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Simple Additive Weighting approach to Personnel Selection problem

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***Abstract*— Selection of qualified personnel is a key success factor for an organization. The complexity and importance of the problem call for analytical methods rather than intuitive decisions. In literature, there are various methods regarding personnel selection. This paper considers a real application of personnel selection with using the opinion of expert by one of the decision making model, it is called SAW method. This paper has applied seven criteria that they are qualitative and positive for selecting the best one amongst five personnel and also ranking them. Finally the introduced method is used in a case study.**

***Index Terms*— Multi Criteria Decision Making (MCDM), Personnel Selection, Simple Additive Weighting (SAW).**

I. Introduction

Personnel selection directly and significantly affects the quality of employees, and hence, it has always been an important topic for organizations, including public agencies and private enterprises. Various approaches have been developed to help organizations make best personnel selection decisions to place the right people in the right jobs.

Many studies have reported a positive association between various human resources practices and objective and perceptual measures of selecting human resources, some authors have expressed concern that results may be biased because of methodological problems. Traditional methods for selection of human resources are mostly based on statistical analyses of test scores that are treated as accurate reflections of reality. Modern approaches, however, recognize that selection is a complex process that involves a significant amount of vagueness and subjectivity [1].

In general, personnel selection, depending on the firm's specific targets, the availability of means and the individual preferences of the decision makers (DMs), is a highly complex problem. The multi criteria nature of the problem makes Multi- Criteria Decision Making (MCDM) methods and copes with this, given that they consider many criteria at the same time, with various weights and thresholds, having the potential to reflect at a very satisfactory degree the vague preferences of the DMs.

In this paper, SAW method is suggested to solve personnel selection problem using multi-criteria decision-making process. The rest of the paper is organized as follows: In the next section, some relevant studies on the personnel selection problem are presented. In Section III, the principle of the SAW is demonstrated in brief. Section IV briefly presents an empirical application of the proposed approach for the personnel selection of a senior IT officer. Finally, future steps and research challenges are discussed.

II. Literature review

Among the MCDM problems that are encountered in real life is the personnel selection problem. This problem, from the multi-criteria perspective, has attracted the interest of many scholars. One class of approaches that deal with subjectivity includes techniques based on the well-known analytic hierarchy process (AHP) which reduces complex decisions to a series of pair wise comparisons and synthesizes the results. AHP and its extensions have been utilized extensively in the selection of human resources. Typical applications include the ones presented by Lai [3], Iwamura and Lin [4], and Labib et al. [5]. Albayrak and Erensal [6] used AHP, which determines the global priority weights for different management alternatives, to improve human resource performance outcomes. A detailed review of various applications of AHP in different settings is provided by Vaidya and Kumar [7].

The other contemporary methods in the employee selection are artificial intelligence techniques that are the fuzzy sets and neural networks. In contrast to conventional sets where a given value v is either included or not included in a set A, in fuzzy set theory each value is associated with a certain grade of membership in set A. This grade is expressed by a membership function that reflects the degree to which it can be argued that value v is included in A. Examples of such approaches can be found in Laing and Wang [8], Yaakob and Kawata [9], Lovrich [10], and Wang et al. [11]. Lazarevic [12] introduces a two-level fuzzy model for minimizing subjective judgment in the process of identifying the right person for a position. And Royes et al. [13] propose a combination of fuzzy sets and multi criteria tools for employee selection. In a similar approach, Golec and Kahya [14] propose a hierarchical structure and use a fuzzy model that has two levels: evaluation and selection.

Some studies focused on proposed expert systems (ESs) or

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decision support systems to assist personnel selection. A working ES named EXPER [15] was developed to assist managers in making job placement decisions. Brunsson et al, [16] developed and tested a rule-based ES, BOARDEX, to perform the Yes/No vote to screen officer personnel records in the first phase of board procedure. Experiment on a mock officer personnel records showed that BOARDEX was successful at selecting the records. Drigas et al. [17] present an expert system using Neuro Fuzzy techniques that investigate a corporate database of unemployed and enterprises profile data for evaluation of the unemployed at certain job position.

III. Methodology

Simple Additive Weighting (SAW) which is also known as weighted linear combination or scoring methods is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of magnitude of the standardized scores remains equal. Process of SAW consist of these steps:

Step 1:

1) Construct a pair-wise comparison matrix (n × n) for criteria with respect to objective by using Saaty's 1-9 scale of pairwise comparisons shown in table 1. In other words, it is used to compare each criterion with each other criterion, one-by-one.

