Fuzzy Analytical Hierarchy Process (F-AHP) Method in Evaluating E-Wallet Payment System in Malaysia

Soo-Fen Fam[1*],Zun-Liang Chuan[2],Sentot Imam Wahjono[3], Nur Dalila Zaini[4]
[1,4]Faculty of Technology Management and Technopreneurship, Universiti Teknikal Malaysia Melaka, Malaysia
[2]Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang
[3]Faculty of Economics and Business, Universitas Muhammadiyah Surabaya, Indonesia
Corresponding author:famsoofen@utem.edu.my

Article Info
Page Number: 742 – 749
Publication Issue:
Vol. 71 No. 3 (2022)

Article History
Article Received: *12 January 2022*
Revised: *25 February 2022*
Accepted: *20 April 2022*
Publication: *09 June 2022*

Abstract
A digital wallet also known as "E-wallet" refers as financial transaction that proceeding payment through an electronically system and device. The digital revolution continues to transform most of our everyday lives especially in this challenging world of pandemic Covid-19. In the new norms, government encouraged to utilize e-wallet as a way to prevent contagious by incentive of eBelia also ePenjana. As e-wallet actively used, this has increased the mass growth of E-wallet providers. Due to accumulation of e-wallet, the aim is to provide overall ranking towards e-wallet payment system for consumers in selecting efficient payment system for transaction. For the solution, this research has utilized the Multi-Criteria Decision Making (MCDM) method of Fuzzy Analytical Hierarchy Process (FAHP). In order to assist consumers in selecting a higher-quality digital wallet payment system, this study assess 4 criteria of E-wallet Payment System quality, with the top 3 alternative of e-wallet providers. Based on the highest weightage value, the most preferable criteria and alternatives for e-wallet will established. Touch 'n Go had become the preferable e-wallet with weightage of 0.419. Among all criteria, security became the most essential factor in selecting e-wallet. In the future, researchers are encouraged to use another approach in MCDM.

Keywords: E-wallet Payment System, System Quality, MCDM method, Fuzzy AHP analysis.

Introduction:

In Malaysia, E-wallets are in a growing trend. Despite cyber-security concerns, increasingly individuals are beginning to utilize computerized wallets to pay for bills, nourishment, tolls, petrol, basic supplies and retail expenses. E-money exchanges produced to 1.4 million in volume and RM10.6 billion in esteem as of January to Admirable 2019, agreeing to Bank Negara Malaysia data. Many industry specialists respect Malaysia as a prime showcase for the development of E-wallets, due to its tall potential and great demographics to boost E-wallet selection within the country [1]. At the end of March 2022, Bank Negara Malaysia (BNM) [1] acclaim over 40 E-Money Issuer from non-bank and adjoining 6 bank on E-Money issuer, with a total of 47 e-money licences issued by the central bank, the E-wallet scene is still quite a crowded battleground. By cause of an escalation on E-money payment system and adjoining rising to increase by year, the consumer can be complicate by the e-wallet battleground on selecting the most efficient and secured E-wallet issuer.

This research utilizing one of Multi-Criteria Decision Making (MCDM) method namely Fuzzy Analytical Hierarchy Process (F-AHP). Fuzzy AHP is an advanced method for dealing with uncertainly and vagueness compared to the normal Analytical Hierarchy Process (AHP). This method also valuable to measure relative contribution to synthesize a solution. This research aims to rank the most three favourite alternative application E-wallet payment system in Malaysia which are Touch n' Go E-wallet, Maybank QR Pay, and Boost App based on their preferences on the efficiency [2]. While, the four performance evaluation criteria's influence the preferences of E-Wallet payment system are convenience, speed, security and cashback [3-8].

Flow of E-Wallet System Ranking
The Fuzzy AHP have the hierarchical structure relationships of the goal, objectives (criteria), and alternatives. An 8-step proposed technique for Fuzzy AHP is defined by Tesfamariam and Sadiq[9] to achieve a result. Strategy for F-AHP is schematically given. These eight steps are taken after through a progressive structure. A step-by-step portrayal of the strategy is displayed as following.

