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APPLICATION OF FUZZY TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO THE IDEAL SOLUTION IN THE SELECTION OF CANDIDATES

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ABSTRACT

Selecting the right candidate for the right cause is similar to identifying the most compromising solution of multi-criteria decision making (MCDM) problem. In real life the selection criteria may involve vague and incomplete data which cannot be expressed in precise mathematical form or numerical values. Apparently fuzzy-based technique can be applied to describe and represent these data in fuzzy numbers. This paper presents a MCDM fuzzy TOPSIS based model designed to solve the selection problem for allocation of government staff quarters. Result shows that the proposed model is suitable and appropriate. It was also found that the MCDM model which uses single decision maker rating process can also be applied to multiple decision makers. It is recommended that the application of fuzzy TOPSIS can be extended to other selection processes such as vendor selection, training evaluation or group marking of project works.

Keywords: *Multi-criteria decision making, TOPSIS, fuzzy-based technique, complex decision making.*

INTRODUCTION

Decision making process is part of human daily activities. In many situations one has to make decision after considering the cost and benefit of the situation based on certain criteria. Selecting the best alternative

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from all possible options available is a part of decision making process. Good decision makings normally require decision makers to employ multiple criteria in assessing (Chen, 2000). The selection process will be more difficult if the evaluation involves features that cannot be measured accurately by crisp numbers and the number of decision makers is more than one. In addition, the complexity of decision makers' opinions will also complicate the selection process.

Data obtained in real life are usually imprecise in nature due to incomplete and vague information and hence not deterministically described (Olson, 2004). In the past a selection method was generally developed based on the measurement of crisp output, such as its standard deviation, the quartile deviation, the coefficients of skewness and kurtosis (Lalla, Facchinetti, & Mastroleo, 2008). Crisp values are inadequate to the real life situation because human evaluations are often ambiguous and cannot be estimated with exact numerical values (Kuo, Tzeng & Huang, 2007). Modern approaches such as fuzzy set approaches recognized selection as a complex process mounted with a significant amount of subjective information. Kahraman (2008) pointed out that these approaches provide problem modeling and solution technique and are suitable to use when the modeling of human knowledge is necessary and human evaluations are needed in multi-criteria condition.

MULTI-CRITERIA DECISION MAKING (MCDM)

A MCDM method was developed to identify solution for a set of alternatives based on certain considered criteria. A MCDM problem deals with selection of alternatives based on a set of criteria (Weber, Current, & Benton, 1991). According to Hwang and Yoon (1981), a MCDM problem can be simply expressed in matrix format as

$$\widetilde{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} \widetilde{x}_{11} & \widetilde{x}_{12} & \cdots & \widetilde{x}_{1n} \\ \widetilde{x}_{21} & \widetilde{x}_{22} & \cdots & \widetilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \widetilde{x}_{m1} & \widetilde{x}_{m2} & \cdots & \widetilde{x}_{mn} \end{bmatrix}$$
$$C_1 \quad C_2 \quad \cdots \quad C_n$$

$$\widetilde{W} = \left[\widetilde{w}_1 \quad \widetilde{w}_2 \quad \cdots \quad \widetilde{w}_n\right]$$

where $A_1, A_2, \ldots, A_m$ are possible alternatives to be selected $C_1, C_2, \ldots,$ C_n are criteria with which alternative performance are measured, $\widetilde{x}_{ij}$ is the rating of alternative A_i with respect to criterion C_j and W_j is the weight of criterion C_j.

TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

TOPSIS is one of the 14 methods employed in the MCDM outlined by Hwang and Yoon (1981). TOPSIS works on a simple principle that is the chosen alternative should be close to the ideal solution and far from the negative-ideal solution. The ideal solution is the composite of the best performance values exhibited (in the decision matrix) by any alternative for each attribute. The negative-ideal solution is the composite of the worst performance values. The closeness coefficient is the main parameter in determining the ranking of all alternatives. It is the distance between fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) (Chen, 2000). In order to solve the ambiguous criteria in information from human evaluation, fuzzy set theory can be use to establish fuzzy TOPSIS (Dursun & Karsak, 2010). In fact, fuzzy TOPSIS has been applied in a variety of situations. For instance, in implementing a rabbit-breeding farm, Armero, Garc´ıa-Cascales, Go´mez-Lo´ pez, and Lamata (2011) applied fuzzy TOPSIS in making decisions to design a structure for housing the animals. In addition, Taghavifard, Rostami and Mousavi (2011) applied fuzzy hierarchical TOPSIS method to evaluate and select the best resource of technology.

STATEMENT OF PROBLEM

Selecting the right person for the right cause is a difficult task. Selecting the right candidates for limited vacancy in government staff quarters based on staff performance and personality is definitely challenging for decision makers. The arrival of large number of new staff to the Royal Malaysian Customs Department (RMCD) lately has increased the number of applications for accommodation at *rumah jabatan* (staff quarters) of RMCD. Since the number of staff quarters of RMCD is limited, the housing administration personnel needs to be more vigilant and selective in order to make sure that the most deserved staff are chosen.

A variety of characteristics or criteria are evaluated when selecting staff for accommodation. For example, the extensiveness of staff involvement in the department activities, job position, income, grade and state are considered. As such, the staff selection formed a MCDM problem, finding an appropriate method of selection is crucial for housing administrators of RMCD. Thus this paper presents the findings of a study that investigated the use of MCAM model based on fuzzy TOPSIS to help the RMCD heads of department to make decision based on multi-criteria attributes. The study utilized three decision makers to determine the criteria and rating the staff for the *rumah jabatan* in a single decision maker rating process.

METHODOLOGY

Selection Procedures Based on Fuzzy TOPSIS

The selection procedures based on fuzzy TOPSIS were adapted from Chen, Lin and Huang (2006). Assume that a committee of K decision makers D_1, D_2,..., D_K are responsible for assessing m possible alternatives (A_1, A_2,... , A_m) with respect to n criteria (C_1, C_1,... , C_n) as well as assessing the importance of the criteria. The suitable ratings of alternatives under subjective criteria and their weight were assessed in linguistic terms represented by triangular fuzzy numbers.

The important weight of criteria and the ratings of alternatives are expressed in linguistic variables as shown in Table 1 and Table 2 respectively. The linguistic variables are represented in triangular fuzzy numbers that are shown in Figure 2 and Figure 3 respectively.

Table 1: Linguistic variable for the weighting of each criterion

Symbol	Important Weight	Fuzzy Number
VL	Very Low	(0.0,0.0,0.1)
L	Low	(0.0,0.1,0.3)
ML	Medium Low	(0.1,0.3,0.5)
M	Medium	(0.3,0.5,0.7)
MH	Medium High	(0.5,0.7,0.9)
H	High	(0.7,0.9,1.0)
VH	Very High	(0.9,1.0,1.0)

Table 2: Linguistic variable for ratings of each alternative

Symbol	Rating of Alternative	Fuzzy Number
VP	Very Poor	(0,0,2)
P	Poor	(0,2,6)
MP	Medium Poor	(2,6,10)
F	Fair	(6,10,14)
MG	Medium Good	(10,14,18)
G	Good	(14,18,20)
VG	Very Good	(18,20,20)

