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Application of Fuzzy TOPSIS in Selecting Poverty Case Among UiTM Perlis Students due to COVID-19 Pandemic

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HIGHLIGHTS

- Fuzzy Technique for Others Preference by Similarity to Ideal Solution (TOPSIS) method is suitable to be used in selecting the most suitable candidates to receive financial aids.
- The new model generated makes the financial aid easier and faster to be channelled.
- Candidates are chosen equally without biasness.

ABSTRACT

The effects of Covid-19 are not only in terms of health, but many things arise along with its existence. One of them is poverty. Due to this, Universiti Teknologi MARA(UiTM) has taken the initiative to offer several financial aids to the affected students. However, the students must fill in the application form to obtain the aid. They need to provide the supporting documents such as parents pay slip, information on family dependent and so on, which will be inspected, graded and selected by the committee to determine the qualification for the financial aids. Due to this, it will be a long process to select the rightful applicants, which involves a significant length of time as it consisted of hundreds of applicants. Hence, the aim of this study is to select and rank the most eligible candidates among UiTM Perlis students with fairness, fast and accurate manner. In this study, the Fuzzy Technique for Others Preference by Similarity to Ideal Solution (TOPSIS) method was used to solve the problem. The model was run using Microsoft Excel. The selection of UiTM Perlis students were based on a set of criteria that had been predetermined which includes family income, occupation and the number of dependent in the family. The findings of the study showed that from 35 samples of UiTM Perlis students, the highest-ranking was student 35 (S35) with 1.0000 relative closeness. Meanwhile, the lowest ranking was student 30 (S30) with 0.6478 relative closeness. It is also shown that all samples are qualified to receive financial aid due to sufficient allocation amount provided by UiTM Perlis. As a result, the mistakes during the selection process can be reduced by using this method compared to manual selection. Thus, making it easier and faster to channel the aid. All in all, it has been demonstrated that this method is very suitable to be used in this study.

Keywords: *Fuzzy TOPSIS, UiTM Perlis, financial aid, rank, select, fairness, fast*

INTRODUCTION

Total number of poverty cases in Malaysia have increased due to the Coronavirus (COVID-19) pandemic. According to Rahman (2020), many people were instructed to take unpaid leave because some industries and factories had been closed during the Movement Control Order (MCO) period. Factors that affect poverty in Malaysia due to pandemics was caused by unemployment and loss of daily income especially for those who are involved in business. This had caused thousands of daily-paid, part-time jobs and many of them were jobless. Only several businesses and services such as banks, selected restaurants, pharmacies and supermarkets can remain open during the pandemic. Through this, it causes increases number of poverty rate in the country due to lack of supply of daily needs such as food, drinks, clothes and others.

Meanwhile, during the pandemic, UiTM had offered several aids to the students. In order to obtain financial aid from UiTM, the students must fill in the application form. They need to provide the supporting document such as parents pay slip, information on family dependent and so on, which will be inspected, selected and graded by a committee to determine who is qualified for assistance. Therefore, the selection for financial aid recipients must meet specific criteria or achievements set by UiTM. Through this, UiTM as an academic institution plays its role in helping the students to ease the burden that they were facing during the pandemic by giving quick financial aid to the students in need.

Thus, the main purpose of the research study is regarding the selection of poverty among 35 students in UiTM Perlis with fairness bases on the identified criteria and rank the selection of poverty by all criteria with fairness and fast and accurate manner. The data taken are secondary data from the Student Affairs Division (HEP) of UiTM Perlis from March 2022 until August 2022 consisting of three criteria which are family income (C1), occupations (C2) and number of dependents in the family (C3) among the Bottom 40% (B40) students in UiTM Perlis. It was obtained from the HEP by providing a letter of permission. There were two decision makers involved in the study, Assistant Registrar of HEP and the Coordinator of Zakat, Alms & Endowment Unit, UiTM Perlis.

Fuzzy TOPSIS method was introduced by Yoon and Hwang in 1980, It helps the researchers by comparing each alternative and rank the best alternative or the worst alternatives among all the alternative problems (Nadaban et al., 2016). On top of that, Wardana and Rianto (2021) indicated that TOPSIS method is simple and being selected to solve complex problems in various fields and also has been used by many researchers. As an example, Kusumawardani and Agintiara (2015) have used this method in their study to select the human resource manager in Indonesia. The researchers also stated that they chose this method because it can accurately manage data measured on a scale of linguistic and numerical decision-making problems with various resources and data.

