Journal of Quality Measurement and Analysis *JQMA* 21(3) 2025, 207-220
e-ISSN: 2600-8602 *http://www.ukm.my/jqma*
https://doi.org/10.17576/jqma.2103.2025.13

FUZZY DECISION-MAKING MODEL FOR GROCERY STORE SELECTION WITH STRENGTH AND WEAKNESS ANALYSIS

(*Model Pembuatan Keputusan Kabur untuk Pemilihan Kedai Runcit dengan Analisis Kekuatan dan Kelemahan*)

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ABSTRACT

Decision-making is a complex process which involves assessment over multiple criteria in obtaining the best option. Usually, decision-making process is fashioned by uncertainty and vagueness due to lack of information and complexity of alternatives. This issue can be overcome by reducing the number of evaluations over pairwise comparisons using consistent fuzzy preference relation (CFPR). This research integrates the CFPR with weighted aggregated sum product assessment (WASPAS) approach to rank the best grocery stores by evaluating several criteria: price, convenience, freshness, service and parking area. Among these criteria, respondents tend to prioritize freshness or quality of products in selecting the best grocery store. The CFPR promises consistent decision preferences in evaluating the criteria weights, while the WASPAS combines the aggregated sum and aggregated product of decision preferences in ranking the alternatives. The stability of the obtained results is tested using different utility values in combining the weighted sum and weighted product of alternatives selection in WASPAS. Further, the strength and weakness of each grocery store are analysed over all criteria. The findings of the research can be shared with the grocery stores to improve their offered service to stay relevant in the industry.

Keywords: consistent fuzzy preference relation; grocery store selection; fuzzy decision-making

ABSTRAK

Pembuatan Keputusan merupakan suatu proses yang rumit, melibatkan penilaian terhadap beberapa kriteria dalam menentukan pilihan terbaik. Kebiasaanya, proses pembuatan keputusan dicirikan oleh ketakpastian dan keraguan disebabkan kekurangan maklumat dan kerumitan alternatif. Masalah ini boleh diatasi dengan mengurangkan jumlah penilaian pada perbandingan berpasangan menggunakan hubungan keutamaan kabur konsisten (CFPR). Kajian ini menggabungkan CFPR dengan penilaian hasil tambah dan darab berpemberat beragregat (WASPAS) untuk memangkatkan kedai runcit terbaik dengan menilai beberapa kriteria: harga, keselesaan, kesegaran, servis dan kawasan parkir. Antara kriteria-kriteria ini, responden cenderung mengutamakan kesegaran atau kualiti produk dalam memilih kedai runcit terbaik. CFPR menjamin keutamaan keputusan yang tekal dalam pengiraan pemberat kriteria, manakala WASPAS menggabungkan hasil tambah dan hasil darab agregat keutamaan keputusan dalam pemeringkatan alternatif. Kestabilan keputusan yang diperolehi diuji menggunakan nilai utiliti berbeza dalam menggabungkan hasil tambah dan darab berpemberat bagi pemilihan alternatif dalam WASPAS. Seterusnya, kekuatan dan kelemahan setiap kedai runcit dianalisa berdasarkan semua kriteria. Hasil kajian boleh dikongsi bersama kedai-kedai runcit untuk meningkatkan servis yang ditawarkan untuk kekal relevan dalam industry.

Kata kunci: hubungan keutamaan kabur konsisten; pemilihan kedai runcit; pembuatan keputusan kabur

1. Introduction

Real-world decision-making process involves complexity of selection process since human preferences are commonly uncertain and vague. In fact, humans tend to be influenced by psychological biases, confusion due to complexity of alternatives and sometimes incompetent of giving opinions, which leads to imperfect information and uncertainty (Aliev *et al.* 2021).

Fuzzy decision-making, an approach combining decision-making methods with fuzzy logic, was introduced to overcome this issue. In fuzzy decision-making, the human preferences are expressed in linguistic terms instead of precise crisp numbers. This helps decision makers in giving descriptions more effectively since linguistic terms are more understandable to human beings. In fact, many decision-making approaches have been integrated with fuzzy knowledge previously. Consistent fuzzy preference relation (CFPR) is one of the previously developed powerful tool in describing decision information using pairwise comparison.

