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Application of AHP for Finding out The Best Car Service Center in Bhopal: A Case Study

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Abstract— **The objective of this research paper is to finding out the best car service center in Bhopal, the selection of city is based on random choice, as it is the capital of Madhya Pradesh and one of the growing city in the state, in terms of emerging market for automobile segments. Basically the study is based on multi criteria decision making with the help of Analytic Hierarchy Process (AHP). The criteria and sub criteria for the study were selected with the help of research papers and questionnaires from survey. The study help in finding out the best car service center in the city as well as help in the finding the most suitable vehicle supplier who provide the best service to the customer after sales.**

Index Terms— **Analytic Hierarchy Process (AHP), Multi Criteria Decision Making (MCDM), Pairwise Comparisons.**

I. INTRODUCTION

The case study is focused on selecting the best automobile car service centre in the city of Bhopal, for conducting the research work different factors are considered and analysis was carried out with the help of a survey, and the best alternatives present in city are selected. A pilot survey was done with the existing customers and service providers to decide the factors to be considering for the research work, apart from that some factors from literatures are considered. This was followed by a final survey to get the rating for different authentic car service centers. The data collected from different service centers and reviews of customers of different ages were used.

The Analytic Hierarchy Process and Decision Making Matrix were used to concentrate these data into final result. All the calculations of pairwise comparison matrix were done using the Ms-Excel tool. The result obtained decided the best car service center in Bhopal

II. LITERATURE REVIEWS

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria, and alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency. [1]

Analytic Hierarchy Process (AHP) is an MCDM approach, proposed by Saaty, for handling multi objective problems. This approach selects best alternatives based on criterion. AHP is well structured mathematical approach uses consistent matrices and their associated eigenvectors to produce relative weights. AHP combines historical data and expert opinion by quantifying subjective judgment. It structures the given problem as a hierarchy, with required goal as parent node and criteria for assessing it are placed in levels below it. Weights are assigned to each node and many pairwise comparisons and matrix multiplications are made assessing the relative importance of these criteria. The end result of this method is to provide a formal, systematic means of extracting, combining, and capturing expert judgments and their relationship to analogous reference data [2].

III. METHODOLOGY ADOPTED

In the beginning of the research works aims is to find out the factors which are to be consider for the evaluation purpose. The nature of this research required a methodology that could be flexible to allow open questionnaires with the help of survey, so that data will be collected the required information. The data used in this research are mainly collected through different sources of evidence such as: semi-structured, face-to-face interaction, questionnaires, service centers standards, web sites, and onsite visits. In this research, the analysis of the data is divided in two stages, the first stage with AHP for the calculating the weightage of the defined criteria or factors and the second stage where the calculated weightage is used in the developed evaluation matrix for the purpose of rating of the service centers on the basic of the performance of service providing.

AHP is a method for ranking decision alternatives and selecting the best one when the decision maker has multiple criteria with AHP, the decision maker selects the alternative that best meets his or her decision criteria developing a numerical score to rank each decision alternative based on how well each alternative meets them. In AHP, preferences between alternatives are determined by making pairwise comparisons. In a pairwise comparison, the decision maker examines two alternatives by considering one criterion and indicates a preference. These comparisons are made using a preference scale, which assigns numerical values to different levels of preference. The standard preference scale used for AHP is 1-9 scale which lies between “equal importances’s” to “extreme importance” where sometimes different evaluation scales can be used such as 1 to 5. In the pairwise comparison

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matrix, the value 9 indicates that one factor is extremely more important than the other, and the value 1/9 indicates that one factor is extremely less important than the other, and the value 1 indicates equal importance. Therefore, if the importance of one factor with respect to a second is given, then the importance of the second factor with respect to the first is the reciprocal. Ratio scale and the use of verbal comparisons are used for weighting of quantifiable and non-quantifiable elements [3].

The steps to follow in using the:
Define the problem and determine the objective.
Structure the hierarchy from the top through the intermediate levels to the lowest level.
Construct a set of pair-wise comparison matrices for each of the lower levels. The numerical value for the element depends on Saaty Nine Point Scale shown in Table 1.
There are n (n-1) / 2 judgments required to develop the set of matrices.

Having done all the pair-wise comparisons and entered the data, the consistency is determined using the Eigen value.
Steps 3 and 5 are performed to have relative importance of each attribute for all levels and clusters in the hierarchy.
To do so, normalize the column of numbers by dividing each entry by the sum of all entries. Then sum each row of the normalized values and take the average. This provides Principal Vector [PV].

The check of the consistency of judgments is as follows:

Table No. 1 The Fundamental Scale for Pairwise Comparisons

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6 and 8 can be used to express intermediate value		

Let the pair-wise comparison matrix be denoted M1 and principal vector be denoted M2.
Then define M3 = M1*M2; and M4 =M3/M2.
λmax = average of the elements of M4.
Consistency index (CI) = (λmax - N) / (N - 1)
Consistency Ratio (CR) = CI/RCI corresponding to N.
Where RCI = Random Consistency Index and N = Numbers of elements.

