	20	24	37	4	5	26	44	16	1	2			

Note: 1. [a] is the weight of each performance evaluation criterion (as shown in Table 8)

2. [b] is obtained from $w_i \frac{|f_i^* - f_{ij}|}{|f_i^* - f_i^-|}$ (the weighted value of the arithmetic average of the original performance evaluation value given by experts).

3. [c] are rankings based on the rules (the smaller the value of Q_j is, the better it is.).

4. * represents the worst performance of the 11 evaluation criteria in every staff member's performance evaluation values.

TABLE 11. VIKOR evaluation value and the ranking of the aircraft maintenance staff of C Airline (Continued)

Evaluation	Performance Evaluation[b]																										PIS/NIS		Relative Weight
Criteria	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40	S41	S42	S43	S44	S45	S46	S47	S48	S49	S50	S51	f_i^*	f_i^-	w_i [a]
P1	0.077	0.046*	0.062	0.093*	0.093*	0.062*	0.108*	0.062	0.201*	0.108*	0.031	0.123*	0.015	0.093*	0.062	0.108*	0.077*	0.046	0.154*	0.077	0.093	0.139	0.139*	0.093*	0.077	0.015	5	1	0.201
P2	0.046	0.019	0.037	0.019	0.046	0.010	0.046	0.028	0.091	0.064	0.064	0.073	0.073	0.037	0.037	0.064	0.019	0.037	0.091	0.055	0.055	0.101	0.073	0.037	0.064	0.046	5	1	0.100
P3	0.046	0.015	0.015	0.000	0.025	0.025	0.041	0.020	0.056	0.035	0.035	0.041	0.041	0.030	0.030	0.035	0.030	0.010	0.056	0.005	0.046	0.056	0.101	0.025	0.025	0.051	5	1	0.051
I1	0.012	0.021	0.029	0.021	0.012	0.008	0.021	0.016	0.033	0.029	0.033	0.025	0.037	0.012	0.012	0.021	0.008	0.008	0.033	0.029	0.033	0.029	0.037	0.025	0.042	0.021	5	1	0.037
I2	0.016	0.008	0.011	0.005	0.016	0.003	0.014	0.005	0.025	0.022	0.022	0.022	0.016	0.011	0.011	0.014	0.008	0.011	0.030	0.011	0.028	0.030	0.022	0.008	0.014	0.022	5	1	0.036
I3	0.022	0.018	0.029	0.022	0.025	0.014	0.029	0.025	0.044	0.025	0.029	0.025	0.040	0.022	0.018	0.033	0.025	0.022	0.033	0.033	0.029	0.040	0.033	0.029	0.037	0.029	5	1	0.046
T1	0.064	0.032	0.064*	0.064	0.048	0.016	0.080	0.064*	0.160	0.096	0.144*	0.080	0.096*	0.048	0.080*	0.080	0.032	0.048*	0.096	0.096*	0.096	0.144*	0.128	0.064	0.112*	0.112*	5	1	0.160
T2	0.064	0.025	0.038	0.025	0.051	0.038	0.064	0.038	0.115	0.076	0.102	0.115	0.076	0.064	0.051	0.064	0.051	0.025	0.128	0.051	0.089	0.128	0.076	0.064	0.076	0.089	5	1	0.128
D1	0.091*	0.034	0.034	0.022	0.068	0.045	0.080	0.045	0.091	0.091	0.091	0.103	0.057	0.080	0.034	0.045	0.057	0.045	0.126	0.057	0.126*	0.126	0.103	0.057	0.068	0.103	5	1	0.123
D2	0.041	0.029	0.052	0.035	0.041	0.035	0.035	0.029	0.075	0.052	0.064	0.046	0.058	0.035	0.035	0.046	0.035	0.029	0.075	0.052	0.052	0.069	0.069	0.046	0.0052	0.058	5	1	0.093
D3	0.013	0.011	0.011	0.009	0.009	0.009	0.015	0.009	0.015	0.009	0.013	0.017	0.013	0.017	0.011	0.015	0.013	0.009	0.026	0.006	0.011	0.034	0.015	0.013	0.009	0.015	5	1	0.025
S_j	0.492	0.258	0.381	0.314	0.434	0.265	0.531	0.342	0.906	0.608	0.628	0.671	0.523	0.448	0.380	0.525	0.355	0.290	0.848	0.472	0.657	0.896	0.706	0.460	0.576	0.561			
R_j	0.091	0.046	0.064	0.093	0.093	0.062	0.108	0.064	0.201	0.108	0.144	0.123	0.096	0.093	0.080	0.108	0.077	0.048	0.154	0.096	0.126	0.144	0.139	0.093	0.112	0.112			
Q_j	0.423	0.149	0.277	0.323	0.395	0.201	0.498	0.253	1.000	0.544	0.664	0.626	0.457	0.403	0.324	0.494	0.333	0.174	0.825	0.426	0.627	0.823	0.695	0.411	0.536	0.527			
Rank [c]	21	3	11	13	17	7	30	8	51	38	43	41	27	18	14	29	12	6	49	22	42	48	45	19	36	35			

