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The Best Online Shopping Website Using Fuzzy TOPSIS Approach

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Abstract: One of the common problems faced by customers before shopping online is choosing the best shopping website to shop online. This is because there are many cases that the goods received do not reach their expectations. Therefore, it is important for the customers to choose the right shopping website that can be trusted. This study implements fuzzy TOPSIS to rank the best online shopping website. Factors that influence customers' selection are the technology acceptance factor, website service quality and specific holdup cost. Decision-makers are asked to rank these factors by giving rank from very high(VH) to very low(VL) for criterion assessment weight, while for alternative assessment from very good(VG) to very poor(VP); very high and very good indicate the most influencing factor while very low and very poor indicate the least influencing factors. Each data ranking is transformed into matrix form to get a normalized decision matrix (NDM). After that, the weighted normalized decision matrix and the distance of each alternative from the worse condition and the best condition were calculated. Lastly, the closeness of coefficient of each alternative was obtained and all the alternatives were ranked. The performance and ranking were measured based one the value of the relative closeness.

Keywords: Fuzzy TOPSIS, decision making, online shopping website

1 Introduction

In line with the development of technology and digital marketing techniques, most merchants choose to trade their products online. The use of online business platforms has gained the attention of all levels of buyers and trades. On this factor, the community began to choose to switch to online purchases provided by sales platforms. The emergence of numerous sales platforms allows users to make a choice to choose the best shopping website. Therefore, this study was conducted to find the best online shopping website according to the selected criteria using Fuzzy TOPSIS method. By using Fuzzy TOPSIS, we list good shopping criteria and four most popular shopping websites among UiTM Machang's students and make comparison in terms of services, price and quality of the products that can assist customers to make the right choice and own the goods at the price that the users deserve to pay.

To conduct this study, three criteria were listed and four alternatives were selected from the largest shopping websites in Malaysia namely Lazada, Lelong.my, 11street and Shopee. It is not easy for the decision-makers to choose accurate performance ratings for alternatives to the predefined features. This prolongs TOPSIS to the fuzzy circumstances by Yang and Hun [1]. This study aims to show UiTM Machang students the vagueness of traditional shopping methods and to address inaccuracies and obtain the inheritance of criteria assessment part.

A theory of a Fuzzy set was introduced in dealing with ambiguity and vagueness in making a decision as discussed in Zadeh [2]. The theory introduced was based on the rationality of uncertainty. The fuzzy set can be explained as a scale of zero to one, an object class with membership function that represented uncertainty and vagueness in mathematical terms [2]. Fuzzy set theory definition carries out the groups of data with unclearly-defined boundaries which is fuzzy.

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The goal is to rank the best online shopping website that meets the needs of the users in terms of the selected alternatives and listed criteria. Data collected is taken from the survey among students of UiTM Machang.

Definition 1.1 [3]: Fuzzy Set
Let $\tilde{P}$ be a Fuzzy set in a universal set *Y*. Set *Y* is represented by a membership function $\mu\left(y|\tilde{P}\right)$ that maps to each *y* element in Y to an actual number in the interval [0,1]. The function value $\mu\left(y|\tilde{P}\right)$ is named a membership grade of *y* in $\tilde{P}$. The closest unity value will give the higher evaluation of participation *y* in $\tilde{P}$.

Definition 1.2 [3]: Triangular Fuzzy Number
The triangular fuzzy number used in the studies is described using real numbers (*I,m,u*). Figure 1 shows the membership function of the triangular fuzzy number.