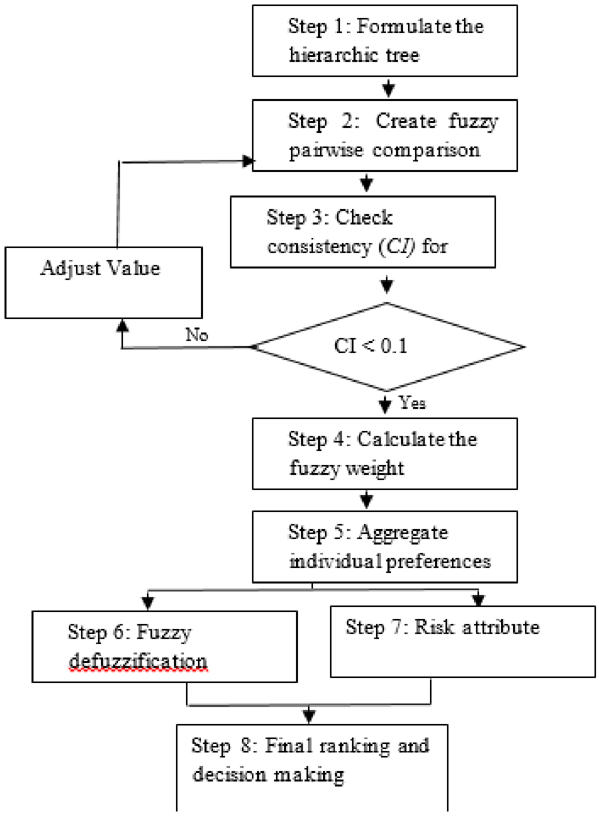

Figure 1: An 8-step proposed methodology for fuzzy AHP(Tesfamariam & Sadiq, 2006) [9]

Taking after the fuzzy ranking, the strategy proposed by Liou aand Wang [10] is utilized to change over fuzzy numbers to fresh numbers, considering -cut and idealistic or critical sees subject to the accuracy of the matched comparison.

Fuzzy AHP (FAHP) Method
Fuzzy theory is utilized to handle most of genuine world phenomenon where instability exists and parts of sets, numbers and phenomena in genuine world could be defended utilizing fuzzy rationale technique. In Fuzzy AHP fuzzy concepts are generalized so that combined comparison matrices can be created [11].

Since oftentimes the options are assessed by fuzzy numbers in a vague environment, a comparison between these fuzzy numbers is undeniably important in a comparison between choices. Fuzzy AHP is a modern approach for dealing with AHP is introduced, with the utilize of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, and the utilize of the degree investigation method for the synthetic degree value of the pairwise comparison.

Fuzzy Sets and Fuzzy Number
Establish by Zadeh [12], Fuzzy Set Theory (FST) is for managing with uncertainly and vagueness. The capacity to reflect unknown information may be a major commitment of Fuzzy Set Theory. A Fuzzy Set (FS) is an object class with a continuum of relationship functions levels. Hence, the set is characterized by a participation function, which distributes “zero” to “one” to each levels. Fuzzy numbers express linguistic variables. A Fuzzy number is a fuzzy set on the real line, which meets the normal and convex conditions. Typically, an amount with an uncertain value, instead of the precise number of “ordinary” numbers. Besides, analyst will apply Triangular Fuzzy Number (TFN) for the inquire about strategy, Fuzzy AHP.in evaluating E-wallet payment system in Malaysia.

Triangular Fuzzy Number

Triangular Fuzzy Number is an exceptional situation of a trapezoidal fuzzy number. It is as well popular in fuzzy method applications. As shown in Figure 2(a), the Triangular Fuzzy Number $\tilde{M}$ is represented by (a, b, c) and the membership function is defined as:

$$\mu_{\tilde{m}}(x) = \begin{cases} \frac{x-a}{b-a}, a \leq x \leq b \\ \frac{c-x}{c-b}, b \leq x \leq c \\ 0, \quad \text{otherwise} \end{cases} \tag{1}$$

A significant concept of Fuzzy sets in the α-cut. The α-cut of a fuzzy number $\tilde{M}$ is the crisp set $\tilde{M}$ that has all the essentials elements of the universal set U whose functional levels grades in $\tilde{M}$ are greater than or equal to the specified value of α, as shown in Figure 2(b).

