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# Selection of the Best Petrol Car on the Basis of Qualitative and Quantitative Attributes Using Hybrid MCDM Methods

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**ABSTRACT**

**Decision problems, especially, multi-criteria decision problems are very tough and complex in nature. Car selection is one of the complex and tough multi attribute decision problems. Due to advancement in technologies and competitiveness in the market, there are varieties of petrol car in the price range of 8-10 lakh available in the market. The choice of selection of the petrol car varies from person to person based on various qualitative and quantitative attributes. In this research paper, six important qualitative and six important quantitative attributes have been considered as per the group of experts of automobile engineering field for selection of the best petrol car from five shortlisted car. To solve this kind of complex multi criteria decision problem, hybrid MCDM (Fuzzy AHP and TOPSIS) method has been used. The weight of all the qualitative attributes have been determined by huge customer survey and group of experts while equal weights have been considered for all the quantitative attributes. The results obtained from MCDM hybrid (Fuzzy AHP and TOPSIS) method have been compared with the results obtained from another MCDM hybrid method (Fuzzy AHP and MOORA) method in order compare the rank of all the five shortlisted car.**

**Index Terms – Car Selection, Fuzzy AHP Method (FAHP), Hybrid MCDM Method, MOORA Method, TOPSIS Method.**

## 1. INTRODUCTION

Car selection is very common problem but it is one of the complex decision problem. Now-a-days, it has become very common and is used by government or private employees, businessmen etc.. Due to availability of various alternatives which are subjective in nature, decision making becomes tough and complex [1]. Most of the common persons fail to take decision when more numbers of attributes and alternatives are available for the multi criteria decision problem. Systematic arrangement of the multi criteria decision problem is one the important and fundamental steps to take best decision among available alternatives under the given constraints.

There are lots of car of different companies with different models and variants are available in the market. Depending on the objectives of different persons, choice of car of each person may be different. As technologies are developing at very fast speed and due to that design and manufacturing of recent car have been changed lot from the traditional car. Even after that, customer's expectations and requirements have been given priorities over changing or modifying the design of car. In the beginning of 2000s, automotive owners looked for additional features that were offered by luxury car in mid-range of price. This is the reason to get success in automobile sector to provide high quality products and services in reasonable range of prices. The customer chooses those model and variant of car which not only meet their performance, but also cost, safety, after sale services etc. during purchasing decision of automobile [2]. Safety is comparatively given more preferences than performance and mileage of the car by most of the people [3]. The competition of purchasing car is increasing with time and due to this reason, car manufacturer companies are struggling to provide the best products to the customers in reasonable range of price [4]. The demand of car is changing with the time and also car manufacturers are improving designs, adding new technologies and features to meet customer's need and satisfaction in reasonable price range. The hybrid and electric car such as Prius, Tesla etc. have increased alternatives of car selection. Thus, among lots of choices or alternatives of car and preferences of customer, the problem of car selection becomes complex multi criteria decision problem. Manufacturing of car by considering different attributes that customer needs is very challenging since attributes would conflict each other. Therefore, different attributes needs to be recognized and prioritized. Then, MCDM technique could be applied. MCDM aims to select the best decision (process, product, service, strategy etc.) among various alternatives under given conflicting attributes or situations [5], [6].

There are various MCDM techniques (AHP [7] ; VIKOR [8], [9] ; SAW [10] ; TOPSIS [11] ; SMART [12] ; PROMETHEE [13] etc.) which have developed for decision problems and have been applied in various decision problems in different fields. In this research paper, hybrid MCDM method has been used for selection of the best petrol car under the price range of 8-10 lakh with the help of Fuzzy AHP, TOPSIS and MOORA method. To select the best petrol car among five alternatives of car internal appearance, external appearance, safety, on road reliability, add on features and after sales service of the car have been considered as qualitative attributes while ex-showroom price, mileage, power, torque, displacement and distance of service centre been considered as quantitative attributes. Pair-wise comparison of each alternative with another, customer survey has been done with the help of group of experts of automobile field.

## 2. LITERATURE REVIEW

MCDM methods are very useful and widely used tools for selection of the best option or alternative or option from the available alternatives [14]. Recently, in few years, lots of researchers have applied MCDM methods for various complex decision problems such as strategies to tackle COVID-19 outbreak [15], selection of electric vehicle charging station [16], Wire EDM performance [17], selection of mobile model [18], selection of renewable energy source [19], selection of material for tool holder [20] etc.. The Fuzzy AHP methodology is based on the concept of Fuzzy Theory [21]. Fuzzy AHP was proposed by Saaty in 1980 which extension of AHP method [22], [21]. Fuzzy AHP is one the popular and effective method which has been recently applied in evaluation of e-service quality of the airline industry [23], supplier selection [24], evaluation of hotel websites [25] etc.. Chan and Kumar [26] applied Fuzzy AHP for global supplier selection including risk factors. For selection of global supplier, Chan and Kumar considered four different attributes i.e., quality, supplier's profile, cost and service performance along with risk factors. Lee et al [27] applied Fuzzy AHP method with balanced score cars (BSC) in manufacturing industry for evaluation of IT department in Taiwan. Duran and Aguilo [28] applied Fuzzy AHP methodology for selection of computer aided tool in their paper. Chang et al [29] applied Fuzzy AHP to select unstable slicing machine in electronics industry to control water slicing quality. In 2010, Hsu et al [30] implemented Fuzzy AHP technique for selection of technology in oil industry. Cebeci [31] applied Fuzzy AHP method in textile industry to select best Enterprise Planning System (ERP).

TOPSIS is one the most used MCDM technique in which an alternative is identified which is closest to positive ideal solution and farthest to the negative ideal solution in multi-dimensional computing space [32]. TOPSIS method has very simple process, easy to use and programmable. It has lots of advantages over another MCDM methods but has some disadvantages also. The main advantages of TOPSIS method are that the simplicity of the method has ability to maintain the fixed or same numbers of steps even the size of decision problem is big or small and thus this method allows to quickly review other methods and compare the results with the results of other method. One of the disadvantage in TOPSIS method is that Euclidean distance is not considered in the correlation of attributes. Recently, researcher have applied TOPSIS method for selection of sustainable product design [33], selection of waste to energy method [34], effective link prediction in multiplex networks [35]. Researchers have also applied TOPSIS methods in various fields such as engineering and manufacturing systems [36], [37] ; water resources management [38] ; business and marketing management [39], [40], [41] ; supply chain management and logistics [42] and human resources management [43].

MOORA method was firstly developed by Brauers in 2004 to solve many types of complex MCDM problems. Multi-objective optimization is the technique by which two or more objectives can be optimized simultaneously. Some of the examples of multi-objective optimization problems are maximizing performance together with minimizing fuel consumption of the automobile ; maximizing strength of the engineering materials or components and minimizing weight of that engineering components ; and maximizing the profit and minimizing the cost of the materials [44]. Ranking or selection of the optimum or the best alternative is done by considering beneficial and non-beneficial attributes in MOORA method [45], [46]. Recently MOORA method has been applied in various fields such as biomass material selection for sustainable environment [47], decision support system for selection technique [48] etc.

Many researchers have already combined Fuzzy AHP with other MCDM methods such as COPRAS [49], ANN [50], TOPSIS [51], VIKOR [52] to make hybrid MCDM method. Das et al [53] implemented hybrid or integrated MCDM method i.e., Fuzzy AHP and COPRAS method for evaluation of technical institutions in India. Secme et al [54] applied hybrid MCDM method for evaluation of banks in Turkey. In their study, only five largest commercial bank were considered and examined and then performance of these banks were evaluated. The performance of banks were evaluated in terms of financial as well as non-financial indicators. For determining weight of all the attributes, they applied Fuzzy AHP method and then these determined weight were used in finding the rank of banks by TOPSIS method.