CFPR is known for its simplified computation, effectiveness as well as consistency (Lu *et al.* 2019). Compared to analytic hierarchy process (AHP), CFPR reduces the number of evaluations from $n(n-1)/2$ to only $(n-1)$ in the pairwise comparisons. This leads to higher rate of response rate when distributing the questionnaire since the number of questions is reduced (Lu *et al.* 2019). Also, the consistency of the decision makers' opinions is assured. Compared to the AHP, the consistency of the evaluation must always be checked and the evaluation process must be repeated if inconsistency issue arises.

Another powerful decision-making tool is weighted aggregated sum product assessment (WASPAS). This model combines the weighted sum model and weighted product model. The integration of this model with fuzzy logic makes the evaluation more systematic and objective (Ou & Chen 2025).

In this paper, an integrated fuzzy decision-making model is presented, namely the CFPR-WASPAS model. The model is further used to rank four grocery stores in Jengka, Pahang over five criteria: price, convenience, freshness, service and parking area. Furthermore, the strengths and weaknesses of each grocery store are analysed to identify which criteria that needs improvement.

This paper is structured as follows: Section 1 introduces the background of the research; Section 2 reviews some previous works on grocery store selection, CFPR and WASPAS; Section 3 presents the integrated CFPR-WASPAS model; Section 4 implements the fuzzy decision-making model to rank grocery stores; and Section 5 concludes the paper.

2. Literature Review

Reviewing the previous literature, this section will be divided into two main sections: grocery store selection and consistent fuzzy preference relation (CFPR). Grocery store selection is influenced by a variety of criteria based on different customers. Customers have different preferences in determining the best grocery store for shopping. In fact, there have been many previous studies conducted to determine the attributes which influence the grocery store selection as listed in Table 1.

Fujino *et al.* (2008) preassumed that there are central orientations of grocery store selection which could explain the heterogeneity of customers' shopping behaviour. They considered 13 variables such as price, parking, one-stop shopping, neighbourhood, assortment, product information, atmosphere, self-service, organic products, cooking information, operation hours, promotions and staff services.

In another study by, they found that assortment is more important than the price in determining the customers' choice of grocery stores. Also, they found that the advertisement or marketing does not affect the store selection on average. Hence, they suggested that changes of assortment and price are likely to have substantial impact on lifetime value of retail customers.

Hsu *et al.* (2010) investigated the interrelationships among grocery store image, location, consumer's satisfaction and behavioural intentions among undergraduate college students. One of their major findings is that the store location is positively related to customers' satisfaction indicating that students prefer to avoid distant stores.

In another study by Martínez-Ruiz *et al.* (2010), customer services and convenience (CSC) have a significant impact on Spanish customers. These factors include assortment variety, customer attention, additional service, operation hours and store atmosphere. Another important factor after CSC is the economic value of the purchase which includes the price and promotion.

Later, Laine (2014) investigated the effects of bought, owned and earned media on the grocery store selection which include the frequency of visiting grocery stores, shopping companion and decision-maker, and shopping list usage and impulse buying. In this study, it was found that assortment is the leading factor in grocery store selection, followed by location, discount, parking, service and other factors.

On the other hand, Netopil *et al.* (2014) investigated the grocery store selection among retirees. One major finding of this study is that the retirees prefer to shop regularly at their favourite grocery store. Compared to other age groups, they get more information on special discounts from leaflets. The store orientation and assortment of goods is the most influential factor in determining the best grocery store among retired people.

Nilsson et al. (2015) investigated the grocery store attributes that influence the shopping behaviour of Swedish consumers. In this study, accessibility of the store by car is the most influential factor, meanwhile the availability of facilities for children is the least important factor. Meanwhile, Zulqarnain *et al.* (2015) performed the correlation analysis on some factors of grocery store selection and found that location of grocery store and income level of customers are negatively correlated. They also revealed that customers do not give much preference to store location if there are discounts offered. Variety and prices are positively correlated with discounts and there is no correlation between quality and discounts.

Later in 2018, Selema and Makgosa (2018) examined the grocery store selection factors among 160 female shoppers in Botswana. They revealed that convenience is the only significant factor for store selection. This result is almost linked to the result obtained by Martínez-Ruiz *et al.* (2010). On the other hand, service was found to have a negative effect on the store selection.

