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Evaluating Antecedents of Customer Satisfaction and Loyalty at Automobile After-Sales Service Centres (AASSC): A Multi-Criteria Decision-Making Approach

Vigneshwaran S.R. and M. Mathirajan
Department of Management Studies,
Indian Institute of Science, Bengaluru, Karnataka, India.

Abstract
This study investigates the key antecedents of Customer Satisfaction (CS) and Customer Loyalty (CL) within the highly competitive Indian automobile after-sales service centers (AASSC), aiming to prioritize factors that significantly influence CS and CL for enhanced strategic decision-making. A structured questionnaire was administered to selected customers of AASSCs, and two Multi-Criteria Decision-Making (MCDM) techniques—Analytic Hierarchy Process (AHP) and Best Worst Method (BWM)—were independently applied to determine the relative importance and rankings of the identified factors. Kendall's tau correlation test was used to assess consistency between the methods, revealing a statistically significant correlation and validating the robustness of the results. The analysis identified Product Quality, Service Quality, and Belief as the most critical factors, while factors such as Warranty Handling and Brand Awareness were found to be less influential. These findings provide actionable insights for managers to improve service quality and customer retention strategies. This research fills a gap by comparing two MCDM methods in the context of AASSCs and contributes to the literature by offering a structured, evidence-based approach for customer experience enhancement.

Keywords-Customer Satisfaction, Customer Loyalty, Multi Criteria Decision Making, Analytic Hierarchy Process, Best Worst Method

1. Introduction

Customer satisfaction (CS) is fundamental to the success and longevity of any business organization. Satisfied customers contribute significantly to business sustainability by fostering customer loyalty (CL), reducing complaints, and promoting positive word-of-mouth (Fornell, 1992). In essence, satisfaction occurs when the perceived service meets or exceeds expectations, while dissatisfaction arises when service performance falls short of expectations. However, satisfaction is not uniformly experienced; customers differ in needs, goals, and prior experiences, making it difficult to ensure consistent satisfaction across a broad customer base.

In today's intensely competitive environment, businesses must rapidly adapt to changing market dynamics. The automobile after-sales service centers (AASSC), in particular, have witnessed significant transformations over the years. These service centers face unique challenges such as increasing competition, rapid technological advances, a shrinking customer base, and diminishing profit margins. To retain customers, AASSCs are continually striving to meet evolving consumer expectations. However, identifying which factors truly influence customer satisfaction and loyalty remains a complex and ongoing challenge.Several researchers have identified and studied various factors contributing to customer satisfaction and loyalty within AASSC contexts (Kumar et al., 2017;Sundari, 2024;Rangappa and Chaitra, 2024). Yet, a comprehensive and prioritized analysis of these factors—especially in the Indian AASSClandscape—is still lacking. Most previous studies have examined these factors in isolation or without a clear mechanism for ranking their influence.

To address this gap, the present study aims to consolidate all relevant factors identified in prior literature and determine their relative importance in achieving CS and CL in AASSC (henceforth referred to as CS-CL-AASSC). This prioritization is carried out using two robust multi-criteria decision-making (MCDM) techniques: Analytic Hierarchy Process (AHP) and Best Worst Method (BWM).

The structure of this paper is as follows: Section 2 presents a literature review of factors influencing CS and CL in AASSC, along with relevant applications of the AHP and BWM methods. Section 3 outlines the research methodology, including sample design and the steps involved in implementing AHP and BWM. Section 4 presents and discusses the findings from both MCDM methods. Finally, Section 5 concludes the paper with key takeaways and implications.

2. Review of Literature

The literature review is predominantly divided into three parts: – the first part pin point the relevant factors influencing CS and CL at AASSC. In the second part, the a brief review related to the application of AHP is collected, followed by a brief literature related to application of BWM used in a different area of study is analysed in the third part.