Many researchers have implemented lots of MCDM methods for car selection [55], [56], [57]. In this research paper, hybrid MCDM method i.e., integration of Fuzzy AHP with TOPSIS method and integration of Fuzzy AHP and MOORA method have been applied for selection of the best petrol car in range of 8-10 lakh.

## 3. MATERIALS AND METHODS

A customer residing in Jalpaiguri, West Bengal has to buy a car in the range of 8-10 lakh. Customer has decided to buy only petrol car by keeping pollution concern in his mind. For that, his family has shortlisted five petrol car based on normal observation of specification of car. Out of the five shortlisted car, decision to buy the best suitable car has become the challenge for customer and customer has to buy only one car but he is not able to select the best alternatives of car available to him. This is multi criteria decision type problem in which proper arrangement of the problem is very important step and then assumptions & preferences has been defined in order to solve it analytically. Two basic constraints of this problem is (i) Type of fuel of car – Petrol and (ii) Budget for car – 8-10 lakh.

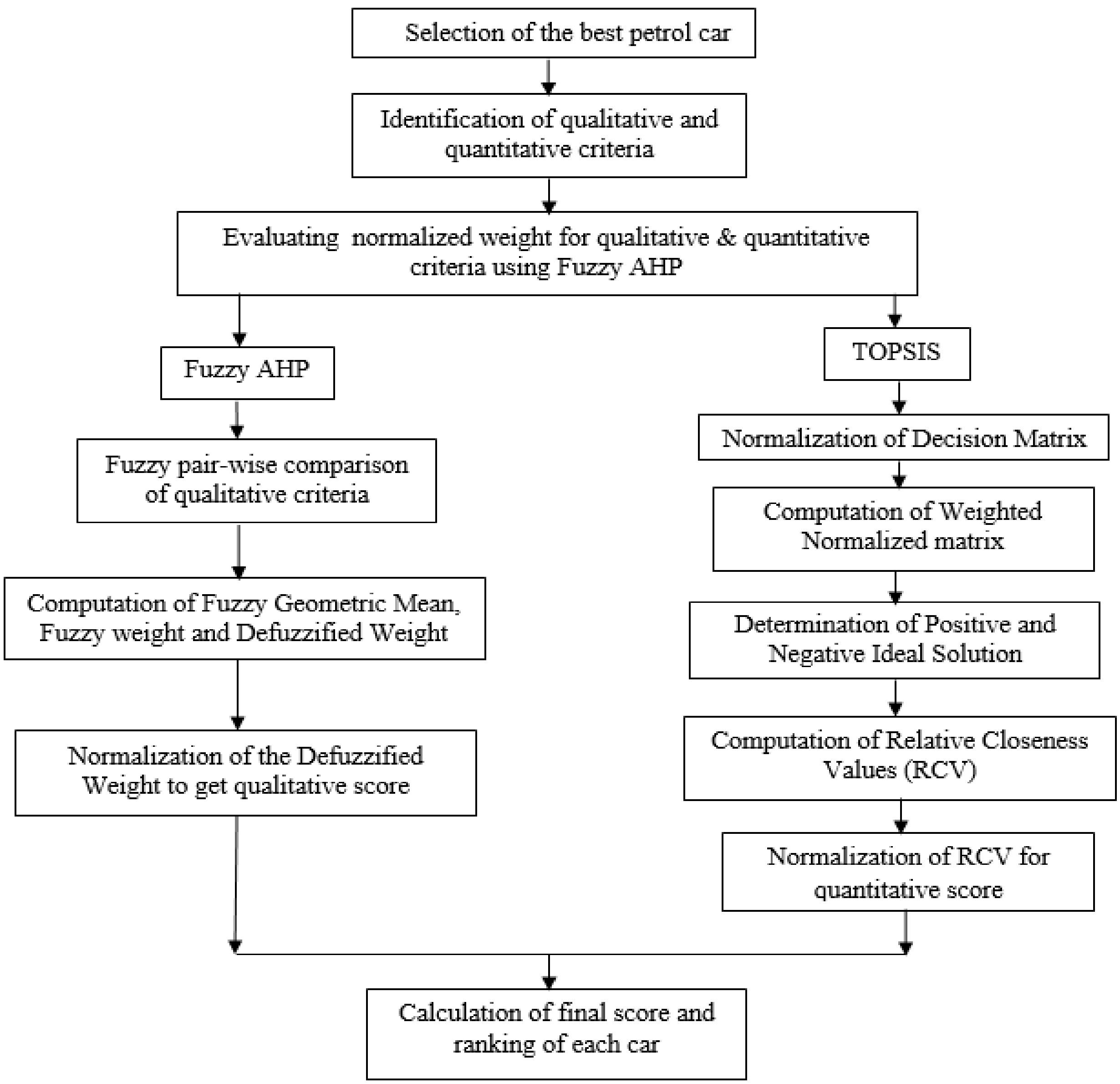


Figure 1 Methodology Framework for Selection of the Petrol Car Using Hybrid MCDM Method i.e., Combination of FAHP and TOPSIS Method

Selection of the best petrol car has been done on the basis of six qualitative and quantitative criteria. Internal Appearance, external appearance, safety, on road reliability, add on features, after sales service are the six qualitative criteria and ex-showroom price, mileage, power, torque, displacement and distance of service centre are the six quantitative criteria considered for the selection of car. Quantitative criteria has been given higher preference over the qualitative criteria by group of experts with the help of huge customer survey. Two different hybrid MCDM method have been used to solve this complex problem. At first, FAHP method has been used to find the normalized weight of qualitative and quantitative criteria then again, FAHP method has been used to find the qualitative score of each car. TOPSIS and MOORA method have been applied to find out the quantitative score of each car separately. Finally, FAHP and TOPSIS or MOORA method have been combined together as hybrid MCDM method to find out the final score of the car. Based on the final score of each car, ranking of five shortlisted car has been done in descending order of final score to select the best petrol car in the range of 8-10 lakh. The methodology framework for selection of the best petrol car is shown in Figure 1 and 2.