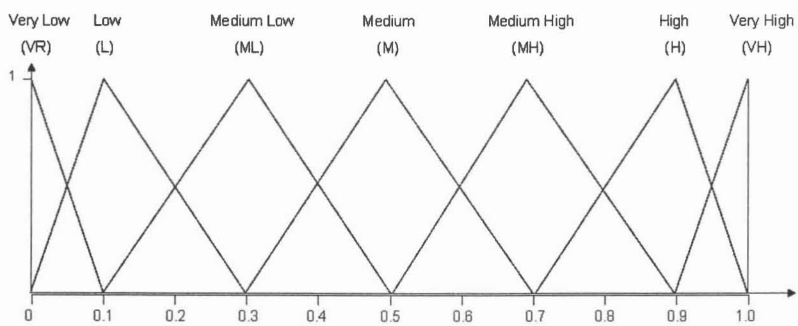

Figure 1: Linguistic Variables for Importance Weight of Each Criterion

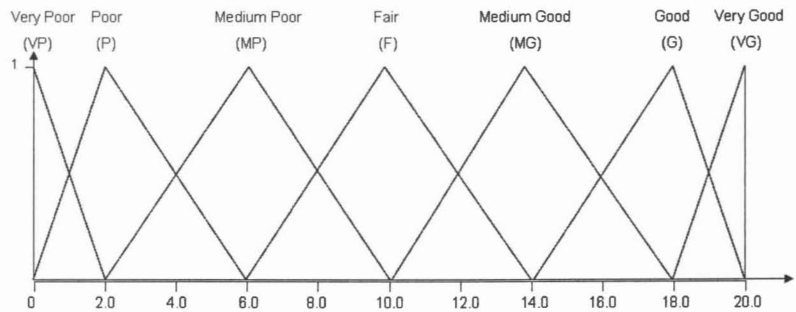

Figure2: Linguistic Variables for Rating of Each Alternative

In this study, the selection procedure based on fuzzy TOPSIS was conducted in six steps as follow:

Step 1: Determining the fuzzy weight of evaluation criteria.

Pool the decision makers' opinions to get the aggregated weight of criteria, $\widetilde{w}_j$ and fuzzy rating for alternative $\widetilde{x}_{ij}$. The importance criteria and fuzzy rating of alternative can respectively be calculated as

$$\widetilde{w}_j = \frac{1}{K}\left(\widetilde{w}_j^1 + \widetilde{w}_j^2 + \cdots + \widetilde{w}_j^k\right) \tag{1}$$

and

$$\widetilde{x}_{ij} = \frac{1}{K}\left(\widetilde{x}_{ij}^1 + \widetilde{x}_{ij}^2 + \cdots + \widetilde{x}_{ij}^k\right) \tag{2}$$

where $\widetilde{w}_j$ and $\widetilde{x}_{ij}$ are the importance weight and the rating of the k^{th} decision maker. The corresponding fuzzy evaluation matrices and fuzzy weight are given respectively as

$$\widetilde{D} = \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{bmatrix} \widetilde{x}_1 & \widetilde{x}_2 & \cdots & \widetilde{x}_{1n} \\ \widetilde{x}_2 & \widetilde{x}_2 & \cdots & \widetilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \widetilde{x}_{m1} & \widetilde{x}_{m2} & \cdots & \widetilde{x}_m \end{bmatrix}$$
$$\quad C_1 \quad C_2 \quad \cdots \quad C_n$$

$$\widetilde{W} = \begin{bmatrix} \widetilde{w}_1 & \widetilde{w}_2 & \cdots & \widetilde{w}_n \end{bmatrix}$$

where $\widetilde{w}_j$ and $\widetilde{x}_{ij}$ are linguistic variable that can be described by fuzzy numbers $\widetilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$ and $\widetilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$.

Step 2: Construct the normalized fuzzy decision matrix, $\widetilde{R}$, and the weighted normalized fuzzy decision matrix, $\widetilde{V}$.

$$\widetilde{R} = \left[\widetilde{r}_{ij}\right]_{mxn}$$

where

$$\widetilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+} \right), \qquad j \in B; \tag{3}$$

and

$$\widetilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}} \right), \qquad j \in C;$$

such that

$$c_j^+ = \max_i c_{ij} \text{ if } j \in B;$$

$$a_j^- = \min_i a_{ij} \text{ if } j \in C,$$

where B and C are the set of benefit criteria and cost criteria respectively.

