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Grant Selection Process Using Simple Additive Weighting Approach

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ABSTRACT

Selection of educational grant is a key success factor for student learning and academic performance. Among popular methods, this paper contributes a real problem of selecting educational grant using data of grant application forms by one of the multi criteria decision making model, SAW method. This paper introduces nine criteria that are qualitative and positive for selecting grant for the students amongst fifteen application forms and also ranking them. Finally, the proposed method is demonstrated in a case study on selecting educational grant for students.

***Keywords:** Multi Criteria Decision Making(MCDM); Grant Selection; Simple Additive Weighting(SAW); Consistency Index(CI); Random Index(RI); Consistency Ratio(CR)*

1. INTRODUCTION

Nowadays, it is important to support the development of human resources and our University supports a program to award educational grants. The purpose of the Grant Program is to provide students with an opportunity to apply for grants to support higher levels of student learning and enhance student academic performance. The *Grant* Selection Committee reviews and ranks applications according to established criteria. The grant decision will be made based on these criteria and the top 10 finalists are *selected.* In general, 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. MCDM plays a critical role in many real life problems and SAW method is suggested to solve educational grant selection problem in this paper. The main concept of SAW is to select the best alternative among the possible alternatives and needs to normalize all criteria into same range. A weighting technique is used for determination of the criteria importance. Finally, the model shows as a list of sorted result.

2. METHDOLOGY

Simple Additive Weighting (SAW) is a simple and most often used multi attribute decision technique. It is weighted linear combination or scoring method 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. It combines the different criteria and weights corresponding to those objectives to create a single score for each alternative to make them comparable. The formulas used in this model are shown in the followings:

$$Ai^{Score} = \sum_{j=1}^{n} w_j a_j \qquad (1)$$

$$A^{*Score} = max_i \sum_{j=1}^{n} w_j a_{ij} \qquad (2)$$

In these formulas, the Weight Sum Score for an alternative Ai denoted as Ai^{Score} is calculated by adding the products of a weight wj with its corresponding parameter a_{ij}, the value of this objective. This parameter is, for example, the monetary cost which has to be spent to execute the query. The best alternative is chosen as the one which has the maximum WSM score (A^{*Score}). The different objectives are assumed to be positive: the higher the score, the better the alternative. Assuming objectives to be negative (in case of cost models), the best alternative has equivalently the lowest score. This method requires that the attributes be assigned weights of importance. Usually, these weights are normalized to add up to one. There are three steps in utilizing any decision-making technique involving numerical analysis of alternatives:

1. Determining the relevant criteria and alternatives.
2. Attaching numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria.

3. Processing the numerical values to determine a ranking of each alternative.

The determination of criteria and alternatives are very subjective. Notice that the list of criteria and alternatives are not exhausted list. They neither cover all possible criteria nor all possible alternatives. There is no correct or wrong criterion because it is subjective opinion. Different people may add or subtract those lists. Some factors may be combined together and some criterion may be broken down into more detail criteria. Most of decisions makings are based on individual judgments.

A multi-criteria model for ranking m alternatives (A_1, A2, …, Am) by n criteria (C_1,C_2, …., C_n) is presented in Table 1. In this model, the degree in which alternative A_i (i = 1, 2,…, m) satisfies criterion C_j, (j = 1,2,…, n) is denoted by a_{ij}. Without loss of generality, we can assume that the criteria are ordered based on importance, from the most important criterion C_1 to the least important criterion C_n. For different criteria, the performance values of alternatives can be measured by different units.

TABLE I. DECISION MATRIX

	C_1	C_2	…..	C_n
A_1	a_{11}	a_{12}	…..	a_{1n}
A_2	a_{21}	a_{22}		a_{2n}
.	.	.	…..	.
A_m	a_{m1}	a_{11}		A_{mn}

Firstly, the system needs to 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 2. In other words, it is used to compare each criterion with each other criterion, one-by-one.

