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Decision Making Process for Customers through Analytic Hierarchy Process

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Abstract

This paper presents two different Multi Criteria Decision Making approaches; Analytic Hierarchy Process, Interactive Evaluation and Bound procedure, to enable the individual customers to identify the most desired decision alternative in a multi criteria environment. The output of Analytic Hierarchy Process is a prioritised ranking of the decision alternatives based on the overall preferences expressed by the customer. The latter approach calculates the bounds and performs tests to exclude some of the alternatives. This procedure repeats and terminates when a preferred alternative is identified. Both the approaches have been explained in detail for selecting a best choice of the models of the product 'bicycle'.

1. INTRODUCTION

Our values, beliefs and perceptions are the forces behind almost any decision-making activity. They are responsible for the perceived discrepancy between the present and the desirable state. Values are expressed in a goal by an individual or by a group of people, which is often the first step in a formal decision process. The actual decision boils down to selecting 'a best choice' from a number of available alternatives. In the Multi Criteria Decision Making (MCDM) context, evaluating each choice on the set of criteria facilitates the selection. The criteria must be measurable, even if the measurement is performed only at the nominal scale and their outcomes must be measured for every decision alternative. Criterion outcomes provide the basis for comparison of alternatives and consequently facilitate the selection of one, satisfactory alternative. In this context, two MCDM approaches have been explained in detail for selecting a best choice of the models of the product 'bicycle' to validate the result of each approach by the other.

2. ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) developed by Thomas [1] is designed to solve complex multi criteria decision problems. AHP requires the decision maker to provide judgments about the relative importance of each criterion and then specify a preference for each decision alternative against each criterion. The output of AHP is a prioritised ranking of the decision alternatives based on the overall preferences expressed by the decision maker. To demonstrate the procedure of AHP, a bicycle purchasing decision problem is considered in this article. The three models of the brand 'Hercules' of adult category of a leading bicycle manufacturer 'TI Cycles' in Chennai city have been considered for the study. First author's personal judgment (as customer) about the relative importance of each criterion and his preference for each model against each criterion has been considered to demonstrate the approaches. A seven-point likert scale of measurement has been commonly used to measure the qualitative parameters throughout the study, assuming that the customer satisfaction generally varies linearly with the quality level. Focus groups have been used to identify the key quality characteristics [2] of the product 'bicycle' and hence the important criteria that are relevant for the purchase decision process. The data used in this study reflects the first author's personal judgement, not the entire bicycle customers' view and hence it may not reflect the real market purchase decision process of the bicycle. An advantage of AHP [3] is that it can handle situations in which the unique subjective judgments of the individual decision maker constitute an important part of the decision making process.

2.1. Hierarchy for the 'Bicycle Selection' Problem

The first step in AHP is to develop a graphical representation of the problem in terms of the overall goal, the criteria to be used, and the decision alternatives. Such a graph depicts the hierarchy for the problem. Figure-1 shows the hierarchy for the bicycle selection problem chosen for this study.

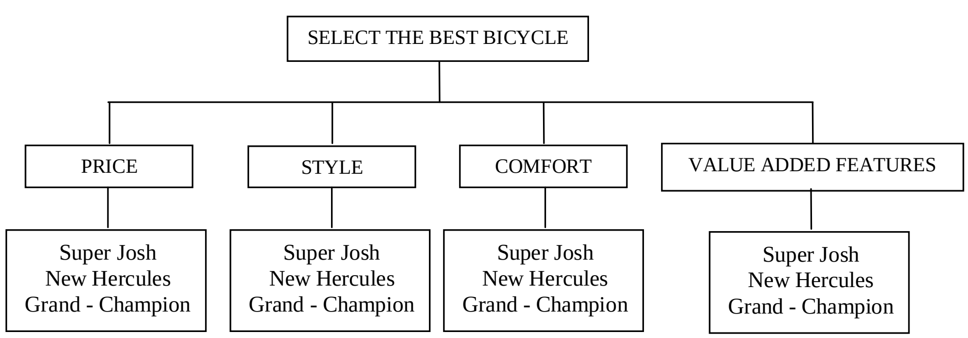

Fig. 1: Hierarchy for the Bicycle Selection Problem

The four important criteria (as judged by focus groups); Price, Style, Comfort, and Value Added Features (VAF) contribute to the achievement of the overall goal of selecting the best bicycle. Each decision alternative; Super Josh, New Hercules, Grand Champion contributes to each criterion in a unique way. Only the male-adult categories (alternatives) of the bicycle of the leading bicycle manufacturer in Chennai city have been considered for the study as the decision maker in this context falls in the same category.

2.1. Establishing Priorities for Criteria using AHP

In establishing the priorities for the four criteria, AHP requires the decision maker to select the more important criterion and to state a judgment of how much more important the selected criterion is, relative to each other criterion when all the criteria are compared, two at a time (pairwise). A seven point likert scale (shown below) has been used to represent the importance of criteria.

