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Evaluation of Passenger Car Service Quality through Fuzzy AHP

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Abstract : *The Automobile Service Industry Plays An Important Role In The Economy Of India With Respect To GDP And Employment. Substantial Profits Are Generated In The Servicing Of Vehicle Therefore Attract And Retain Customers Is The Main Focus Of Every Organization. It Is Necessary To Evaluate The Service Quality Of Passenger Car After Sales, Time To Time. There Is Always Scope Of Improvement In Maintaining Service Quality. In An Effort To Evaluate Service Quality Of Passenger Car This Paper Used Fuzzy Analytic Hierarchy Process (FAHP) For Propose Framework. Numerical Example In Automobile Service Sector, Clarify The Methodology.*

Keywords – *Fuzzy AHP, Service Quality, SERVQUAL*

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I. INTRODUCTION

Service Quality Has Become One Of The Key Issues For Companies In Their Efforts To Improve Quality In The Competitive Market Place. Service Quality Is Considered To Affect Customer Retention And Therefore Profitability And Competitiveness. Service Quality Affects On The Complete Customer Satisfaction Which Is Lead To Effect On Customer Loyalty And Generating Superior Long Term Financial Performance. It Is Also Apparent That High Customer Satisfaction Leads To The Strengthening Of The Relationship Between A Customer And Company And This Deep Sense Of Collaboration, Has Been Found To Be Profitable.

Accordingly Service Quality Is An Important Factor In Passenger Car Service Industry. As Market Become More Competitive, Firms Are More Likely To Attempt To Maintain Their Market Share By Focusing On Retaining Current Customer. To Improve Customer Retention Firm Initiate A Variety Of Activities, Including Programmers On Customer Satisfaction, Complaint Management And Developing Strategies To Meet Customers' Expectations, And Explaining The Impact Of Service Quality On Profit

In This Sense, The Objective Is To Identify Which Quality Dimensions As Most Important To Customers Of Passenger Car Service Industry. In Addition It Also Assesses The Service That Is Delivered To Them. In Order To Accomplish These Objectives, The Paper Is Structured As Fallows Section 2 Contains The Literature Review Related To Service Quality Model. Section 3 Describes Methodology And Numerical Example On Fuzzy Analytic Hierarchic Process. Final Section Discusses The Result, Conclusion And Future Scope.

II. LITERATURE REVIEW

The SERVQUAL Instrument [1] Has Been Widely Used By Many Researcher And Practitioners To Measure Service Quality In Several Fields Like Restaurants, Hotel, Healthcare, Banking, Tourism And Automobile Etc. Many Studies Have Already Been Conducted To Measure Service Quality In Automobile Service Sector The SERVAQUAL Methodology Also Applied In Automobile Sector[2],[3],[4],[5], Other Than SERVQUAL Researcher Also Used Different Methodology [6] Used Neural Network For Measuring Service Quality. Most Important Dimension Identified By Delphi Process [7]. Performance Only Model (SERVPERF) Used For Evaluation Of Attributes [8]. Gray System Theory Finds Service Quality And Customer Satisfaction Are Different Constructs In The Mind Of Customers [9]. Integration Of Perceived Service Quality And Fuzzy Set Theory Evaluate The Customer Satisfaction [10]. Integrated Model Of Fuzzy Logic, EBG, DEA, FFMEA And QFD Applied By [11]For Performance Evaluation Of Service Center.

According To Literature Surveys,[1] Initially Identifies Ten Dimensions Regarding Service Quality In Their SERVQUAL Model, However These Were Reduced To Five Dimensions Namely: Reliability, Assurance, Tangibles, Empathy And Responsiveness.

- **Tangibles** (Physical Cues): The Appearance Of Physical Facilities, Equipment, And Personnel.
- **Reliability** (Promised Delivery): Ability To Perform The Promised Service Dependably And Accurately.