Based on $\widetilde{R}$, the weighted normalized fuzzy decision matrix, $\widetilde{V}$ is obtained by considering the different weight of each criterion. The normalized fuzzy decision matrix can be computed by multiplying weight of criteria and the values in normalized fuzzy decision matrix.

$$\widetilde{V} = \left[\widetilde{v}_{ij}\right]_{mxn}, \quad i = 1,2,...,m \text{ and } j = 1,2,...,n. \tag{4}$$

$$\widetilde{v}_{ij} = \widetilde{r}_{ij}(.)\widetilde{w}_j$$

where $\widetilde{v}_{ij}$ are normalized positive fuzzy numbers and their ranges belong to closed interval [0,1].

Step 3: Determine the fuzzy positive ideal solution (FPIS), A^+ and the fuzzy negative ideal solution (FNIS), A^- such that

$$A^+ = \left(\widetilde{v}_1^+, \widetilde{v}_2^+, \cdots, \widetilde{v}_n^+\right)$$

and

$$A^- = \left(\widetilde{v}_1^-, \widetilde{v}_2^-, \cdots, \widetilde{v}_n^-\right)$$

where $\widetilde{v}_j^+ = (1,1,1)$ and $\widetilde{v}_j^- = (0,0,0)$, $j=1,...,n$.

Step 4: Calculate the distance of each alternative A_i (i=1, 2,..., n) from A^+ and A^- which can be calculated respectively as

$$d_i^+ = \sum_{j=1}^{n} d\left(\widetilde{v}_{ij}, \widetilde{v}_j^+\right), \quad i=1,2,...,m;\ j=1,2,...,n. \tag{5}$$

and

$$d_i^- = \sum_{j=1}^{n} d\left(\widetilde{v}_{ij}, \widetilde{v}_j^-\right), \quad i=1,2,...,m;\ j=1,2,...,n. \tag{6}$$

If $\tilde{v}_{ij}$ = (a, b, c), then

$$d(\tilde{v}_{ij},\tilde{v}_j^{+})=\sqrt{\frac{(1-a)^2+(1-b)^2+(1-c)^2}{3}}$$

and

$$d(\tilde{v}_{ij},\tilde{v}_j^{-})=\sqrt{\frac{(0-a)^2+(0-b)^2+(0-c)^2}{3}}$$

Step 5: Obtain the closeness coefficient, CC_i. The closeness coefficient of each alternative is calculated as

$$CC_i=\frac{d_i^-}{\left(d_i^+ + d_i^-\right)},\ i=1,\ 2\ldots\ m. \tag{7}$$

Step 6: Determine the ranking position of alternatives. According to closeness coefficient, CC_i, the ranking order of all alternatives are determined. The CC_i are sorted in a descending order. The highest value will be placed in the first ranking position.

SELECTION PROCEDURE

The selection of staff for *rumah jabatan* accommodation was conducted using the selection procedure presented above. The hierarchical structure of the selection process is displayed in Figure 3. The evaluation criteria were identified as involvement in activities (C_1), position (C_2), family income (C_3), grade (C_4) and State (C_5). The importance of these criteria was determined by three decision makers. Twenty staff's application forms A_{01}, A_{02} ... , A_{20} were picked at random where data obtained from these application form were used to illustrate the implementation of the model.