TABLE 1: SAATY'S 1-9 SCALE OF PAIRWISE COMPARISONS

Intensity of importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favor one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgment strongly favor one activity over another
6	Strong Plus	
7	Very Strong	An activity is favored very strongly over another
8	Very, very Strong	
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation

2) For each comparison, we will decide which of the two criteria is most important, and then assign a score to show how much more important it is.
3) Compute each element of the comparison matrix by its column total and calculate the priority vector by finding the row averages [18].
4) Weighted sum matrix is found by multiplying the pairwise comparison matrix and priority vector.
5) Dividing all the elements of the weighted sum matrix by their respective priority vector element.
6) Compute the average of this value to obtain $\lambda_{\max}$.
7) Find the Consistency Index, CI, as follows:
$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (1)$$
Where n is the matrix size.

8) Calculate the consistency ratio, CR, as follows:
9) $$CR = \frac{CI}{RI} \quad (2)$$
10) Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in Table 2. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

TABLE 2: AVERAGE RANDOM CONSISTENCY (RI)

Size of matrix	Random consistency
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Step 2:

Construct a decision matrix (m × n) that includes m personnel and n criteria. Calculate the normalized decision matrix for positive criteria:

$$n_{ij} = \frac{r_{ij}}{r_j^*} \quad i=1, \ldots m, \qquad j=1,\ldots n \qquad (3)$$

And for negative criteria:

$$n_{ij} = \frac{r_j^{\min}}{r_{ij}} \quad i=1,\ldots m, \qquad j=1,\ldots n \qquad (4)$$

r_j^* Is a maximum number of r in the column of j.

Step 3:

Evaluate each alternative, A_i by the following formula:

$$A_i = \sum w_j . x_{ij} \qquad (5)$$

Where x_{ij} is the score of the i_{th} alternative with respect to the j_{th} criteria, w_j is the weighted criteria [19].

This methodology is designed in order to select and consider suitable criteria and personnel in one of a sector of Telecommunication's Company respectively. The way of data collection that is applied for this phase is questionnaire. By using Comparison Matrix the weights of criteria will be computed. After computing weights of criteria, specifying of Consistency Rate will be executed. If Consistency of data is more than 0.1, revision of pairwise comparison must be done. So we will continue it until consistency Rate reach to less than 0.1. After CR is less than 0.1, it indicates sufficient consistency. In that time, we use SAW method for ranking personnel. The procedure of methodology has been shown in Fig 1.