2.1. *Consistent fuzzy preference relation (CFPR)*

The consistent fuzzy preference relation (CFPR) is decision-making tool proposed by Herrera-Viedma *et al.* (2004) which is based on pairwise comparisons and promising consistency of evaluation. Suppose there are four criteria: C_1, C_2, C_3 and C_4. Using CFPR, only three evaluations are needed to construct the pairwise comparison matrix which are, comparison between C_1-C_2, C_2-C_3, and C_3-C_4. Meanwhile, in analytic hierarchy process, the number of evaluations is six, which are C_1-C_2, C_1-C_3, C_1-C_4, C_2-C_3, C_2-C_4, and C_3-C_4.

Table 1: Major attributes for grocery store selection in the previous literature

References	Convenience	Variety	Price	Quality	Private labels	Location	Marketing	Assortment	Service	Parking
(Zulqarnain *et al.* 2015)	✓	✓	✓	✓	✓					
(Briesch *et al.* 2009)			✓			✓	✓	✓		
(Nilsson *et al.* 2015)	✓	✓	✓	✓		✓		✓	✓	✓
(Netopil *et al.* 2014)	✓	✓	✓	✓		✓		✓	✓	✓
(Baltas & Papastathopoulou 2003)	✓	✓	✓	✓		✓			✓	
(Laine 2014)						✓		✓	✓	✓
(Selema & Makgosa 2018)	✓						✓		✓	
(Hsu *et al.* 2010)	✓					✓	✓		✓	
(Martínez-Ruiz *et al.* 2010)	✓		✓	✓		✓	✓	✓	✓	
(Fujino *et al.* 2008)	✓		✓			✓		✓	✓	✓

Definition 2.1. (Kamis *et al.* 2011) A fuzzy preference relation R on the set of criteria or alternatives A is a fuzzy set stated on the Cartesian product set $A \times A$ with the membership function $\mu_R : A \times A \to [0,1]$. The preference relation is denoted by $n \times n$ matrix $P = \left(p_{ij}\right)$ where $p_{ij} = \mu_R\left(a_i, a_j\right)$ for all $i, j \in \{1,...,n\}$. The preference ratio, p_{ij} of the alternative a_i to a_j is given by

$$p_{ij} = \begin{cases} 0.5 & a_i \text{ is different to } a_j \\ (0.5,1) & a_i \text{ is preferred than } a_j \\ 1 & a_i \text{ is absolutely preferred than } a_j \end{cases} \tag{1}$$

Proposition 2.2. (Kamis *et al.* 2011) *Suppose there is a set of n alternatives and associated with a reciprocal multiplicative preference relation* $A = \left(a_{ij}\right)$ *for* $a_{ij} \in \left[\frac{1}{9}, 9\right]$. *Then the corresponding reciprocal fuzzy preference relation,* $L = \left(l_{ij}\right)$ *with* $l_{ij} \in [0,1]$ *associated with A is given by*

$$l_{ij} = \frac{1}{2}\left(1 + \log_9 a_{ij}\right) \tag{2}$$

Proposition 2.3. (Kamis *et al.* 2011) *For a reciprocal fuzzy preference relation* $L = \left(l_{ij}\right)$, *the following statements are equivalent:*

(i) $l_{ij} + l_{jk} + l_{ki} = \frac{3}{2} \forall i, j, k$

(ii) $l_{ij} + l_{jk} + l_{ki} = \frac{3}{2} \forall i < j < k$.

Proposition 2.4. (Kamis *et al.* 2011) *For a reciprocal fuzzy preference relation* $L = \left(l_{ij}\right)$, *the following statements are equivalent:*

(i) $l_{ij} + l_{jk} + l_{ki} = \frac{3}{2} \forall i < j < k$

(ii) $l_{i(i+1)} + l_{(i+1)(i+2)} + ... + l_{(j-1)j} + l_{ji} = \frac{j-i+1}{2} \forall i < j$.

Chuang *et al.* (2023) applied the CFPR and combined it with the importance-performance analysis (IPA) to explore the important factors of shared decision-making (SDM) in orthopaedic clinical nursing performance. Meanwhile, the CFPR has also been applied in evaluating the Malay translated hadith expert judgment as conducted by Rodzman and Khalif (2024).

