Application of TOPSIS Method for Decision Making in Selecting the Best New Car in Malaysia

S M Nor-Al-Din1*, N K Razali1, N M Sukri1 and M A Rosli1
1Faculty of Computer and Mathematical Sciences, University Teknologi MARA (UiTM), 21080 Kuala Terengganu, Terengganu, Malaysia

*Corresponding author: sitim907@uitm.edu.my

Abstract. Purchasing and selecting of vehicles especially cars in the market is a tough decision to make due to the variety of the operational and technical parameter specifications such as design, body shape, technology used, and many more. Therefore, selection procedure techniques are required in order to overcome this problem. In the decision-making model, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is one of the selection procedure techniques to be embraced into this study. This technique provides a base for decision-making processes where there are limited numbers of choices but each has a large number of attributes. In this project, the selected vehicles were ranked based on their segments. The best car for sedan is Proton Persona, Proton Iriz was ranked as the best hatchback, Perodua Alza is the best MPV and Perodua Aruz was ranked as the best SUV. This result was based on the main criteria which are cost and total displacement, then follow by seat capacity, boot capacity, and top speed of the vehicle.

1. Introduction

The selection of automobile is crucial for the purchaser due to the complexity created by fake publicity and advertisement from the dealers. Choosing the best one among the choices given becomes a critical decision-making problem. The biggest constraint faced by most purchasers are the possible budget on which car to buy. Other important criteria in selecting the best car includes: fuel economy, comfort, and convenience features, life span, suspension, style, cost, reliability, safety, technology, capacity, convenience, etc. The outcome of this decision-making process will be significant and beneficial for both customers and manufacturers. In this paper, some cars are considered with different attributes and select the best car using TOPSIS technique.

In this study, it will be focusing on the ranking selected car among 1.5 and 1.6 engine capacity (cc) in Malaysia’s market, which released from 2017 until latest 2019. This project will mainly focus on the following objectives:

- To identify the important criteria’s that can be a factor which influenced the consumer in buying a new car.
- To use the TOPSIS method in evaluating the best cars based on selected criteria’s.
- To provide the rank for each selected cars based on the car segment in Malaysia.
2. Literature review

The TOPSIS method is a multiple attribute decision-making method. This paper presents the principles and calculation steps of TOPSIS method in detail and applies it to the quantitative evaluation in selecting the best car based on the customer's priority. Through the analysis of practical application, we found that the TOPSIS method has relatively high rationality and applicability when it is used to evaluate the comprehensively competitive ability during the car selection [1]. TOPSIS method is called an ideal solution and also an effective multiple attribute decision-making method. This method is to construct the ideal solutions and minus idea solutions to the problems of multiple attributes and uses the two benchmarks of being close to the ideal solutions and being far away from the minus ideal solutions as the criteria for evaluating the feasible projects [2]. Based on experiments conducted on 60 datasets for employee placement with AHP, SAW, TOPSIS, and PROMENTHEE methods, obtained different accuracy levels of each method in terms of ranking employees. In terms of accuracy, TOPSIS method has the highest accuracy of 95% followed by PROMENTHEE of 93.34% and SAW 81.67%, and the last AHP of 50%. Regardless of the level of accuracy, TOPSIS is better to work on [3].

3. Methodology

- Step 1: Setting Criteria and Alternative

This research considers nine criteria that can influence the ranking of the car. Table 1 state about criteria which is considered to complete the ranking of the car by their segments. The alternatives involved vehicles from 14 brands such as Perodua, Proton, Honda, Kia, Toyota, Nissan and etc, and make 44 alternatives in total.

| Main Criteria                              | Main Code |
|--------------------------------------------|-----------|
| Cost                                       | C1        |
| Seat Capacity                              | C2        |
| Engine Power (horse power)                 | C3        |
| Fuel Capacity (liter)                      | C4        |
| Total Displacement (cc)                    | C5        |
| Weight                                     | C6        |
| Boot Capacity                              | C7        |
| Top Speed                                  | C8        |
| Maximum Engine Power (rpm)                 | C9        |

