Evaluation of Alternative Payment Methods Effectiveness in Universitas Indonesia Main Gate using Combination of Fuzzy AHP and Fuzzy TOPSIS

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Abstract

Objective: A case study on payment method for entering Universitas Indonesia main gate decision was conducted to demonstrate hybrid method of Fuzzy AHP and Fuzzy TOPSIS

Methods: Fuzzy AHP method was selected for determining the weighting of each decision-making criteria and TOPSIS method to determine the rating for each alternative

Results: Based on the calculations, the CCi values are Cash > Non-cash > Membership payment method. The sensitivity analysis results represented that the ranking of solutions for entering UI main gate is not very sensitive to the different decision-making influence criteria weights

Conclusion: The ranking of alternative solutions can be a guideline and support decision makers or top management to determine policy and strategies for the implementation of payment method on Universitas Indonesia main gate. Therefore, Cash method is still the best method that the respondents have chosen

Keywords: *Fuzzy AHP, Fuzzy TOPSIS, payment method, Cash, Non-Cash, Triangular Fuzzy Number*

Introduction

Decision process can be defined as a set of actions and methods dynamically organized. In choosing alternatives, there are a lot of criteria that has to be included to the calculation in order to make the best decision. Multi criteria decision making is an instrument to investigate multiple conflicting criteria in decision making. Using the right methods in analysis of multi criteria decision is critical to gain the finest result. This paper is concerned with the campus entrance procedures in Universitas Indonesia.

Currently there are several alternatives that is provided by the campus to accommodate the transaction in the main entrance. we are interested in finding which one of them is the best. Analytical Hierarchy Process and TOPSIS are used to evaluate the case. Those two methods are the most known methods in Multi Criteria Decision Making. AHP models are based on a comparative judgement of the alternatives and criteria. Therefore, AHP is a useful approach for evaluating complex multiple criteria alternatives involving subjective judgment. Since project selection problems mostly include several hierarchical criteria with several alternatives and a group of experts with different judgments, AHP models have been used effectively to optimize project selection in the research and development settings. Meanwhile TOPSIS is a method that compares alternatives by identifying weights for each criterias. This paper will be divided into several parts. Part 2 will be discussing about the method while part 3 is regarding the data analysis and the last part will conclude our research, recommendation and the finding that we obtain from the analysis.

Study Case and Methodology

Study Case

The development of non-cash payments has been growing nowadays. In recent years, Indonesia's urban population has been accustomed to use non-cash payment instruments, such as credit cards, debit cards, ATM cards and pre-paid cards, to meet their daily transactional needs. Universitas Indonesia has been applying the cashless regulations for its permission to enter the university. Recently, there are new regulations of payment method for Izin Masuk Kampus (IMK). During the process, Civitas Akademika UI will use *tap cash* or Electronic money from BNI. But UPT PLK UI also

provides manual payment system for non-civitas Akademika UI who do not have it yet. The establishment of KTM (Student Identity Card) UI and BNI tap cash as a means of transaction Non-Board Campus Entitlement is to facilitate the academic community as well as optimize the facilities that have been available. There are several EDC machines at the main UI gateway counter. This regulation has been implemented since February and April for evaluation and has been applied continuously in May 2018.

Number of academic community that is continue increasing, requires Universitas Indonesia to be more thorough in the procurement and management of facilities for the visitors. There are few methods that can be used to enter UI main gate, such as using BNI Tap Cash, cash, and membership. This research will be focusing on how the payment method of entering Universitas Indonesia affect the visitor's decision. We have asked some experts to for their preferences and their opinion about this issue.

Materials

In this research, authors use AHP for data processing to define weights to every criteria in choosing the most effective payment method for entering Universitas Indonesia. Beside AHP, authors use TOPSIS method to prioritize and rank the solutions of payment methods of Entry fee permission. The criterias are shown in the Table 1.