In another study by Solanki *et al.* (2024), the CFPR was used to explore the key performance indicators of Internet of Things and cloud computing for insfrustructure projects in India. The advantages of CFPR were also highlighted in the study conducted by

Jiesisibieke *et al.* (2024). In their study, the cancer risk factors among senior nursing factors were evaluated using CFPR, which led to the improvement of cancer prevention awareness.

3. Methodology

In this section, a hybrid fuzzy decision-making model was developed using consistent fuzzy preference relation (CFPR) and weighted aggregated sum product assessment (WASPAS). The CFPR was used to evaluate the criteria weights, meanwhile the fuzzy WASPAS was used to rank the alternatives using the combination of the weighted sum and weight product models.

3.1. *Consistent fuzzy preference relation (CFPR)*

The consistent fuzzy preference relation (CFPR) is based on pairwise comparison between criteria, in which the comparison is reduced to $(n-1)$ evaluations instead of $\frac{n(n-1)}{2}$ as in the analytic hierarchy process (AHP). In fact, the consistency of the evaluation is no more an issue when the CFPR is used. On the other hand, the consistency of the pairwise comparison using the AHP must always be checked. Once the inconsistency is detected, the evaluation process needs to be repeated. Hence, the AHP is not suitable for application of a high number of respondents. For the evaluation of criteria weights using the CFPR, the following steps are adopted:

Step 1: Obtain the pairwise comparison of criteria from the respondents using linguistic terms.

Step 2: Convert the linguistic terms into triangular fuzzy numbers as shown in Table 2.

Table 2: Linguistic terms for criteria evaluation

Linguistic terms	Triangular fuzzy numbers
Equally important	(1, 1, 1)
Weakly more important	(1, 2, 3)
Moderately more important	(2, 3, 4)
Strongly more important	(3, 4, 5)
Very strongly more important	(4, 5, 5)

Step 3: Aggregate the respondents' opinions using the arithmetic aggregation operator defined in Eq. (3). Further, defuzzify the aggregated fuzzy number using Eq. (4).

$$\theta\left(A_1 + A_2 + \ldots + A_k\right) = \frac{1}{k}\left(A_1 + A_2 + \ldots + A_k\right) = \left(\frac{a_{11} + a_{21} + \ldots + a_{k1}}{k}, \frac{a_{12} + a_{22} + \ldots + a_{k2}}{k}, \frac{a_{13} + a_{23} + \ldots + a_{k3}}{k}\right). \quad (3)$$

where $A_i = \left(a_{i1}, a_{i2}, a_{i3}\right)$ is a triangular fuzzy number for $i = 1,2,\ldots,k$ and k is the number of respondents.

$$deff\left(a_1, a_2, a_3\right) = \frac{a_1 + a_2 + a_3}{3}. \quad (4)$$

Step 4: Construct the pairwise comparison matrix for CFPR using Propositions 2.2 to 2.4.

Step 5: Evaluate the average weights of criteria and normalize such that the sum of the weights is equal to 1.

3.2. *Weighted aggregated sum product assessment (WASPAS)*

The fuzzy weighted aggregated sum product assessment (WASPAS) is the combination of the weighted sum and product sum via a utility function, which allows the determination of the ordering of alternatives in which the alternative with the greatest utility value is the most preferable one. For the ranking of alternatives using the fuzzy WASPAS, the following steps are adopted:

Step 1: Construct the decision matrices using linguistic terms displayed in Table 3.

Table 3: Linguistic terms for criteria evaluation

Linguistic terms	Triangular fuzzy numbers
Very Low	(1, 1, 1)
Low	(1, 2, 3)
Moderate	(2, 3, 4)
High	(3, 4, 5)
Very High	(4, 5, 5)

Step 2: Convert the linguistic variables into triangular fuzzy numbers and aggregate all the decision matrices using the arithmetic aggregation operation defined in Eq. (3).

Step 3: Normalize the aggregated decision matrix using Eq. (5) and Eq. (6) for the benefit and cost criteria, respectively.

$$\tilde{A} = \left(\frac{a_{i1}}{\max_i a_{i3}}, \frac{a_{i2}}{\max_i a_{i3}}, \frac{a_{i3}}{\max_i a_{i3}} \right) \tag{5}$$

$$\tilde{A} = \left(\frac{\min_i a_{i1}}{a_{i3}}, \frac{\min_i a_{i1}}{a_{i2}}, \frac{\min_i a_{i1}}{a_{i1}} \right) \tag{6}$$

Step 4: Evaluate the weighted sum model (WSM) using Eq. (7). For the i-th alternative, the WSM is given by

$$WSM\left(Alt_i\right) = \sum_{j=1}^{n} \omega_j \tilde{A}_{ij} \tag{7}$$

where ω_j is the weight of the j-th criterion and $\tilde{A}_{ij}$ is the normalised aggregated fuzzy number representing the i-th alternative and j-th criterion.