For each comparison, it needs to decide which of the two criteria is most important, and then assign a score to show how much more important it is. Each element of the comparison matrix is computed by its column total and the priority vector is calculated by finding the row averages. Weighted sum matrix is found by multiplying the pairwise comparison matrix and priority vector. Individual elements of the weighted sum matrix have to be divided by their respective priority vector element. The average of this value is computed to obtain λmax. Then, the Consistency Index, CI, can be found as follows:

$$CI = \frac{\lambda max - n}{n-1} \qquad (3)$$

Where, n is the matrix size.

The consistency ratio, CR, is needed to calculate by using the equation (5):

$$CR = \frac{CI}{RI} \qquad (4)$$

TABLE II SAATY'S 1-9 SCALE of PAIRWISE COMPARISON

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

Finally, judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in TABLE III. 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 III: 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

The system needs to construct a decision matrix (m×n) that includes m alternatives and n criteria. As a final step, each alternative, A_i is evaluated by using Equation (1). This methodology is designed in order to select and consider suitable criteria and education level of seven States in Myanmar. By using Comparison Matrix, the weights of criteria will be computed. After computing weights of criteria, specifying of Consistency Rate (CR) 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 WSM method for ranking education level. The procedure of methodology has been shown in Figure 1.

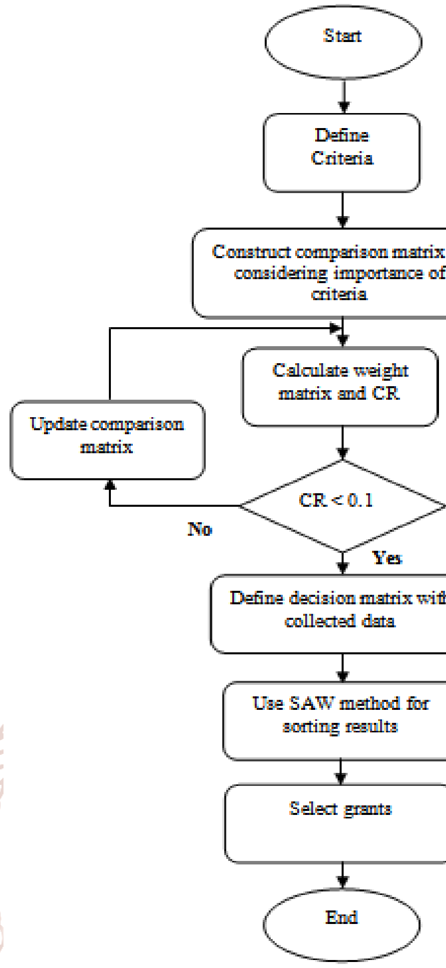

Fig. 1: Structure of research work by using MCDM method

3. NUMERICAL STUDY

This section presents numerical experiment. Data used in the calculation are collected from grant applications form. By using nine criteria like below, the levels of results are sorted. These criteria have been mentioned in TABLE IV as follow.

TABLE IV: NAMES OF CRITERIA

Criteria	Explanation
C1	Parents' Income
C2	Number of Siblings
C3	Number of Siblings who are attending school
C4	Field/Land/Farm or other possessions
C5	Can give promise to study hard if he/she get a grant?
C6	Having enough financial support for his/her study
C7	Parents' health condition
C8	Is he/she working currently?
C9	Board/Committee recommendation

The weights of criteria have been computed by using comparison matrix. Meanwhile, data was gathered by using scale values of 1-5 as shown in TABLE V.

TABLE V: DEFINING THE SCALE VALUES OF 1-5

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

The comparison matrix is shown in TABLE VI, indicating the relative importance of the criterion in the columns compared to the criterion in the rows. The weight of criteria matrix created from comparison matrix is shown in TABLE VII.