2.1 Literature on factors influencing CS and CL at AASSC

Plenty of factors have been identified from the analysis of literature influencing CS and CL at AASSC. Shokouhyar et al. (2020) studied the influence of factor Quality, related to after-sales service, on customer satisfaction. Hong et al. (2020) aim is to find out how the quality of the car maintenance and repair service affects both customer satisfaction and willingness.Nyadzayo and Khajehzadeh (2016) studied the antecedents of customer loyalty and found that there is a moderating effect of brand awareness and belief on customer loyalty. Russo and Confente (2015) aim to study the effect of the after-sales service experience (convenient service, service capability, service cost) and its quality on overall CS and CL within the automotive industry. Guajardo et al. (2015) studied the impact of service attributes (warranty length, economic cost, service quality) on CL with product quality as moderating factor in the U.S. automobile industry.

While there are plenty of factors identified from the literature influencing CS and CL at AASSC, most of them are studied only in the developed countries. But in the developing countries, there are many studies available in the literature, but many factors have not been considered for achieving CS and CL at AASSC. Particularly in India, there are many studies focused only on the factor Service Quality, measured using the SERVQUAL model developed by Parasuraman et al. (1988), is considered. In addition, there are very few studies in India that considered ancillary factors, along with the factor service quality, such as warranty handling (Rangarao 2013), convenient service (Chatterjee 2015), service capability (Kumar et al., 2017), economic service (Reddy et al. 2016), brand awareness (Krishnamurthi and Selvaraj 2017), and product quality (Jahanshahi et al. 2011). Further, from the survey of literature, wecanmake out that both the developed and developing countries have failed to give importance to recent factors like service contracts and insurance handling, which are nowadays offered in many service centers.

With this premise, the detailed analysis of the literatureis carried out with a focus on identifying factors influencing CS and CL at AASSC and finally identified 10 unique factors (input factors): Belief, Economic Service, Brand Image, Product Quality, Service Quality, Service capability, Warranty Handling, Convenient Service, Service Contract, and Insurance Handling. A summary of these identified factors w.r.t. developed countries, developing countries other than India and India are presented in Table 1.

2.2A Brief Literature on the application of Analytic Hierarchy Process (AHP)

AHP, a mathematical contrivance for multiple criteria decision making (MCDM), was originally instigate by Saaty (1980). It bestows with complex problems by breaking them down into a hierarchical structure. AHP has been used to find a solution to many problems in various industries. In particular, it is most widely used in operations management (Vaidya, 2006; Abdullah et al., 2013; Gupta et al., 2015; Claret et al., 2024). This AHP method is used to help many business and government decision makers make the right decisions (González-Prida et al., 2012). It has been widely used, especially for large problems that involve multiple criteria and where the assessment of alternatives is largely subjective. Although many papers describe the development of AHP, it has been largely accepted as a subjective approach. Ali and Marinna (2017) investigate the evolution of AHP in research field using social network analysis and scientometrics and identify its intellectual structure. Theyprovide analyzes based on 8,441 articles published between 1979 and 2017 collected from the ISI Web of Science database. In addition, many studies have been conducted to penalize the factors affecting the Indian automobile service center using AHP (Jadhao et al., 2023).

2.2 A Brief Literature on the application of Best Worst Method (BWM)

Although there are many MCDM methods for prioritizing and ranking factors, this study uses the worst case method (BWM) proposed by Rezaei (2016) for some reasons.The primary reason is that the result associated with BWM is more consistent with the other MCDM approaches (Ahmadi et al., 2017). Secondly, it does only a small group-wise pairwise comparison, whereas with the other MCDM methods, a full pairwise comparison will be carried out. Particularly, it involves a comparison of the best factor (**BF**) with other factors (**OF**) as well as the **OF** with the worst factor (**WF**) only, thereby eliminating secondary comparison which is required in other MCDM methods (Shojaei et al., 2018). Thirdly, the BWM uses a highly structured and easy-to-understand way of collecting data for pairwise comparisons.