Step 5: Evaluate the weighted product model (WPM) using Eq. (8). For the i-th alternative, the WPM is given by

$$WPM\left(Alt_i\right)=\prod_{j=1}^{n}\left(\tilde{A}_{ij}\right)^{\omega_j} \tag{8}$$

where ω_j is the weight of the j-th criterion and $\tilde{A}_{ij}$ is the normalised aggregated fuzzy number representing the i-th alternative and j-th criterion.

Step 6: Evaluate the utility function combining the WSM and WPM using Eq. (9). For the i-th alternative, the utility function is defined by

$$U\left(Alt_i\right)=\delta\cdot deff\left[\sum_{j=1}^{n}\omega_j\tilde{A}_{ij}\right]+\left(1-\delta\right)\cdot deff\left[\prod_{j=1}^{n}\left(\tilde{A}_{ij}\right)^{\omega_j}\right] \tag{9}$$

where $\delta\in\left[0,1\right]$ and the defuzzification of the WSM and WPM follows Eq. (4). If the value of $\delta=0$ is chosen, the model is completely dependent on the weighted product model. On the other hand, the model is completely dependent on the weighted sum model when $\delta=1$.

Step 7: Rank the alternatives based on the utility values. The higher the utility value, the more preferred the alternative.

4. Case Study: Grocery Store Selection

In this section, the proposed approach from Section 3 is applied in solving the grocery store selection. Firstly, the background of the case study is briefly explained. Next, the evaluation of criteria weights using CFPR is explained in details together with the calculation examples. Further, the evaluation of grocery stores using fuzzy WASPAS is detailed in obtaining the ranking. The results are then analysed to explore the strength and weakness of the grocery stores. Also, the results are compared with the existing decision-making approaches from the previous studies.

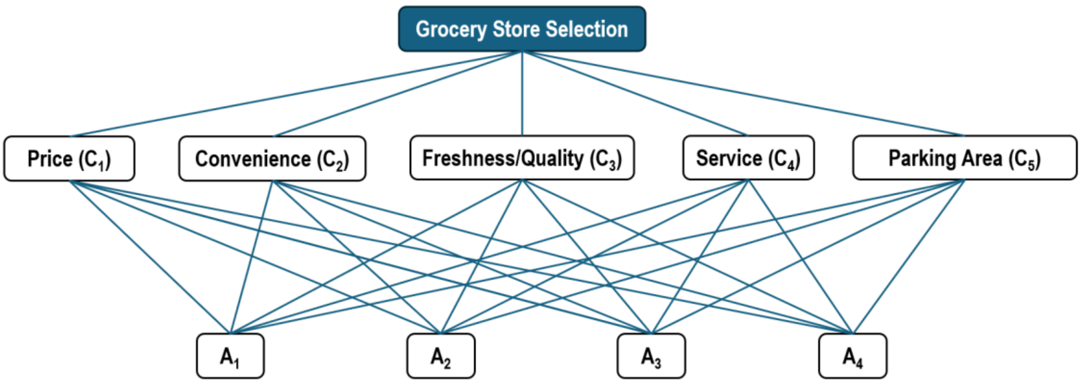

Figure 1: Hierarchical structure of criteria and alternativers for grocery store selection

This research collects the opinions from 71 respondents, who are the academic staffs in Universiti Teknologi MARA Pahang, Jengka campus. Among all the respondents, 35.21% are male lecturers, meanwhile 64.79% are female lecturers. 94.37% of the respondents stay in Jengka, meanwhile the other 5.63% stay outside but work in Jengka. 33.80% of the respondents have been staying in Jengka for less than 5 years, 18.31% for 5-10 years and 11-15 years, 19.72% for 15-20 years, and 9.86% for more than 20 years. In terms of marriage, 76.06% are married and 23.94% are single or unmarried.