Note: 1. [a] is the weight of each performance evaluation criterion (as shown in Table 8)

2. [b] is obtained from $w_i \frac{|f_i^* - f_{ij}|}{|f_i^* - f_i^-|}$ (the weighted value of the arithmetic average of the original performance evaluation value given by experts).

3. [c] are rankings based on the rules (the smaller the value of Q_j is, the better it is.).

4. * represents the worst performance of the 11 evaluation criteria in every staff member's performance evaluation values.

TABLE 12. The comparison between the unweighted and weighted performance

Staff	Current Performance Evaluation		Fuzzy MCDM Performance Evaluation		Distance*
	Un-weighted Value	Ranking [a]	Weighted Value	Ranking [b]	
S 01	33.100	47	0.733	47	0
S 02	39.500	11	0.267	9	(2)
S 03	33.750	46	0.719	46	0
S 04	37.375	25	0.443	25	0
S 05	36.875	29	0.500	31	(2)
S 06	35.250	39	0.556	39	0
S 07	39.375	12	0.370	15	3
S 08	30.625	50	0.905	50	0
S 09	37.125	28	0.426	22	(6)
S 10	36.250	33	0.504	32	(1)
S 11	37.625	23	0.520	33	10
S 12	37.750	21	0.525	34	13
S 13	40.375	7	0.270	10	3
S 14	36.000	34	0.583	40	6
S 15	36.750	30	0.467	28	(2)
S 16	37.625	23	0.414	20	(3)
S 17	38.750	15	0.437	24	9
S 18	35.000	40	0.542	37	(3)
S 19	42.250	3	0.154	4	1
S 20	41.000	4	0.164	5	1
S 21	37.375	25	0.446	26	1
S 22	34.000	45	0.690	44	(1)
S 23	38.375	17	0.393	16	(1)
S 24	44.125	1	0.000	1	0
S 25	42.375	2	0.062	2	0
S 26	37.250	27	0.423	21	(6)
S 27	40.500	6	0.149	3	(3)
S 28	38.500	16	0.277	11	(5)
S 29	40.375	7	0.323	13	6
S 30	38.250	18	0.395	17	(1)
S 31	40.875	5	0.201	7	2
S 32	36.750	30	0.498	30	0
S 33	39.750	10	0.253	8	(2)
S 34	31.500	48	1.000	51	3
S 35	35.750	36	0.544	38	2
S 36	35.000	40	0.664	43	3
S 37	34.750	42	0.626	41	(1)
S 38	35.750	36	0.457	27	(9)
S 39	38.000	19	0.403	18	(1)
S 40	39.125	14	0.324	14	0
S 41	36.625	32	0.494	29	(3)
S 42	39.250	13	0.300	12	(1)
S 43	40.375	7	0.174	6	(1)
S 44	31.375	49	0.825	49	0
S 45	37.875	20	0.426	22	2
S 46	34.625	43	0.627	42	(1)
S 47	30.500	51	0.823	48	(3)
S 48	34.375	44	0.695	45	1
S 49	37.750	21	0.411	19	(2)
S 50	36.000	34	0.536	36	2
S 51	35.625	38	0.527	35	(3)
Spearman rank order correlation coefficient (r_s)			0.967		
Sig.			0.077		
Staff Performance Adjustment Rate (%)			Advancement		39 (20 staff)
			Degeneracy		43 (22 staff)
			Maintenance		18 (9 staff)

Note: Distance* = Ranking [b] – Ranking [a]; numbers in ( ) are negative.

7. **Conclusions and Remarks.**

As previously described, there are several reasons why firms are encountering an intensely competitive environment, such as the rising price of raw materials and the downturned economy. In particular, given the high-speed passenger vehicle industry, airline companies, which play an important role in globalization, are being forced to adapt to new challenges. To gain a competitive advantage, a great number of companies have adopted downsizing as one common way to cut costs. However, for airline companies, reducing the number of aircraft maintenance staff members in charge of aviation maintenance results in heavier workloads for employees, and this effect has the potential to imperil flight safety greatly. Therefore, how to keep aircraft maintenance staff members motivated under such conditions has become an issue of vital importance to aviation safety.