- **Responsiveness** (Willingness To Serve): Willing To Help Customers And To Provide Prompt Service.
- **Assurance** (Confidence And Trust): Knowledge And Courtesy Of Employees And Their Ability To Convey Trust And Confidence.
- **Empathy** (Importance): Provision Of Caring, Individualized Attention To Customers.

III. Methodology

Service Quality In Automobile Sector Is Complex Aspect And May Vary Within The Industry. It Involves Multiple Criteria And Qualitative Factors That Are Difficult To Measure. Measurement Of Service Quality Is Difficult Because Of Ambiguity Of Innovative Technology And Lack Of Experts. Due To Multiple Criteria Structure, A Comprehensive Method Should Be Applied That Can Handle Ambiguity. This Problem Can Be Solved By Applying Multi Criteria Decision-Making Methodology Which Supports The Decision Makers For Evaluation Of Service Quality Performance.

3.1 Fuzzy AHP

The Fuzzy Analytic Hierarchy Process Is An Advanced Analytical Method Developed From The Traditional AHP. Despite The Advantage Of AHP In Handling Both Quantitative And Qualitative Data, It Is Inadequate To Evaluate Decision Maker's Judgments. Decision Makers Judgments Are Subjective In Nature Having Fuzziness And Vagueness.

The Conventional AHP Cannot Imitate The Human Thinking Style. Avoiding These Risks On Evaluation, A Fuzzy Extension Of AHP Developed To Solve The Hierarchical Problems. The Mathematical Theory That Developed To Deal With Linguistics Judgment Is Fuzzy Set Theory. Fuzzy Set Theory Was Introduced By [12] Which Is Used To Manage The Vagueness Of Human Thought; Fuzzy Sets Theory Offers Interval Judgments Than Fixed Value Judgments. It Provides A Framework That Deal With Uncertainty In Language, That Is, Subjective Uncertainty. So Many Researchers Studied The Fuzzy AHP, Which Is A Extension Of Traditional AHP [13],[14],[15],[16],[17],[18].[19] Provide Evidence That Fuzzy AHP Is Sufficient To Deal Uncertainty In Decision Making Problem.

These Merits Of The Method Would Use It In Real Life Problem For Making Effective Decisions [20]. According To Literature Survey Many Researcher Applied Fuzzy Analytic Hierarchy Process In Several Field [21],[22],[23],[24],[25],[26].[27],[28],[29].

In This Approach, Triangular Fuzzy Numbers Are Used For Comparing One Criterion Over Another. Fig. 1 Shows The Membership Function Of A Triangular Fuzzy Number. A Fuzzy Number Is A Special Fuzzy Set

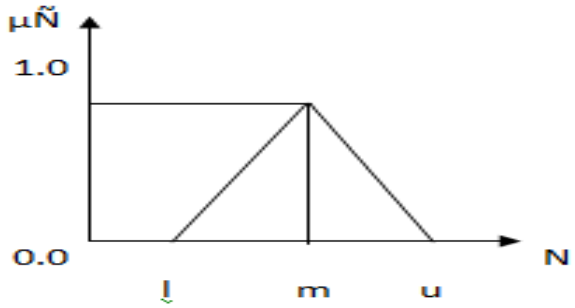

Figure1 Membership Function Of A Triangular Fuzzy Number.

A Triangular Fuzzy Number Is Defined By Ã= (L, M U,) Where L ≤ M ≤ U, Triangular-Type Membership Function Is Defined By Equation (1)

$$\mu\tilde{A}(x) = \begin{cases} 0, & x < l \text{ or } x > u \\ \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \end{cases} \quad (1)$$

The Interval Of Confidence Level For Triangular Fuzzy Number Is Described As Follows

$$\forall\alpha \in [0,1]\tilde{A}_{\alpha} = [l^{\alpha}, u^{\alpha}] = [(m-1)\alpha + l, -(u-m)\alpha + u] \quad (2)$$

In This Study, Linguistic Terms Are Used To Represent The Customer Judgments, And Then Triangular Fuzzy Numbers Are Used For Evaluations (Chai-Chi, 2010) Which Can Be Seen In Table 3.