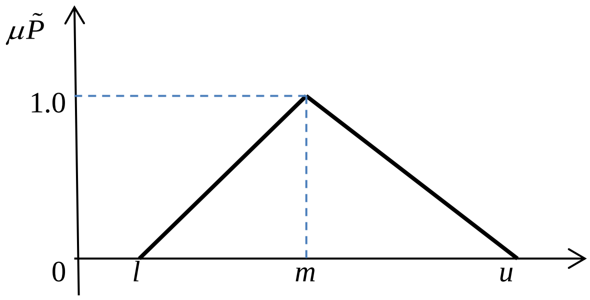

Figure 1: The Membership Function

A real number value (*I,m,u*) can be interpreted as "*l*" the smallest probable value, "*m*" the most probable value and "*u*" the largest probable value. The function is represented as follows.

$$\mu\left(y|\tilde{P}\right)=\begin{cases} 0 & , y<1, y>u \\ \dfrac{y-l}{m-i} & , l\le y<m \\ \dfrac{u-y}{u-m} & m\le l\le u \end{cases}$$

Fuzzy topologies include Fuzzy TOPSIS, Fuzzy Logic, Fuzzy Pay-off, Fuzzy Set, Fuzzy AHP and among others. In this study, we focus on Fuzzy TOPSIS. According to Chamoli [4], TOPSIS was first depicted by Yoon, K. in 1980. Then in 1981, Hwang and Yoon develop a method for solving Multiple Criteria Decision Making (MCDM) problems that assumes the chosen alternatives should be as far as Positive Ideal Solution (PIS) and close to the Negative Ideal Solution (NIS). Assari et al. [5] argued that TOPSIS is derived from the concept that the selected alternative should be the one with the shortest distance from both PIS and NIS. As a technique of compensatory aggregation, the weight of each criterion was identified, scores for each criterion were normalized and compare each alternative to the ideal alternative through geometrics distance. The separation distance between each competitive alternative was calculated using the PIS and NIS. Next, rank each location according to their proximity to the ideal solution.

The research framework includes four alternatives of shopping websites Lazada , Shopee , 11street and Lelong.my. This study adopts the criteria from Sun and Lin [6] and the criteria evaluated are technology acceptance factors [7], website service quality [8] and specific holdup cost [6].

This method has been used in the different fields. In 2006, the fuzzy TOPSIS method was applied for the purpose of selecting suppliers in a supply chain system as explained in Sun and Lin [5]. Next, Wang and Elhag [9] provide a non-linear programming solution procedure using alpha level set. Using the fuzzy model, Büyüközkan et al. [10] identified the strategic main criteria and sub-criteria of alliance partner selection that companies believe are most important and contribute the final partner ranking result. To choose the best initial training aircraft in an uncertain situation, Wang and Chang [11] implement this method to the Air Force Academy in Taiwan. Also, in 2007, Kahraman et al. [12] presented a fuzzy TOPSIS model for the multi-criteria appraisal of the robotic systems industry. Using block angular structures, Abo-Sinna et al. [13] used this method in multi-objective large-scale non-linear programming problems in 2008. Lin and Chang also proposed this method to select price and order for buyer evaluation [14]. Then, Chen and Tsao [15] introduced four TOPSIS methods in decision analysis, based upon interval-valued fuzzy sets.

In 2009, Sun and Lin [6] conducted research on how online shopping sites establish their competitive advantages. According to the results, security and trust were cited as the most crucial elements for enhancing the competitive advantage of shopping websites. Madi and Tap applied this method to select the investment board according to incoming operation risk in 2011 [16]. Following that, Lee et all. developed a multi-criteria approach to flood vulnerability using TOPSIS and Delphi Technique [17]. Yavuz [18] proposed this method to select the open-pit trucks. The criteria considered are Carrying Capacity, Manufacturer of Engine, Truck Box Features, Truck Suspension System, Hill Climbing Ability, Truck Unloading Time, and Delivery Time.

2 Methodology

Step 1: Evaluate the Linguistic Weightage

Using conversion scales, linguistic terms are changed into fuzzy numbers and used to rate the criteria and alternatives. Table 1 shows the triangular fuzzy numbers for five linguistic ratings occupy an interval between 1 and 9 [5].