Fuzzy TOPSIS is a strong decision-making method that uses qualitative and quantitative criteria to rank answers based on similarity and closeness to get the ideal answer (Ebrahim et al., 2017). To support that few studies have been conducted using this method have been identified. Surniandari et al. (2021) used Fuzzy TOPSIS to address selecting aid recipients' problems in Bogor. The villagers in Bogor were chosen based on the requirements including daily income, the family of dependents, occupations, and the family head's age. Then it will be ranked to choose each aid recipient.

Next, Sudiatmika et al. (2017) also applied this method as a solution to the problem in determining the poor in Bali. However, the main criteria used in the research is different from Surniandari's where the criteria used were building condition, frequency of eating per day, inability to get treatment, education level, occupations, saving assets and ability to purchase new clothes. Still this method is perfect for solving the problem in ranking solution and choosing the eligible candidates to receive the aid. Ebrahim et al. (2017),

the Fuzzy TOPSIS is a strong decision-making method that uses qualitative and quantitative criteria to rank answers based on similarity and closeness to get the ideal answer.

METHODOLOGY

The Fuzzy TOPSIS was used to determine and rank the rightful aid recipients. Meanwhile, the fuzzy linguistic variable was used in weighting each alternative. The weight was based on the level of importance of each criterion by prioritizing the essential criteria as the requirements in selecting aid recipients among UiTM Perlis students.

Fuzzy Set Theory

According to Irvanizam (2018), fuzzy set theory is one of the most popular theories to solve decision-making problems. Besides, it helps to handle the vagueness of the criteria to make a quick decision-making process. The Triangular Fuzzy Number (TFN) will be used in this study. TFN is one of the fuzzy number forms that can be used to handle the vagueness of the criteria, which are family income (C1), type of work (C2) and the number of dependents in the family (C3). The membership function $\mu_{(A)}(x)$ of the triangular fuzzy number may be defined by a triplet (a_1, a_2, a_3) as in Equation (1).

$$\mu_{(A)}(x) = \begin{cases} 0 & , x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, & a_2 \le x \le a_3 \\ 0 & , x > a_3 \end{cases} \quad (1)$$

where x represents an infinite set and A represents the triangular fuzzy number defined by a triplet, which are a_1, a_2, a_3. The linguistic variables will be used by the decision-maker to evaluate the importance of the weight for each criterion. The linguistic variable from Ece & Uludag (2017) will be used. As shown in Table 1 below, the better corresponding TFN will be calculated to assess the importance weight of each criterion.

Table 1: Linguistic Variable and Corresponding Triangular Fuzzy Numbers

Linguistic variable	Domain	Triangular Fuzzy Number
Very Low (VL)	$0 \le x \le 0.1$	0,0,0.1
Low (L)	$0 \le x \le 0.1$ $0.1 \le x \le 0.3$	0,0.1,0.3
Medium Low (ML)	$0.1 \le x \le 0.3$ $0.3 \le x \le 0.5$	0.1,0.3,0.5
Medium (M)	$0.3 \le x \le 0.5$ $0.5 \le x \le 0.7$	0.3,0.5,0.7

Medium High (MH)	$0.5 \le x \le 0.7$ $0.7 \le x \le 0.9$	0.5,0.7,0.9
High (H)	$0.7 \le x \le 0.9$ $0.9 \le x \le 1.0$	0.7,0.9,1.0
Very High (VH)	$0.9 \le x \le 1.0$	0.9,1.0,1.0

The crisp number of triangular fuzzy number and normalized weight for the importance weight of each criterion can be defined as in Equation (2) and Equation (3), where $\mu_{(A)}(x)$ represents the membership function of the triangular fuzzy number and w_j represents the value of weightage.

$$\mu_{(A)}(x) = \frac{a_1 + a_2 + a_3}{3} \tag{2}$$

$$w_j = \frac{w_j}{\sum_{j=1}^{m} w_j} \tag{3}$$

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Jumarni and Zamri stated in their article in 2018, TOPSIS is an Multi Criteria Decision Making (MCDM) method that is simple to understand and calculate, it provides a definite value for experts to calculate their results. A better solution for the shortest distance from the Positive Ideal Solution (PIS) and the longest distance from the Negative Ideal Solution (NIS) will be found by this method. The alternatives that supported the closeness coefficient representing the distances to PIS and NIS will be ranked in descending order. Therefore, there are seven steps involved in achieving the desired outcomes or results in this method. The following are the process involve in Fuzzy TOPSIS method.

The first step in Fuzzy TOPSIS is to construct a fuzzy decision matrix D with m alternative and n criteria that can be presented as in Equation (4).