Table1 Fundamental Scale Of FAHP

Intensity Of Importance	Fuzzy Number	Definition	Triangular Fuzzy Scale	Reciprocal Scale
1	$\tilde{1}$	Equal Importance	(1,1,1)	(1,1,1)
3	$\tilde{3}$	Moderate Importance	(2,3,4)	(1/4,1/3,1/2)
5	$\tilde{5}$	Strong Importance	(4,5.6)	(1/6,1/5,1/4)
7	$\tilde{7}$	Very Strong Importance	(6,7,8)	(1/8,1/7,1/6)
9	$\tilde{9}$	Extreme Importance	(8,9,10)	(1/10,1/9,1/8)

3.1.1 Computational Procedure Of FAHP

Step 1: Compare The Response Score On Each Level Of Hierarchy. Linguistic Terms Are Used To Compare Each Pair Of Elements In Same Hierarchy Level.

Step 2: By Using Triangular Fuzzy Number Construct Fuzzy Pair-Wise Comparison Matrix. The Fuzzy Comparison Matrix Ã , Is Constructed As Follows:

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{11} \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix} \quad (3)$$

If i Is Equal To j Then $\tilde{A}_{ij}$ =1, And If I Is Not Equal To J Then $\tilde{A}_{ij}$ = $\tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$ Or $\tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1}$.

Step 3: Calculate The Fuzzy Eigen Value. A Fuzzy Eigen Value, λ Is A Fuzzy Number

$$\tilde{A}\tilde{x} = \tilde{\lambda}\tilde{x} \quad (4)$$

Where, λ_{max} Is The Highest Eigen Value Of Ã And $\tilde{x}$ Is A Non Zero Nxn Matrix.

Step 4: Construct α - Cuts Fuzzy Comparison Matrix For All Service Quality Parameters

$$\tilde{a}_{ij}^{\propto} = \left[a_{ijl}^{\propto}, a_{iju}^{\propto}\right] \quad \tilde{x}_{ij}^{\propto} = \left[x_{ijl}^{\propto}, x_{iju}^{\propto}\right] \quad \tilde{\lambda}_{ijl}^{\propto} = \left[\lambda_{ijl}^{\propto}, \lambda_{iju}^{\propto}\right] \quad (5)$$

Where, $a_{ijl}^{\propto}$, Is The Lower Limit Of Fuzzy Number And $a_{iju}^{\propto}$ Is The Upper Limit Of Fuzzy Number. The Degree Of Satisfaction Is Estimated By The Optimism Index μ For Judgment Matrix. μ Indicate The Degree Of Satisfaction For Judgment Matrix Ã. A Greater Value Of μ Indicates A Higher Degree Of Optimism.

$$\tilde{a}_{ij}^{\propto} = \mu\tilde{a}_{ijl}^{\propto} + (1-\mu)\tilde{a}_{ijl}^{\propto}, \qquad \forall \propto \in [0,1] \quad (6)$$

After Fixing A And μ The Following Matrix Can Be Obtained.

$$\tilde{A} = \begin{bmatrix} \tilde{a}^{\propto}_{11} & \tilde{a}^{\propto}_{12} & \cdots & \tilde{a}^{\propto}_{1n} \\ \tilde{a}^{\propto}_{21} & \tilde{a}^{\propto}_{22} & \cdots & \tilde{a}^{\propto}_{2n} \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ \tilde{a}^{\propto}_{n1} & \tilde{a}^{\propto}_{n2} & \cdots & \tilde{a}^{\propto}_{nn} \end{bmatrix} \quad (7)$$

Step 5: Identifying The Maximum Eigen Value And Check The Consistency Of Judgment Matrix Ã For All Pair-Wise Comparisons. If Consistency Ratio (CR) Is Less Than 0.1 Then The Matrix Is Consistent. If It Is Not Consistent Then It Should Be Revising. The Consistency Ratio (CR) Is Determined By Equation (8).

$$CR = \frac{CI}{RI} \quad (8)$$

Where,

CI= Consistency Index

RI= Random Index

N= Order Of Comparison Matrix

The Consistency Index, $CI = \frac{(\lambda_{max} - n)}{(n-1)}$

Step 6: The Priority Weight Of Each Alternative Can Be Find By Multiplying The Matrix Of Evaluation Ratings By The Vector Of Criteria Weights And Summing Over All Criterion.