Based on Table 1, convenience, price, location, assortment, service and parking are the most commonly used factors in studying the customers' selection behaviour of grocery stores. Since the grocery stores in the location of study which is Jengka, Pahang are all nearby (within 5 km range), hence the location is not suitable to be considered in this study. Meanwhile, the assortment can be combined with convenience, and limited parking at certain grocery stores in Jengka, Pahang has become an issue among customers. Hence, the most suitable criteria to be considered are price (C_1), convenience (C_2), freshness/quality (C_3), service (C_4) and parking area (C_5).

As there are five criteria considered in this research, the evaluation of criteria is performed four times, which are the evaluation between C_1 and C_2, C_2 and C_3, C_3 and C_4, and C_4 and C_5. Hence, the pairwise comparison matrix can be partially contructed by aggregating the opinions of all respondents, converting them into triangular fuzzy numbers and defuzzifying them as shown in Table 4.

Table 4: Partial pairwise comparison matrix involving four evaluations

Criteria	C_1	C_2	C_3	C_4	C_5
C_1	1	1.6417			
C_2		1	0.4459		
C_3			1	2.2690	
C_4				1	1.0792
C_5					1

Next, the actualy pairwise comparison matrix can be constructed by evaluating the entries for l_{12}, l_{23}, l_{34}, and l_{45}. The calculations are shown below:

$$l_{12} = \frac{1}{2}\left(1+\log_5 1.6417\right) = 0.6540, l_{23} = \frac{1}{2}\left(1+\log_5 0.4459\right) = 0.2491,$$
$$l_{34} = \frac{1}{2}\left(1+\log_5 2.2690\right) = 0.7545, l_{45} = \frac{1}{2}\left(1+\log_5 1.0792\right) = 0.5237$$

Further, the calculations for the entries l_{21}, l_{32}, l_{43}, and l_{54} are performed as follows:

$$l_{21} = 1-l_{12} = 1-0.6540 = 0.3460, l_{32} = 1-l_{23} = 1-0.2491 = 0.7509,$$
$$l_{43} = 1-l_{34} = 1-0.7545 = 0.2455, l_{54} = 1-l_{45} = 1-0.5237 = 0.4763$$

Next, the entries l_{31}, l_{42} and l_{53} can be evaluated. Further, the entries l_{13}, l_{24} and l_{35} can simply be calculated. The calculations are shown below:

$$l_{31} = \frac{3}{2} - l_{12} - l_{23} = \frac{3}{2} - 0.6540 - 0.2491 = 0.5969, l_{13} = 1-l_{31} = 1-0.5969 = 0.4031$$
$$l_{42} = \frac{3}{2} - l_{23} - l_{34} = \frac{3}{2} - 0.2491 - 0.7545 = 0.4963, l_{24} = 1-l_{42} = 1-0.4963 = 0.5037$$
$$l_{53} = \frac{3}{2} - l_{34} - l_{45} = \frac{3}{2} - 0.7545 - 0.5237 = 0.2218, l_{35} = 1-l_{53} = 1-0.2218 = 0.7782$$

The entries for l_{41}, l_{52}, l_{14} and l_{25} can be calculated as follows:

$$l_{41} = \frac{4-1+1}{2} - l_{12} - l_{23} - l_{34} = 2 - 0.6540 - 0.2491 - 0.7545 = 0.3423,$$
$$l_{14} = 1 - l_{41} = 1 - 0.3423 = 0.6577$$
$$l_{52} = \frac{5-2+1}{2} - l_{23} - l_{34} - l_{45} = 2 - 0.2491 - 0.7545 - 0.5237 = 0.4727,$$
$$l_{25} = 1 - l_{52} = 1 - 0.4727 = 0.5273$$

Finally, the entries l_{51} and l_{15} can be evaluated in the following:

$$l_{51} = \frac{5-1+1}{2} - l_{12} - l_{23} - l_{34} - l_{45} = \frac{5}{2} - 0.6540 - 0.2491 - 0.7545 - 0.5237 = 0.3187,$$
$$l_{15} = 1 - l_{51} = 1 - 0.3187 = 0.6813$$

Using all the entry values obtained from the above calculations, the full pairwise comparison matrix using the consistent fuzzy preference relation can be constructed as shown in Table 5.