Table 1: Linguistic Weightage and Triangular Fuzzy Number

Triangular Fuzzy Number, TFN	Alternative Assessment	Criteria Assessment
(1,1,3)	Very Poor (VP)	Very Low (VL)
(1,3,5)	Poor (P)	Low (L)
(3,5,7)	Fair (F)	Medium (M)
(5,7,9)	Good (G)	High (H)
(7,9,9)	Very Good (VG)	Very High (VH)

To compute linguistic weightage, we use

$$\tilde{x}_{ij}^k = \left(a_{ij}^k, b_{ij}^k, c_{ij}^k\right) \text{ and } w_j^k = \left(w_{j1}^k, w_{j2}^k, w_{j3}^k\right), \text{ i = 1,2, … , m ; j = 1, 2, … , n} \quad (1)$$

where

$$a_{ij}^k = \min a_{ij}^k, \qquad b_{ij}^k = \frac{1}{k}\sum_{k=1}^{k} b_{ij}^k. \qquad c_{ij}^k = \min c_{ij}^k,$$

i,j = 1,2, … , n, k is the number of decision group, i is the alternative, j is the criterion

Step 2: Establish the Decision Matrix (DM)

When i is the criterion index (i=1,2, …, m) refers to the number of potential sites and j is the alternative index (j=1,2, …, n). The element $C_1, C_2, ..., C_m$ refer to the criteria while $L_1, L_2, ..., L_n$ refer to the alternative location. The elements of the matrix are related to the values of criteria i with respect to alternative j.

$$DM = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{12} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Step 3: Calculate a Normalized Decision Matrix (NDM)

The normalized values denote by NDM represents the relative performance of the generated design alternatives. Using the normalization method

$$NDM = R_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+} \right), \; i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n \tag{2}$$

where

R_{ij} is denoted as normalized aggregated fuzzy decision matrix for alternatives.

$c_j^+ = \max c_j^+$

Step 4: Determine the Weightage Normalized Decision Matrix, $\tilde{V}$

$$\tilde{V} = V_{ij} = W_j \times R_{ij}, \; i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n \tag{3}$$

where

W_j is the weight

$\tilde{V}$ is Weightage Normalized Decision Matrix

Step 5: Find the distance of each alternative from Fuzzy Positive-Ideal Solution (FPIS) and Fuzzy Negative-Ideal Solution (FNIS)

Fuzzy Positive-Ideal Solution (FPIS) is defined as A^+ and Fuzzy Negative-Ideal Solution is defined as A^-.

$$\begin{aligned} A^+ &= \left(p_1^{\,+}, p_2^{\,+}, \ldots, p_n^{\,+} \right) \\ A^- &= \left(p_1^{\,-}, p_2^{\,-}, \ldots, p_n^{\,-} \right) \end{aligned} \tag{4}$$

where

$p_j^{\,+} = \max p_{ij3} \quad , i = 1, 2, 3, \ldots, m$

$p_j^{\,-} = \max p_{ij1} \quad , i = 1, 2, 3, \ldots, m$

The distance of each alternative from FPIS and FNIS, d is

$$d(a,b) = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left[\left(a_i - b_i \right)^2 \right]}, \; i = 1, 2, \ldots, n \tag{5}$$

The distance, d_i of each weighted alternative is given by

$$\begin{aligned} d_i^{\,+} &= \sum_{i=1}^{n} d\left(\bar{p}_{ij}, p_j^+ \right), \; i = 1, 2, \ldots, n \\ d_i^{\,-} &= \sum_{i=1}^{n} d\left(\bar{p}_{ij}, p_j^- \right), \; i = 1, 2, \ldots, n \end{aligned} \tag{6}$$

Step 6: Find the Closeness of Coefficient of each alternative

$$CC_i = \frac{A^-}{A^- + A^+},\ 0 \le CC_i \le 1 \tag{7}$$

where

if $CC_i = 0$ for the solution of the worse condition

while if $CC_i = 1$ for the solution of the best condition

Step 7: Rank the Alternative according to CC_i for i = 1,2, … , m

Based on the CC_i value obtained, the alternative that has the best ranking and performance is directly proportional to the CC_i value.