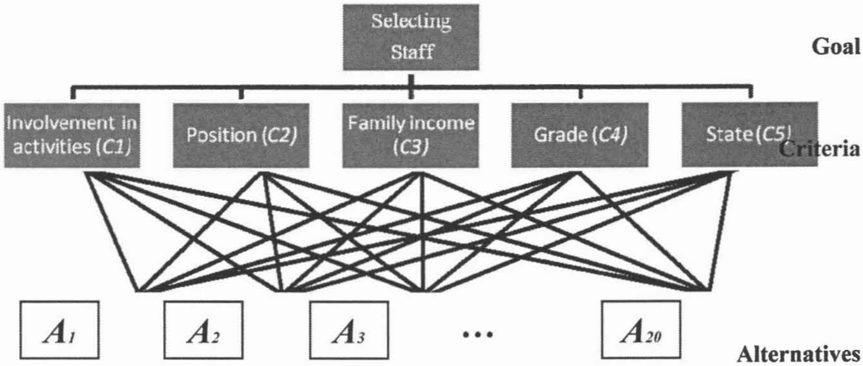

Figure3: The Hierarchical Structure Of The Selection Process

Criteria listed on the application form by RMCD Administration are shown in Table 3, while the evaluation on criteria importance by the three decision makers D_1, D_2 and D_3 are displayed in Table 4.

The evaluation of importance of each criterion by decision makers, represented in the form of fuzzy number and the average weights of the criteria, were obtained using (1) as shown in Table 5. An example of calculation for the average importance of the criterion "Activities / Involvement"C_1, is calculated as

$$w_1 = \frac{1}{3}[H + VH + H]$$

$$= \frac{1}{3}[(0.7,0.9,1.0) + (0.9,1.0,1.0) + (0.7,0.9,1.0)]$$

$$= (0.77,0.93,1.00)$$

Table 3: Criteria for Evaluation

Criteria	Description	Notation
C_1: Activities/ Involvement	None	*C11*
	Member of society	*C12*
	Committee	*C13*
	Represent RMC	*C14*
	Represent Malaysia	*C15*
	World participation	*C16*
C_2: Position	Ketua Kastam Daerah	*C21*
	Penolong Kanan Pengarah Kastam	*C22*
	Penolong Penggarah Kastam	*C23*
	Penguasa Kastam	*C24*
	Penolong Penguasa Kastam	*C25*
	Pegawai Kastam Tinggi/Kanan	*C26*
	Pegawai Kastam.	*C27*
C_3: Family income	RM0 - RM500	*C31*
	RM501 - RM800	*C32*
	RM801 - RM1000	*C33*
	RM1001 - RM2500	*C34*
	RM2501-RM4000	*C35*
	RM40001 - RM5000	*C36*
	RM5001 - RM 100000000	*C37*
C_4: Grade	W17	*C41*
	W26/W22	*C42*
	W41	*C43*
	W27	*C44*
	W44	*C45*
	W48	*C46*
	W52	*C47*

C_5: State	*Kuala Lumpur, Putrajaya & Selangor*	*C51*
	N. Sembilan, Melaka & Johor	*C52*
	Perlis, Kedah, Perak, P.P, Kelantan, Terengganu, Pahang	*C53*
	Sabah, Sarawak & Labuan	

The average fuzzy weights of all criteria were calculated using the same process and procedure. Table 5 presents the average weights of all criteria. After average weights of all criteria were calculated, the performance rating of each candidate by a single decision maker, (K=1) was evaluated. Table 6 displays the performance of each candidate with respect to the criteria.

Table 4: Importance of criteria by decision makers

Criteria	Decision's Maker		
	D1	*D2*	*D3*
C_1 = Activities/Involvement	*H*	*VH*	*H*
C_2 = Position	*H*	*ML*	*L*
C_3 = Family Background	*VH*	*H*	*VH*
C_4 = Grade	*M*	*M*	*L*
C_5 = State	*L*	*MH*	*H*

Table 5: Average fuzzy weight for each criterion

Criteria	Decision's Maker			Average Weight for Each Criterion
	D1	*D2*	*D3*	
C_1	(0.7, 0.9, 1.0)	(0.9, 1.0, 1.0)	(0.7, 0.9, 1.0)	(0.77, 0.93, 1.00)
C_2	(0.7, 0.9, 1.0)	(0.1, 0.3, 0.5)	(0.0, 0.1, 0.3)	(0.27, 0.43, 0.60)
C_3	(0.9, 1.0, 1.0)	(0.7, 0.9, 1.0)	(0.9, 1.0, 1.0)	(0.83, 0.97, 1.00)
C_4	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.0, 0.1, 0.3)	(0.20, 0.37, 0.57)
C_5	(0.0, 0.1, 0.3)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.40, 0.57, 0.73)