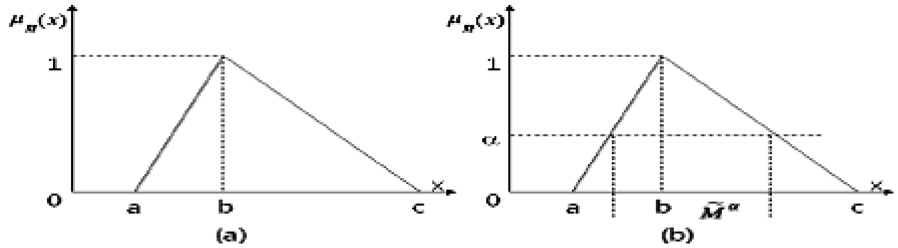

Figure 2: Triangular Fuzzy Number: (a) Functional of a Triangular Fuzzy Number (b) $\tilde{M}$ = (a, b, c), (b) α-cut of Triangular Fuzzy Number $\tilde{M}$ (Kwon & Seo, 2014) [13]

From equation (1), a and c mean the lower and upper bounds of the fuzzy number $\tilde{M}$, and b is the modal value for $\tilde{M}$. The TFN can be denoted by $\tilde{M}$ = (a, b, c). The operational laws of TFN: M1 = (a1, b1, c1) and M2 = (a2, b2, c2) are displayed as following Equation (2) – (6).

Addition of the fuzzy number ⊕

$$\begin{aligned} M_1 \oplus M_2 &= (a_1, b_1, c_1) \oplus (a_2, b_2, c_2) \\ &= (a_1 + a_2, b_1 + b_2, c_1 + c_2) \end{aligned} \tag{2}$$

Multiplication of the fuzzy number ⊗

$$\begin{aligned} M_1 \otimes M_2 &= (a_1, b_1, c_1) \otimes (a_2, b_2, c_2) \\ &= (a_1 a_2, b_1 b_2, c_1 c_2) \end{aligned} \tag{3}$$

Subtraction of the fuzzy number ⊖

$$\begin{aligned} M_1 \Theta M_2 &= (a_1, b_1, c_1) \Theta (a_2, b_2, c_2) \\ &= (a_1 - c_2, b_1 - b_2, c_1 - a_2) \end{aligned} \tag{4}$$

Division of a fuzzy number ⊘

$$\begin{aligned} M_1 \oslash M_2 &= (a_1, b_1, c_1) \oslash (a_2, b_2, c_2) \\ &= \left(\frac{a_1}{c2}, \frac{b_1}{b_2}, \frac{c_1}{a2}\right) \end{aligned} \tag{5}$$

Reciprocal of the fuzzy number

$$\begin{aligned} (M)^{-1} &= (a_1, b_1, c_1)^{-1} \\ &= \left(\frac{1}{a_1}, \frac{1}{b_1}, \frac{1}{c_1}\right) \end{aligned} \tag{6}$$

Fuzzy AHP Steps
STEP 1: Hierarchical Chart Development

This step employs the hierarchical framework diagram shown in Figure 3. In this framework, the research problems (goal) lie on the Goal layer. There are k assessment aspects on the Aspects layer, and p + … + q + … + r assessment factors on the Factors layer.

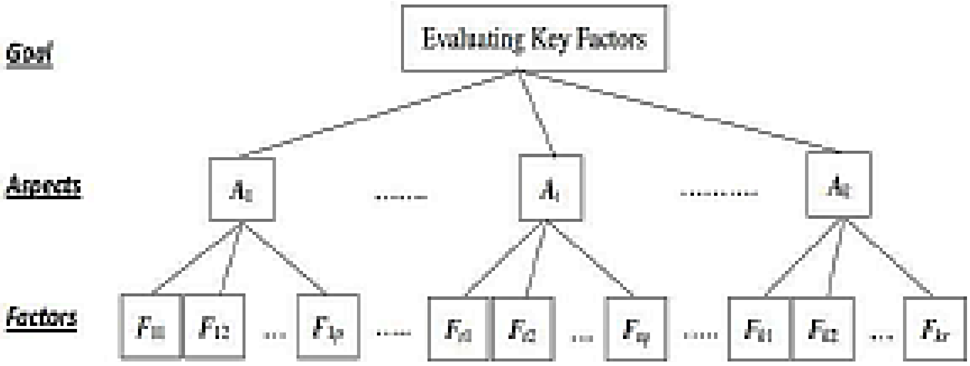

Figure 3: The Hierarchy Structure (Ding & Kuo, 2018)

