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A Fuzzy Analytic Hierarchy Process (FAHP) Application for Multi-Criteria Purchase Decisions Regarding Various Brands of Motorcycles

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HIGHLIGHTS

- Since riding a motorcycle makes traveling much more accessible, many people use it as their primary transportation.
- This study focused on motorcycles manufactured by Honda, Yamaha, Suzuki, and Modenas, specifically those equipped with 125 cubic centimetres or smaller engines.
- Different purchasers give each brand of motorcycle differing amounts of importance.
- The study highlights the significance of understanding the numerous motorcycle manufacturers and models available on the market, as different customers give each brand extra importance.

ABSTRACT

It shows that motorbikes are widely employed as a primary means of transportation for everyday movement despite the hot environment and frequent downpours, as they discovered that a motorcycle was more effective and efficient due to the congestion. Transport is currently becoming highly important to support all human activities. Because different clients place different values on other brands, the study stresses the need to know about the various motorbike manufacturers and models available on the market. By understanding customer preferences and demands, motorcycle dealers can enhance profitability and buyer satisfaction by offering products that meet or exceed expectations in design, price, availability of special offers, and reliability. The Fuzzy Analytical Hierarchy Process is used in this study to choose the top motorcycle brand names and rate the importance of four criteria. The financial features, promotion and types of motorcycles were employed in this study's Analytical Hierarchy Process (AHP) comparison of each motorcycle brand. These criteria are analysed in detail to give buyers essential insights for making well-informed decisions and optimising their daily satisfaction while minimising costs. The findings of this research contribute to the existing knowledge of decision-making methodologies and provide practical implications for motorcycle businesses in Kota Bharu. The outcome demonstrates that, among the scores of possibilities, Honda is the finest brand for people to purchase concerning related criteria is 0.3881, followed by Suzuki (0.3029), Yamaha (0.2615), and Modenas (0.0476). It is also demonstrated by the approach that finances are the most crucial factor to consider before a buyer engages in a motorcycle purchase by having the highest weight score, which is 0.5920, followed by features (0.2439), motorbike kinds (0.1157) and promotions (0.0484).

Keywords: *Fuzzy Analytical Hierarchy Process, motorcycles, purchasing decisions, customer behaviours*

INTRODUCTION

Two-wheeled vehicles, including scooters, motorcycles, and mopeds, are considered standard and prevalent modes of transportation worldwide, particularly in Asia (Biswas & Saha, 2019). As in many other Southeast Asian countries, there are a lot of two-wheeled vehicles on the roads and highways in Malaysia. Even though it gets sweltering and rains a lot in Malaysia, many people use motorcycles as their primary way to get around. Using a motorcycle brings in significant cost savings and other pleasures. According to Gareth Evans (2021), a bike with 125 cubic centimetres (CC) and below engine size uses considerably less fuel than an automobile, especially on longer journeys. The big city has limited parking; a motorcycle can park easily and find parking space. Aside from that, traffic is always a problem when going somewhere, and motorcycles are no longer stuck in traffic congestion. Instead of waiting for their turn to move, they can travel between cars on the highway (Hussain et al., 2005).

Motorcycles are trendy transportation among the people in Kota Bharu. Since most residents of Kota Bharu use motorcycles to commute to work, school, and other destinations, they frequently buy motorcycles from local dealers. A motorcycle is typically less expensive than other vehicles, such as automobiles (Dumrak et al., 2002). In many developing cities, motorcycles offer mobility that other transportation options have been unable to match. As the standard of living rises, their salaries are sufficient for prudent spending. Due to this, buyers will have limited funds, and they must purchase a motorcycle that fits within their budget. Some people in the market for a motorcycle are interested in buying an inexpensive model but are highly particular about the design and construction of the motorcycle. In addition to purchasing their preferred motorcycle, buyers can also do so due to the promotion offered by motorcycle dealers. Additionally, buyers can purchase through bank loans with instalments that fit their budgets.