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ M \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & L & C_n \end{array} \\ \begin{pmatrix} x_{11} & x_{12} & x_{13} & L & x_{1n} \\ x_{21} & x_{22} & x_{23} & L & x_{2n} \\ x_{31} & x_{32} & x_{33} & L & x_{3n} \\ M & M & M & O & M \\ x_{m1} & x_{m2} & x_{m3} & L & x_{mn} \end{pmatrix} \end{array} \tag{4}$$

where students are defined as m alternative, which is $\mathrm{A}_j = (i = 1,2,3,...,m)$ and the criteria were set as n attributes $C_j = (j = 1,2,3,...,n)$. Meanwhile, x_{ij} represents performance rating of the i[th] alternatives which is $i = 1,2,3,..m$ with respect to the j[th] criterion; $j = 1,2,3,..n$.

The second step, the decision matrix, *R* is normalised and that is shown in Equation (5) and each element in matrix *D* can be normalised using Equation (6), where r_{ij} represents a normalised value.

$$R = \begin{array}{c} \\ \mathrm{A}_1 \\ \mathrm{A}_2 \\ \mathrm{A}_3 \\ \mathrm{M} \\ \mathrm{A}_m \end{array} \begin{array}{c} \begin{array}{cccccc} \mathrm{C}_1 & \mathrm{C}_2 & \mathrm{C}_3 & \mathrm{L} & \mathrm{C}_n \end{array} \\ \begin{pmatrix} r_{11} & r_{12} & r_{13} & \mathrm{L} & r_{1n} \\ r_{21} & r_{22} & r_{23} & \mathrm{L} & r_{2n} \\ r_{31} & r_{32} & r_{33} & \mathrm{L} & r_{3n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{O} & \mathrm{M} \\ r_{m1} & r_{m2} & r_{m3} & \mathrm{L} & r_{mn} \end{pmatrix} \end{array} \tag{5}$$

$$r_{ij} = \frac{x_{ij}}{\sqrt{\left(\sum_{i=1}^{m} x_{ij}^2\right)}} \tag{6}$$

Next, the third step in fuzzy TOPSIS is to find the weight of normalised matrix, *V* as in Equation (7). Weighting value was determined by the decision-maker using the linguistic variables as stated in Table 1, with consideration of relative relevance of each criterion and essential criteria satisfied as the requirements for selecting aid recipients among UiTM Perlis students. Next, multiply two fuzzy numbers: the value of weightage and the value of each element from the normalised decision matrix to get the weighted normalised matrix using Equation (8), where w_j represent the weightage and r_{ij} represent the value of each element in the normalised decision matrix.

$$V = \begin{array}{c} \\ \mathrm{A}_1 \\ \mathrm{A}_2 \\ \mathrm{A}_3 \\ \mathrm{M} \\ \mathrm{A}_m \end{array} \begin{array}{c} \begin{array}{cccccc} \mathrm{C}_1 & \mathrm{C}_2 & \mathrm{C}_3 & \mathrm{L} & \mathrm{C}_n \end{array} \\ \begin{pmatrix} v_{11} & v_{12} & v_{13} & \mathrm{L} & v_{1n} \\ v_{21} & v_{22} & v_{23} & \mathrm{L} & v_{2n} \\ v_{31} & v_{32} & v_{33} & \mathrm{L} & v_{3n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{O} & \mathrm{M} \\ v_{m1} & v_{m2} & v_{m3} & \mathrm{L} & v_{mn} \end{pmatrix} \end{array} \tag{7}$$

$$v_{ij} = w_j \times r_{ij} \tag{8}$$

Then in fourth step, the positive ideal solution (PIS), A^+ and the negative ideal solution (NIS), A^- are determined by using Equation (9) and Equation (10).

$$PIS = \mathrm{A}^+ = \left\{ \underset{i}{Max}\, v_{ij}; j \in J \right\} = \left\{ v_1^+, v_2^+, v_3^+, ..., v_m^+ \right\} \tag{9}$$

$$NIS = \mathrm{A}^- = \left\{ \underset{i}{Min}\, v_{ij}; j \in J \right\} = \left\{ v_1^-, v_2^-, v_3^-, ..., v_m^- \right\} \tag{10}$$

where J is associated with benefit criteria.

The next step, separation using the Euclidean distance is being measured. The separation of each alternative from PIS, D^+ can be calculated as shown in Equation (11) and the separation of each alternative from NIS, D^- can be calculated as in Equation (12).