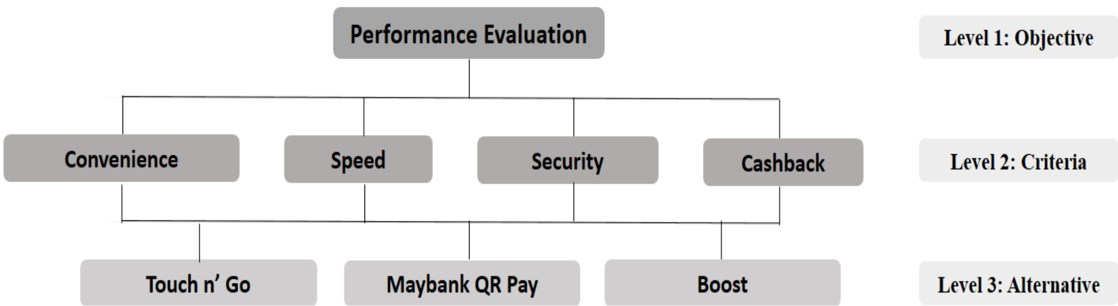

Figure 4: The Research in Evaluating E-wallet Payment System Hierarchy Structure

STEP 2: Collecting Pairwise Comparison Matrices for Decision Attributes

Analyst chose experts to compile pairwise comparison matrices for decision attributes, which represented the relative importance of each pairwise attribute.

The relative importance of the two sub-elements	Fuzzy triangular	Reciprocal fuzzy
Equally important	1 1 1	1, 1, 1
intermediate value between 1 and 3	1 2 3	1/3, 1/2, 1
Slightly important	2 3 4	1/4, 1/3, 1/2
intermediate value between 3 and 5	3 4 5	1/5, 1/4, 1/3
Important	4 5 6	1/6, 1/5, 1/4
intermediate value between 5 and 7	5 6 7	1/7, 1/6, 1/5
Strongly important	6 7 8	1/8, 1/7, 1/6
intermediate value between 7and	7 8 9	1/9, 1/8, 1/7
Extremely important	9 9 9	1/9, 1/9, 1/9

Figure 5: Fuzzy number for pair-wise comparison

(3) Let $x_{ij}^{h} \in \left[\frac{1}{9}, \frac{1}{8}, \dots, \frac{1}{2}, 1\right] \cup [1,2, \dots ,8,9], h = 1,2, \dots , n$ be the relative importance given to assessment aspects i to assessment aspect j by expert h on the Aspects layer. Then, the pairwise comparison matrix is defined as $\left[x_{ij}^{k}\right]_{kxk}$.

(4) Let $k_{uv}^{h} \in \left[\frac{1}{9}, \frac{1}{8}, \dots, \frac{1}{2}, 1\right] \cup [1,2, \dots ,8,9], h = 1,2, \dots , n$ be the relative importance given to assessment factor u in comparison with assessment factor v by expert h on the Factors layer. Then, the pairwise comparison matrix with respect to each assessment aspect is defined as $[x_{uv}^{h}]_{pxp'\cdots x}, [x_{uv}^{h}]_{qxq'}, \dots , [x_{uv}^{h}]_{rx\tau'}$.

STEP 3: Establishing Triangular Fuzzy Numbers

To aggregate all information generated by different averaging operations, Analyst use the grade of membership to demonstrate their strength after considering all approaches. Triangular fuzzy numbers characterized through use of min, max, and geometric mean operations [14]. Therefore, used to convey the views of all experts.

Let $x_{ij}^{h} \in \left[\frac{1}{9}, \frac{1}{8}, \dots, \frac{1}{2}, 1\right] \cup [1,2, \dots ,8,9], h = 1,2, \dots , n, \forall i, j =1,2,\dots,k$, be the relative importance given to assessment aspect I in comparison with assessment aspect j by expert h on the Aspects layer. After integrating the opinions of all n experts, the triangular fuzzy numbers can be expressed as

$$T_{ij}^{A} = \left(c_{ij}, a_{ij}, b_{ij}\right)$$

$$\text{where } c_{ij} = min\left\{x_{ij}^{1}, x_{ij}^{2}, \dots , x_{ij}^{n}\right\}, a_{ij} = \left(\prod_{h=1}^{n} x_{ij}^{h}\right)^{1/n}$$