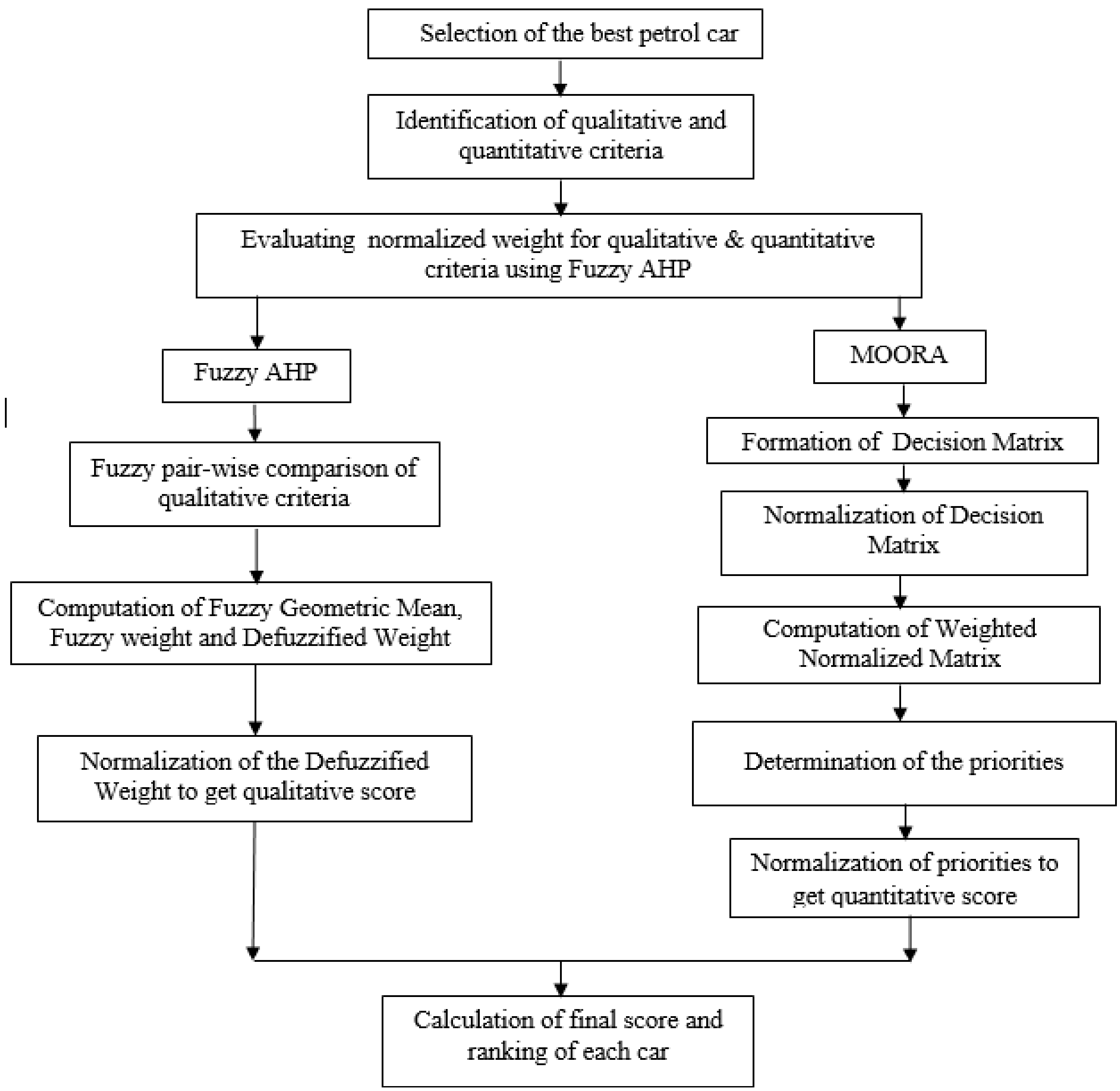


Figure 2 Methodology Framework for Selection of the Best Petrol Car Using Hybrid MCDM Method i.e., Combination of Fuzzy AHP and MOORA Method

## 4. FUZZY AHP METHODOLOGY

Zadeh introduced concept of set theory to deal with uncertainties and unclear conditions such that mathematical operators and programming are applied in the fuzzy domain.[58], [59]. By AHP model, Complex MCDM problems are solved by breaking decision problem into hierarchies and then, importance or preferences are given in deciding priorities in all the hierarchies to take decision. FAHP helps decision maker to incorporate quantitative as well as qualitative aspects of complex decision problem. As AHP cannot be directly applied to solve uncertain and complex decision problems due to the reason that some criteria are quantitative but some are qualitative. In this case, it will be very tough for decision maker to provide definite values. So, it is better to introduce Fuzzy evaluations. To overcome this limitation, FAHP model was introduced to track imprecision as well as uncertainty during the evaluation process. Input for Fuzzy AHP is comparative judgmental which is generally given by experts. The qualitative types of inputs are converted into some crisp value. Saaty's AHP combined with Fuzzy Set Theory results in Fuzzy Analytic Hierarchy Process. Fuzzy ratio scales become very important in determining comparative strength of a factor in the corresponding criteria. From this, matrix called 'Fuzzy Judgmental Matrix' is constructed. To deal with uncertainties in AHP method, Fuzzy comparison ratios obtained by triangular membership functions are used [59], then nine level scales of judgment are represented by Triangular Fuzzy Numbers (TFNs) to represent relative importance of hierarchy's criteria. The relation between numerical values and linguistic variables are represented by Fuzzified Saaty's scale are shown in Table 1. In TFN, M is denoted by three real numbers (l, m, u) as illustrated in Figure 3 where l, m, u represents smallest, most promising and largest possible values of membership function $\mu_M(x)$ respectively. The importance of each criteria is represented by linguistic variables as illustrated in figure 4. The membership function of TFN has been represented in equation 1.

$$\mu_M(x) = \begin{cases} \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0, & x < l \;\&\; x > u \end{cases} \quad \ldots\ldots (1)$$

The values of membership function can be in between 0 and 1.

In this research paper, we followed the method proposed by [60] for finding Fuzzy weights. For defuzzyfying and obtaining crisp weights, [61] has been followed. Algebraic operations (equation 2-4) between two TFNs, let $A(l_1, m_1, u_1)$ and $B(l_2, m_2, u_2)$ are as follows :

Addition : $A+B = (l_1+ l_2, m_1+ m_2, u_1+ u_2)$ … (2)

Multiplication : $A*B = (l_1.l_2, m_1.m_2, u_1.u_2)$ … (3)

Inverse : $(1/u_1, 1/m_1, 1/l_1)$ … (4)

Fuzzy geometric mean, fuzzy weight and defuzzified weight are determined using equation 5, 6 and 7 respectively.

Fuzzy Geometric Mean ($r_i$) can be calculated as :

$r_i = \{(l_1*l_2*l_3\ldots*l_n)^{1/n}, (m_1*m_2*m_3\ldots*m_n)^{1/n}, (u_1*u_2*u_3\ldots*u_n)^{1/n}\}$ … (5)

where, n = number of order of matrix

i = 1, 2, 3, …, n

Fuzzy Weight can be calculated as :

$W_i = r_i*(r_1+r_2+r_3+r_4\ldots\ldots..+r_n)^{-1}$ … (6)

where, n = number of order of matrix

i = 1, 2, 3……, n

Defuzzified weight = $\frac{l+m+u}{3}$ ... (7)

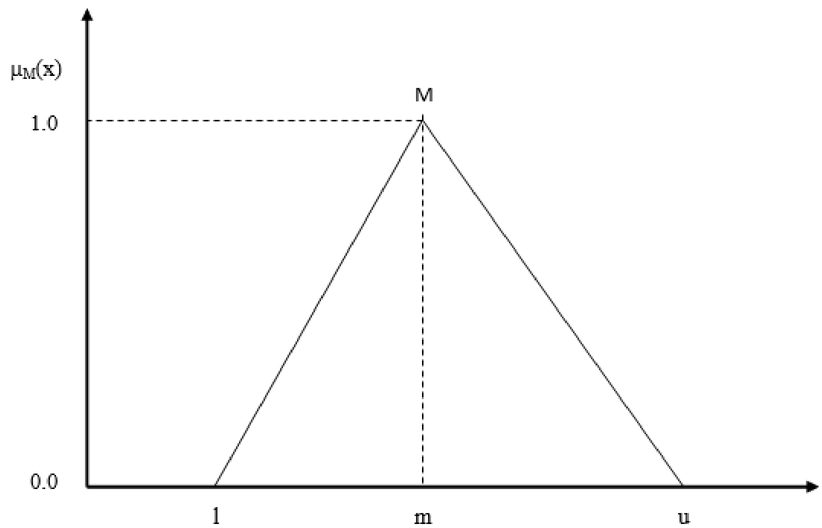


Figure 3 Representation of Triangular Fuzzy Numbers (TFNs)