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+ \right)^2}, 1 \le i \le m \tag{11}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^- \right)^2}, 1 \le i \le m \tag{12}$$

The sixth step, the relative closeness to the ideal solution, RC_i^+ can be determined from the separation of each alternative in Step 5, which can be calculated in Equation (13). Since $D_i^- \ge 0$ and $D_i^+ \ge 0$ then, $RC_i^+ \in [0,1]$.

$$RC_i^+ = \frac{D_i^-}{D_i^- + D_i^+}, 1 \le i \le m \tag{13}$$

Finally, the last step is to rank the preference order of each alternative in descending order. The larger value of RC_i^+ means the better chance for the alternative to receive an aid.

FINDINGS AND DISCUSSIONS

The data collected for 35 students is sorted into two types, alternative and criteria. Alternative (S) represents each of the student and criteria (C) represents the criteria. The actual data is not represented here as it is confidential. Three criteria have been considered as mentioned above, C1, C2 and C3. The information gathered for C1 and C2 is converted into a range number as represented in Table 2 and Table 3. Criteria C1 was classified into five classes and criteria C2 was classified into two classes.

Table 2: Family Income Range

Family income	Range
0-1000	5
1000-2000	4
2000-3000	3
3000-4000	2
>4000	1

Table 3: Type of Work Range

Type of work	Range
Government	1
Non-government	2

Firstly, decision-makers used the linguistic variables in Table 1 to assess the importance weight of each criterion. This linguistic variable is converted into fuzzy triangular numbers to construct the fuzzy decision matrix and determine each criterion's weight fuzzy number. Table 4 below demonstrates the significance of the criterion's weight from the perspective of the decision-maker.

Table 4: Importance weight of the criteria from decision-maker

Criteria	Weight			Rank	Crisp Number	Normalized Weight
C1	0.5	0.9	1.0	2	0.7833	0.3357
C2	0.3	0.7	1.0	3	0.6667	0.2857
C3	0.7	1.0	1.0	1	0.8833	0.3786

Then, the values were entered into a normalised decision matrix using equation (6). The normalised decision matrix for S1 and C2 is calculated as follows.

$$r_{12} = \frac{2}{\sqrt{\begin{array}{l}2^2+1^2+1^2+1^2+2^2+2^2+2^2+2^2+2^2+2^2+1^2+2^2+2^2+2^2+2^2+2^2+2^2+2^2 \\ +2^2+2^2+2^2+2^2+2^2+2^2+2^2+1^2+2^2+2^2+2^2+1^2+2^2+2^2+2^2+1^2+2^2\end{array}}}$$

$$= \frac{2}{\sqrt{119}} = 0.1833$$

Next, each element of the normalised matrix multiplied by the weightage determined from fuzzy set theory in Table 4. Equation (8) was then used to generate a weighted normalised matrix. The calculation from the weight normalised matrix for S1 and C2 is shown below:

$$v_{12} = 0.2857 \times 0.1833 = 0.0523$$

Hence, equation (9) and equation (10) were used to calculate the positive and negative ideal solutions, respectively. The outcome of this process is shown in Table 5.

Table 5: Positive Ideal Solution and Negative Ideal Solution

PIS and NIS	C1	C2	C3
PIS (A+)	0.0750	0.0524	0.1141
NIS (A-)	0.0150	0.0262	0.0104

Then, the separation of positive was calculated using Equation (11) and the separation measure of negative was calculated using Equation (12). The calculation of the positive separation measure for student 1 is shown below:

$$S_1 = \sqrt{(0.0600 - 0.0750)^2 + (0.0524 - 0.0524)^2 + (0.0726 - 0.1141)^2}$$
$$= 0.0441$$

The calculation of the negative separation measure for student 1 is also shown as below:

$$S_1 = \sqrt{(0.0600 - 0.0150)^2 + (0.0524 - 0.0262)^2 + (0.0726 - 0.0104)^2}$$
$$= 0.0812$$

The closeness of each alternative was determined using Equation (13) for the next step. The maximum value of closeness indicates that the best alternatives are preferred to choose a poverty case among UiTM Perlis students. The calculation of the closeness coefficients of alternative 1 for student 1 is shown below.

$$RC_1^+ = \frac{0.0812}{0.0812 + 0.0441} = 0.6478$$

Eventually, the final step was to rank each alternative's preference order in descending order. The alternative with the greatest relative closeness (RC_i^+) is the better option for receiving aid. As a result, Table 6 displays the ranking results of students who are eligible for financial aid.