Table 1. Criteria and Sub-Criteria

No	Criteria	Sub-Criteria	Explanation
1.	Transaction Speed (TS)	Processing time (TS 1) Queuing time (TS 2)	This variable has direct impact to the operational of vehicle entry permission in Universitas Indonesia main gate. Every morning, there are 4 counters open for payment but there are also long queue of cars seen around peak hours. Therefore, fast service is needed.
2.	Ease of use (EOU)	Flexibility (EOU 1) Error frequency in a few transactions (EOU 2) Accessibility (EOU 3)	This variable is one of the criteria of how important the product is for the customer according to 5 Es (Efficient, Effective, Engaging, Error tolerant and Easy to learn).
3.	Ease of Top-Up (EOTU)	Location of top up (EOTU 1) Top up time (EOTU 2)	Defines the ease of refilling the e-cash account. Whether the e-cash account can be replenished through internet banking or at some retail stores.
4.	User Satisfaction (US)	Satisfaction level (US1) Overall error rate (US 2) User Knowledge (US 3)	Examine the regulations of using e-payment system and cash whether or not, visitors of Universitas Indonesia are satisfied with the new payment system together with the error rate during each transaction.

Alternatives

In this research, there are three types of alternatives that authors decided to examine. Such as: Non-cash payment method (Tap Cash BNI), Cash Payment method (regular payment), and membership (Subscribe each month for Lecturer and officer only). These alternatives were chosen since all methods are in Universitas Indonesia regulations for entering permission in UI main gate.

Respondents or Experts

Respondents in this research consist of 5 different parties, such as: Lecturers, University students, PLK, Rektorat, and Adkesma BEM UI. Respondents from the lecturers are selected from lecturers who have been or are teaching in UI and driving a car so it is considered to know the payment system in UI main gate. Respondents from Adkesma BEM UI are selected from students who have been reviewing this new regulation change from cash payment to e-cash payment method. Respondents from PLK, Rectorate and officers are selected to give their opinions as decision makers and those who carry out the regulation. From their opinion, author can analyze from different point of views.

Fuzzy AHP and Fuzzy TOPSIS

In this study, 3 phase methodology has been applied for identifying, prioritizing, and ranking three alternatives and solutions. The first phase studied the current situation in Universitas Indonesia about regulations of Entry Fee Permission. The second phase used fuzzy AHP to get weight of criteria and sub-criteria of the service from the payment methods given. The third phase applied fuzzy TOPSIS to prioritize and rank the solutions of payment methods of Entry fee permission. Even though decision making can be done by using fuzzy AHP, multi-criteria decision making process can be improved if it is integrated with other decision support tools [1]. Therefore, this study proposed hybrid methods of fuzzy AHP and fuzzy TOPSIS to rank solutions for the most effective payment method.

Phase 1 : Identification of Payment Methods

In this phase, paying methods for entering Universitas Indonesia main gate have been identified and evaluated by experts including (Lecturer, PLK officers, BEM UI, and Rectorate) through relevant literature reviews in which the identified steps were illustrated in the Figure 1.

Phase 2 : Fuzzy AHP

Fuzzy AHP approach was presented by [4], triangular fuzzy number (TFN) are preferred for pairwise comparison scale of Fuzzy AHP and extent analysis method was used for the synthetic extent value of pairwise comparison.

Definition 1. A fuzzy number M on R to be TFN if its membership function (x) : R → [0,1] is equal to following Equation (1)