Table 6: Performance for Each Candidate

	Criteria				
Candidate	***C1***	***C2***	***C3***	***C4***	***C5***
A01	*L*	*H*	*ML*	*MH*	*M*
A02	*L*	*H*	*MH*	*ML*	*M*
A03	*ML*	*M*	*VL*	*MH*	*M*
A04	*ML*	*M*	*VL*	*M*	*H*
⋮	⋮	⋮	⋮	⋮	⋮
A19	*ML*	*ML*	*VL*	*ML*	*MH*
A20	*L*	*ML*	*VL*	*MH*	*H*

The performances of each candidate by decision makers represented in the form of fuzzy numbers are shown in Table 7.

The corresponding normalized fuzzy entries or decision matrix with respect to Criteria 1 was calculated using (3) and the values were presented in Table 8. An example of calculation for finding the normalized entries of the decision matrix with respect to criterion C_1 is shown below.

$$c_1^+ = \max(0.00, 0.10, 0.30, 0.70, 0.90, 1.00, 0.10, 0.30, 0.50, 0.50, 0.70, 0.90, 0.30, 0.50, 0.70) = 1.00$$

$$\tilde{r}_{11} = \left(\frac{0.0}{1}, \frac{0.1}{1}, \frac{0.3}{1}\right) = (0.0, 0.1, 0.3)$$

The overall entries for normalized fuzzy decision matrix for Criteria 1 are displayed in Table 8.

Table 7: Candidates' Performance For Criteria 1

Candidate	Criteria 1			
	C1			
A01	*L*	(0.0,	0.1,	0.3)
A02	*L*	(0.0,	0.1,	0.3)
A03	*ML*	(0.1,	0.3,	0.5)
A04	*ML*	(0.1,	0.3,	0.5)
A05	*VH*	(0.9,	1.0,	1.0)
⋮	⋮		⋮	
A19	*ML*	(0.1,	0.3,	0.5)
A20	*L*	(0.0,	0.1,	0.3)

Table 8: Normalized Fuzzy Decision Matrix For Criteria 1

Candidate	Normalized Fuzzy Decision Matrix		
	C1		
A01	(0.00,	0.10,	0.30)
A02	(0.00,	0.10,	0.30)
A03	(0.11,	0.33,	0.56)
A04	(0.14,	0.43,	0.71)
A05	(0.90,	1.00,	1.00)
⋮		⋮	
A19	(0.20,	0.60,	1.00)
A20	(0.00,	0.11,	0.33)

The weighted normalized decision matrix can then be constructed using (4). For example, the weighted normalized decision value for the criterion "Activities / Involvement" C_1 and candidate A01 is calculated as

$$\tilde{v}_{11} = \tilde{r}_{ij}(.)\tilde{w}_{ij} = (0.0,0.1,0.3) \times (0.77,0.93,1.00) = (0.00,0.09,0.30)$$

The overall weighted normalized fuzzy decision matrix for Criteria 1 is displayed in Table 9.