TABLE VI: DEFINING THE COMPARISON MATRIX

CRITERIA	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1	0.5	0.5	1	0.3	1	1	0.5	0.25
C2	2	1	2	0.33	2	0.5	1	1	0.5
C3	2	0.5	1	2	1	2	1	2	0.5
C4	1	3	0.5	1	2	1	1	0.5	0.25
C5	3	0.5	1	0.5	1	0.5	1	0.5	0.5
C6	1	2	0.5	1	2	1	1	0.5	0.33
C7	1	2	1	2	1	2	1	0.5	0.5
C8	2	1	0.5	2	2	2	2	1	0.33
C9	4	2	2	4	2	3	2	3	1
TOTAL	17	13	9	13.8	13	13	10	9.5	4.16

TABLE VII: WEIGHTS OF CRITERIA BY COMPARISON MATRIX

W1	0.05464
W2	0.09103
W3	0.10782
W4	0.0819
W5	0.07553
W6	0.07582
W7	0.09815
W8	0.10968
W9	0.20542

The consistency rate was 0.081 that is less than 0.1, indicating sufficient consistency. Calculating the WSM is shown in TABLE VIII. By applying that matrix, we can compute the consistency vector. The result of consistency vector is shown in TABLE IX.

TABLE VIII: WEIGHT SUM VACTOR

1.0	0.5	0.5	1.00	0.3	1.0	1.0	0.5	0.25		0.061		0.6
2.0	1.0	2.0	0.33	2.0	0.5	0.5	1.0	0.5		0.101		0.99
2.0	0.5	1.0	2.00	1.0	2.0	1.0	2.0	0.5		0.12		1.19
1.0	3.0	0.5	1.00	2.0	1.0	0.5	0.5	0.25		0.091		0.94
3.0	0.5	1.0	0.50	1.0	0.5	1.0	0.5	0.5	?	0.084	=	0.81
1.0	2.0	0.5	1.00	2.0	1.0	0.5	0.5	0.33		0.084		0.86
1.0	2.0	1.0	2.00	1.0	2.0	1.0	0.5	0.5		0.109		1.1
2.0	1.0	0.5	2.00	2.0	2.0	2.0	1.0	0.33		0.122		1.22
4.0	2.0	2.0	4.00	2.0	3.0	2.0	3.0	1		0.228		2.28

TABLE IX: CONSISTINCY VECTOR

0.601176		0.060706		9.903042
0.992683		0.101146		9.814333
1.193126		0.119802		9.959146
0.939665		0.091001		10.32591
0.808156	/	0.083922	=	9.629786
0.856778		0.084248		10.16966
1.101336		0.109056		10.09886
1.216105		0.121868		9.978834
2.281281		0.22825		9.994658

The amount of Consistency Index (CI) is calculated using Equation (3), so CI =0.1232 and the amount of Random Index could be applied by referring Table X, according to the value of n (n is size of matrix).

TABLE X: THE AVERAGE STOCHASTIC UNIFORMITY INDEX TARGET VALUE of JUDG MENT 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

TABLE XI: SCALING CRITERIA

Criteria	Explanation	Scaled values
C1	Parents' Income	0-500000
C2	Number of Siblings	0-6
C3	Number of Siblings who are attending school	0-6
C4	Field/Land/Farm or other possessions	0-9
C5	Can give promise to study hard if he/she get a grant?	0,1
C6	Having enough financial support for his/her study	0-9
C7	Parents' health condition	0-9
C8	Is he/she working currently?	0,1
C9	Board/Committee recommendation	0-9

To define the decision matrix we need to collect data by using student application forms. Collected data matrix and normalized collected data matrix are shown in TABLE XII and TABLE XIV. In table XIII shows the result of weight criteria by testing of allowable CR.