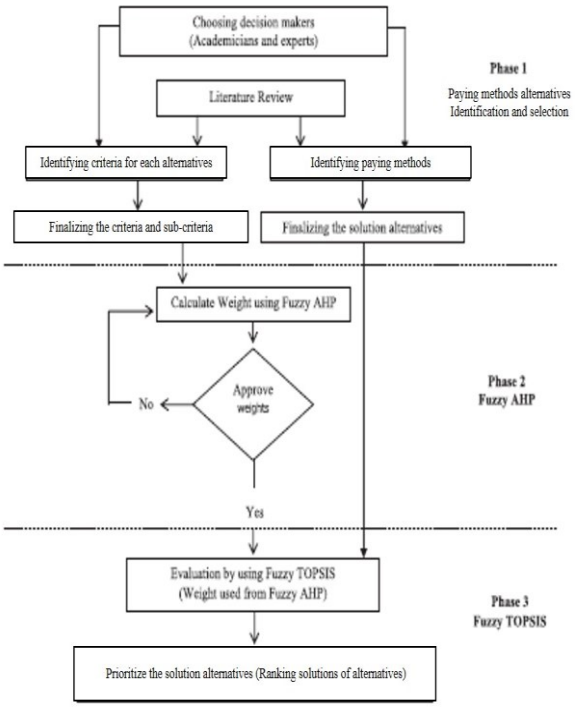

Figure 1. Research Methodology

$$\mu_M(x) = \begin{cases} \frac{(x-l)}{(m-l)} \\ \frac{(x-u)}{(m-u)} \\ 0 \end{cases} \begin{matrix} x \in [l,m] \\ x \in [m,u] \\ \text{otherwise} \end{matrix} \quad (1)$$

From Eq. (1) $l \leq m \leq u$, which l and u mean the lower and upper value of fuzzy number M, and m is the modal value (as Fig.3). TFN can be denoted by M = (l, m, u). According to [2], the operational laws of TFN M1 = (l1, m1, u1) and M2 = (l2, m2, u2) are shown as following equation (2) – (6)

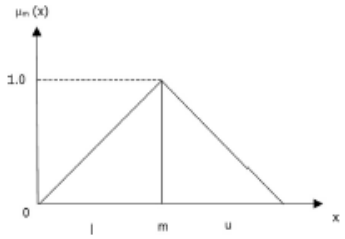

Figure 2. The membership function of TFN

$M1 + M2 = (l1, m1, u1) + (l2, m2, u2)$
$= (l1+l2 , m1 + m2, u1+u2)$
For l1,l2 > 0; m1,m2 > 0 ; u1,u2 > 0 (2)
$M1 - M2 = (l1, m1, u1) - (l2, m2, u2)$
$= (l1 - u2 , m1 - m2, u1-l2)$
For l1,l2 > 0; m1,m2 > 0 ; u1,u2 > 0 (3)
$M1 \times M2 = (l1, m1, u1) \times (l2, m2, u2)$
$= (l1\, l2,\ m1\, m2,\ u1\, u2)$
For l1,l2 > 0; m1,m2 > 0 ; u1,u2 > 0 (4)
$M1 \div M2 = (l1, m1, u1) / (l2, m2, u2)$
$= (l1 / u2 , m1 / m2, u1 / l2)$
For l1,l2 > 0; m1,m2 > 0 ; u1,u2 > 0 (5)
$M1^{-1} = (l1, m1, u1)^{-1}$
$= (1/ u1 , 1 / m1, 1 / l1)$
For l1,l2 > 0; m1,m2 > 0 ; u1,u2 > 0 (6)

According to the method of extent analysis of [4].

$M_{gt}^1, M_{gt}^2, M_{gt}^3 \ldots\ldots, M_{gt}^m,$

i = 1, 2, 3, 4, 5, ..., n (7)

Where all the (j = 1,2,3,4,5,....,m) are triangular fuzzy numbers given in Table. 2

Table 2. Triangular Fuzzy Number

Fuzzy Number	Linguistic Variables	Triangular Fuzzy Numbers
9	Extreme Importance	(8, 9, 10)
8	Very Strong to Extreme Importance	(7, 8, 9)
7	Very Strong Importance	(6, 7, 8)
6	Strong to Very Strong Importance	(5, 6, 7)
5	Strong Importance	(4, 5, 6)
4	Moderate to Strong Importance	(3, 4, 5)
3	Moderate Importance	(2, 3, 4)
2	Equal to moderate importance	(1, 2, 3)
1	Equal Importance	(1, 1, 1)

The steps of [4] analysis can be displayed as follows:

Step 1. The fuzzy judgment matrix $\tilde{A}$ (aij) can be expressed mathematically as in Equation [3]

$$\tilde{A} = \begin{pmatrix} 1 & \tilde{a}_{12} & \tilde{a}_{13} & \cdots & \tilde{a}_{1(n-1)} & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \tilde{a}_{23} & \cdots & \tilde{a}_{2(n-1)} & \tilde{a}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{(n-1)1} & \tilde{a}_{(n-1)2} & \tilde{a}_{(n-1)3} & \cdots & 1 & \tilde{a}_{(n-1)n} \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \tilde{a}_{n3} & \cdots & \tilde{a}_{n(n-1)} & 1 \end{pmatrix} \quad (8)$$

The fuzzy judgement matrix $\tilde{A}$ is an n x n fuzzy matrix containing fuzzy numbers $\tilde{a}ij$.

$$\tilde{A}_{ij} = \begin{cases} 1, & i = j \\ 1,3,5,7,9 \text{ or } \ldots 1^{-1},3^{-1},5^{-1},7^{-1},9^{-1} & i \neq j \end{cases} \quad (9)$$

Step 2. The values of Fuzzy synthetic extent with respect to i-th criterion is defined as :

$$S_i = \sum_{j=1}^{m} M_{gi}^j \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right] \quad (10)$$

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}\right)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right] = \left(\frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} uj}, \frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} mj}, \frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} lj}\right)$$

where l is the lower limit value, m is the most promising value and u is the upper limit value

Step 3. The degree of possibility of M2 = (l2, m2, u2) ≥ M1 = (l1, m1, u1) can be defined as :

$$V(M_2 \geqslant M_1) = hgt(M_2 \cap M_1) = \mu(d)$$

$$= \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_2 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \quad (11)$$

where μd is the highest interaction between two fuzzy (see Figure 3).

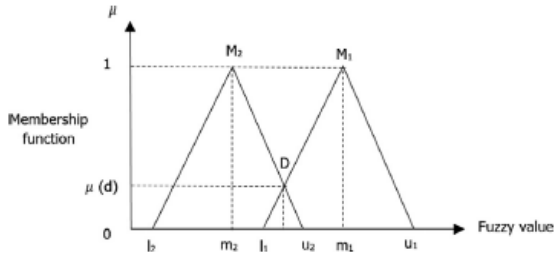

Figure 3. Intersection Between 2 Fuzzy Numbers

To compare between M1 and M2 it is required to compute both V (M 2 ≥ M1) and V (M 1 ≥ M2). The degree of possibility for convex fuzzy numbers to be greater than k convex fuzzy numbers Mi (i = 1,2,3,..,k) can be defined as :

$$V(M \geqslant M_1, M_2, \ldots, M_k) = V[(M \geqslant M_1), (M \geqslant M_2), \ldots, (M \geqslant M_k)]$$
$$= \min V(M \geqslant M_i), \quad i = 1,2,3,\ldots,k \quad (12)$$

By assuming that $d'(A_i) = \min V(S_i \geqslant S_k)$

For k = 1,2,3,4,5,....,n (k ≠ i), Then the weight vectors are given by

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \quad (14)$$

where W is a non-fuzzy number.

Phase 3 : Fuzzy TOPSIS

The steps of fuzzy TOPSIS method used in this study, according to [4] [5] [6], can be given as in the following:

Step 1. Determine the weight of evaluation criteria, this study applied fuzzy AHP to find the fuzzy preference weight. The Triangular fuzzy numbers given in Table 3.