$$b_{ij} = max\left\{x_{ij}^{1}, x_{ij}^{2}, \dots , x_{ij}^{n}\right\}$$

Researchers can integrate the views of all n experts on the Factors layer in the same way, so that the triangular fuzzy numbers can be expressed as

$$\tilde{T}_{uv}^{A} = (c_{uv}, a_{uv}, b_{uv})$$

$$\forall u, v = 1, \dots , | p; \dots , \forall u, v = 1, \dots , q; \dots , \forall u, v = 1, \dots , r,$$

$$\text{where } c_{uv} = min\{x_{uv}^{1}, x_{uv}^{2}, \dots , x_{uv}^{n}\}$$

$$a_{uv} = \left(\prod_{h=1}^{n} x_{ij}^{h}\right)^{1/n}, b_{uv} = max\{x_{uv}^{1}, x_{uv}^{2}, \dots , x_{uv}^{n}\}$$

STEP 4: Building Fuzzy Positive Reciprocal Matrices

Analyst uses integrated triangular fuzzy numbers to build fuzzy positive reciprocal matrices. For the Aspects layer, the fuzzy positive reciprocal matrix can be expressed as

$$T_{k}^{A} = \left[\tilde{T}_{ij}^{A}\right]_{kxk} = \begin{bmatrix} 1 & T_{12}^{A} & \dots & \tilde{T}_{1k}^{A} \\ 1/\tilde{T}_{12}^{A} & \tilde{1} & \vdots & \tilde{T}_{2k}^{A} \\ \vdots & \vdots & \cdots & \vdots \\ 1/\tilde{T}_{1k}^{A} & 1/\tilde{T}_{2k}^{A} & \cdots & \tilde{1} \end{bmatrix}$$

$$\text{where } T_{ij}^{A} \otimes T_{ji}^{A} = 1, \forall i, j = 1,2, \dots , k$$

The equations of the fuzzy positive reciprocal matrices on the Factors layer can be denoted by

$$T_{p}^{F} = [\tilde{T}_{uv}^{F}]_{pxp} = \begin{bmatrix} \tilde{1} & \tilde{T}_{12}^{F} & \dots & \tilde{T}_{1p}^{F} \\ 1/\tilde{T}_{12}^{F} & \tilde{1} & \dots & \tilde{T}_{2p}^{F} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{T}_{1p}^{F} & 1/\tilde{T}_{2p}^{F} & \cdots & \tilde{1} \end{bmatrix}$$

where $\tilde{T}^F_{uv} \otimes \tilde{T}^F_{vu} = 1, \forall u, v = 1, 2, \ldots, p., \ldots\ldots$

$$T^F_q = \left[\tilde{T}^F_{uv}\right]_{qxq} = \begin{bmatrix} \tilde{1} & \tilde{T}^F_{12} & \cdots & \tilde{T}^F_{1q} \\ 1/\tilde{T}^F_{12} & \tilde{1} & \cdots & \tilde{T}^F_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{T}^F_{1q} & 1/\tilde{T}^F_{2q} & \cdots & \tilde{1} \end{bmatrix}$$

where $\tilde{T}^F_{uv} \otimes \tilde{T}^F_{vu} = 1, \forall u, v = 1, 2, \ldots, q, \ldots\ldots,$ and

$$T^F_r = \left[\tilde{T}^F_{uv}\right]_{rxr} = \begin{bmatrix} \tilde{1} & \tilde{T}^F_{12} & \cdots & \tilde{T}^F_{1r} \\ 1/\tilde{T}^F_{12} & \tilde{1} & \cdots & \tilde{T}^F_{2r} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{T}^F_{1r} & 1/\tilde{T}^F_{2r} & \cdots & \tilde{1} \end{bmatrix}$$

where $\tilde{T}^F_{uv} \otimes \tilde{T}^F_{vu} = 1, \forall u, v = 1, 2, \ldots, r$