This study of the Fuzzy Analytic Hierarchy Process is used to rank motorcycle brands based on needs, lifestyle, and budgetary considerations. There are numerous motorcycle brands in Kota Bharu, Kelantan. However, not all criteria satisfied the preferences and opinions of every buyer regarding each motorcycle brand. Therefore, they must establish a method for determining motorcycle brand rankings. By employing this method, the outcomes will be more precise and effective. The main objective of this study is to assist in finding a solution for ranking motorbike brands and purchasing criteria in terms of decision-making that uses the Fuzzy Analytic Hierarchy Process. This method will be used to compare motorcycle brands based on their finances, features, promotion, and types of motorcycles. All these criteria originate from Suryawanshi's (2022) journal article. Identifying and learning about the various motorcycle manufacturers helps a business adapt to the needs of its buyer base. Customers may attribute different levels of importance to various motorcycle brands when purchasing (Meylano et al., 2020).

METHODOLOGY

This study applied the questionnaire survey to the customers in Kota Bharu to get the primary data needed. Interviews were conducted with customers with significant knowledge concerning motorcycles, and questionnaires were provided for them to fill out. Because the data are relevant to the ranking of motorcycle brands, the data will mainly focus on Yamaha, Honda, Suzuki, and Modenas. A Fuzzy Analytic Hierarchy Process (FAHP) is used to identify the best-selling motorcycle brands and the customers' preferred criteria according to the main criteria: financial, features, promotion, and types of motorcycles. The four criteria are taken from the journal article written by Suryawanshi in 2022. These criteria were used to develop the surveys. The processes involved in applying the Fuzzy Analytic Hierarchy Process to the data analysis are shown in Figure 1.

Step 1: Identify all the criteria and formulate the decision-making problem.

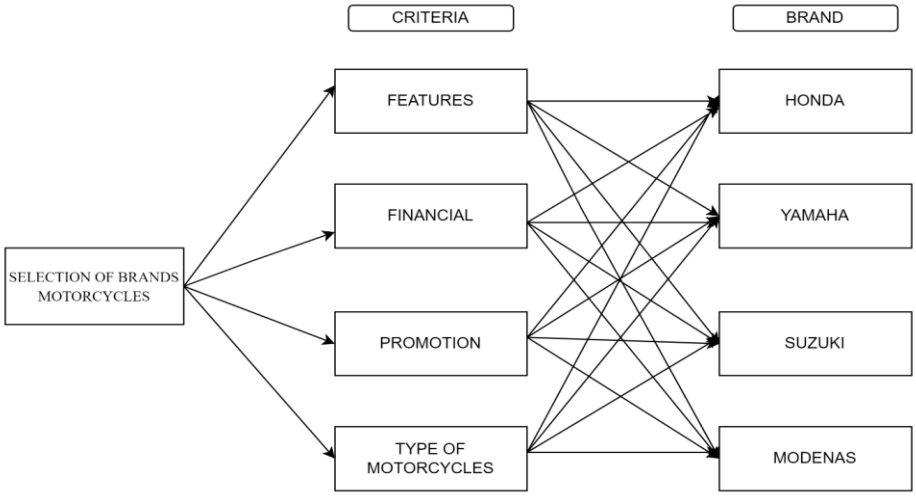

Figure 1: General Hierarchy for Criteria of Brand Motorcycles

Step 2: Create fuzzy pairwise comparison matrix via linguistic terms.

Table 1: Linguistic Terms with Triangular Fuzzy Numbers

Saaty scale	Definition	Fuzzy triangular scale
1	Equally important (E. Imp)	(1,1,1)
3	Moderately important	(2,3,4)
5	Strongly more important	(4,5,6)
7	Very strong important	(6,7,8)
9	Extremely more important	(9,9,9)
2	Intermediate more important	(1,2,3)
4 6 8	The values that alternate between two adjacent scales	(3,4,5) (5,6,7) (7,8,9)

(Source: Ayhan, 2013)

According to the corresponding triangular fuzzy numbers of these linguistic terms, for example if the decision maker states Criteria 1 (C1) is Weakly Important than Criteria 2 (C2), then it takes the fuzzy triangular scale as (2, 3, 4). In contrast, the pairwise contribution matrix of the criteria, comparison of C2 to C1 will take the fuzzy triangular scale as (1/4, 1/3, 1/2). The pairwise contribution matrix is shown in

Equation 3.1, where indicates the $\boldsymbol{k^{th}}$ decision maker's preference of $\boldsymbol{i^{th}}$criteria over $\boldsymbol{j^{th}}$criteria via fuzzy triangular numbers.