3 Implementation

There are three criteria to be considered. The criteria are technology acceptance factor(C1), website service quality(C2) and specific holdup cost(C3). For the alternatives, we choose four online shopping websites that are familiar among students of UiTM Machang; Lazada(A1), Shopee(A2), 11street(A3) and Lelong My(A4).

Step 1: Evaluate the Linguistic Weightage

The fuzzy questionnaire is used to obtain the linguistic variable for alternative and the linguistic scale for criterion. Three different decision makers who are familiar with the alternatives given are chosen between the students of UiTM Machang. Table 2 and Table 3 show the weight of alternative and criteria according to Sun and Lin [5]. Meanwhile Table 4 and Table 5 show the weighted assessment of the importance of each criterion and alternatives.

Table 2: Linguistic Variable for the Rating of Each Alternative

Linguistic Terms	Corresponding Triangular Fuzzy Number
Very Poor (VP)	(1,1,3)
Poor (P)	(1,3,5)
Fair (F)	(3,5,7)
Good (G)	(5,7,9)
Very Good (VG)	(7,9,9)

Table 3: Linguistic Scale for the Importance of Each Criterion

Linguistic Terms	Corresponding Triangular Fuzzy Number
Very Low (VL)	(0.0, 0.1, 0.3)
Low (L)	(0.1, 0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
High (H)	(0.5, 0.7, 0.9)
Very High (VH)	(0.7, 0.9, 1.0)

Table 4: Evaluation of the Importance Weight of Each Criterion by Decision Makers

Criteria	DM_1		DM_2		DM_3	
C_1	VH	(0.7,0.9,1.0)	VH	(0.7,0.9,1.0)	H	(0.5,0.7,0.9)
C_2	VH	(0.7,0.9,1.0)	VH	(0.7,0.9,1.0)	H	(0.5,0.7,0.9)
C_3	H	(0.5,0.7,0.9)	H	(0.5,0.7,0.9)	H	(0.5,0.7,0.9)

Table 5: Evaluation of Decision Makers for Alternatives

Criteria	Alternatives	DM_1		DM_2		DM_3	
C_1	A_1	VG	(7,9,9)	G	(5,7,9)	G	(5,7,9)
	A_2	VG	(7,9,9)	VG	(7,9,9)	F	(3,5,7)
	A_3	VG	(7,9,9)	VG	(7,9,9)	G	(5,7,9)
	A_4	F	(3,5,7)	G	(5,7,9)	F	(3,5,7)
C_2	A_1	VG	(7,9,9)	VG	(7,9,9)	G	(5,7,9)
	A_2	G	(5,7,9)	VG	(7,9,9)	F	(3,5,7)
	A_3	VG	(7,9,9)	G	(5,7,9)	G	(5,7,9)
	A_4	G	(5,7,9)	F	(3,5,7)	F	(3,5,7)
C_3	A_1	G	(5,7,9)	G	(5,7,9)	F	(3,5,7)
	A_2	F	(3,5,7)	G	(5,7,9)	F	(3,5,7)
	A_3	F	(3,5,7)	F	(3,5,7)	F	(3,5,7)
	A_4	F	(3,5,7)	F	(3,5,7)	F	(3,5,7)

From Equation (1), compute aggregated fuzzy rating for the criteria and the alternatives and established the Decision Matrix. For criteria 1, C_1

$$w_{11} = \frac{1}{3}\left[(0.7, 0.9, 1.0) + (0.7, 0.9, 1.0) + (0.5, 0.7, 0.9)\right] = (0.63, 0.83, 0.97)$$

For Criteria 2 and Criteria 3, the linguistic weightages are (0.63, 0.83, 0.97) and (0.5, 0.7, 0.9) respectively.