Table 3. Triangular Fuzzy Number TOPSIS

Fuzzy Number	Linguistic Variables	Triangular Fuzzy Numbers
1	Very Poor (VP)	(0, 1, 2)
2	Poor (P)	(1, 2, 3)
3	Medium Poor (MP)	(2, 3.5, 5)
4	Fair (F)	(4, 5, 6)
5	Medium Good (MG)	(5, 6.5, 8)
6	Good (G)	(7, 8, 9)
7	Very Good (VG)	(8, 9, 10)

Step 2. Construct the fuzzy performance/matrix for alternatives by considering a group of k decision makers $(D1, D2, D3, \ldots, Dk)$ containing m alternatives $(A1, A2, A3, \ldots, Am)$ and n criteria $(C1, C2, C3, \ldots, Cn)$ where rmn is the rating of alternative *Am* with respect to criterion *Cn*

$$D = \begin{array}{c} \\ A1 \\ \vdots \\ Am \end{array} \begin{array}{c} \begin{array}{ccc} C1 & \cdots & Cn \end{array} \\ \begin{pmatrix} r11 & \cdots & r1n \\ \vdots & \vdots & \vdots \\ rm1 & \cdots & rmn \end{pmatrix} \end{array} \quad (15)$$

Step 3. Aggregate fuzzy rating for the solutions

Fuzzy rating of the Nth decision maker $\tilde{x}abN = (l_{abN}, P_{abN}, U_{abN})$ where *a* = 1,2,3,4,5,…,*m* and *b* = 1,2,3,4,5,…,*n* then the fuzzy aggregated fuzzy rating ab of solutions with respect to each criteria is given by $\tilde{x}ab = (l_{ab}, P_{ab}, U_{ab})$, where

$$a = \min_N \{IabN\},$$
$$b = \frac{1}{N}\sum_{n=1}^{N} PabN,\ c = \max_N \{UabN\} \quad (16)$$

Step 4. Normalized fuzzy decision matrix

The normalized fuzzy decision matrix denoted by is defined as follows:

$$\tilde{B} = [Pij]\ mxn$$

Where i = 1,2,3,4,5,...,m and j = 1,2,3,4,5,...,n

$$\tilde{p} = \left(\frac{aij}{cj}, \frac{bij}{cj}, \frac{cij}{cj}\right) and\ cj = maxcij\ (benefit\ criteria) \quad (17)$$

$$\tilde{p} = \left(\frac{aj}{cij}, \frac{aj}{cij}, \frac{aj}{cij}\right) and\ aj = minaij\ (cost\ criteria)$$

Step 5. Weighted fuzzy normalized decision matrix is shown as follows:

$$\tilde{v} = [\tilde{v}ij]_{mxn}\ I = 1,2,3,\ldots,\ and\ j = 1,2,3,\ldots,n \quad (18)$$

$$where\ \tilde{v} = \tilde{P}ij\ x\ Wj$$

Step 6. Determine the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) as per the following formula:

$A+ = \{v1+, \ldots, Vn+\}$ where

$Vj^+ = \{\max(Vij)\ if\ j \in J; \min(vij)\ if\ j \in J'\}$ (19)

j = 1,2,3,4,5,…,n

$A^- = \{v1-, \ldots, Vn-\}$ where

$Vj^- = \{\max(Vij)\ if\ j \in J; \min(vij)\ if\ j \in J'\}$,

j = 1,2,3,4,5,…,n

Step 7. Calculate the distance of each alternative from FPIS and FNIS

The calculation of distance ($\bar{d}_1^+ and\ \bar{d}i$) of each alternative from A^+ and A^- is computed as follows:

$$d1+ = \{\sum_{j=1}^{n}(vij - vij+)2\}^{1/2},\ i = 1, \dots, m \quad (20)$$

$$d1^- = \{\sum_{j=1}^{n}(vij - vij-)2\}^{1/2},\ i = 1, \dots, m$$

Step 8. Calculate the closeness coefficient (CCi) of each alternative by using the following eq:

$$CCi = \frac{d1-}{d1- + d1+},\ i = 1, \dots, m.\ \ C1 \in (0,1) \quad (21)$$

Step 9. Find the ranks of alternatives
The alternatives are ranked by their CCi to the ideal solution in descending order.