$$\tilde{A}^{k} = \begin{bmatrix} \tilde{p}^{k}_{11} & \tilde{p}^{k}_{11} & \cdots & \tilde{p}^{k}_{1n} \\ \tilde{p}^{k}_{21} & \cdots & \cdots & \tilde{p}^{k}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{p}^{k}_{n1} & \tilde{p}^{k}_{n1} & \cdots & \tilde{p}^{k}_{n1} \end{bmatrix} \tag{1}$$

Step 3: Check consistency ratio, CR

An evaluation for consistency was examined to guarantee the consistency of the expert's opinions. If CR is consistent, then $\boldsymbol{\lambda max}$= n and in general $\boldsymbol{\lambda max}$ greater than n. So, a measure of consistency is built around the difference ($\boldsymbol{\lambda max}$ − n).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

λ_{max} = The largest eigenvalue of the comparison matrix
n = The dimension of the matrix

The matrix's consistency ratio CR and consistency ratio CI. The random consistency, or RI, depends on the matrix n's size.

$$CR = \frac{CI}{RI} \tag{3}$$

Step 4: Pairwise comparison matrix

According to averaged preferences, the pairwise comparison matrix is updated as shown in Equation 4.

$$\tilde{A} = \begin{bmatrix} \tilde{p}_{11} & \cdots & \tilde{p}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{p}_{n1} & \cdots & \tilde{p}_{nn} \end{bmatrix} \tag{4}$$

Step 5: If there is more than one decision maker, apply equation 5.

When there are many decision-makers, the preferences of each decision-maker $\tilde{p}_{ij}^{k}$, are averaged, resulting in the calculation of $\tilde{p}_{ij}^{k}$, as described in Equation 5.

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{K} \tilde{p}^{k}_{ij},}{K} \tag{5}$$

Step 6: The geometric mean of fuzzy comparison values.

The geometric mean of fuzzy comparison values of each criterion is calculated as shown in Equation 6.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{p}_{ij} \right)^{\frac{1}{n}} \tag{6}$$

Step 7: The fuzzy weights.

The fuzzy weights of each criterion can be found with Equation 7, by incorporating the next steps below.

i. Find the vector summation of each, $\tilde{r}_i$

ii. Find the (-1) power of the summation vector. Replace the fuzzy triangular number to make it in an increasing order

iii. Find the fuzzy weight of criteria $\tilde{w}_i$ multiply each $\tilde{r}_i$ with reverse vector.

$$\tilde{w}_i = \tilde{r}_i \oplus (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3)^{-1} = (lw_{i,} mw_{i,} uw_i) \tag{7}$$

Step 8: Normalization.

Since $\tilde{w}_i$ are still fuzzy triangular numbers, they need to be defuzzied by the center of area method applying the Equation 8. M_i is a non-fuzzy number. But it needs to be normalized by following Equation 9.

$$M_i = \frac{(lw_i + mw_i + uw_i)}{3} \tag{8}$$

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \tag{9}$$

Step 9: Analyse motorbike brands.

The next step is to compute an alternative value where the alternative resolution measures are similar to the criterion fulfilment stages. Each alternative element's weight value will be computed by the weight of the criteria element and applied to the decision outcomes.

Step 10: Decision-making and final rating.

The outcome is the weight ranking computation.

FINDINGS AND DISCUSSIONS

The initial step in fuzzy AHP is constructing the hierarchy tree, as shown in Figure 1. A questionnaire was given to the experts, and the results were then transformed to generate a fuzzy comparison matrix. The normalization of each pairwise comparison must be computed. A consistent evaluation was carried out to guarantee the continuity of the expert's points of view. The result element estimates are acceptable if CR (consistency ratio) is less than 0.10. A pairwise comparison matrix must be generated to determine the average pairwise comparison matrix. The preferences of each decision-maker are averaged and calculated if there are many decision-makers. The averaged preferences update the pairwise contribution matrix, as illustrated in Equation 3.