Step 2: Establish the Decision Matrix (DM)

The aggregated fuzzy rating for alternative 1 to each criterion is given by

$$x_{11} = \frac{1}{3}\left[(7,9,9) + (5,7,9) + (5,7,9)\right] = (5.67, 7.67, 9.00)$$

$$x_{12} = \frac{1}{3}\left[(7,9,9) + (7,9,9) + (5,7,9)\right] = (6.33, 8.33, 9.00)$$

$$x_{13} = \frac{1}{3}\left[(5,7,9) + (5,7,9) + (3,5,7)\right] = (4.33, 6.33, 8.33)$$

Repeat the calculation to other alternatives. Next, the average fuzzy decision matrix for each criterion is obtained as follows:

$$DM = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{bmatrix} (5.67, 7.67, 9.00) & (5.67, 7.67, 8.33) & (6.33, 8.33, 9.00) & (3.67, 5.67, 7.67) \\ (6.33, 8.33, 9.00) & (5.00, 7.00, 8.33) & (5.67, 7.67, 9.00) & (3.67, 5.67, 7.67) \\ (4.33, 6.33, 8.33) & (3.67, 5.67, 7.67) & (3.00, 5.00, 7.00) & (3.00, 5.00, 7.00) \end{bmatrix}$$

Subsequently, the average fuzzy weight for each criterion is obtained.

$$\tilde{W} = \begin{bmatrix} (0.63, 0.83, 0.97) \\ (0.63, 0.83, 0.97) \\ (0.50, 0.70, 0.90) \end{bmatrix}$$

Step 3: Calculate a Normalized Decision Matrix (NDM)

Next, for each column of alternatives, each fuzzy value in fuzzy decision matrix is divided by the greatest value of that column using Equation (8).

$$Normalizing = \frac{Fuzzy\ Value\ of\ Criterion}{Maximum\ Value\ of\ Alternative} \qquad (8)$$

Normalization for A_1:

$$\tilde{r}_{11} = \left(\frac{5.67}{9.00}, \frac{7.67}{9.00}, \frac{9.00}{9.00}\right) = (0.63, 0.85, 1.00)$$

$$\tilde{r}_{12} = \left(\frac{6.33}{9.00}, \frac{8.33}{9.00}, \frac{9.00}{9.00}\right) = (0.70, 0.93, 1.00)$$

$$\tilde{r}_{13} = \left(\frac{4.33}{9.00}, \frac{6.33}{9.00}, \frac{8.33}{9.00}\right) = (0.48, 0.70, 0.93)$$

Repeat the calculation to other alternatives. Then, the normalized fuzzy decision matrix of each alternative is as follows.

$$NDM = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{bmatrix} (0.63, 0.85, 1.00) & (0.68, 0.92, 1.00) & (0.70, 0.93, 1.00) & (0.48, 0.74, 1.00) \\ (0.70, 0.93, 1.00) & (0.60, 0.84, 1.00) & (0.63, 0.85, 1.00) & (0.48, 0.74, 1.00) \\ (0.48, 0.70, 0.93) & (0.44, 0.68, 0.92) & (0.33, 0.56, 0.78) & (0.39, 0.65, 0.91) \end{bmatrix}$$

Step 4: Determine the Weightage Normalized Decision Matrix, $\tilde{V}$

Next by row, from Equation (3), the weighted normalized fuzzy decision matrix, $\tilde{V}$ was obtained from $\tilde{v}_{ij} = \tilde{r}_{ij} * \tilde{w}_{ij}$. Thus, for C_1,

$$\tilde{v}_{11} = (0.63, 0.85, 1.00) * (0.63, 0.83, 0.97) = (0.40, 0.71, 0.97)$$

$$\tilde{v}_{12} = (0.68, 0.92, 1.00) * (0.63, 0.83, 0.97) = (0.43, 0.76, 0.97)$$

$$\tilde{v}_{13} = (0.70, 0.93, 1.00) * (0.63, 0.83, 0.97) = (0.44, 0.77, 0.97)$$

$$\tilde{v}_{14} = (0.48, 0.74, 1.00) * (0.63, 0.83, 0.97) = (0.30, 0.61, 0.97)$$