Verbal Judgment	Numerical Rating
Extremely more important	7
Strongly more important	5
Moderately more important	3
Equally important	1

Intermediate judgments such as ‘equally to moderately’ are possible and would receive a numerical rating of 2. The flexibility of AHP can accommodate the unique preferences of each individual decision maker. The choice of the criteria that are considered can vary depending upon the decision maker. Not everyone would agree that Price, Style, Comfort, VAF are the only criteria to be considered in a bicycle selection problem. Perhaps any one can add safety, resale value, percentage of interest for installment scheme and other criteria when they take their own decision. Table-1 provides a summary of six pairwise comparison that the first author provided for the given bicycle selection problem.

Table 1
Pairwise comparison of Criteria

pairwise comparison	*more important criterion*	*how much more important*	*numerical rating*
Price–Style	Price	Equally to moderately	2
Price–Comfort	Price	Equally to moderately	2
Price–VAF	Price	Strongly	5
Style–Comfort	Style	Equally to moderately	2
Style–VAF	Style	Moderately to strongly	4
Comfort–VAF	Comfort	Moderately	3

Putting the data given in Table-1 in matrix form, we get

	Price	*Style*	*Comfort*	*VAF*
Price	1	2	2	5
Style	½	1	2	4
Comfort	½	½	1	3
VAF	$^{1}/_{5}$	¼	1/3	1
Total	2.2	3.75	5.33	13

Dividing each element of the matrix by its column's total and then getting the average of the elements in each row, we get priority for each criterion as given below.

	Price	*Style*	*Comfort*	*VAF*	*Priority*
Price	0.455	0.533	0.375	0.384	0.437
Style	0.227	0.267	0.375	0.308	0.294
Comfort	0.227	0.133	0.188	0.231	0.195
VAF	0.091	0.067	0.062	0.077	0.074

AHP synthesisation procedure provides the priority of each criterion in terms of its contribution to the overall goal of selecting the best bicycle. Thus, in this context, AHP determines that 'Price' with a priority of 0.437 is the most important criterion in the bicycle selection process based on the judgments of the first author. 'Style' with a priority of 0.294 stands second in importance and is followed by 'Comfort' with a priority of 0.195. 'VAF' is the least important criterion with a priority of 0.074

2.3 Establishing Priorities for Alternatives using AHP

Continuing with the AHP analysis of the bicycle selection problem, the pairwise comparison is to be made to rank the alternatives. The pairwise comparison is done for all the alternatives against each criterion one at a time. Following is the comparison scale used to state the preference of alternatives.

Verbal Judgment	Numerical rating
Extremely preferred	7
Strongly preferred	5
Moderately preferred	3
Equally preferred	1

The pairwise comparison matrix showing the preferences for the bicycles against each criterion is given below:

Criterion →	PRICE			STYLE			COMFORT			VAF		
Alternative	*Super Josh*	*New Hercules*	*Grand Champion*	*Super Josh*	*New Hercules*	*Grand Champion*	*Super Josh*	*New Hercules*	*Grand Champion*	*Super Josh*	*New Hercules*	*Grand Champion*
Super Josh	1	2	½	1	1/3	3	1	1/3	1	1	¼	3
New Hercules	½	1	¼	3	1	4	3	1	3	4	1	6
Grand champion	2	4	1	1/3	¼	1	1	1/3	1	1/3	1/6	1
Total	3.5	7	1.75	4.33	1.58	8	5	1.66	5	5.33	1.42	10

Following the same procedure, which was adopted for prioritising the criteria, the priorities for each alternative against each criterion can be calculated as given below:

Alternatives	Price	Style	Comfort	VAF	Priority
Super Josh	0.283	0.272	0.2	0.221	0.260
New Hercules	0.143	0.608	0.6	0.685	0.409
Grand Champion	0.571	0.120	0.2	0.093	0.331

For example, Overall priority of Super Josh

= 0.437 (0.286) + 0.294 (0.272) + 0.195 (0.2) + 0.074 (0.221)

= 0.260

Ranking these priorities, we get the AHP ranking for the decision alternatives as:

Ranking	*Bicycle*	*Priority*
1.	New Hercules	0.409
2.	Grand Champion	0.331
3.	Super Josh	0.260

3. INTERACTIVE EVALUATION AND BOUND PROCEDURE

The other MCDM approach, Interactive evaluation and bound procedure [4] to select the best alternative is interactive in the sense that it progresses by seeking certain information from the decision maker. The contribution of the procedure is in reducing the information burden on the decision maker and thus providing practical assistance to him. The reduction in information burden is measured in terms of the simplicity of judgments and the number of judgments that are required from the decision maker in identifying a preferred alternative. In this procedure, the lower and upper bounds on the utilities of alternatives are established. Raiffa [5] and Lawrence [6] have described similar approaches to define these lower and upper bounds using additive utility function. Accordingly, the additive utility function of each alternative can be expressed as $U(x)=\sum_{i=1}^{n}U_i(x_i)$ for all x $\in$ X