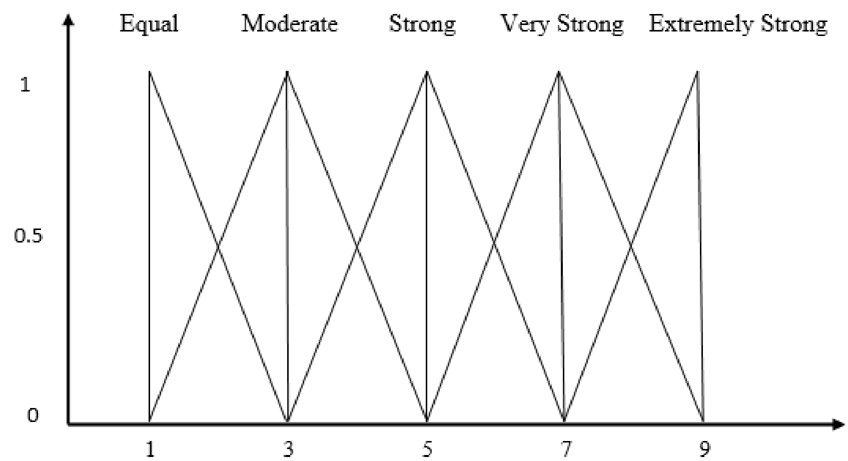


Figure 4 Representation of Linguistic Variables

Table 1 Fuzzified Saaty's Scale for TFN of Crisp Numeric Values

| Linguistic Variable | Crisp value or Fuzzy Number | FAHP or TFN Scale (l, m, u) | Reciprocal of TFN |
|---|---|---|---|
| Just Equal | 1 | (1, 1, 1) | (1, 1, 1) |
| Equally Important | 1 | (1, 1, 3) | (1/3, 1, 1) |
| Moderately Important | 3 | (1, 3, 5) | (1/5, 1/3, 1) |
| Strongly Important | 5 | (3, 5, 7) | (1/7, 1/5, 1/3) |
| Very Strongly Important | 7 | (5, 7, 9) | (1/9, 1/7, 1/5) |
| Extremely Preferred | 9 | (7, 9, 9) | (1/9, 1/9, 1/7) |
| Intermediate values | 2 | (1, 2, 3) | (1/3, ½, 1) |
| | 4 | (3, 4, 5) | (1/5, 1/4, 1/3) |
| | 6 | (5, 6, 7) | (1/7, 1/6, 1/5) |
| | 8 | (7, 8, 9) | (1/9, 1/8, 1/7) |

## 5. TOPSIS METHODOLOGY

Steps involved in TOPSIS method to solve MCDM problem are as follows [62] :

**Step 1**: Formation of Decision matrix

The decision matrix, M as shown below denotes performance measures of all the alternatives or $i^{th}$ criteria with respect to all the attributes or $j^{th}$ attribute.

$$M = \begin{array}{c} \\ \end{array} \begin{matrix} C_1 & C_2 & C_3 & \dots & C_n \end{matrix}$$

$$M = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \begin{matrix} A_1 \\ A_2 \\ A_3 \\ \dots \\ A_m \end{matrix}$$

Here, decision matrix has m numbers of alternatives and n numbers of attributes. The interaction of each alternative and attribute is represented by $x_{ij}$ .

Step 2 : Formation of normalized decision Matrix

Decision matrix, M can be normalized as follows :

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad \dots (8)$$

where, i = 1, 2, 3, …, m

j = 1, 2, 3, …, n

Step 3. Weighted Normalization of decision matrix

$$v_{ij} = r_{ij}.w_j (i = 1, 2, 3, \dots, m ; \; j = 1, 2, 3, \dots, n) \quad \dots (9)$$

where, $w_j$ is the weight of the attribute $C_j$

Step 4 : Finding PIS and NIS

$[p_1^+, p_2^+, \dots, p_n^+] = \{(\max p_{ij}, i = 1, 2, \dots, m, \; j \in k), (\min p_{ij}, i = 1, 2, \dots, m, \; j \in k')\}$ … (10)

$[p_1^-, p_2^-, \dots, p_n^-] = \{(\min p_{ij}, i = 1, 2, \dots, m, \; j \in k), (\max p_{ij}, i = 1, 2, \dots, m, \; j \in k')\}$ … (11)

where, k is the index set of beneficial attributes

k' is the index of non-beneficial attributes

Step 5 : Separation from PIS and NIS

The two Euclidean distances for each alternative are calculated as follows :

$$s_j^+ = \sqrt{\sum_{j=1}^{n} (p_{ij} - p_j^+)^2} \;, (i = 1, 2, 3, \dots, m ; \; j = 1, 2, 3, \dots, n) \quad \dots (12)$$

$$s_j^- = \sqrt{\sum_{j=1}^{n} (p_{ij} - p_j^-)^2} \;, (i = 1, 2, 3, \dots, m ; \; j = 1, 2, 3, \dots, n) \quad \dots (13)$$

Step 6 : Calculation of Relative Closeness Value (RCV) for each alternative

RCV is represented by $c_i$ and calculated as follows :

$$c_i = \frac{s_j^-}{s_j^+ + s_j^-} \;, (i = 1, 2, \dots, m) \quad \dots (14)$$

Where, $0 \leq c_i \leq 1$

It can be concluded from the above equation that

$c_i = 1$ (for best solution)

$c_i = 0$ (for Worst solution)

Step 7: Ranking of alternatives

Ranking of all alternatives are done in descending order of $c_i$ values.

## 6. MOORA METHODOLOGY

The decision matrix, M as shown below denotes performance measures of $i^{th}$ criteria with respect to all the attributes or $j^{th}$ attribute.

$$\begin{array}{c} \\ M = \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & C_3 & \dots & C_n \end{matrix} \\ \begin{bmatrix} b_{11} & b_{12} & b_{13} & \dots & b_{1n} \\ b_{21} & b_{22} & b_{23} & \dots & b_{2n} \\ b_{31} & b_{32} & b_{33} & \dots & b_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ b_{m1} & b_{m2} & b_{m3} & \dots & b_{mn} \end{bmatrix} \end{array} \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \dots \\ A_m \end{array}$$

Steps involved in MOORA method for determining the rank of all the available alternatives are as follows [63], [64]:

Step 1 : Normalization of decision matrix ($x_{ij}$)

$$x_{ij} = \frac{b_{ij}}{\sqrt{\sum_{i=1}^{m} {b_{ij}}^2}} \qquad \dots (15)$$

where, $b_{ij}$ is the performance value of alternative $A_i$ for attribute $C_j$.

Step 2 : Weighted normalization of decision matrix ($W_{ij}$)

$$W_{ij} = w_j . x_{ij} \qquad \dots (16)$$

where, $w_j$ is the weight of the attribute $C_j$

Step 3: Determination of priorities ($Q_i$)

Priorities can be calculated as the difference of summation of all beneficial attributes and the summation of all non-beneficial attributes.

$$Q_i = \sum_{j=1}^{g} W_{ij} - \sum_{j=g+1}^{n} W_{ij} \qquad \dots (17)$$

where, g shows the quantities of attributes for maximization, then (n-g) shows the quantities of attributes for minimization.