Table 5: Pairwise comparison matrix using consistent fuzzy preference relation

Criteria	C_1	C_2	C_3	C_4	C_5	Average	Normalised
C_1	0.5000	0.6540	0.4031	0.6577	0.6813	0.5792	0.2317
C_2	0.3460	0.5000	0.2491	0.5037	0.5273	0.4252	0.1701
C_3	0.5969	0.7509	0.5000	0.7545	0.7782	0.6761	0.2704
C_4	0.3423	0.4963	0.2455	0.5000	0.5237	0.4216	0.1686
C_5	0.3187	0.4727	0.2218	0.4763	0.5000	0.3979	0.1592

The weightage of criteria which determines the store selection for grocery shopping using consistent fuzzy preference relation is displayed in Table 6. Among all the criteria, the freshness and quality constitutes the highest weightage for selecting the stores for grocery shopping, followed by the price, convenience, service and parking area.

Table 6: Weightage of criteria for grocery store selection

Criteria	Weightage (%)
Price	23.17
Convenience	17.01
Freshness/Quality	27.04
Service	16.86
Parking Area	15.92

For the ranking of the grocery stores, four stores A_1, A_2, A_3, and A_4 are evaluated based on the above five criteria. Among all the criteria, the price (C_1) is the only cost criterion, and the others are the benefit criteria, which requires the normalization of the decision matrix. The normalised decision matrix is presented in Table 7.

Table 7: Normalised decision matrix

Stores	C_1	C_2	C_3	C_4	C_5
A_1	(0.37, 0.47, 0.68)	(0.65, 0.85, 1.00)	(0.49, 0.70, 0.91)	(0.58, 0.80, 1.00)	(0.71, 0.91, 1.00)
A_2	(0.44, 0.61, 1.00)	(0.63, 0.83, 1.00)	(0.60, 0.81, 1.00)	(0.58, 0.80, 1.00)	(0.67, 0.88, 0.99)
A_3	(0.41, 0.56, 0.88)	(0.42, 0.63, 0.82)	(0.51, 0.73, 0.93)	(0.50, 0.71, 0.92)	(0.30, 0.49, 0.68)
A_4	(0.41, 0.55, 0.85)	(0.47, 0.67, 0.87)	(0.57, 0.78, 0.97)	(0.48, 0.69, 0.91)	(0.43, 0.61, 0.78)

Further, the weighted sum model and weighted product model are evaluated and defuzzified using Eq. (2) as displayed in Table 8.

Table 8: Weighted sum model and weighted product model

Stores	Weighted sum	Defuzzified	Weighted Product	Defuzzified
A_1	(0.54, 0.72, 0.90)	0.7209	(0.53, 0.70, 0.89)	0.7066
A_2	(0.58, 0.78, 1.00)	0.7831	(0.57, 0.77, 1.00)	0.7791
A_3	(0.44, 0.63, 0.86)	0.6431	(0.43, 0.63, 0.85)	0.6372
A_4	(0.48, 0.67, 0.88)	0.6754	(0.47, 0.66, 0.88)	0.6716

Hence, the utility values combining the defuzzified weighted sum and weighted product can be calculated. Table 9 presents the utility values using $\delta = 0.1, 0.2, ..., 1.0$.

Table 9: Utility values

Stores	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
A_1	0.7080	0.7094	0.7109	0.7123	0.7138	0.7152	0.7166	0.7181	0.7195	0.7209
A_2	0.7819	0.7819	0.7819	0.7819	0.7819	0.7819	0.7819	0.7819	0.7819	0.7820
A_3	0.6418	0.6418	0.6418	0.6418	0.6418	0.6418	0.6418	0.6418	0.6418	0.6418
A_4	0.6741	0.6741	0.6741	0.6741	0.6741	0.6741	0.6741	0.6741	0.6741	0.6741

In reference to Table 9, the grocery stores are ranked as follows: $A_2 \succ A_1 \succ A_4 \succ A_3$. Store A_2 is the most preferred, meanwhile store A_3 is the least preferred. The ranking maintains although the value of δ is changed, which exhibits the stability of the developed fuzzy decision-making method.

Next, the most preferred and least preferred criteria are analysed. For this purpose, the normalised decision matrix from Table 7 is defuzzified and normalised as shown in Table 10.