Results and Analysis

The hybrid fuzzy AHP and fuzzy TOPSIS methods made it more systematic and helpful for the decision maker to choose the best alternative from criteria and solutions to solve which is the best alternative for entering UI main gate by prioritizing and ranking processes due to the difficulty of comparison of which one is more important than the other

Fuzzy AHP

The highest weightage value used to consider the most important criteria which were represented such that TS > EOU > EOTU > US which is given in Table 4. It is shown that Transaction Speed are the most important criteria for entering permission in UI main gate. Sub-criteria in this study represented that Transaction Speed sub-criteria are TS 1 > TS 2 (Table 5), which show Processing time is the highest sub-criteria weight and Queueing time is the lowest sub-criteria weight of all Transaction Speed.

Ranking value of Ease of use are EOU2 > EOU1 > EOU3 (Table 6) respectively, in which Error frequency in a few transactions is the highest sub-criteria weight and Accessibility is the lowest sub-criteria weight of all. Ease of Top-Up ranking value are EOTU1 > EOTU 2 (Table 7) respectively, in which Location of top u is the highest sub-criteria weight and Top up time is the lowest sub-criteria weight of all. User satisfaction ranking value are US2 > US1 > US3 (Table 8) respectively, in which Overall error rate is the highest sub-criteria weight and User Knowledge is the lowest sub-criteria weight of all. The final weight and global rank of all sub-criteria can be seen in Table 9.

Fuzzy TOPSIS

To solve these barriers, ranking of solutions for entering UI main gate have been suggested to the decision makers to make the best alternative for solutions due to the fact that as mentioned above. Hence, the highest CCi value were used to consider for ranking of solutions. The CCi values are Cash > BNI Tapcash > Membership respectively, which is given in Table 12. The highest CCi value is using cash for entering UI main gate and the lowest CCi value is using membership for entering UI main gate. When we converted linguistic variable to fuzzy number (see Table 3) and analyzed the total scores of fuzzy number of each of the solutions from the experts, we found that if the decision makers use cash to be the first priority for entering UI main gate, it can be solve start from the Location of top up (EOTU 1), Top up time (EOTU 2) or Overall error rate (US 2), Error frequency in a few transactions (EOU 2), Accesability (EOU 3) or User Knowledge (US 3), Flexibility (EOU 1), Satisfaction level (US 1), Processing time (TS 1), and last is Queueing time (TS 2), in which the results are given in Table 11. Therefore, the decision makers should focus on the ranking of both criteria and solutions for entering UI main gate and choose for the most important criteria for entering UI main gate.

Sensitivity Analysis

The results of the payment method decision-making are influenced by multiple payment related criteria. The purpose of the sensitivity analysis is to test the sensitivity of criteria weight and 11 experiments were tested by using fuzzy TOPSIS for CCi values of which are given in Table 12. In this study, the high weights of criteria were replaced and other criteria weights were constant. In sensitivity analysis experiment 1, weight of the

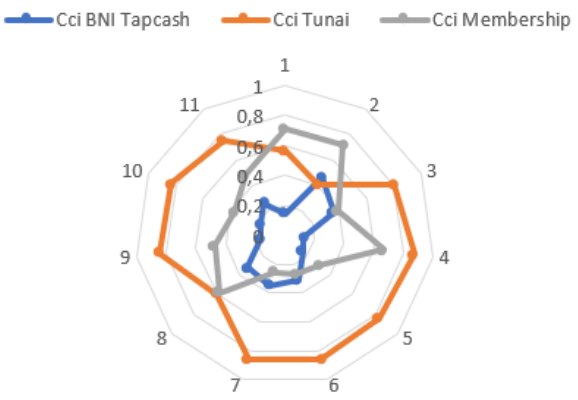

Figure 4. Sensitivity Analysis Result

Table 4. Fuzzy Aggregated Decision Making Criteria

	TS			EOU			EOTU			US			Weight	Rank
TS	1	1	1	0.17	4.24	7	1	3.8	6	0.33	3.7	7	0.28006	1
EOU	0.143	0.24	6	1	1	1	0.2	2.05	6	0.17	1.37	6	0.24930	2
EOTU	0.167	0.26	1	0.17	0.488	5	1	1	1	0.2	3.05	6	0.23768	3
US	0.143	0.27	3	0.17	0.728	6	0.167	0.328	5	1	1	1	0.23296	4