Step 4 : Ranking of alternatives

All the alternatives are ranked in descending order of priorities $Q_i$ values.

## 7. PROPOSED HYBRID MCDM METHOD

Combination of two or more than two MCDM method are known as hybrid MCDM method. Fuzzy AHP method has been combined together with TOPSIS method as shown in equation 18. Similarly, Fuzzy AHP method has been combined together with MOORA method as shown in equation 19.

Car score = (Normalized weight of qualitative criteria * Qualitative score by Fuzzy AHP method) + (Normalized weight of quantitative criteria * Quantitative score by TOPSIS method) …. (18)

Car score = (Normalized weight of qualitative criteria * Qualitative score by Fuzzy AHP method) + (Normalized weight of quantitative criteria * Quantitative score by MOORA method) … (19)

## 8. CALCULATION BY FUZZY AHP METHOD

Methodology framework of hybrid MCDM method for selection of car has been illustrated in Figure 1. According to Figure 1, at first, normalized weightage of qualitative and quantitative criteria for selection of the best car has been determined as shown in Table 3. For determining normalized weight of both the criteria, Fuzzy pair-wise comparison matrix of qualitative and quantitative criteria has been shown in Table 2. Fuzzy Geometric mean, Fuzzy weight and defuzzified weight have been calculated by using equation 5, 6 and 7 respectively. Fuzzy weight has been calculated using the equation 6 with the help of equation 2, 3 and 4. After calculating normalized weight of qualitative criteria, six qualitative criteria have been compared using Fuzzy pair-wise comparison as shown in Table 4. The Fuzzy weight, defuzzified weight and normalization have been calculated in Table 5. After getting normalized value for each qualitative criteria, Fuzzy pair-wise comparison matrix of cars based on six different qualitative criteria i.e., Internal Appearance, external appearance, safety, on road reliability, add on features, after sales service have been shown in Table 6, 8, 10, 12, 14 & 16. The Fuzzy weight, defuzzified weight and normalization of each car on the basis of Internal Appearance, external appearance, safety, on road reliability, add on features, after sales service, separately, have been illustrated in Table 7, 9, 11, 13, 15 & 17. Finally, normalized weight of each car has been calculated for ranking of the car based on qualitative criteria by FAHP as illustrated in Table 18. The qualitative score of each car has been calculated by summation of product of normalized weight of each qualitative criteria and qualitative score of each car in corresponding criteria.

Table 2 Fuzzy Pair-Wise Comparison Matrix of Qualitative and Quantitative Criteria

| Criteria | Qualitative | Quantitative |
|---|---|---|
| Qualitative | 1, 1, 1 | 1/5, 1/4, 1/3 |
| Quantitative | 3, 4, 5 | 1, 1, 1 |

Table 3 Determination of Fuzzy Weight and Normalization of Qualitative and Quantitative Criteria

| Criteria | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalized weight |
|---|---|---|---|---|
| Qualitative | 0.447, 2.500, 0.557 | 0.159, 0.200, 0.265 | 0.208 | 0.204 |
| Quantitative | 1.732, 2.000, 2.236 | 0.616, 0.800, 1.026 | 0.814 | 0.796 |
| Total | | | 1.022 | |

Table 4 Fuzzy Pair-Wise Comparison of Six Qualitative Criteria

| Criteria | Internal Appearance | External Appearance | Safety | On Road Reliability | Add on Features | After Sales Service |
|---|---|---|---|---|---|---|
| Internal Appearance | 1, 1, 1 | 1/5, 1/3, 1 | 1/5, 1/3, 1 | 1, 3, 5 | 3, 4, 5 | 3, 5, 7 |
| External Appearance | 1, 3, 5 | 1, 1, 1 | 1/5, 1/3, 1 | 3, 4, 5 | 5, 7, 9 | 5, 7, 9 |
| Safety | 1, 3, 5 | 1, 3, 5 | 1, 1, 1 | 1, 3, 5 | 5,7,9 | 5, 6, 7 |
| On Road Reliability | 1/5, 1/3, 1 | 1/5, 1/4, 1/3 | 1/5, 1/3, 1 | 1, 1, 1 | 1/5, 1/3, 1 | 3, 5, 7 |
| Add on Features | 1/5, 1/4, 1/3 | 1/9, 1/7, 1/5 | 1/9, 1/7, 1/5 | 1, 3, 5 | 1, 1, 1 | 5, 7, 9 |
| After Sales Service | 1/7, 1/5, 1/3 | 1/9, 1/7, 1/5 | 1/7, 1/6, 1/5 | 1/7, 1/5, 1/3 | 1/9, 1/7, 1/5 | 1, 1, 1 |

Table 5 Determination of Fuzzy Weight and Normalization of Six Qualitative Criteria

| Criteria | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalized weight |
|---|---|---|---|---|
| Internal Appearance | 0.843, 1.372, 2.365 | 0.663, 0.157, 0.455 | 0.226 | 0.176 |
| External Appearance | 1.570, 2.410, 3.557 | 0.124, 0.275, 0.684 | 0.361 | 0.281 |
| Safety | 1.710, 3.229, 4.460 | 0.134, 0.369, 0.858 | 0.454 | 0.353 |
| On Road Reliability | 0.411, 0.599, 1.152 | 0.032, 0.068, 0.221 | 0.107 | 0.084 |
| Add on Features | 0.481, 0.689, 0.918 | 0.038, 0.105, 0.177 | 0.106 | 0.083 |
| After Sales Service | 0.182, 0.227, 0.258 | 0.014, 0.026, 0.050 | 0.029 | 0.023 |
| Total | 5.197, 8.755, 12.71 | | | 1.000 |

Table 6 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'Internal Appearance' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 1, 3, 5 | 1/5 , 1/3, 1 | 5, 7, 9 | 1/5, 1/3, 1 |
| Car 2 | 1/5, 1/3, 1 | 1, 1, 1 | 5, 7, 9 | 7, 9, 9 | 5, 7, 9 |
| Car 3 | 1, 3, 5 | 1/9, 1/7, 1/5 | 1, 1, 1 | 1/5, 1/3, 1 | 1, 3, 5 |
| Car 4 | 1/9, 1/7, 1/5 | 1/9, 1/9, 1/7 | 1, 3, 5 | 1, 1, 1 | 1/7, 1/5, 1/3 |
| Car 5 | 1, 3, 5 | 1/9, 1/7, 1/5 | 1/5, 1/3, 1 | 3, 5, 7 | 1, 1, 1 |

Table 7 Determination of Fuzzy Weight and Normalization of Car Based on 'Internal Appearance' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 0.725, 2.333, 2.141 | 0.078, 0.349, 0.599 | 0.342 | 0.258 |
| Car 2 | 2.036, 2.713, 3.737 | 0.219, 0.406,1.045 | 0.557 | 0.420 |
| Car 3 | 0.467, 0.844, 1.380 | 0.050, 0.126, 0.386 | 0.188 | 0.141 |
| Car 4 | 0.281, 0.394, 0.544 | 0.030, 0.059, 0.152 | 0.080 | 0.061 |
| Car 5 | 0.067, 0.394, 1.476 | 0.007, 0.059, 0.413 | 0.160 | 0.120 |
| Total | | | 1.327 | 1.000 |