Table 10: Defuzzified normalised decision matrix

Stores	Defuzzified Values					Normalised Percentage (%)				
	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5
A_1	0.505	0.831	0.701	0.793	0.874	20.94	**28.26**	23.40	**26.52**	**31.01**
A_2	0.685	0.819	0.801	0.793	0.847	**28.42**	27.83	**26.71**	**26.52**	30.04
A_3	0.62	0.623	0.723	0.711	0.491	25.69	21.18	24.13	23.75	17.44
A_4	0.602	0.669	0.772	0.695	0.606	24.95	22.73	25.75	23.22	21.51

Among all the grocery stores, A_2 contributes the highest percentage for the price (C_1), freshness/quality (C_3) and service (C_4), meanwhile A_1 contributes the highest percentage for the convenience (C_2), service (C_4) and parking area (C_5). However, since the price (C_1) and freshness/quality (C_3) have the top weightages among all criteria (refer to Table 5), hence A_2 is ranked higher than A_1.

By analysing this result, the grocery store which contributes the highest percentage of criteria with the greatest weightages can be determined as the most preferred alternative.

Hence, it is suggested for other grocery stores to consider the improvement in terms of the price as well as the freshness/quality to fulfill the customer's needs and satisfaction.

Next, the obtained results are compared with the previous studies. In this case, the criteria weights are kept unchanged, but the alternative evaluation is applied using other approachers. The results are then compared with different methods from previous studies as displayed in Table 11.

Table 11: Comparison of the obtained results with other approaches from previous studies

	Proposed Method		Fuzzy TOPSIS (Baharin *et al.* 2021)		Simple Additive Weighting (Aliyeva *et al.* 2023)	
Stores	Utility value	Ranking	Closeness coefficient	Ranking	Final rating	Ranking
A_1	0.7138	2	0.6020	2	0.1605	1
A_2	0.7819	1	0.9594	1	0.1585	2
A_3	0.6418	4	0.2079	4	0.1510	4
A_4	0.6741	3	0.3754	3	0.1542	3

The proposed method has similar ranking of alternatives with fuzzy TOPSIS method proposed in Baharin et al. (2021). However, the simple additive weighting method proposed by Aliyeva *et al.* (2023) has a slight change in the ranking of A_1 and A_2. This factor may be influenced by the calculation in the ranking of alternatives. In fuzzy TOPSIS, each alternative is evaluated based on its distance from the positive and negative ideal solutions. The proposed method on the other hand combines the weighted sum and weighted product using a utility function. Meanwhile, the simple additive weighting only considers the weighted sum to rank the alternatives, in which some information might not be reliable.

5. Conclusion

The grocery store selection is influenced by multiple factors or criteria among customers. This research has applied fuzzy decision-making method, namely the integrated CFPR-WASPAS in identifying the most influential factor and ranking the grocery stores in Jengka, Pahang. Among all criteria, freshness or quality was identified as the most important factor in grocery store selection, followed by price, convenience, service and parking area. All the criteria are evaluated using pairwise comparison which has been simplified using CFPR instead of analytic hierarchy process (AHP). The CFPR also promises consistent results which evaluates more effective weights of criteria. The weightage of each criterion was then used to assess several stores, which were then ranked using fuzzy WASPAS model. In the WASPAS model, the aggregated sum and aggregated product of decision information are combined using the utility function, which allows flexibility in ranking the alternatives. The inclusion of fuzzy logic in the decision-making process allows for effective evaluation and makes it more realistic since the linguistic terms were used for evaluation instead of crisp numbers. This helps addressing the issue of uncertainty and vagueness of decision information. The triangular fuzzy numbers were used in this research, which limits the calculation into triangular fuzzy arithmetic. The strength and weakness of each store were then analysed with respect to each criterion. This provides insights for grocery stores involved in this study to improve their service to meet customers' demand. Also, by identifying the most important factor which influences the customers' selection of grocery stores, the owners of these grocery stores are able to accommodate customers' needs by prioritizing the quality or freshness, price, convenience, service and finally parking are. In future, other forms of fuzzy numbers such as Pythagorean, Fermatean and spherical fuzzy numbers can be used to depict the decision information. Also, this integrated model can be used to assess other alternatives such as car brands, smartphones and others.

Acknowledgments

Thank you to all respondents who have involved in the completion of the questionnaire for this study.

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Received: 12 March 2025
Accepted: 18 April 2025

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