STEP 5: Calculating the Fuzzy Weights of the Fuzzy Positive Reciprocal Matrices

Let $\hat{R}^A_i = (T^A_{i1} \otimes T^A_{i2} \otimes \ldots \otimes T^A_{ik})^{1/k}, \forall i = 1,2, \ldots, k,$ be the geometric mean of triangular fuzzy number of i assessment aspect on the Aspects layer. The fuzzy weights of the ith assessment aspect can then be expressed as

$$\widetilde{W}^A_i = \tilde{R}^A_i \otimes \left(\tilde{R}^A_1 \oplus \tilde{R}^A_2 \oplus \ldots \oplus \tilde{R}^A_k\right)^{-1}$$

For convenience, the fuzzy weight is expressed as $\mathcal{W}^A_i = (c^{Aw}_i, a^{Aw}_i, b^{Aw}_i)$

By the same concept,

Let $\tilde{R}^F_u = \left(\tilde{T}^F_{u1} \otimes \tilde{T}^F_{u2} \otimes \ldots \otimes \tilde{T}^F_{up}\right)^{1/p}, \forall u = 1,2, \ldots, p$ be the geometric mean of triangular fuzzy number of uth factor on the Factors layer. Then the fuzzy weight of u factor can be denoted by

$$\widetilde{W}^F_u = \tilde{R}^F_u \otimes \left(\tilde{R}^F_1 \oplus \tilde{R}^F_2 \oplus \ldots \oplus \tilde{R}^F_k\right)^{-1}$$

where the fuzzy weight is denoted by

$$\widetilde{W}^F_u = (c^{Rw}_u, a^{Rw}_u, b^{Fw}_u)$$

For saving space, the fuzzy weights of [(p + … + q … + r) – p] factors can be obtained by the above-mentioned method. For saving space, the equations of fuzzy weights are omitted to reason by analogy on the Factors layer.

STEP 6: Defuzzifying The Fuzzy Weights to Obtain Crisp Weights

To perform defuzzification in an effective manner, the grade mean integration representation (GMIR) method proposed by Chen & Hsieh (2000) is used to defuzzify the fuzzy weights.

Let $W^A_i = (c^{Aw}_i, a^{Aw}_i, b^{Aw}_i), \forall i = 1,2, \ldots, k$ be k triangular fuzzy numbers. The GMIR of crisp weights k can then be expressed

$$G\left(\widetilde{W}^A_i\right) = \frac{c^{Aw}_i + 4a^{Aw}_i + b^{Aw}_i}{6}, \forall i = 1,2, \ldots, k$$

The defuzzification of fuzzy weights on the Factors layer can be performed using an analogous method.

STEP 7: Standardizing the Crisp Weights

To facilitate comparison of the relative importance of assessment aspects on different layers, the crisp weights are standardized and expressed as

$$CW_i^A = G(\widetilde{W}_i^A) / \sum_{i=1}^{k} G(\widetilde{W}_i^A)$$

STEP 8: Calculating the Integrated Weights for Each Layer

Let CW_i^A *and* CW_u^F be the normalized crisp weights on the Aspects and Factors layers. Then,

(1) The integrated weight of each assessment aspect on the Aspects layer is

$$IW_i^A = CW_i^A, \forall i = 1,2, \ldots, k$$

(2) The integrated weight of each assessment factor on the Factors layer is

$$IW_u^F = CW_i^A \times CW_u^F, \forall i = 1,2, \ldots, k$$
$$\forall u = 1, \ldots, p; \forall u = 1, \ldots, q; \forall u = 1, \ldots, r\}$$

Criteria Pairwise Comparison

Table 1 illustrates the pairwise comparison among the four criteria. The indications of the numbers are 1= equality important, 2=slightly important, 3-4 =intermediate slightly important to important, 5=important, 6-7=intermediate important to strongly important, 8= strongly important 9=extremely important

Table 1: Fuzzy AHP criteria pairwise comparison statement scale

1.	Convenience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Speed
2.	Convenience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Security
3.	Convenience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cashback
4.	Speed	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Security
5.	Speed	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cashback

Summary of the Final Results and Weights of Criteria and Alternative

Through the evaluation of the analysis, the highest score for E-wallet payment system has finally come to a decision. The score of E-wallet payment system evaluation that nearest to the value 1 can consider the highest choice and the best result. the result shows the Normalized weight (Ni) for Touch n' Go E-wallet, Maybank QR Pay and Boost Application are respectively 0.419, 0.336 and 0.244 as shown in Table 2. The final decision in evaluation of E-wallet payment system shows that Touch n' Go E-wallet is a number 1 the most efficient E-wallet favourite by Malaysian user. the result proven that it is E-wallet payment system that deliver the performance higher than expectation. Touch n' Go E-wallet is stands as a top rank between the three alternatives followed by the second efficient, Maybank QR Pay and finally number three is, Boost Application. In conclusion, the best E-wallet payment system in Malaysia is Touch n' Go E-wallet.