Table 5. Fuzzy Aggregated Decision Matrix of Sub-Criteria 1

	TS 1			TS 2			Weight	Rank
TS 1	1	1	1	1	3.8	6	0.708029197	1
TS 2	0.1667	0.2632	1	1	1	1	0.291970803	2

Table 6. Fuzzy Aggregated Decision Matrix of Sub-criteria 2

	EOU 1			EOU 2			EOU 3			Weight	Rank
EOU 1	1	1	1	0.143	0.933	4	0.25	1.583	4	0.332615678	2
EOU 2	0.25	1.071	7	1	1	1	0.167	2.507	6	0.349315607	1
EOU 3	0.25	0.632	4	0.167	0.399	6	1	1	1	0.318068715	3

Table 7. Fuzzy Aggregated Decision Matrix of Sub-criteria 3

	EOTU 1			EOTU 2			Weight	Rank
EOTU 1	1	1	1	0.25	1.367	4	0.519837692	1
EOTU 2	0.25	0.7317	4	1	1	1	0.480162308	2

Table 8. Fuzzy Aggregated Decision Matrix of Sub-criteria 4

	US 1			US 2			US 3			Weight	Rank
US 1	1	1	1	0.125	1.179	4	0.25	1.533	4	0.333513617	2
US 2	0.25	0.848	8	1	1	1	0.25	3.367	8	0.355730859	1
US 3	0.25	0.652	4	0.125	0.297	4	1	1	1	0.310755524	3

Table 9. Final Ranking of Criteria

	Criteria Weight	Sub-Criteria	Sub-Criteria Weight	Final Weight	Global Rank
TS	0.28006	Processing time	0.70803	0.1983	1
		Queuing time	0.29197	0.0818	7
EOU	0.24930	Flexibility	0.33262	0.0829	5
		Error frequency in a few transactions	0.34932	0.0871	4
		Accessibility	0.31807	0.0793	8
EOTU	0.23768	Location of top up	0.51984	0.1236	2
		Top up time	0.48016	0.1141	3
US	0.23296	Satisfaction level	0.33351	0.0777	9
		Overall error rate	0.35573	0.0828	6
		User Knowledge	0.31076	0.0724	10

barriers TS 1 = 0.46 and other barriers TS 2-US 3=0.06 remained constant. For experiment 2, weight of the barriers TS 2 = 0.46 and weight of other barriers TS 1, TS 3 - US 3 = 0.06 remained constant. The same process was used to test the experiment right through until experiment 10. In the last test experiment, the weights of all barriers were assumed to have the same value TS 1 - US 3 = 0.1.

Hence, the final rank of CCi values were represented in Table 12 and Fig.4. It can be seen that cash payment had the highest CCi value in nine experiments (3,4,5,6,7,8,9,10,11). Furthermore, membership payment method had the highest CCi value in two experiments (1,2) and for the non-cash payment method had the lowest CCi value in eight experiments.

Table 10. Closeness Coefficient (CCi) and Final Ranking

	D+	D-	CCi	Rank
BNI Tapcash	0.088647	0.027421	0.236248	3
Cash	0.032481	0.081328	0.7146	1
Membership	0.05684	0.059842	0.512861	2

Table 11. Total Score of Fuzzy Number

	BNI Tapcash	Cash	Membership
TS 1	19	22	33
TS 2	26	15	32
EOU 1	24	27	25
EOU 2	14	32	30
EOU 3	22	30	22
EOTU 1	25	34	22
EOTU 2	27	33	20
US 1	28	25	30
US 2	22	33	28
US 3	23	30	25

