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Study on a Multi-Criteria Decision Making Selection Problem using Preference Selection Index (PSI) Method

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Abstract

Multi-Criteria Decision Making (MCDM) is greatly used to make decisions, where the decision making process associated with multi directive aspects. The Decision Makers or the stakeholders are those who has to take statistical measure or strong analytical observations to make decisions. In this study the selection of best alternative among four scooter model is being done. To solve this several criterions are being selected based on the market survey that was conducted in account of gathering customer's reviews. The decision making is being done by using the Preference Selection Index (PSI) method of MCDM tool. Depending upon the weightage, the Preference Selection Index (I_j) is being calculated and Scooter D was ranked 1 in this selection process on the basis of the highest value of I_j.

Keywords: *MCDM, PSI, Selection, Scooter*

1. Introduction

Multi-attributes decision making (MCDM) is one of the most useful techniques where the selection is to be made by taking care of several issues and aspects. The process of completing research and ranking answers to as many competing requirements as possible is known as a multi-criteria decision process. It is often used in many different industries, including finance, logistics, and environmental management [1]. When the process starts, the analyst and DMs usually concentrate on describing the challenges, their goals, and how the final decision should be made. Typically, the analyst and DMs begin the process by concentrating on defining the issues, their objectives, and the rationale behind the ultimate choice [2]. The process associated with some alternatives, among which the best or most suitable one is to be selected. These measures are taken care by the criterions which are used to measure alternatives. They can be either quantitatively (for example, cost, time) or qualitatively (for example, customer satisfaction). In some instances, an improvement in one criterion can degrade another. MCDM provides ways of managing such trade-offs. The decision

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manager is one who by any statistical approaches and observations gives the measures of criterions by providing weightages. Criteria can be given varying weights depending on stakeholder or Decision maker's preferences [3].

There are several MCDM tools that are used to make decisions. The Preference Selection Index (PSI) method is proposed by Kalpesh Maniya and M.B. Bhat [4] in the year of 2010. The Preference Selection Index method, or PSI, is a multi-criteria decision-making support tool for alternative selection based on criteria. The method turns out to be pretty useful for ranking multiple criteria-based options on a scale of weights. This process is different from other MCDM method in the way that in this method we ranked the alternatives without deciding the relative importance between the attributes. Important Features of the PSI Method includes the Performance Score of each alternative measured against the criteria. These scores give the degree to which each of the alternatives will satisfy the criteria. Then the weighting of each criterion based on which the decision is to be made is being done by the decision makers. The weights of the attributes are also calculated based on objective methodology. Benefit of this type of methodology is the computational complexity is very low [5]. So the chance of progress the errors are very low. This method is useful when there is conflict presents in deciding the relative importance between the attributes. Therefore, factors that are deemed more important should carry much weight in the decision-making process. A study by Attri R and Grover S evaluates the how the PSI method will rank options through the integration of stakeholders' preferences and assist in more-informed selection and be mindful of resource constraints as well as environmental impacts for enhancing decision-making within the production system lifecycle [6]. Study by Arifin et. al effectively addresses the application of the Preference Selection Index (PSI) method in creating a decision support system for the student scholarship selection [7]. Multiple criteria are introduced in scholar scholarship, which also captures the preferences of different stakeholders involved, thereby increasing the transparency and fairness of the allocation process. Windarto et. al also used the Preference Selection Index method to determine the best coffee shop under various criteria of quality, services, and ambiance [8]. This way, it shows how PSI can be used to streamline a decision-making process by efficiently capturing customer preferences.

2. Methodology

The four best-selling scooter of 125cc available on Indian market is being choose as the alternative for the problem. From those four, the best possible alternative is to be manifested using the PSI method. The Criterions that are chosen to formulate the problem is also selected based on a market survey, that is being done to gather information about the customer's end. The criterions selected are, Torque (N-m), Power output (p.s), Fuel Economy (kmpl), Weight of the scooter (kg), Service provided and parts availability (rating provided by the customers between 1 to 5 in survey) and Price of the Scooter (INR). In the stated criterions, except the weight of the scooter and the price is the "Non-beneficial criterions" where the lower value is desired and for others the higher values are desired and are stated as "beneficial criterions". The details of Criteria and Alternatives are given in Table 1.