IV. Numerical Example

Step 1.Evaluation Framework: In Passenger Car Service Quality Measurement, The Goal Is To Find Out The Best Service Provider Among Alternatives. Service Provider Of Three Leading Companies In Nagpur City Of India Choose For This Study. A Questionnaire Was Applied To The Customers Of These Firms With 1197cc Were Selected. 51 Customers Replied Questionnaires. Customers Were Asked To Give Their Preferences Among Attributes.

Step 2: Develop A Model For The Decision: Break Down The Decision Into A Hierarchy Of Goals, Criteria And Alternatives. Model Constitute In Three Levels. Level One Is Objective Of Our Research is To Find The Best Service Quality Provider For Passenger Car. Level 2 Is Main Criterion That Is Tangible, Reliability, Responsiveness, Assurance And Empathy And Level Three Is Alternative.

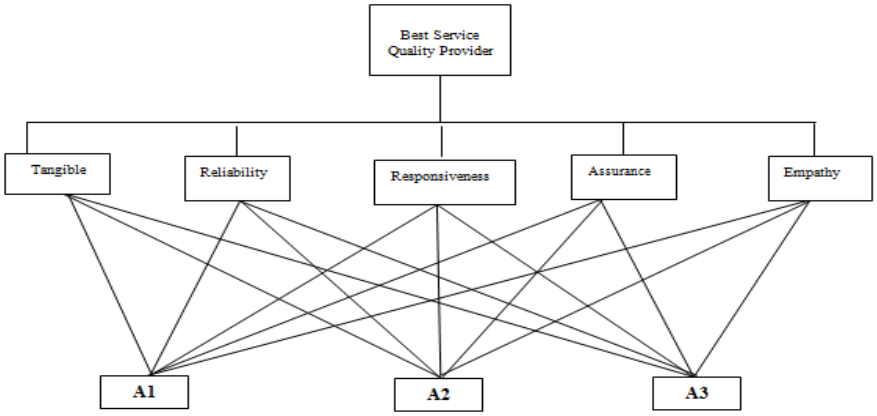

Figure2 Hierarchy Model Of Service Quality.

Step 3: Construct Pair Wise Comparison Matrix By Using Equation 3. Used Fundamental Scale Of FAHP, As Shown In Table1,For Judgment Matrix Ã.

Step 4: Derive Priorities (Weights) For The Criteria And Alternatives. The Importance Of Criteria Is Compared Pair Wise With Respect To The Desired Goal To Derive Their Weights. Priority Weights Were Calculated By Eigen Value Method. Then Check The Consistency Of Judgment Matrix. If Consistency Ratio (CR) Is Less Than 0.1 Then The Matrix Is Consistent. Table 2-7 Shows The Evaluation Matrices.

Table2. Pair Wise Comparison Of Main Criteria With Respect To Goal

Criteria	C1	C2	C3	C4	C5	Priority Vector
C1	(1,1,1)	(1/6,1/5,1/4)	(1/4,1/3,1/2)	(1/8,1/7,1/6)	(1/4,1/3,1/2)	0.064
C2	(4,5,6)	(1,1,1)	(2,3,4)	(1/4,1/3,1/2)	(2,3,4)	0.241
C3	(2,3,4)	(1/4,1/3,1/2)	(1,1,1)	(1/6,1/5,1/4)	(1,1,1)	0.120
C4	(6,7,8)	(2,3,4)	(4,5,6)	(1,1,1)	(4,5,6)	0.455
C5	(2,3,4)	(1/4,1/3,1/2)	(1,1,1)	(1/6,1/51/4)	(1,1,1)	0.120