Table 6: Final Results for Determining the Poverty Case Among Students

Alternative	Rank	RC_i^+
S35	1	1.0000

S20	2	0.9166
S18	3	0.7928
S33	4	0.7875
S16	5	0.7585
S27	6	0.7212
S22	7	0.6800
S1	8	0.6478
S29	8	0.6478
S7	10	0.6169
S28	10	0.6169
S15	12	0.5907
S10	13	0.5898
S19	14	0.5764
S21	14	0.5764
S23	14	0.5764
S12	17	0.5097
S6	18	0.4542
S25	18	0.4542
S5	20	0.4527
S8	20	0.4527
S17	20	0.4527
S31	20	0.4527
S24	24	0.4499
S26	25	0.4217
S3	26	0.4093
S9	27	0.3914
S13	27	0.3914
S11	29	0.3522
S4	30	0.3429
S32	31	0.3318
S2	32	0.3148
S14	33	0.2795
S34	34	0.2415
S30	35	0.0834

There are several students with the same rank, such as S1 and S29. This is because their results show the same relative closeness of the alternative (RC_i^+). S35 is the first student to be selected to receive financial aid whose father is a labourer with RM1000 monthly income with eleven dependents in the family. On the other hand, S30 is the worst alternative candidate to receive aid. This is due to the father's occupation as a human resource officer with RM4400 monthly income and has two dependents and the result showed the

smallest relative closeness of the alternatives (RC_i^+). The overall result is presented graphically in Figure 1 below.

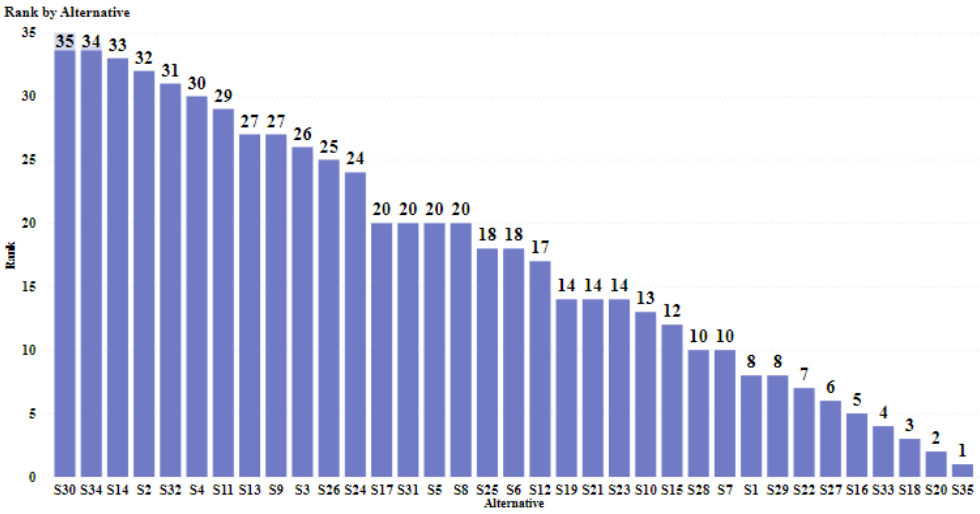

Figure 1: The result generated in the stacked column charts

CONCLUSION AND RECOMMENDATIONS

UiTM Perlis has allocated RM 88,700 in subsistence zakat aid to students for the semester of March 2022-August 2022, with aid ranging from RM100 to RM700 per person. Allocation provided by UiTM Perlis for each semester is different because the income or source for each semester is different. All thirty-five students have been chosen to receive aid considering that the allocation provided by UiTM for the semester is sufficient for all of them. If the fund is not sufficient for the students, Zakat, Alms & Endowment Unit of UiTM Perlis must restrict the number of candidates which are being chosen to accept the funds and successful candidates to receive aid can be chosen from the rank of applicants generated using Fuzzy TOPSIS method. The study demonstrated that the method used, Fuzzy TOPSIS has successfully achieved the goals which are to select a poverty case among students with fairness, fast, and accuracy, and rank the selection based on all criteria and standards.

In conclusion, Fuzzy TOPSIS method has proven its vital role in reducing selection process errors compared to manual selection. Besides, UiTM Perlis can add several criteria, such as chronic health problem faces by the applicant or family member that requires ongoing treatment and also the background of the applicant's either having parents or orphan. Furthermore, it is advised to use software such as MATLAB and Python to generate the results. In terms of method, this research can be implemented using other methods such as the Fuzzy Analytical Hierarchy Process (AHP) method and the Simple Additive Weighting (SAW) method. Nevertheless, future researchers can use this study as a reference in decision-making problems and achieve better results. Thus, UiTM Perlis can pursue this method to assist the management staff in providing quick and accurate decision in selecting students who are in dire need of financial aid.

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CONFLICT OF INTEREST DISCLOSURE

All authors declare that they have no conflicts of interest to disclose

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