Table 1. Criteria and Alternatives

Criteria type →	Beneficial Criteria				Non-Beneficial Criteria	
Criteria / Alternatives	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scoote (INR)**
Scooter A	10	8.7	53.2727	4.36	104	87262
Scooter B	10.3	8.2	47.6154	4.77	111	84056
Scooter C	10.3	8.2	45.4444	4.44	99	82330
Scooter D	10.4	9.0	45.0901	4.64	113	78400
Max/Min	10.4	9	53.2727	4.77	99	78400

After the criterions and the corresponding values are formulated, the following steps are used to get the results associated with the PSI method:

Step 1: Establishing the Pair-wise comparison matrix

$$A = \begin{matrix} C_1 & C_2 & C_3 & \dots & \dots\ C_n \end{matrix} \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1j} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2j} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3j} \\ \vdots & \vdots & \vdots & : & \vdots \\ x_{i1} & x_{i2} & x_{i3} & \dots & x_{ij} \end{bmatrix} \quad (1)$$

Step-2: Data processing part or Normalization of the pair-wise comparison matrix has to be done to obtain the project outcome R_{ij} for all the attributes.

For Beneficial attributes:

$$R_{ij} = \frac{x_{ij}}{x_{ij}^{max}} \quad (2)$$

For Non-Beneficial attributes:

$$R_{ij} = \frac{x_{ij}^{min}}{x_{ij}} \quad (3)$$

Step 3: Calculation of Preference variation value (PV_j):

$$PV_j = \sum_{i=1}^{N} |R_{ij} - \overline{R_j}|^2 \quad (4)$$

Where, $\overline{R_j}$ is the mean of normalized value of attribute j and $\overline{R_j} = \frac{1}{N}\sum_{I=1}^{N} R_{ij}$

Step 4: Determine the overall preference

$$\psi_j = \frac{\phi_j}{\sum_{j=1}^{M} \phi_j} \tag{5}$$

Where,

$$\phi_j = 1 - PV_j \tag{6}$$

Step 5: Calculating the Preference Selection Index (I_j):

$$I_j = \sum_{j=1}^{M} (R_{ij} \times \psi_j) \tag{7}$$

Step 6: Ranking of the Alternatives has been done by the value of I_j.

3. Results and discussion

The normalization of the pair-wise comparison matrix is being done for beneficial and non-beneficial criterions by using Equation 2 and 3 and the normalized decision matrix is given in Table 2.

Table 2. Normalized decision matrix

Criteria type →	Beneficial Criteria				Non-Beneficial Criteria	
Criteria / Alternatives	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter (INR)**
Scooter A	0.961538	0.966667	1	0.914046	0.951923	0.898444
Scooter B	0.990385	0.911111	0.893804894	1	0.891892	0.932712
Scooter C	0.990385	0.911111	0.853052314	0.930818	1	0.952265
Scooter D	1	1	0.846401628	0.972746	0.876106	1
Mean	0.985577	0.947222	0.898314709	0.954403	0.92998	0.945855

After the normalization, the Calculation of Preference variation value (PV_j) is being done by Equation 4 and the Weights (ψ_j) for each criterion is being calculated by using Equation 5. The results are being shown in Table 3.