Table No. 2 Random Index Table

N	1	2	3	4	5
RCI	0	0	0.58	0.9	1.12
N	6	7	8	9	10
RCI	1.24	1.32	1.41	1.45	1.51

If CR is less than 10%, judgments are considered consistent. And if CR is greater than 10%, the quality of judgments should be improved to have CR less than or equal to 10%.

IV. DATA COLLECTION AND ANALYSIS

On the basis of research paper and selective service factor, a set of criteria is selected for the performance evaluation of the service centers. As the criteria is finalized second stage is to select the number of service centers for the evaluation purpose, in this research work five top automobile companies and their service centers are selected. The selected organizations are providing the same types of services to the customers.
From the valuable interaction with the experts of the service center and the customer's views, we were able to choke out the factors that were necessary to a car service center. The factors were further broken down into sub-factors for better understanding. The factors are shown in table below.

Table No. 3 Criteria and Sub Criteria

Customer Service	Advice to Customer
• Attention to customer	• Explanation of work required
• Soft skills	• Insurance advice
• Sanitation and hygiene	• Offer and Perks
Value for Money	Effectiveness of Servicing
• Labor cost	• Transparency
• Service charge	• Break down service
• Warranty of spare parts	• Additional servicing required
Time Taken	Overall Satisfaction
• On-time car service	• Desire to visit again
• On-time delivery	• Post service follow-up

Once the factors were finalized, the next step was to create a survey form to collect the data from the customers. For this the team went through the survey forms of various companies related to automobile sector as well as searched through the websites to get a concrete idea about how to form questions for the survey form. We went through various questionnaires.

After some study, we formulated some points that must be kept in mind for a good survey form. These were:-

Evaluate the goals of customer service and the information you want to measure in a survey. For example, a service goal may be to greet each customer with a smile and refer to them by name. Your survey would want to have these specific goals evaluated.

Establish the questions that help define whether your goals are being met and to what degree. Question one might be, "Did the representative smile when they met you?" Question two might be, "Did the representative use your name in the conversation.

The questions must be simple and easy to understand language.

Make sure your questions are measurable, meaning you can count the number of like responses—10 "yes" answers to five "no".

Decide how you will present your survey to customers: mail survey, phone survey or survey form picked up at the establishment. You may also conduct email surveys or even conduct one-on-one interviews. Determine the most efficient and cost-effective method for your organization.

Print the survey in an easy-to-read format. The more simple the survey is to read and fill out, the more likely consumers will spend time completing it.

Add non-measurable questions at the end. These are open-ended questions, such as, "How can we improve service?" Customer service questions are essential to any customer survey. Customer service questions are particularly important for companies that produce technical products. The goal with customer service questions is to measure performance and determine where customers may be having issues with the company's customer service department or training.

It is best to use a closed-ended format for product satisfaction questions.

The questions must cover all the criteria that need to be evaluated.

V. CALCULATIONS

A pair-wise comparison matrix developed as shown in Table 5. In constructing the matrix, the question to be asked as each factor comparison is being made is "how much more strongly does this element (or activity) possess – or contribute to, dominate, influence, satisfy, or benefit – the property than does the element with which it is being compared?" (Saaty, 1990).

Table No. 4 Nomenclature of criteria

F1	Customer's Requirement	CR
F2	Advice to Customer	AC
F3	Time Taken for service	TT
F4	Value for money	VM
F5	Effectiveness of service	ES
F6	Overall satisfaction	OS

The first element of the comparison is in the left column and the second element is found in the top row to the right of the first element's row position. A score is assigned indicating the importance of the first element in comparison to the second element. When comparing a factor to itself in the matrix, the relationship will always be one. Therefore, there will always be a diagonal of ones in the matrix. The different criteria where arrange into random priority, with the help of AHP the weight of each criteria will be calculated and the calculated weight will help to calculate the rating of the criteria for individual automobile service centre in the city. The sum of all the criteria selected by customer help to

Table No. 5 Pairwise Comparison Matrix Formation

	CR	AC	TT	VM	ES	OS
CR						
AC						
TT						
VM						
ES						
OS						

Table No. 6 Pairwise Comparison Matrix Formation

	CR	AC	TT	VM	ES	OS
CR	1	9	5	8	1/2	1/3
AC	1/9	1	1/2	1/9	1/9	1/9
TT	1/5	2	1	1/3	1/4	1/5
VM	1/2	9	2	1	1/3	1
ES	2	9	4	3	1	2
OS	3	9	5	1	1/5	1

Table No. 7 Pairwise Comparison Matrix

	CR	AC	TT	VM	ES	OS
CR	1	9	5	2	0.5	0.333
AC	0.111	1	0.5	0.111	0.111	0.111
TT	0.2	2	1	0.333	0.25	0.2
VM	0.5	9	3	1	0.333	1
ES	2	9	4	3	1	2
OS	3	9	5	1	0.5	1