- Step 2: Establish the decision matrix

The first step of the TOPSIS method involves the construction of a Decision Matrix (DM).

\[
\text{DM} = \begin{bmatrix}
C_1 & C_2 & \cdots & C_n \\
L_1 & X_{11} & X_{12} & \cdots & X_{1n} \\
L_2 & X_{21} & X_{22} & \cdots & X_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
L_m & X_{m1} & X_{m2} & \cdots & X_{mn}
\end{bmatrix}
\]

where
- \( i = \) criterion index (\( i = 1 \ldots n \))
- \( n = \) number of potential sites
- \( j = \) alternative index (\( j = 1 \ldots m \)).
- \( C_1, C_2, \ldots, C_n = \) criteria
- \( L_1, L_2, \ldots, L_m = \) alternative locations
Step 3: Calculate a normalized decision matrix

The normalized values denote the Normalized Decision Matrix (NDM) which represents the relative performance of the generated design alternatives.

\[
NDM = R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}}
\]

Step 4: Determine the weighted decision matrix

Not all the criteria may be equal importance and hence weighting were introduced from pairwise comparison technique to quantify the relative importance of the different selection criteria. The weightage preferences are shown in Table 2 while the weightage preference for criteria selected was presented in Table 3.

### Table 2. Weightage preference

| Weight Preference | Weight |
|-------------------|--------|
| Not at all important | 1 |
| Slightly important | 2 |
| Important | 3 |
| Fairly Important | 4 |
| Very Important | 5 |

### Table 3. Weightage preference for criteria

| Criteria                  | Weight preference |
|---------------------------|-------------------|
| Cost                      | 5                 |
| Seat Capacity             | 4                 |
| Engine Power (hp)         | 3                 |
| Fuel Capacity (liter)     | 3                 |
| Total Displacement (cc)   | 5                 |
| Weight                    | 3                 |
| Boot Capacity             | 4                 |
| Top Speed (km/h)          | 4                 |
| Max Engine Power (rpm)    | 3                 |

Step 5: Identify positive and negative ideal solution

The positive ideal (A+) and the negative ideal (A-) solutions are defined according to the weighted decision matrix.

\[
PIS = A^+ = \left\{ V_1^+, V_2^+ , \ldots , V_n^+ \right\}, \text{ where: } V_j^+ = \left\{ \max_i \left( V_{ij} \right) \text{ if } j \in J ; \left\{ \min_i V_{ij} \text{ if } j \in J' \right\} \right\}
\]

\[
NIS = A^- = \left\{ V_1^- , V_2^- , \ldots , V_n^- \right\}, \text{ where: } V_j^- = \left\{ \max_i \left( V_{ij} \right) \text{ if } j \in J ; \left\{ \min_i V_{ij} \text{ if } j \in J' \right\} \right\}
\]
Step 6: Calculate the separation distance of each competitive alternative from the ideal and non-ideal solution.

\[
S^+ = \sqrt{\sum_{j=1}^{n} (V'^+_j - V'_j)^2} \quad i = 1, \ldots, m \\
S^- = \sqrt{\sum_{j=1}^{n} (V'^-_j - V'_j)^2} \quad i = 1, \ldots, m
\]

where  
\[ i = \text{criterion index} \]  
\[ j = \text{alternative index} \]

Step 7: Measure the relative closeness of each location to the ideal solution.

Step 8: Rank the preference order.

The flow chart in figure 1 represents the research steps that have been used in this project:

![Flow chart of research steps](image-url)
4. Results and discussion
Pair-wise comparison has been used to obtain the weightage for every criterion. Table 4 shown the weightage of the main criteria:

| Criteria                  | Weightage % |
|---------------------------|-------------|
| Cost                      | 17.3913043  |
| Seat Capacity             | 13.0434783  |
| Engine Power (hp)         | 6.52173913  |
| Fuel Capacity (litres)    | 6.52173913  |
| Total Displacement (cc)   | 17.3913043  |
| Weight (kg)               | 6.52173913  |
| Boot capacity (litres)    | 13.0434783  |
| Top Speed (km/h)          | 13.0434783  |
| Max Engine Power (rpm)    | 6.52173913  |