Table 3. Calculation of Preference variation value (PV_j)

Criteria type →	Beneficial Criteria				Non-Beneficial Criteria	
Criteria / Alternatives	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of th scooter (INR)**
Scooter A	0.000578	0.000378	0.010339898	0.001629	0.000481	0.002248
Scooter B	2.31E-05	0.001304	2.03384E-05	0.002079	0.001451	0.000173
Scooter C	2.31E-05	0.001304	0.002048684	0.000556	0.004903	4.11E-05
Scooter D	0.000208	0.002785	0.002694968	0.000336	0.002902	0.002932
Sum of $\boldsymbol{PV_j}$	0.000832	0.005772	0.015103889	0.004601	0.009737	0.005393
$\boldsymbol{\phi_j}$	**0.999168**	**0.994228**	**0.984896111**	**0.995399**	**0.990263**	**0.994607**
Weights ($\boldsymbol{\psi_j}$)	**0.167686**	**0.166857**	**0.165290929**	**0.167054**	**0.166192**	**0.166921**

After calculating the weights, the Preference Selection Index (PSI) is being calculated in Table 4 for each alternative by using Equation 7.

Table 4. Calculation of Preference Selection Index (I_j)

Criteria / Alternative	**Torque (N-m)**	**Power output (p.s)**	**Fuel Economy (kmpl)**	**Service provided by the company and parts availability**	**Weight of the scooter (kg)**	**Price of the scooter (INR)**	
Scooter A	0.161237	0.161295	0.165291	0.152695	0.158202	0.149969	**0.948688**
Scooter B	0.166074	0.152025	0.147738	0.167054	0.148225	0.155689	**0.936804**
Scooter C	0.166074	0.152025	0.141002	0.155496	0.166192	0.158953	**0.939742**
Scooter D	0.167686	0.166857	0.139903	0.162501	0.145601	0.166921	**0.949469**

Then finally the ranking of alternatives is being done on the basis of the Preference Selection Index (PSI). For ranking of alternatives, the highest value is ranked as 1. The subsequent ranking of alternatives is shown in Table 5.

Table 5. Ranking of the alternatives on the basis of Preference Selection Index (I_j)

Alternatives	**Preference Selection Index($\boldsymbol{I_j}$)**	**Rank**
Scooter A	0.948688	**2**
Scooter B	0.936804	**4**
Scooter C	0.939742	**3**
Scooter D	0.949469	**1**

Similar thing is being shown in Figure 1 also where the ranking of alternatives is being shown.

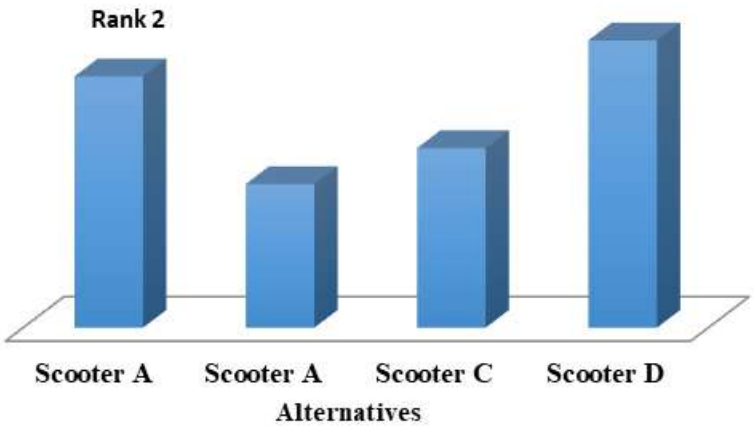

Fig. 1 Alternatives Vs. final score for ranking of each scooter based on Preference Selection Index (PSI) method of decision making

4. Conclusions

In this mathematical modeling we obtained a result that the Scooter D is the best among the 4 leading scooter available in the Indian market of same segment as it holds rank 1 in the PSI modeling technique of MCDM. The survey that was previously conducted can vary if it is being extended for further collection of data regarding current market statistics. This can establish variation in the result that has been obtained. Subjective estimation would be more realistic with a higher degree of certainty if there were much more data from surveys that accounted for different strata in society. The problem can also be solved through a range of alternative MCDM techniques to validate the result obtained by PSI method of MCDM technique.

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