Table 2: Average pair wise comparison of the criteria

Criteria	C1			C2			C3			C4		
C1	1.000	1.000	1.000	3.000	4.000	5.000	6.500	7.500	8.500	4.500	5.500	6.500
C2	0.200	0.250	0.333	1.000	1.000	1.000	5.000	6.000	7.000	2.000	3.000	4.000
C3	0.118	0.134	0.155	0.146	0.171	0.208	1.000	1.000	1.000	0.225	0.292	0.417
C4	0.155	0.183	0.225	0.250	0.333	0.500	2.500	3.500	4.500	1.000	1.000	1.000

Table 2 displays the average pair-wise comparison of the criteria, where C1 through C4 represent feature, finance, promotion, and motorbike type, respectively. Calculating the geometric mean of fuzzy comparison results for each criterion is performed using Equation 6.

$$\tilde{r}_i = [(1*4*2*7.5)^{\frac{1}{4}},(1*4*2*7.5)^{\frac{1}{4}},(1*4*2*7.5)^{\frac{1}{4}}]$$
$$= [2.7832, 3.3098, 3.7793]$$

Table 3: The result of the geometric mean

Criteria	ri		
C1	3.061	3.584	4.077
C2	1.189	1.456	1.748
C3	0.249	0.286	0.340
C4	0.558	0.680	0.844

Equation 7 is used to calculate the fuzzy weights of each criterion by including the procedures that follow.

Table 4: The power of summation vector and the increasing order

Total	5.1273	6.1152	7.2552
Power (-1)	0.1950	0.1635	0.1378
Increasing	0.1378	0.1635	0.1950

Since $\tilde{w}_i$ are still fuzzy triangular numbers, they need to be defuzzied. By the centre of area method applying the Equation 7.

$$\tilde{w}_i=(2.7832*0.1378+3.3098*0.1635+3.7793*0.195)$$
$$=(0.3836,0.5412,0.7371)$$

Table 5: Fuzzy weight of criterion

Alt	wi		
A1	0.3836	0.5412	0.7371
A2	0.0619	0.0915	0.1334
A3	0.2258	0.3188	0.4732
A4	0.0354	0.0485	0.0713

Table 5 displays the representation of Honda, Yamaha, Suzuki, and Modenas by the labels A1 to A4. Individual evaluations of each alternative are provided for each criterion in order to determine the outcome.

Table 6: The ratings of alternatives with respect to the related criteria

Criteria	Scores Of Alternatives with respect to related Criteria				
	Weight (Ni)	A1	A2	A3	A4
C1. Financial	0.5920	0.5324	0.0919	0.3260	0.0497
C2. Features	0.2439	0.1331	0.6011	0.2289	0.0370
C3. Promotion	0.0484	0.5534	0.1000	0.2981	0.0486
C4. Types of motorcycles	0.1157	0.1179	0.4806	0.3429	0.0587
Total (score alt x weight criteria)		0.3881	0.2615	0.3029	0.0476

The results of evaluating the scores of the various alternatives according to the respective criteria are shown in Table 6. The table demonstrates that the financial factor is the most relevant criterion when compared to the other criteria.

Table 7: The rank of alternatives with respect to related criteria.

Alternatives	Description	Scores Of Alternatives with respect to related Criteria	Rank
A1	Honda	0.3881	1
A2	Yamaha	0.2615	3
A3	Suzuki	0.3029	2
A4	Modenas	0.0476	4

Table 7 shows that Honda obtained the most excellent possible total score. According to the four criteria and the expert's subjective taste, this motorbike brand is the best choice.

CONCLUSION AND RECOMMENDATIONS

As a result of the results from the previous chapter, it showed that respondents preferred Honda motorcycles over Suzuki, Yamaha, and Modenas. Regarding relevant parameters, Honda obtains the greatest score among the alternatives (0.3881) for using a motorcycle for everyday commuting or work. Meanwhile, Suzuki has been selected as the runner-up with 0.3029. Yamaha and Modenas are the third and fourth selections, respectively, with ratings of 0.2615 and 0.0476. Finances are of the most considerable significance before purchasing a motorcycle. This is because when compared to the other categories,

financial has the most significant weight (0.5920). The features, with a weight of 0.2439, came next. The type of motorcycles, with a weight value of 0.1157, came in third place. Promotion, unfortunately, falls in last place with a weight value of 0.0484.

There are several suggestions accessible for this investigation. To begin, the survey results provided by AHP can be used in future studies to compare clients from various states. Second, when applied to the same problem, the outcomes of future investigations can be compared using fuzzy TOPSIS. With the assistance of this recommendation, the investor will be able to focus on the Criteria that provide the highest ranking in buyer choice or on other possibilities that provide more accurate results.

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CONFLICT OF INTEREST DISCLOSURE

The authors declared that they have no conflicts of interest to disclose.

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