TABLE XII: COLLECTED DATA MATRIX (DECISION MATRIX)

Stu.	C1	C2	C3	C4	C5	C6	C7	C8	C9
S1	100000	3	2	2	1	4	4	1	9
S2	200000	2	2	3	0	6	5	1	6
S3	120000	4	3	3	1	4	4	1	8
S4	150000	1	1	4	1	4	5	1	8
S5	300000	2	2	5	1	7	7	0	6
S6	400000	4	3	6	0	9	8	0	2
S7	200000	2	2	3	1	5	5	1	8
S8	450000	5	3	7	1	9	9	0	3
S9	260000	2	2	4	0	5	6	1	5
S10	180000	1	1	2	1	6	5	1	7
S11	220000	4	3	3	1	6	6	1	5
S12	320000	2	2	5	1	8	7	0	5
S13	450000	3	2	7	0	9	7	0	3
S14	500000	3	2	8	0	9	9	0	3
S15	240000	2	1	4	1	8	6	1	7

TABLE XIII: WEIGHT CRITERIA

C1	C2	C3	C4	C5	C6	C7	C8	C9
0.061	0.101	0.120	0.091	0.084	0.084	0.109	0.122	0.228

TABLE XIV: NORMALIZED DECISION MATRIX

S1	0.8	0.5	0.3	0.8	1.0	0.6	0.6	1.0	1.0
S2	0.6	0.3	0.3	0.7	0.0	0.3	0.5	1.0	0.7
S3	0.8	0.7	0.5	0.7	1.0	0.6	0.6	1.0	0.9
S4	0.7	0.2	0.2	0.6	1.0	0.6	0.4	1.0	0.8
S5	0.4	0.3	0.3	0.4	1.0	0.2	0.3	0.0	0.7
S6	0.2	0.7	0.5	0.3	0.0	0.0	0.1	0.0	0.2
S7	0.6	0.3	0.3	0.7	1.0	0.4	0.5	1.0	0.9
S8	0.1	0.8	0.5	0.2	1.0	0.0	0.0	0.0	0.3
S9	0.5	0.3	0.3	0.6	0.0	0.4	0.3	1.0	0.6
S10	0.6	0.2	0.2	0.8	1.0	0.3	0.4	1.0	0.8
S11	0.6	0.7	0.5	0.7	1.0	0.3	0.3	1.0	0.5
S12	0.4	0.3	0.3	0.4	1.0	0.2	0.2	0.0	0.6
S13	0.1	0.5	0.3	0.2	0.0	0.0	0.2	0.0	0.3
S14	0.0	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.3
S15	0.5	0.3	0.2	0.6	1.0	0.1	0.4	1.0	0.7

By applying formula 2 we can compute the score matrix. The simple additive method evaluates each alternative, A_*^{Score}. Ranking resultant score matrix and sorting score matrix are shown in TABLE XV and TABLE XVI.

TABLE XV: RANKING

S1	0.751282
S2	0.527386
S 3	0.755262
S4	0.625828
S5	0.423481
S6	0.232646
S7	0.671392
S8	0.330488
S9	0.475814
S10	0.606326
S11	0.606345
S12	0.387376
S13	0.217118
S14	0.176702
S15	0.558215

TABLE XVI: SORTING RANKING RESULTS

No.	Students	Values
1	S3	0.755262
2	S1	0.751282
3	S7	0.671392
4	S4	0.625828
5	S11	0.606345
6	S10	0.606326
7	S15	0.558215
8	S2	0.527386
9	S9	0.475814
10	S5	0.423481
11	S12	0.387376
12	S8	0.330488
13	S6	0.232646
14	S13	0.217118
15	S14	0.176702

Finally according to the SAW method the best student is S3 and then S1, S7, S4, S11, S10, S15, S2, S9, S5 will be selected for the first 10 students to grant the scholarship.

4. CONCLUSION

In this study, we presented one of MCDM methodologies, SAW method for selecting granted students. The method has applied data from grant application forms. MS EXCEL program is used in this work to increase the efficiency and ease- of-use. The application of Simple Additive Weighting (SAW) method in decision making of selecting granted students is done by finding weight sum of criteria for each alternative and attributes which need normalization decision matrix. SAW ignores the fuzziness of committee's 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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