Table3. Pair Wise Comparison Of Alternative With Respect To Tangible

	A1	A2	A3	FAHP Eigen Vector
A1	(1,1.1)	(1/4,1/3,1/2)	(1/8,1/7,1/6)	0.082
A2	(2,3,4)	(1,1,1)	(1/4,1/3,1/2)	0.243
A3	(6,7,8)	(2,3,4)	(1,1,1)	0.674

Table4. Pair Wise Comparison Of Alternative With Respect To Reliability

	A1	A2	A3	FAHP Eigen Vector
A1	(1,1,1)	(1,1,1)	(1,1,1)	0.33
A2	(1,1,1)	(1,1,1)	(1,1,1)	0.33
A3	(1,1,1)	(1,1,1)	(1,1,1)	0.33

Table5. Pair Wise Comparison Of Alternative With Respect To Responsiveness

A1	A2	A3	FAHP Eigen Vector

A1	(1,1,1)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	0.152
A2	(2,3,4)	(1,1,1)	(1,1,1)	0.423
A3	(2,3,4)	(1,1,1)	(1,1,1)	0.423

Table6. Pair Wise Comparison Of Alternative With Respect To Assurance

	A1	A2	A3	FAHP Eigen Vector
A1	(1,1,1)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	0.152
A2	(2,3,4)	(1,1,1)	(1,1,1)	0.423
A3	(2,3,4)	(1,1,1)	(1,1,1)	0.423

Table 7 Pair Wise Comparison Of Alternative With Respect To Empathy

	A1	A2	A3	FAHP Eigen Vector
A1	(1,1.1)	(1,1,1)	(1/4,1/3,1/2)	0.204
A2	(1,1,1)	(1,1,1)	(1/4,1/3,1/2)	0.204
A3	(2,3,4)	(2,3,4)	(1,1,1)	0.590

Table 8 Final Ranking Best Service Provider For Passenger Car.

	C1	C2	C3	C4	C5	Alternative Priority Weight
Weight	0.064	0.241	0.120	0.455	0.120	
A1	0.082	0.33	0.152	0.152	0.204	0.20
A2	0.243	0.33	0.423	0.423	0.204	0.36
A3	0.674	0.33	0.423	0.423	0.590	0.44

V. Result

This Study Applied The Fuzzy Ahp Methodology For Evaluation Of Passenger Car Service Quality Through Five Main Dimensions. Table 1shows The Most Important Dimensions. After Assessing, The Service Quality Of Passenger Car Assurance Is The Most Important Dimension With 45.5%. After Words, Reliability 24.1%, Responsiveness And Empathy Are Equally Important With 12%. Lastly Tangible Is 6.4 % Important. It Means Customer Neglects The Tangible Dimension. Service Center Should Focus On The Responsiveness And Empathy For Service Quality Improvement. According To The Result Show In Table- 7 Alternative A3 Is The Best Service Quality Provider Among The Alternatives, With Respect To 5 Criteria. Alternative A1 And A2 Should Identify The Short Fall And Improve The Service Quality.

VI. Conclusion

Depending On Various Criteria, Best Service Provider Is One Of The Important Tasks To Customer. Intension Of Purchasing A Vehicle Depends On Many Factors But Service Quality Is One Of Them. Selection Of Best Service Provider After Sale Of Vehicle Is A Tedious Job. In This Study Fuzzy Analytic Hierarchy Process Methodology Is Used For Evaluation Of Service Quality Of Passenger Car Among Three Alternatives. These Alternatives Are Evaluated With Respect To 5 Criteria Namely; Tangible, Reliability, Responsiveness, Assurance And Empathy. As The Result From Numerical Example Alternative A3 Is A Best Service Provider Among Others.

In Further Studies, Four Level Hierarchy Model Can Be Developed By Adding Sub Criterion At Third Level. Also Application Of AHP And Fuzzy AHP Can Be Compare, With Their Results.

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