Table 9: Weighted Normalized Fuzzy Decision Matrix for Criteria 1

	Weighted Normalized Fuzzy Decision Matrix		
Candidate		*C1*	
A01	(0.00,	0.09,	0.30)
A02	(0.00,	0.09,	0.30)
A03	(0.09,	0.31,	0.56)
A04	(0.11,	0.40,	0.71)
A05	(0.69,	0.93,	1.00)
⋮		⋮	
A19	(0.15,	0.56,	1.00)
A20	(0.00,	0.10,	0.33)

In this study, the FPIS, A^+ and the FNIS, A^- are respectively defined as

$$A^+ = \left(\tilde{v}_1^+, \tilde{v}_2^+, \cdots, \tilde{v}_n^+\right) = [(1,1,1), (1,1,1), (1,1,1), (1,1,1), (1,1,1)]$$

and

$$A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, \cdots, \tilde{v}_n^-\right) = [(0,0,0), (0,0,0), (0,0,0), (0,0,0), (0,0,0)]$$

Based on Table 9, the distance for candidate *A01* performance with respect to Criteria 1 from FPIS and FNIS were calculated as

$$d(_{11}^{+}, A^+) = \sqrt{\frac{(1-0.00)^2 + (1-0.09)^2 + (1-0.30)^2}{3}} = 0.88$$

$$(d_{11}^-, A^-) = \sqrt{\frac{(0-0.00)^2 + (0-0.09)^2 + (0-0.30)^2}{3}} = 0.18$$

The distances of performance for all candidates from both FPIS and FNIS with respect to all criteria were calculated using (5) and the result are presented in Table 10.

The d_i^+ and d_i^- for all criteria and alternatives were calculated using the same procedures and the values obtained are as shown in Table 10.

Table 10: Distance from FPIS, $d(V_{ij}, A^+)$ and distance from FNIS, $d(V_{ij}, A^-)$

	$d(V_{ij}, A^+)$						$d(V_{ij}, A^-)$					
Candidate	***C1***	***C2***	***C3***	***C4***	***C5***	d_i^+	***C1***	***C2***	***C3***	***C4***	***C5***	d_i^-
A01	0.88	0.63	0.73	0.73	0.71	3.68	0.18	0.43	0.34	0.33	0.35	1.63
A02	0.88	0.63	0.39	0.87	0.71	3.48	0.18	0.43	0.69	0.18	0.35	1.82
A03	0.71	0.75	0.96	0.70	0.68	3.81	0.37	0.31	0.06	0.37	0.38	1.50
A04	0.64	0.69	0.95	0.72	0.38	3.39	0.48	0.40	0.08	0.36	0.77	2.09
A05	0.18	0.69	0.55	0.80	0.71	2.94	0.88	0.37	0.51	0.25	0.35	2.36
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
A19	0.55	0.73	0.94	0.76	0.41	3.39	0.67	0.38	0.12	0.35	0.92	2.43
A20	0.87	0.84	0.96	0.70	0.48	3.86	0.20	0.21	0.06	0.37	0.60	1.45

In particular for candidate *A01*,

$$d_1^+ = \sum_{j=1}^{5} d(\tilde{v}_{ij}, v_j^+) = 0.88 + 0.63 + 0.73 + 0.73 + 0.71 = 3.68$$

$$d_1^- = \sum_{j=1}^{5} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right) = 0.18 + 0.43 + 0.34 + 0.33 + 0.35 = 1.63$$

In Step 5, the closeness coefficient for Candidate *A01* is calculated using (8) as shown below

$$CC_{A01} = \frac{1.63}{3.68 + 1.63} = 0.3063$$

Finally the candidates were ranked by sorting the corresponding closeness coefficient in descending order. The ranking is displayed in Table 11 in descending order.

Table 11: Ranking of candidates

Ranking	Candidate	Closeness Coefficient
1	A05	0.4453
2	A19	0.4180
3	A09	0.4130
4	A06	0.3984
5	A16	0.3833
6	A17	0.3831
7	A04	0.3815
8	A13	0.3615
9	A02	0.3438
10	A18	0.3436
11	A10	0.3427
12	A12	0.3398
13	A11	0.3082
14	A01	0.3063
15	A14	0.2876
16	A03	0.2821
17	A20	0.2730
18	A15	0.2618

After considering all the criteria, candidate A05 managed to get an index of 0.4453 in term of overall performance. Similar process and procedures also apply to the rest of the candidates. Table 11 shows that candidate A05 gets the highest rating after all the candidates based on the closeness coefficient.