According on the table above, the most weight criteria are cost of the car and total displacement that are same weight and followed by three criteria with same level which is seat capacity, boot capacity, and top speed. Next, engine power, fuel capacity, weight of the car and max engine power in revolution per minutes got the last place among all the criteria where it is not really important to concern about when looking for car. The overall ranking was established by using TOPSIS model but the car ranking based on their segment will be more beneficial. Table 5 shows car ranking by their segment.

| Segment            | Rank | Car                    | Total final weightage |
|--------------------|------|------------------------|-----------------------|
| Sedan              | 1    | Persona                | 0.997416              |
|                    | 2    | Preve                  | 0.997276              |
|                    | 3    | Almera                 | 0.997081              |
|                    | 4    | Mazda 2                | 0.997023              |
|                    | 5    | City                   | 0.996976              |
|                    | 6    | Vios                   | 0.996837              |
|                    | 7    | Vento Comfortline      | 0.996495              |
|                    | 8    | Cerato                 | 0.995281              |
|                    | 9    | Civic                  | 0.994944              |
|                    | 10   | Focus Sedan            | 0.992666              |
|                    | 11   | 408 e-THP              | 0.991799              |
|                    | 12   | Mazda 3                | 0.991785              |
|                    | 13   | Veloster Turbo / Turbo Sport | 0.989966          |
|                    | 14   | BMW 3 Series           | 0.983223              |
|                    | 15   | C-Class 200 Avantgarde  | 0.970992              |
| Hatchback          | 1    | Iriz                   | 0.997379              |
|                    | 2    | Myvi                   | 0.99737               |
|                    | 3    | Jazz                   | 0.997067              |
|                    | 4    | Yaris                  | 0.99705               |
|                    | 5    | Polo MPI Comfortline Vienna | 0.996895     |
|                    | 6    | Fiesta                 | 0.996546              |
|                    | 7    | Ioniq HEV / HEV Plus   | 0.995917              |
|                    | 8    | 208 Gti                | 0.992675              |
| MPV                | 1    | Alza                   | 0.997305              |
|                    | 2    | Exora                  | 0.997262              |
|                    | 3    | Avanza                 | 0.996550              |
|                    | 4    | 5008                   | 0.989196              |
SUV 1 Aruz 0.996964
2 BR-V 0.99667
3 Rush 0.996016
4 HR-V 0.994888
5 Tucson T-GDI 0.992055
6 CR-V 0.990469
7 3008 THP Plus 0.990435
8 5008 THP Plus 0.988275
9 GLA 200 Style 0.978605
10 GLA 200 Night Edition 0.974304
11 Countryman ALL4 0.973002
Coupe 1 CLA 200 Night Edition 0.974732
2 C-Class Coupe AMG Line 0.947835
3 i8 Coupe eDrive 0.128265
Wagon 1 508 SW THP 0.987217
Sports 1 i8 Roadster eDrive 0.0001745

5. Conclusion
Choosing the best and right option becomes a critical decision-making problem. To overcome this problem, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method has been used. TOPSIS method was used in evaluating the best cars based on numerous criteria’s. This study also significant in providing the rank for each selected cars based on segment in Malaysia which is hatchback, sedan, SUV, MPV, coupe and sports. This outcome can be beneficial to the consumer who are intend to choose the best car based on the criteria selected. According to the survey, the criteria that be the best option to be consider are the cost matter, follow by total displacement (cc), and follow with seat and boot capacity and also top speed. Thus, TOPSIS has been successfully applied in to accomplish the objective of this study. Other than this method, Fuzzy TOPSIS, AHP, MAUT also can be used to find the best car in the market. The results shown that there might be a slight different if it used the other multi-criteria decision-making method. In the further studies, other models of multi-criteria decision-making method can be used for this problem and the results of this study and further studies can be compared. In conclusion, there are many methods that can be used for various type of problems.

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