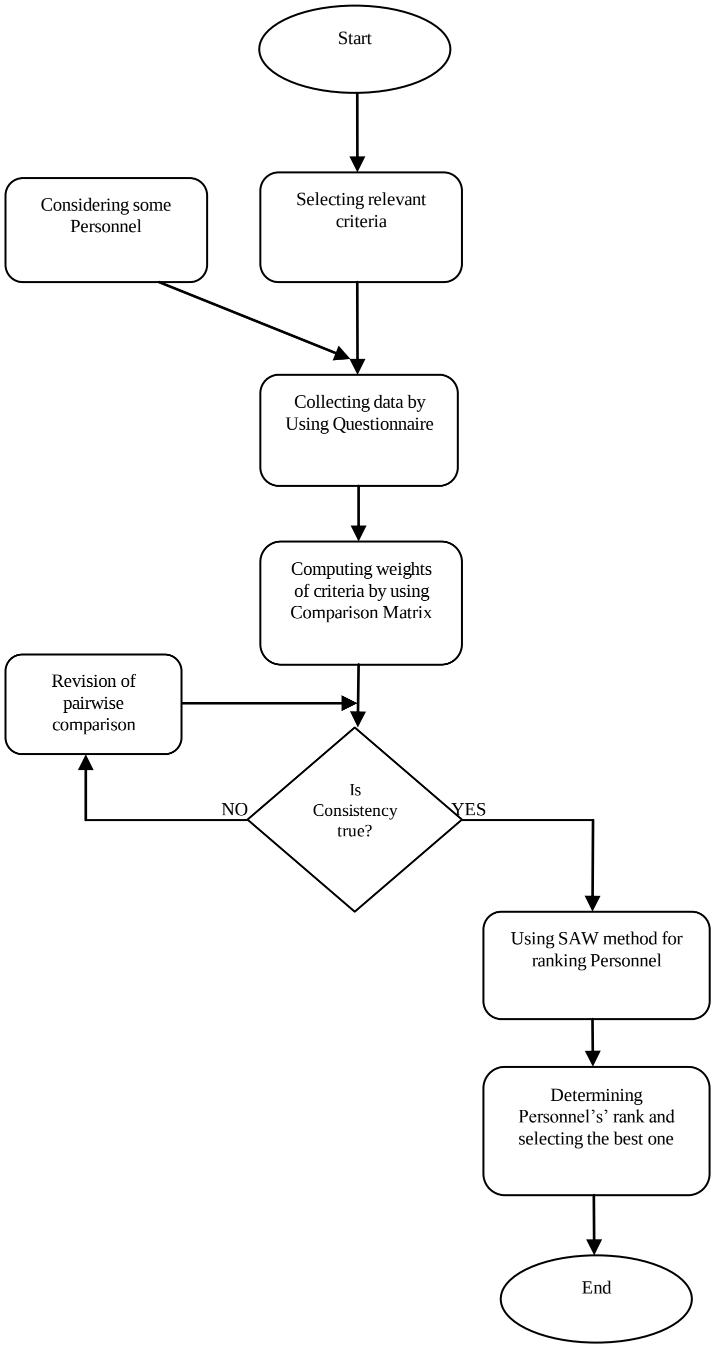

Fig 1: research framework

IV. Numeric Example

By using seven criteria like below, Telecommunication Company wants to sort five people which have passed the exam. These criteria have been mentioned in table 3 as follows:

TABLE III: CRITERIA'S NAME

Criteria	Explanation
C1	Ability to work in different business units
C2	Past experience
C3	Team player
C4	Fluency in a foreign language
C5	Strategic thinking
C6	Oral communication skills
C7	Computer skills

The weights of criteria have been computed by using comparison matrix. Meanwhile, Data was gathered from five expert's opinion with questionnaire in one of sector of Telecommunication Company by using scale values of 1-5 as shown in table 4 and it has been shown in fig 2.

TABLE IV: SPECIFYING THE SCALE VALUES OF 1-5

Intensity of importance	Definition
1	Equal importance
2	Moderate importance
3	Strong importance
4	Very strong
5	Extreme importance

The comparison matrix is shown in Table III, indicating the relative importance of the criterion in the columns compared to the criterion in the rows.

Fig. 2: Weights of criteria by Comparison matrix

CRITERIA	C1	C2	C3	C4	C5	C6	C7	weights
C1	1.00	2.00	2.00	4.00	3.00	2.00	3.00	0.283
C2	0.50	1.00	1.00	3.00	2.00	1.00	2.00	0.162
C3	0.50	1.00	1.00	3.00	2.00	1.00	2.00	0.162
C4	0.25	0.33	0.33	1.00	0.50	0.33	2.00	0.070
C5	0.25	0.50	0.50	2.00	1.00	0.50	1.00	0.085
C6	0.50	1.00	1.00	3.00	2.00	1.00	2.00	0.162
C7	0.33	0.50	0.50	0.50	1.00	0.50	1.00	0.076
Total	3.33	6.33	6.33	16.50	11.50	6.33	13.00	1.000

Test of consistency:

The consistency Rate calculated was 0.031 that is less than 0.1, indicating sufficient consistency. The following steps will show how the test of consistency will be done.

Step 1:

In order to calculate computing Weighted Sum Vector (WSM):

$$\begin{bmatrix} 1.00 & 2.00 & 2.00 & 4.00 & 3.00 & 2.00 & 3.00 \\ 0.50 & 1.00 & 1.00 & 3.00 & 2.00 & 1.00 & 2.00 \\ 0.50 & 1.00 & 1.00 & 3.00 & 2.00 & 1.00 & 2.00 \\ 0.25 & 0.33 & 0.33 & 1.00 & 0.50 & 0.33 & 2.00 \\ 0.25 & 0.50 & 0.50 & 2.00 & 1.00 & 0.50 & 1.00 \\ 0.50 & 1.00 & 1.00 & 3.00 & 2.00 & 1.00 & 2.00 \\ 0.33 & 0.50 & 0.50 & 0.50 & 1.00 & 0.50 & 1.00 \end{bmatrix} \times \begin{bmatrix} 0.283 \\ 0.162 \\ 0.162 \\ 0.070 \\ 0.085 \\ 0.162 \\ 0.076 \end{bmatrix} = \begin{bmatrix} 2.018311 \\ 0.922087 \\ 1.343395 \\ 0.497137 \\ 0.61498 \\ 1.245876 \\ 0.576408 \end{bmatrix}$$