Table No. 8 Pairwise Comparison Matrix

	CR	AC	TT	VM	ES	OS
CR	1	9	5	2	0.5	0.333
AC	0.111	1	0.5	0.111	0.111	0.111
TT	0.2	2	1	0.333	0.25	0.2
VM	0.5	9	3	1	0.333	1
ES	2	9	4	3	1	2
OS	3	9	5	1	0.5	1
Total	6.811	39	18.5	7.444	2.694	4.644

Table No. 9 Normalized Matrix

	CR	AC	TT	VM	ES	OS	Sum	PV
CR	0.15	0.23	0.27	0.27	0.19	0.07	1.17	0.20
AC	0.02	0.03	0.03	0.02	0.04	0.02	0.15	0.03
TT	0.03	0.05	0.05	0.05	0.09	0.04	0.32	0.05
VM	0.07	0.23	0.16	0.13	0.12	0.22	0.94	0.16
ES	0.29	0.23	0.22	0.40	0.37	0.43	1.95	0.32
OS	0.44	0.23	0.27	0.13	0.19	0.22	1.48	0.25

Check of the consistency
Let M1 = Pairwise comparison matrix,
M2 = Principal matrix

M1 =

1	9	5	2	0.5	0.33
0.11	1	0.5	0.11	0.11	0.11
0.2	2	1	0.33	0.25	0.2
0.5	9	3	1	0.33	1
2	9	4	3	1	2
3	9	5	1	0.5	1

M2 =

0.196
0.025
0.053
0.157
0.324
0.246

M3= M1*M2, then M4 = M3 / M2

λ max = Average of the elements of M4.

M3 =

1.239
0.154
0.324
0.99
2.111
1.638

M4 =

6.335
6.184
6.162
6.321
6.512
6.656

λ =

6.362

Now consistency index (CI) = (λ max – N) / (N-1)
= (6.362– 6) / (6-1)
= 0.0724
And Consistency Ratio (CR) = CI / RCI
Where, RCI corresponding to N from the Table No.2 from methodology section
Where, RCI = Random Consistency Ratio
N = Numbers of elements
Now, CR = 0.0724/ 1.24
= 0.058 i.e., CR < 0.1
So result is consistent.

VI. EVALUATION MATRIX ACTIVITY

An Evaluation Matrix is a list of values in rows and a column that allows an ologist to systematically identify, analyze, and rate the performance of relationships between sets of values and information. Elements of a decision matrix show decisions based on certain decision criteria. The matrix is useful for looking at large masses of decision factors and assessing each factor's relative significance. Supplier Performance Evaluation Matrix, which is shows as a 2-dimension, L-shaped decision matrix as, and then compute the scores for each solution regarding the criteria with the formulas below: Score = Rating x Weight, And then Total Score = SUM (Scores)

The weightage of all criteria calculated with the help of AHP Pair-wise Comparison method and justified according to the derived method, the numerical values of priority vector also define as the weightage of the criteria. The weightage of the criteria are slightly lower values so for the calculation of the score the actual weight is multiplied by 100. Finally the one more survey is done with the help of existing customer of particular service centre and rating are observed, the rating are given by the customer in the form of survey report in which different types of questions were asked to the customer related to the criteria and factors affecting the quality of service provided by the service centres.

For each service centre total weight is calculated and then grand total of all the criteria is calculated and the comparison is carried out with the summation of the total weight.

Table No. 10 Evaluation Matrix

Criteria	Weight age	Service Centre 1		Service Centre 2		Service Centre 3		Service Centre 4		Service Centre 5		Grand Total
		Rating	T W	Rating	T W	Rating	T W	Rating	T W	Rating	T W	
CR	20	18	352	18	352	15	293	16	313	17	333	2011
AC	2	1	2	2	5	1	2	2	5	2	5	
TT	5	3	16	4	21	3	16	3	16	4	21	
VM	16	15	235	11	172	14	219	14	219	13	204	
ES	32	26	843	25	811	25	811	30	973	28	908	
OS	25	23	566	20	492	21	517	23	566	22	541	
Grand Total		2014		1853		1858		2092		2011		

VII. CONCLUSION AND DISCUSSION

The AHP provides a convenient approach for solving complex MCDM problems in engineering. There is sufficient evidence to suggest that the recommendations made the AHP should not be taken literally. In matter of fact, the closer the final priority values are with each other, the more careful the

user should be. On the basis of the derived matrix and the final score calculated on the basis of weight and rating we conclude that service centre 5 is the most prioritized se among the group, with all the capability of fulfilling the most of the required criteria of customers satisfaction.

The above observations suggest that MCDM methods should be used as decision support tools and not as the means for deriving the final answer. To find the truly best solution to a MCDM problem may never be humanly possible. The conclusions of the solution should be taken lightly and used only as indications to what may be the best answer. Although the search for finding the best MCDM method may never end, research in this area of decision-making is still critical and very valuable in many scientific and engineering applications.

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