Table 12. Sensitivity Analysis

no	Sub-criteria	Weight	Sub-Criteria	Weight	BNI Tapcash		Cash		Membership	
					CCi	Rank	CCi	Rank	CCi	Rank
1	TS 1	0.46	Other	0.06	0.1426542	3	0.55988518	2	0.70991	1
2	TS 2	0.46	Other	0.06	0.4556801	2	0.40044211	3	0.71737	1
3	EOU 1	0.46	Other	0.06	0.3585826	3	0.80676101	1	0.39225	2
4	EOU 2	0.46	Other	0.06	0.1270109	3	0.87697994	1	0.67065	2
5	EOU 3	0.46	Other	0.06	0.1630911	3	0.84141288	1	0.30657	2
6	EOTU 1	0.46	Other	0.06	0.3124249	2	0.86233399	1	0.26691	3
7	EOTU 2	0.46	Other	0.06	0.3528866	2	0.86442826	1	0.26293	3
8	US 1	0.46	Other	0.06	0.3242067	3	0.59663806	1	0.58278	2
9	US 2	0.46	Other	0.06	0.1620065	3	0.84248607	1	0.46570	2
10	US 3	0.46	Other	0.06	0.1742095	3	0.83039612	1	0.37017	2
11	All Weight same			0.1	0.25633777	3	0.748184694	1	0.480504	2

From the sub-criteria, the results of sensitivity analysis experiment represented that the ranking of solutions for entering UI main gate is not very sensitive to the different decision-making influence criteria weights.

Thus, the final rank of CCi values were represented in Table.12 and Fig.4. It can be seen that cash payment had the highest CCi value in nine experiments (3,4,5,6,7,8,9,10,11). Furthermore, membership payment method had the highest CCi value in two experiments (1,2) and for the non-cash payment method had the lowest CCi value in eight experiments. From the sub-criteria, the results of sensitivity analysis experiment represented that the ranking of solutions for entering UI main gate is not very sensitive to the different decision-making influence criteria weights.

Limitations and Future Research

Although the research has reached its aims, there were some unavoidable limitations. Because of the alternatives limitations, the expert judgments of this research was conducted only for lecturers, officers, and student councils. The membership alternative is one of the limitations because not all of UI visitors can use it as the payment methods. Therefore, to generalize the results for larger groups, the study should have involved more experts from people outside UI and regular students. This proposed framework, gives a new valid and reliable approach

for prioritizing the solutiof of entering ui main gate based on its criteria. It is the main contribution of this study. For further research, the results of this study can be compared with that of other fuzzy multi-criteria techniques such as Fuzzy ELECTRE, fuzzy PROMETHEE, or fuzzy VIKOR

CONCLUSION

Payment method decision-making is a multi-criteria problem. It used to be determined based on limited factor and subjective judgment. A case study on payment method for entering Universitas Indonesia main gate decision was conducted to demonstrate hybrid method of Fuzzy AHP and Fuzzy TOPSIS. Fuzzy AHP method was selected for determining the weighting of each decision- making criteria in this study. It is capable to incorporating all of the related criteria for payment method, considering their relative importance. After authors got the criteria weights, authors also use TOPSIS method to determine the rating for each alternative. In this research, there are three types of alternatives that authors decided to examine. Such as: Non-cash payment method (Tap Cash BNI), Cash Payment method (regular payment), and membership (Subscribe each month for Lecturer and officer only).

A total of four criterion were considered, including transaction speed, ease of use, ease of top-up and user satisfaction. Each of the criteria also has several sub-criteria. Then, the weighting values were determined through Fuzzy AHP method. After the quantification of weighting values for the four criteria and sub-criteria, the comprehensive ranking value was determined using fuzzy TOPSIS to make the best alternative solutions. Hence, the highest CCi value were used to consider the rank of alternative solutions. Based on the calculations, the CCi values are Cash > Non-cash > Membership payment method. The sensitivity analysis results represented that the ranking of solutions for entering UI main gate is not very sensitive to the different decision-making influence criteria weights. The ranking of alternative solutions can be a guideline and support decision makers or top management to determine policy and strategies for the implementation of payment method in Universitas Indonesia main gate.

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