By rounding off the number to three decimal places, we will get Consistency vector (CV). In following division, each corresponding cell must be divided each other. For example, the value of 7.130 has been extracted from 2.018 divided by 0.283 and so on.

$$\begin{bmatrix} 2.018 \\ 0.922 \\ 1.343 \\ 0.497 \\ 0.615 \\ 1.246 \\ 0.576 \end{bmatrix} / \begin{bmatrix} 0.283 \\ 0.162 \\ 0.162 \\ 0.070 \\ 0.085 \\ 0.162 \\ 0.076 \end{bmatrix} = \begin{bmatrix} 7.130 \\ 5.696 \\ 8.298 \\ 7.090 \\ 7.212 \\ 7.696 \\ 7.598 \end{bmatrix}$$

$$\lambda_{\max} = \frac{7.130+5.696+8.298+7.090+7.212+7.696+7.598}{7} = 7.246 \quad (6)$$

Calculating amount of Consistency Index (CI):

$$CI = \frac{7.246-7}{7-1} = 0.041 \quad (7)$$

Consistency rate will be computed as follows as the amount of Random Index (RI) could be got by looking at table 3, according to the value of n (n is size of matrix).

$$CR = \frac{0.041}{1.32} = 0.031 \quad (8)$$

TABLE 3: THE AVERAGE STOCHASTIC UNIFORMITY INDEX TARGET VALUE OF JUDGMENT MATRIX

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.85	0.9	1.12	1.24	1.32	1.41	1.45	1.51

So the Consistency Index is indicating that the opinion of experts is sufficient. After preparing collected data from experts, based on scale values 1-9 in table 1 and computing weights of criteria in Fig 2, we will start following steps will show procedure of SAW method:

Fig 3: Collected data based on scale values (1-9)

	C1	C2	C3	C4	C5	C6	C7
P1	4	7	3	2	2	2	2
P2	4	4	6	4	4	3	7
P3	7	6	4	2	5	5	3
p4	3	2	5	3	3	2	5
P5	4	2	2	5	5	3	6

C means Criteria and P means Personnel.

TABLE 5: THE WEIGHTED CRITERIA

C1	C2	C3	C4	C5	C6	C7
0.283	0.162	0.162	0.07	0.085	0.162	0.076

Step 2:

Calculate the normalized decision matrix for positive criteria:

$$n_{ij} = \frac{r_{ij}}{r_j^*} \qquad i=1,\dots 5, \qquad j=1,\dots 7 \quad (9)$$

And for negative criteria:

$$n_{ij} = \frac{r_j^{\min}}{r_{ij}} \qquad i=1,\dots 5, \qquad j=1,\dots 7 \quad (10)$$

So in this case of study, criteria have positive and the result as shown in fig 4.

r_j^* Is a maximum number of r in the column of j.

Fig 4: The normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
P1	0.5714	1.0000	0.5000	0.4000	0.4000	0.4000	0.2857
P2	0.5714	0.5714	1.0000	0.8000	0.8000	0.6000	1.0000
P3	1.0000	0.8571	0.6667	0.4000	1.0000	1.0000	0.4286
P4	0.4286	0.2857	0.8333	0.6000	0.6000	0.4000	0.7143
P5	0.5714	0.2857	0.3333	1.0000	1.0000	0.6000	0.8571

Step 3:

The simple additive weighting method evaluates each alternative, A_i. By the following formula:

$$A_i = \sum w_j . x_{ij} \qquad i=1,\dots 5, \quad j=1,\dots 7 \quad (11)$$

Where x_{ij} is the score of the i^{th} alternative with respect to the j^{th} criteria, w_j is the weighted criteria.

TABLE 6: THE RANKED PERSONNEL

P1	0.553181
P2	0.713468
P3	0.837488
P4	0.51466
P5	0.579524

Finally in SAW method, the best personnel is P3 and then P2, P5, P1 and P4 will be respectively.

V. Conclusion

In this study, we presented a MCDM methodology for Personnel selection. The method was applied using data from a real case in the Telecommunication sector of Iran. To increase the efficiency and ease-of-use of the proposed model, simple software such as MS Excel can be used. Evaluation of the candidates on the basis of the criteria only will be sufficient for the future applications of the model and implementation of this evaluation via simple software will speed up the process. The limitation of this article is that SAW ignores the fuzziness of executives' judgment during the decision-making process. Besides, some criteria could have a qualitative structure or have an uncertain structure which cannot be measured precisely. In such cases, fuzzy numbers can be used to obtain the evaluation matrix and the proposed model can be enlarged by using fuzzy numbers.

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