As shown by relevant research, rewarding employees through fair performance evaluations is generally appreciated. Most airline companies, like the case company (C Airline), carry out performance evaluations using established evaluation dimensions and criteria with equal weights. This practice results in unfair compensation because these evaluation standards are unable to reflect employee performance; such inaccuracy and unfairness are even more apparent when the workload for each employee has increased drastically, and especially when it has increased for those who work as aircraft maintenance staff, causing them to question the performance evaluation standards that the airline uses, and thus, directly influencing motivation and work quality and causing additional risks to flight safety. Based on a case airline (C Airline), this research has used a hybrid MCDM model, combining FAHP and VIKOR based on domain experts' opinions, to determine the relative importance of the evaluation dimensions and criteria that had been officially proposed and utilized for years by C Airline and to further investigate the fair and reasonable performance scores of the aircraft maintenance staff at C Airline.

In accordance with the FAHP results, "Basic Knowledge", i.e., general education/specialized training in aircraft maintenance undertaken by the staff should be the top concern in evaluating their performance, followed by "Responsibility", "Teamwork", "Work Quality", etc. In this regard, to improve the performance of the airline maintenance staff significantly and efficiently, this study proposes that periodic examination of airline maintenance skills should be conducted. Updating the basic knowledge by annual on-the-job training and through opportunities for learning aboard, are also required and recommended. Because the evaluation dimension "Team", which includes two evaluation criteria (i.e., "Responsibility" and "Teamwork"), is within the top five, this study argues that task demands (e.g., autonomy, task variety, degree of automation) and role demands (e.g., role expectations) should be clearly addressed and transparently posted. Doing so can provide not only a clarified performance evaluation standard for management but also a better understanding of the different importance and workloads for each staff member. Therefore, the rewards based on evaluation performances can be more reasonably distributed, and this result would effectively motivate the staff on their tasks. In addition, "Work Quality", especially for aircraft maintenance, cannot be too strongly emphasized because the quality of the aircraft maintenance staff has greater impact on safety issues than that of any other assessment. Compared with the evaluation criterion "Workloads", which is used to measure "quantity", the "quality" of work results of the aircraft maintenance staff should be of more concern. That is, the quality of work should outweigh its quantity when evaluating the performance of the aircraft maintenance staff. In practical cases, the management is advised to take into account differences in the difficulty and complexity of tasks in the performance evaluation of the aircraft maintenance staff and to compensate them accordingly. Therefore, the practical use of the theoretical results obtained in this study, using a case airline company, is articulated in terms of performance evaluation information but should be given different evaluated weights, based on different difficulty and complexity, both to make the right performance evaluation and to motivate the staff toward their tasks successfully for better performance.

Also, based on the VIKOR analysis, the performance of a total of 51 aircraft maintenance staff members was generated. Moreover, when one compares the unweighted and weighted performance values, the results reveal that unweighted performance evaluation is indeed causing unfair judgment and, thus, prove that the evaluation proposed by this research can prove helpful in addressing such a problem. On the whole, if seeking to evaluate the performance of the aircraft maintenance staff fairly at C Airline, the management is strongly advised to take into account the weights of the evaluation criteria explored by this study. In other words, the results of the proposed model can provide an important reference, not only for the management to use in distinguishing different levels of staff compensation as rewards for performance but also for employees, as they seek to understand better the aspects of their work that need most improving. To be precise, the aircraft maintenance staff members of C Airline are encouraged to improve their performance in compliance with the prior evaluation criteria examined in this study.

Although the proposed approach provides important benefits, it also has certain limitations. Therefore, some suggestions for further studies are offered as follows to supplement the deficiencies. First, because the results of this study were acquired on the basis of information related to C Airline, future research should either broaden the evaluation dimensions and criteria or diversify the sample experts to make the results suitable for use by more airlines. Second, because the interrelationship effect of the evaluation dimensions and criteria, which might reflect real practice, was not considered in the FAHP analysis, future research is advised to use the fuzzy analytic network process (FANP) to computer more precisely the relative weights for each evaluation dimension and criterion [48]. Third, because our study was undertaken mainly to provide a way for the top manager to measure performance correctly and to assist the staff in clearly identifying aspects of their work that need to be improved in accordance with the importance of the evaluation criteria, other analytical tools, such as data envelop analysis (DEA) [49] can be utilized to evaluate the improved performance and to select the learning benchmarks for the aircraft maintenance staff. Finally, the performance evaluation model presented by this research can also be extended to other situations (i.e., other evaluation systems), giving consideration to the unequal weights of various evaluation criteria.

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