Repeat the calculation to other criteria. Therefore, the weighted normalized fuzzy decision matrix $\tilde{V}$ is given as follows:

$$\tilde{V} = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{bmatrix} (0.40, 0.71, 0.97) & (0.43, 0.76, 0.97) & (0.44, 0.77, 0.97) & (0.30, 0.61, 0.97) \\ (0.44, 0.77, 0.97) & (0.38, 0.70, 0.97) & (0.40, 0.71, 0.97) & (0.25, 0.54, 0.88) \\ (0.24, 0.48, 0.83) & (0.22, 0.48, 0.83) & (0.17, 0.39, 0.70) & (0.20, 0.46, 0.82) \end{bmatrix}$$

Step 5: Find the Distance of Each Alternative from Fuzzy Positive-Ideal Solution (FPIS) and Fuzzy Negative-Ideal Solution (FNIS)

The FPIS, A^+ is $\left[(1,1,1),(1,1,1),(1,1,1),(1,1,1)\right]$ and FNIS, A^- is $\left[(0,0,0),(0,0,0),(0,0,0),(0,0,0)\right]$. From Equation (6), the distance for positive and negative ideal solutions for Alternative 1 are as follows,

$$A^+ = \sqrt{\frac{1}{3}\left[(0.40-1)^2 + (0.71-1)^2 + (0.97-1)^2\right]} + \sqrt{\frac{1}{3}\left[(0.44-1)^2 + (0.77-1)^2 + (0.97-1)^2\right]}$$
$$+ \sqrt{\frac{1}{3}\left[(0.24-1)^2 + (0.48-1)^2 + (0.83-1)^2\right]} = 1.27$$

$$A^- = \sqrt{\frac{1}{3}\left[(0.40-0)^2 + (0.71-0)^2 + (0.97-0)^2\right]} + \sqrt{\frac{1}{3}\left[(0.44-0)^2 + (0.77-0)^2 + (0.97-0)^2\right]}$$
$$+ \sqrt{\frac{1}{3}\left[(0.24-0)^2 + (0.48-0)^2 + (0.83-0)^2\right]} = 2.07$$

Repeat the calculation to other alternatives then the values are as in Table 6.

Table 6: The Distance from Positive and Negative Ideal Solution

Alternative	A^+	A^-
A_1	1.27	2.07
A_2	1.31	2.05
A_3	1.35	1.96
A_4	1.54	1.85

Step 6: Find the Closeness of Coefficient of each alternative
By using Equation (7), the closeness of coefficient is obtained as Table 7.

Table 7: The Closeness of Coefficient of Each Alternative

Alternative	Closeness Coefficient, CC_i
A_1	0.62
A_2	0.61
A_3	0.59
A_4	0.55

4 Result and Discussion

The following table shows the final results of the study.

Table 9: The Rank of the Alternative Based on Closeness of Coefficient

Alternative	
A_1	Lazada
A_2	Shopee
A_3	11Street
A_4	Lelong.my

Lazada has the largest value of the closeness coefficient, next by Shoppee, 11Street and Lelong.my. according to the proposed fuzzy TOPSIS techniques. As a result, Lazada is clearly the top online buying website of these four online shopping websites. The Lazada shopping website is user-friendly, offer a wide range of product and ships quickly. Lazada frequently offer large discounts especially during big events. As a result, Lazada meets our technological acceptability factor, online service quality and specific holdup cost criteria.

5 Conclusion and Recommendation

Lazada, 11Street, Shopee and Lelong.my are the alternatives used in this study that decision makers considered while deciding on the top shopping websites. These alternatives are sorted according to the criteria of online buying website using fuzzy TOPSIS. Specific holdup cost, website service quality and technology adoption issues are among the criteria. People nowadays prefer to shop online rather than offline. This study was conducted to assist customer in making the best decision and obtaining the goods at the prices and services that users are entitled to. Because Lazada has the greatest value of closeness coefficient, it is clear that Lazada is the best online shopping website. This study can be used for other case studies or other multicriteria decision making problem. Furthermore, the fuzzy TOPSIS approach can be further enhanced by introducing fuzzy TOPSIS-Based Software to make the process easier.

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