Table 8 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'External Appearance' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 1,3,5 | 1/7, 1/5, 1/3 | 5, 7, 9 | 1/5, 1/3, 1 |
| Car 2 | 1/5, 1/3, 1 | 1, 1, 1 | 3, 5, 7 | 7, 9, 9 | 3, 5, 7 |
| Car 3 | 3, 5, 7 | 1/7, 1/5, 1/3 | 1, 1, 1 | 1/5, 1/3, 1 | 1/7, 1/5, 1/3 |
| Car 4 | 1/9, 1/7, 1/5 | 1/9, 1/9, 1/7 | 1, 3, 5 | 1, 1, 1 | 1/5, 1/3, 1 |
| Car 5 | 1, 3, 5 | 1/7, 1/5, 1/3 | 3, 5, 7 | 1, 3, 5 | 1, 1, 1 |

Table 9 Determination of Fuzzy Weight and Normalization of Car Based on 'External Appearance' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 0.678, 1.070, 1.719 | 0.077, 0.178, 0.441 | 0.232 | 0.188 |
| Car 2 | 1.660, 2.371, 3.380 | 0.189, 0.394, 0.867 | 0.483 | 0.392 |
| Car 3 | 0.414, 0.582, 0.951 | 0.047, 0.097, 0.244 | 0.129 | 0.105 |
| Car 4 | 0.301, 0.437, 0.491 | 0.034, 0.073, 0.126 | 0.078 | 0.063 |
| Car 5 | 0.844, 1.552, 2.255 | 0.096, 0.258, 0.579 | 0.311 | 0.252 |
| Total | | | 1.233 | 1.000 |

Table 10 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'Safety' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 3, 5, 7 | 1, 3, 5 | 7, 9, 9 | 5, 7, 9 |
| Car 2 | 1/7, 1/5, 1/3 | 1, 1, 1 | 3, 5, 7 | 5, 7, 9 | 1, 3, 5 |
| Car 3 | 1/5, 1/3, 1 | 1/7, 1/5, 1/3 | 1, 1, 1 | 1/7, 1/5, 1/3 | 1/5, 1/3, 1 |
| Car 4 | 1/9, 1/9, 1/7 | 1/9, 1/7, 1/5 | 3, 5, 7 | 1, 1, 1 | 1/5, 1/4, 1/3 |
| Car 5 | 1/9, 1/7, 1/5 | 1/5, 1/3, 1 | 1, 3, 5 | 3, 4, 5 | 1, 1, 1 |

Table 11 Determination of Fuzzy Weight and Normalization of Car Based on 'Safety' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 2.536, 3.936, 4.904 | 0.252, 0.528, 0.961 | 0.580 | 0.501 |
| Car 2 | 1.165, 1.838, 2.536 | 0.116, 0.246, 0.497 | 0.286 | 0.247 |
| Car 3 | 0.241, 0.338, 0.644 | 0.024, 0.045, 0.126 | 0.065 | 0.056 |
| Car 4 | 0.580, 0.456, 0.582 | 0.058, 0.061, 0.114 | 0.078 | 0.067 |
| Car 5 | 0.582, 0.894, 1.380 | 0.058, 0.120, 0.270 | 0.149 | 0.129 |
| Total | | | 1.159 | 1.000 |

Table 12 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'On Road Reliability' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 1/5, 1/3, 1 | 3, 5, 7 | 1/7, 1/5, 1/3 | 4, 5, 6 |
| Car 2 | 1, 3, 5 | 1, 1, 1 | 1, 2, 3 | 1/5, 1/4, 1/3 | 1/5, 1/3, 1 |
| Car 3 | 1/7, 1/5, 1/3 | 1/3, 1/2, 1 | 1, 1, 1 | 1/9, 1/7, 1/5 | 1/9, 1/7, 1/5 |
| Car 4 | 3, 5, 7 | 3, 4, 5 | 5, 7, 9 | 1, 1, 1 | 1, 3,5 |
| Car 5 | 1/6, 1/5, 1/4 | 1, 3, 5 | 5, 7, 9 | 1/5, 1/3, 1 | 1, 1, 1 |

Table 13 Determination of Fuzzy Weight and Normalization of Car Based on 'On Road Reliability' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 0.807, 1.108, 1.695 | 0.085, 0.176, 0.385 | 0.215 | 0.178 |
| Car 2 | 0.525, 0.870, 1.380 | 0.055, 0.138, 0.314 | 0.169 | 0.140 |
| Car 3 | 0.226, 0.290, 0.422 | 0.024, 0.046, 0.096 | 0.055 | 0.046 |
| Car 4 | 2.141, 3.347, 4.360 | 0.226, 0.530, 0.991 | 0.582 | 0.483 |
| Car 5 | 0.699, 1.070, 1.623 | 0.074, 0.111, 0.369 | 0.184 | 0.153 |
| Total | | | 1.206 | 1.000 |

Table 14 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'Add On Features' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 1, 3, 5 | 1/9, 1/7, 1/5 | 1/7, 1/5, 1/3 | 1/5, 1/4, 1/3 |
| Car 2 | 1/5, 1/3, 1 | 1, 1, 1 | 1/7, 1/6, 1/5 | 1/5, 1/3, 1 | 1/9, 1/7, 1/5 |
| Car 3 | 5, 7, 9 | 5, 6, 7 | 1, 1, 1 | 1/3, 1/2, 1 | 3, 5, 7 |
| Car 4 | 3, 5, 7 | 1, 3, 5 | 1, 2, 3 | 1, 1, 1 | 1/5, 1/3, 1 |
| Car 5 | 3, 4, 5 | 5, 7, 9 | 1/7, 1/5, 1/3 | 1, 3, 5 | 1, 1, 1 |

Table 15 Determination of Fuzzy Weight and Normalization of Car Based on 'Add on Features' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 0.316, 0.464, 0.644 | 0.033, 0.191, 0.142 | 0.122 | 0.103 |
| Car 2 | 0.230, 0.305, 0.525 | 0.024, 0.040, 0.116 | 0.060 | 0.050 |
| Car 3 | 1.904, 2.560, 3.380 | 0.201, 0.334, 0.748 | 0.428 | 0.359 |
| Car 4 | 0.903, 1.585, 2.536 | 0.096, 0.207, 0.561 | 0.288 | 0.242 |
| Car 5 | 1.165, 1.758, 2.371 | 0.123, 0.229, 0.525 | 0.292 | 0.246 |
| Total | | | 1.190 | 1.000 |

Table 16 Fuzzy Pair-Wise Comparison Matrix of Car Based on 'After Sales Service' Criteria

| Car | Car 1 | Car 2 | Car 3 | Car 4 | Car 5 |
|---|---|---|---|---|---|
| Car 1 | 1, 1, 1 | 1/5, 1/3, 1 | 3, 4, 5 | 1/3, 1/2, 1 | 7, 9, 9 |
| Car 2 | 1, 3, 5 | 1, 1, 1 | 1, 3, 5 | 1/5, 1/3, 1 | 3, 5, 7 |
| Car 3 | 1/5, 1/4, 1/3 | 1/5, 1/3, 1 | 1, 1, 1 | 1/9, 1/7, 1/5 | 1/5, 1/3, 1 |
| Car 4 | 1, 2, 3 | 1, 3, 5 | 5, 7, 9 | 1, 1, 1 | 3, 5, 7 |
| Car 5 | 1/9, 1/9, 1/7 | 1/7, 1/5, 1/3 | 1, 3, 5 | 1/7, 1/5, 1/3 | 1, 1, 1 |