Table 2: Summary of Final Results in Evaluating E-wallet Payment System in Malaysia

CRITERIA			Scores of Alternatives with respect to related Criterion		
	Weights (Ni)	**Rank**	**Touch n' Go E-wallet**	**Maybank QR Pay**	**Boost Application**
C1. CONVENIENCE	0.306	2	0.360	0.308	0.332
C2. SPEED	0.213	3	0.460	0.342	0.198
C3. SECURITY	0.350	1	0.434	0.386	0.180
C4. CASHBACK	0.131	4	0.453	0.260	0.288
TOTAL (Score Alt x weight criteria)			0.419	0.336	0.245
GLOBAL RANK			1	2	3

Acknowledgment

This work was supported in part by Centre for Research and InnovationManagement (CRIM), Universiti Teknikal Malaysia Melaka (UTeM). The authors would like to thank Faculty of Technology Management and Technopreneurship (FPTT) and research group SUIT for the direct and indirect contributions.

References

[1] BNM,List of Non-bank E-money issuers, Retrieved on March 2022 https://www.bnm.gov.my/non-bank-e-money-issuers
[2] The best e-wallets in Malaysia, as ranked by users. (n.d.). Retrieved January 1, 2021, from https://themalaysianreserve.com/2019/10/29/the-best-e-wallets-in-malaysia-as-ranked-by-users/
[3] Abdullah, N., Redzuan, F., & Daud, N. A. (2020). E-wallet: Factors influencing user acceptance towards cashless society in Malaysia among public universities. Indonesian Journal of Electrical Engineering and Computer Science, 20(1).
[4] Udo, G. J. (2001). Privacy and security concerns as major barriers for e-commerce: A survey study. Information Management and Computer Security, 9(4), 165–174.
[5] Ballestar, M. T., Grau-Carles, P., & Sainz, J. (2016). Consumer behavior on cashback websites: Network strategies. Journal of Business Research, 69(6), 2101–2107.
[6] Best E-Wallet Comparison in Malaysia 2020 | CompareHero. (n.d.). Retrieved January 7, 2021, from https://www.comparehero.my/e-wallet/articles/best-ewallet-malaysia.
[7] Hassan Amozad Khalili. (2012). Evaluation of e-payment systems in Iran using analytic hierarchy process. African Journal of Business Management, 6(19), 5950–5956.
[8] Nizam, F., Hwang, H. J., & Valaei, N. (2019). Measuring the effectiveness of E-wallet in Malaysia. In Studies in Computational Intelligence (Vol. 786). Springer International Publishing.
[9] Tesfamariam, S., & Sadiq, R. (2006). Risk-based environmental decision-making using fuzzy analytic hierarchy process (F-AHP). Stochastic Environmental Research and Risk Assessment, 21(1), 35–50.
[10] Liou, T. S., & Wang, M. J. J. (1992). Ranking fuzzy numbers with integral value. Fuzzy Sets and Systems, 50(3), 247–255.
[11] Pourali, A., & Hashempour, E. (2015). An evaluation of business models in e-mobile payment by using multiple criteria decision making. Journal of Advanced Computer Science & Technology, 4(1), 103.
[12] Zadeh, L. (1975) The concept of a linguistic variable and its application to approximate reasoning. Information Sciences, Volume 8, Issue 3, 1975, Pages 199-249.
[13] Kwon, H.K and Seo,K.K, 2014. A Fuzzy AHP based Multi-criteria Decision-making Model to Select a Cloud Service. International Journal of Smart Home. 8(3):175-180
[14] Saaty, T.L. (1980) The Analytic Hierarchy Process. McGraw-Hill, New York. - References - Scientific Research Publishing.
[15] Sabbaghi Lalimi A H, Damavandi H. Using Machine Learning Methods in the Financial Market for Technical Analysis Based on Hybrid Models. sjamao. 2020; 2 (4) :1-11, URL: http://sjamao.srpub.org/article-7-87-en.html