According to this ranking system, Fuzzy TOPSIS clearly decide that candidate A05 is the best candidate to be selected compared to other staff/candidates. Since candidate A05 satisfied all the criteria that were determined by housing administration, this candidate should be given highest priority in the selection process. On the contrary, candidate A07 just managed to get 0.2563 score only, which means that this candidate has the lowest chance of being selected for the *rumah jabatan* accommodation.

CONCLUSION AND RECOMMENDATION

In this paper we present a multi-criteria decision making model based on fuzzy TOPSIS model in order to solve the selection problem for staff quarters allocation. The selection model takes into consideration criteria such as activities involvement, position, family income, grade and state. All these criteria were scored in the evaluation process to ensure that the selected candidates fulfilled majority of the terms and conditions. The TOPSIS technique uses the overall weighted normalized decision matrix as well as the closeness coefficient to rank the performance of each candidate. The higher the value of closeness coefficient of the candidates' performance will lead to a higher chance of being selected for the allocation. As such, the result of the selection is deemed reasonably fair and impartial.

A single decision maker rating process was used. However multiple decision makers can also apply the same procedure. We acknowledge that fuzzy TOPSIS is an effective and efficient tool capable in dealing with other uncertainty or vagueness problem. In future research, the application of fuzzy TOPSIS can be extended to other areas of selection process such as vendor selection, training evaluation or project markings by a group of examiners.

REFERENCES

Armero, E., Garc´ıa-Cascales,M.S., Go´mez-Lo´pez, M.D. and Lamata, M.T. (2011). Decision making in uncertain rural scenarios by means of fuzzy TOPSIS method. *Advances in Decision Sciences,.2011*, Article ID 937092, 15 pages. DOI:10.1155/2011/937092

Chen, C.T. (2000). Extension of the TOPSIS for group decision making under fuzzy enviroment. *Fuzzy Sets and Systems,* 114(1), 1-9.

Chen, C.T., Lin, C.T., and Huang, S.F. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. *International Journal of Production Economics,* 102(2), 289-301.

Dursun, M., and Karsak, E. (2010), A fuzzy MCDM approach for personal selection, *Expert System with Application*, 37, 4324-4330.

Hwang, C.L. and Yoon, K. (1981). *Multiple Attributes Decision Making Methods and Application,* Berlin Heidelberg: Springer.

Kahraman, C. (2008).Multi-criteria decision making methods and fuzzy sets. In C. Kahraman (ed.), *Fuzzy Multi-Criteria Decision Making, Vol. 16*, pp. 1-18. Springer Science + Business Media, LLC. DOI: 10.1007/978-0-387-76813-7

Kuo, M.S., Tzeng, G.H. and Huang, W.C. (2007). Group decision-making based on concepts of ideal and anti-ideal points in a fuzzy environment. *Mathematical and Computer Modelling*, 45 (3–4), 324–339.

Lalla, M., Facchinetti,G., and Mastroleo, G. (2008). Vagueness evaluation of the crisp output in a fuzzy inference system. *Fuzzy Sets and Systems,* 159(24), 3297-3312.

Olson, D.L. (2004). Comparison of weight in TOPSIS models, *Mathematical and Computer Modelling,* 40, 721-727.

Taghavifard, M., Rostami, M., Seyed Mahdi Makhzan Mousavi (2011). A hierarchical fuzzy TOPSIS model for evaluating technology transfer of medical equipment. *International Journal of Academic Research,* 3(3), 511-519.

Weber, C.A., Current, J.R., and Benton, W.C. (1991). Vendor selection criteria and methods, *European Journal of Operational Research,* 50(1), 2-18.

Yoon, K.P. (1987). A reconciliation among discrete compromise solutions, *Journal of the Operational Research Society,* 38(3), 277-286.