Table 17 Determination of Fuzzy Weight and Normalization of Car Based on 'After Sales Service' Criteria

| Car | Fuzzy Geometric Mean Value | Fuzzy Weight | Defuzzified Weight | Normalization /Score |
|---|---|---|---|---|
| Car 1 | 1.070, 1.431, 2.141 | 0.115, 0.246, 0.506 | 0.289 | 0.237 |
| Car 2 | 0.903, 0.719, 2.809 | 0.097, 0.124, 0.664 | 0.295 | 0.242 |
| Car 3 | 0.245, 0.331, 0.582 | 0.026, 0.057, 0.138 | 0.074 | 0.061 |
| Car 4 | 1.719, 2.914, 3.160 | 0.185, 0.501, 0.746 | 0.477 | 0.392 |
| Car 5 | 0.296, 0.422, 0.602 | 0.032, 0.072, 0.142 | 0.082 | 0.068 |
| Total | | | 1.217 | 1.000 |

Table 18 Weightage of Car Based on Qualitative Criteria by Fuzzy AHP

| Criteria | Internal Appearance | External Appearance | Safety | On Road Reliability | Add on Features | After Sales Service | Normalizatio n /Score |
|---|---|---|---|---|---|---|---|
| Weightage | 0.176 | 0.281 | 0.353 | 0.084 | 0.083 | 0.023 | |
| Car 1 | 0.258 | 0.188 | 0.501 | 0.178 | 0.103 | 0.237 | 0.304 |
| Car 2 | 0.420 | 0.392 | 0.247 | 0.140 | 0.050 | 0.242 | 0.293 |
| Car 3 | 0.141 | 0.105 | 0.056 | 0.046 | 0.359 | 0.061 | 0.109 |
| Car 4 | 0.061 | 0.063 | 0.067 | 0.483 | 0.242 | 0.392 | 0.122 |
| Car 5 | 0.120 | 0.252 | 0.129 | 0.153 | 0.246 | 0.068 | 0.172 |

## 9. CALCULATION BY TOPSIS METHOD

The comparison of six quantitative criteria of five shortlisted car are shown in Table 19. For calculation of normalization of the decision matrix, square root of sum of the square of all the quantitative data of each column were needed, so it has been determined and shown in Table 20. The weight of all the attributes have been taken equal i.e., 1/6. Using equation 8, the decision matrix has been normalized in Table 21. After finding the normalization of the decision matrix, decision matrix for weighted normalization has been determined using equation 9 as shown in Table 22. Positive and Negative Ideal Solution has also been calculated in the same table (Table 22) with the help of equation 10 and 11. Separation from positive and negative ideal solution has been determined in Table 23 using equation 12 and 13. With the help of separation from positive and negative ideal solution, relative closeness value (RCV) has been determined with the help of equation 14. Based on obtained RCV values, ranking has been done as shown in Table 23.

Table 19 Comparison of Six Quantitative Criteria of Five Shortlisted Car

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 8.86 | 19.05 | 108 | 140 | 1199 | 44 |
| Car 2 | 9.55 | 20 | 98.6 | 152 | 999 | 156 |
| Car 3 | 8.43 | 18.3 | 89 | 110 | 1199 | 44 |
| Car 4 | 8.02 | 21.21 | 113 | 113 | 1197 | 3 |
| Car 5 | 8.66 | 21 | 99 | 172 | 998 | 46 |

Table 20 Square of all the Quantitative Data Available in Table 19 with Square Root of Sum of the Square of all the Quantitative Data of Each Column

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 78.5 | 362.9 | 11664 | 19600 | 1437601 | 1936 |
| Car 2 | 91.2 | 400 | 9728 | 23104 | 998001 | 24336 |
| Car 3 | 71.06 | 334.9 | 7921 | 12100 | 1437601 | 1936 |
| Car 4 | 64.32 | 449.9 | 12769 | 12769 | 1432809 | 9 |
| Car 5 | 75 | 441 | 9801 | 29584 | 996004 | 2116 |
| | | | | | | |
| Sum | 380.1 | 1989 | 51883 | 97157 | 6302016 | 30333 |
| $\sqrt{Sum}$ | 19.496 | 44.594 | 227.78 | 311.7 | 2510.4 | 174.16 |

Table 21 Calculation of Normalization of the Decision Matrix

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 0.454459 | 0.427184 | 0.474146 | 0.44915 | 0.477617 | 0.252636 |
| Car 2 | 0.489851 | 0.448487 | 0.433009 | 0.487648 | 0.397947 | 0.895709 |
| Car 3 | 0.432403 | 0.410366 | 0.390731 | 0.352903 | 0.477617 | 0.252636 |
| Car 4 | 0.411372 | 0.475621 | 0.496097 | 0.362528 | 0.47682 | 0.017225 |
| Car 5 | 0.4442 | 0.470912 | 0.434633 | 0.551812 | 0.397549 | 0.264119 |

Table 22 Calculation of Weighted Normalized Decision Matrix, Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 0.075743 | 0.071197 | 0.079029 | 0.074858 | 0.079603 | 0.042106 |
| Car 2 | 0.081642 | 0.074748 | 0.07215 | 0.081275 | 0.066325 | 0.149285 |
| Car 3 | 0.072067 | 0.068394 | 0.065126 | 0.058817 | 0.079603 | 0.042106 |
| Car 4 | 0.068562 | 0.07927 | 0.082688 | 0.060421 | 0.07947 | 0.002871 |
| Car 5 | 0.074033 | 0.078485 | 0.072443 | 0.091969 | 0.066258 | 0.04402 |
| | | | | | | |
| PIS | 0.068562 | 0.07927 | 0.082688 | 0.091969 | 0.079603 | 0.002871 |
| NIS | 0.081642 | 0.068394 | 0.065126 | 0.058817 | 0.066258 | 0.149285 |

Table 23 Calculation of Relative Closeness Values (RCV) and Rankling of all the Alternatives

| Car | $s_j^+$ values | $s_j^-$ values | RCV | Normalization/ Score | Rank |
|---|---|---|---|---|---|
| Car 1 | 0.044298 | 0.110266 | 0.713402 | 0.233569 | 2 |
| Car 2 | 0.148426 | 0.024373 | 0.14105 | 0.04618 | 5 |
| Car 3 | 0.055474 | 0.10843 | 0.661544 | 0.216590 | 4 |
| Car 4 | 0.031548 | 0.149037 | 0.825302 | 0.270205 | 1 |
| Car 5 | 0.044798 | 0.111324 | 0.713059 | 0.233456 | 3 |

## 10. CALCULATION BY MOORA METHOD

The comparison of six quantitative criteria of five shortlisted car have been shown in Table 24. For calculation of normalization of the decision matrix, sum of the square of all the quantitative data and its square root were needed, so it has been shown in Table 25. With the help of equation 15, the decision matrix has been normalized in Table 26. After finding the normalization of the decision matrix, decision matrix for weighted normalization has been determined using weight of each attribute and has been taken equal i.e., 1/6 and equation 16 as shown in Table 27. After calculation of decision matrix for weighted normalization, priorities of all the alternatives have been determined with the help of equation 17 and ranking has been done for all the alternatives.