An alternative representation of the additive utility function is

$$U(x)=\sum_{i=1}^{n} w_i \; f_i(x_i) \text{ for all } x \in X$$

$$U(x_*)=0, \qquad U(x^*)=1,$$
$$f_i(x_{i*})=0, \qquad f_i(x_i^{\,*})=1,$$
$$\& \quad \sum_{i=1}^{n} w_i = 1, \qquad w_i \geq 0,$$

where U(x) is the utility function over 'x' alternative
X is the population space of alternatives
n is the total number of criteria
$f_i(x_i)$ is the conditional utility function for criterion 'i' scaled
w_i is the scaling factor (weightage) for criterion 'i'

If $\underline{B}^k$ is the lower bound on the utility of k^{th} alternative
$\overline{B}^k$ is the upper bound on the utility of k^{th} alternative
$\underline{f}_i(x_i^k)$ is the lower bound on the utility of k^{th} alternative's score on the i^{th} criterion
$\overline{f}_i(x_i^k)$ is the upper bound on the utility of k^{th} alternative's score on the i^{th} criterion

then, $$\underline{B}^k = \sum_{i=1}^{n} w_i \, \underline{f}_i(x_i^{\,k}) \;\&$$

$$\overline{B}^k = \sum_{i=1}^{n} w_i \, \overline{f}_i(x_i^{\,k})$$

The lower and upper bounds for the conditional utility function for each alternative against each criterion can be expressed as

$$\underline{f}_i(x_i^k) = 1 \quad if\ x_i^k = x_i^*$$
$$= 0 \quad otherwise$$
$$\overline{f}_i(x_i^k) = 0 \quad if\ x_i^k = x_{i*}$$
$$= 1 \quad otherwise$$

3.1. Establishing Priorities for Alternatives

To apply the procedure, it requires the decision maker to provide the weightage to each criterion and the preference of each alternative against each criterion on a nominal scale [7]. Following matrix is the collection of data of first author's own judgments (the same qualitative measure used in AHP) on a seven-point scale towards the importance of each criterion and the preference of alternative against each criterion.

	Price	*Style*	*Comfort*	*VAF*
Importance (weightage)	7	5	4	3
Weightage (in fraction)	0.37	0.26	0.21	0.16
Super Josh	5	5	6	5
New Hercules	5	7	7	7
Grand Champion	7	4	6	3

Using the procedure described in last chapter, the lower and upper bound values of utility function of each alternative against each criterion can be determined as given in table 2. For example, for alternative-Super Josh, against criterion–Price, the lower bound value of utility function is 0. Because, the utility value of Super Josh is not equal to the upper utility value of all alternatives against the criterion–Price. Similarly, the upper bound value of utility function of Super Josh also is 0. Because, the utility value of Super Josh is equal to lower utility value of all alternatives against the criterion–Price.

Table 2
Lower & Upper Bounds of Utility Function of Alternatives

	Alternatives		*Super Josh*		*New Hercules*		*Grand Champion*	
i	Criterion	w_i	$\underline{f}_i$	$\overline{f}_i$	$\underline{f}_i$	$\overline{f}_i$	$\underline{f}_i$	$\overline{f}_i$
1	*Price*	0.37	0	0	0	1	1	1
2	*Style*	0.26	0	1	1	1	0	0
3	*Comfort*	0.21	0	0	1	1	0	0
4	*VAF*	0.16	0	1	1	1	0	0
	Bounds		$\underline{B}^1 = 0$	$\overline{B}^1 = 0.36$	$\underline{B}^2 = 0.57$	$\overline{B}^2 = 1$	$\underline{B}^3 = 0.37$	$\overline{B}^3 = 0.37$

Since $\overline{B}^2$ (lower bound of alternative-2) is greater than $\overline{B}^1$ (upper bound of alternative-1), alternative-1 i.e., Super Josh is dropped out. Similarly, alternative-3 also is dropped out as $\underline{B}^2$ is greater than $\overline{B}^3$. Hence, alternative-2 i.e., New Hercules is most preferred. Since $\underline{B}^3$ is greater than $\overline{B}^1$, the second preference goes to alternative-3 i.e., Grand Champion. The alternative-1 i.e., Super Josh is favoured last.

4. CONCLUSIONS

While it is felt that both the approaches discussed here would work well for any purchase decision process, only four criteria have been considered in this context to select the best alternative. The number of criteria and its nature may vary from person to person. However, the same format can be extended to incorporate the additional criteria and more alternatives if any. For a large number of criteria and alternatives, a mathematical programming with the background of any of the MCDM approaches should be developed for easy comparison and evaluation. The procedures should also include consistency checks to detect and query the decision maker about his inconsistent judgments.

5. REFERENCES

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