Table 24 Comparison of Six Quantitative Criteria of Five Shortlisted car of all Attributes

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 8.86 | 19.05 | 108 | 140 | 1199 | 44 |
| Car 2 | 9.55 | 20 | 98.6 | 152 | 999 | 156 |
| Car 3 | 8.43 | 18.3 | 89 | 110 | 1199 | 44 |
| Car 4 | 8.02 | 21.21 | 113 | 113 | 1197 | 3 |
| Car 5 | 8.66 | 21 | 99 | 172 | 998 | 46 |

Table 25 Square of all the Quantitative Data Available in Table 24

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 78.4996 | 362.9025 | 11664 | 19600 | 1437601 | 1936 |
| Car 2 | 91.2025 | 400 | 9727.877 | 23104 | 998001 | 24336 |
| Car 3 | 71.0649 | 334.89 | 7921 | 12100 | 1437601 | 1936 |
| Car 4 | 64.3204 | 449.8641 | 12769 | 12769 | 1432809 | 9 |
| Car 5 | 74.9956 | 441 | 9801 | 29584 | 996004 | 2116 |
| | | | | | | |
| Sum | 380.083 | 1988.6566 | 51882.88 | 97157 | 6302016 | 30333 |
| $\sqrt{Sum}$ | 19.495718 | 44.594356 | 227.7781 | 311.7002 | 2510.38164 | 174.1637 |

Table 26 Calculation of Normalization of the Decision Matrix

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 0.454458 | 0.427184 | 0.474146 | 0.44915 | 0.477617 | 0.252636 |
| Car 2 | 0.489851 | 0.448487 | 0.433009 | 0.487648 | 0.397947 | 0.895709 |
| Car 3 | 0.432403 | 0.410366 | 0.390731 | 0.352903 | 0.477617 | 0.252636 |
| Car 4 | 0.411372 | 0.475621 | 0.496097 | 0.362528 | 0.47682 | 0.017225 |
| Car 5 | 0.4442 | 0.470912 | 0.434633 | 0.551812 | 0.397549 | 0.264119 |

Table 27 Calculation of Weighted Normalized Decision Matrix

| Car | Ex - Showroom Price (in lakh) | Mileage (in km per litre) | Power (in bhp) | Torque (in Nm) | Displacement (in CC) | Distance of service centre (in kms) |
|---|---|---|---|---|---|---|
| Car 1 | 0.060641 | 0.066774 | 0.083221 | 0.079582 | 0.086717 | 0.044461 |
| Car 2 | 0.065364 | 0.070104 | 0.076001 | 0.086403 | 0.072252 | 0.157635 |
| Car 3 | 0.057698 | 0.064145 | 0.06858 | 0.062528 | 0.086717 | 0.044461 |
| Car 4 | 0.054892 | 0.074346 | 0.087074 | 0.064234 | 0.086572 | 0.003031 |
| Car 5 | 0.059272 | 0.07361 | 0.076286 | 0.097772 | 0.07218 | 0.046482 |

Table 28 Calculation of Priorities and Rank of all the Alternatives

| Car | Priorities ($Q_i$) | Normalization/ Score | Rank |
|---|---|---|---|
| Car 1 | 0.211191 | 0.224395 | 3 |
| Car 2 | 0.081761 | 0.086873 | 5 |
| Car 3 | 0.179811 | 0.191053 | 4 |
| Car 4 | 0.254302 | 0.270202 | 1 |
| Car 5 | 0.214092 | 0.227478 | 2 |

## 11. CALCULATION BY HYBRID (FAHP & TOPSIS) MCDM METHOD

Normalized weight of qualitative and quantitative attribute or criteria have been illustrated in Table 3. Qualitative and quantitative score of each car by Fuzzy AHP and TOPSIS method have been shown in Table 18 and 23 respectively. Using equation 18, Table 3, 18 and 23, the result or final score of hybrid (FAHP and TOPSIS) MCDM method has been shown in Table 29. Based on the final score determined from hybrid (FAHP and TOPSIS) MCDM method, ranking has been done in Table 29.

Table 29 Final Score and Rank by Combination of FAHP and TOPSIS Method for Selection of the Best Petrol Car

| Car | Normalized Weightage | | Final Score | Rank |
|---|---|---|---|---|
| | Qualitative (0.204) | Quantitative (0.796) | | |
| Car 1 | 0.304 | 0.233569 | 0.2479369 | 1 |
| Car 2 | 0.293 | 0.04618 | 0.0965313 | 5 |
| Car 3 | 0.109 | 0.216590 | 0.1946416 | 4 |
| Car 4 | 0.122 | 0.270205 | 0.2399712 | 2 |
| Car 5 | 0.172 | 0.233456 | 0.220919 | 3 |

## 12. CALCULATION BY HYBRID (FAHP & MOORA) MCDM METHOD

Normalized weight of qualitative and quantitative attribute or criteria have been illustrated in Table 3. Qualitative and quantitative score of each car by Fuzzy AHP and MOORA method have been shown in Table 18 and 28 respectively. Using equation 19, Table 3, 18 and 28, the result or final score of hybrid (FAHP and MOORA) MCDM method has been shown in Table 30. Based on the final score determined from hybrid (FAHP and MOORA) MCDM method, ranking has been done in Table 30.

Table 30 Final Score and Rank by Combination of FAHP and MOORA Method for Selection of the Best Petrol Car

| Car | Normalized Weightage | | Final Score | Rank |
|---|---|---|---|---|
| | Qualitative (0.204) | Quantitative (0.796) | | |
| Car 1 | 0.304 | 0.211191 | 0.2406344 | 1 |
| Car 2 | 0.293 | 0.081761 | 0.1289229 | 5 |
| Car 3 | 0.109 | 0.179811 | 0.1743142 | 4 |
| Car 4 | 0.122 | 0.254302 | 0.2399688 | 2 |
| Car 5 | 0.172 | 0.214092 | 0.2161605 | 3 |

## 13. RESULTS AND CONCLUSIONS

The selection of the best petrol car from the five shortlisted petrol car based on six qualitative and six quantitative criteria was really very tough MCDM. The normalized weight of qualitative and quantitative attributes have been shown in Table 3. The qualitative score of each car by Fuzzy AHP method has been shown in Table 18 while quantitative score of each car by TOPSIS and MOORA method have been shown in Table 23 and 30 respectively. Based on the quantitative attribute only, the ranking of car by TOPSIS and MOORA method have been shown in Table 31. The ranking determined by both the methods were approximately the same order.

Table 31 Ranking of Car by TOPSIS and MOORA Method Based on Six Quantitative Criteria Only

| Car | Ranking by TOPSIS method | Ranking by MOORA method |
|---|---|---|
| Car 1 | 2 | 3 |
| Car 2 | 5 | 5 |
| Car 3 | 4 | 4 |
| Car 4 | 1 | 1 |
| Car 5 | 3 | 2 |

Based on the hybrid MCDM method i.e., combination of FAHP & TOPSIS method and Combination of FAHP and MOORA method, the ranking of each car has been shown in Table 29 and 30 respectively. It can be concluded from Table 32 that there were no change in order of ranking of car based on hybrid MCDM method as shown in Table 32.

Table 32 Ranking of Car by Two Different Hybrid MCDM Method

| Car | Ranking by FAHP and TOPSIS | Ranking by FAHP and MOORA |
|---|---|---|
| Car 1 | 1 | 1 |
| Car 2 | 5 | 5 |
| Car 3 | 4 | 4 |
| Car 4 | 2 | 2 |
| Car 5 | 3 | 3 |

This research can be further extended by changing the weight of qualitative and quantitative criteria or change in preferences of one criteria over another. This research can also be extended by increasing and decreasing the qualitative and quantitative criteria. Any type of modification or changing will definitely change the rank of each car. Similar type of research can be applied in various science and management fields. Ranking of unlimited alternatives based on considered two different hybrid MCDM method can be done.

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