Table 1: A Summary, on Closely Related Literature, on Factors Affecting CS-CL-AASSC

Researcher	Year	Country	Factors								Objectives	
			Service Quality	Warranty Handling	Economic service	Brand Awareness	Product Quality	Belief	Convenient Service	Service Capability	CS	CL
Developed Nations												
Hashem et al.	2024	Spain						✓				✓
Takumi Kato	2021	Japan	✓		✓	✓			✓	✓		✓
Shokouhyar et al.	2020	Iran	✓	✓					✓	✓	✓	

Hong et al.	2020	South Korea	✓				✓				✓	✓
Hidayat et al.	2020	Germany	✓					✓				
Hong et al.	2020	South Korea	✓		✓			✓				✓
Chen et al.	2018	Taiwan	✓									✓
Borchardt et al.	2018	USA	✓	✓	✓						✓	
Syahrial et al.	2017	USA	✓		✓						✓	✓
Nyadzayo and Khajehzadeh	2016	Australia	✓			✓		✓			✓	✓
Russo and Confente	2015	Italy	✓		✓				✓	✓	✓	✓
Fard and Hosseini	2015	Iran	✓		✓					✓	✓	
Guajardo et al.	2015	USA	✓	✓	✓		✓		✓			✓
Gonzalez	2015	Spain	✓	✓					✓		✓	✓
Al-Shammari and Kanina	2014	USA	✓								✓	✓
Hunecke and Gunkel	2012	Germany	✓		✓	✓	✓				✓	✓
Urban	2010	Poland	✓								✓	
Devaraj et al.	2001	USA	✓	✓	✓	✓	✓	✓				✓
Andaleep and Basu	1994	USA	✓						✓		✓	
Bouman and Wiele	1992	Netherland	✓					✓		✓	✓	
Developing Nations, other than India												
Danarkusuma et al.	2024	Indonesia	✓		✓			✓			✓	✓
Jannah et al.	2023	Malaysia					✓				✓	✓
Ekasari et al.	2023	Indonesia	✓								✓	✓
Dennis et al.	2022	Nigeria		✓		✓	✓			✓		
Aiyesehinde and Aigbavboa	2021	Nigeria	✓								✓	
Noranee et al.	2021	Malaysia	✓				✓				✓	
Balinado et al.	2021	Philippines	✓								✓	
Rahman and Saidin	2021	Malaysia	✓			✓						✓

Noviyanti	2021	Indonesia	✓								✓	
Sheriff et al.	2020	Malaysia	✓								✓	
Dwi and Yuni	2020	Indonesia	✓		✓		✓				✓	
Alqadri et al.	2020	Indonesia	✓			✓					✓	✓
Hanafi and Zamalia	2019	Malaysia						✓				✓
Orfyanny et al.	2019	Indonesia	✓			✓					✓	✓
Adusei and Koduah	2019	Ghana	✓	✓						✓	✓	
Renjith Kumar et al.	2018	Oman	✓	✓	✓					✓	✓	
Furaida et al.	2018	Indonesia	✓								✓	
Negede and Seifu	2018	Ethiopia	✓	✓						✓	✓	
Tenkir and Rahel	2018	Ethiopia	✓	✓						✓	✓	
Famiyeh et al.	2018	South Africa	✓								✓	✓
Saidin et al.	2018	Malaysia	✓		✓	✓				✓		✓
Lotko et al.	2018	Poland	✓									✓
Piriyasup and Kim	2017	Thailand	✓			✓			✓			✓
Sabbagh et al.	2017	Malaysia	✓	✓			✓				✓	

Table 1: A Summary, on Closely Related Literature, on Factors Affecting CS-CL-AASSC … Contd.

Researcher	Year	Country	Factors								Objectives	
			Service Quality	Warranty Handling	Economic service	Brand Awareness	Product Quality	Belief	Convenient Service	Service Capability	CS	CL
Nordin et al.	2016	Malaysia	✓	✓					✓		✓	
Azman and Gomiseek	2014	Slovenia	✓								✓	✓
Saeed et al.	2013	Pakistan	✓		✓					✓		✓

Shuqin and Gang	2012	China	✓					✓	✓		✓	
Datsomor	2012	South Africa	✓									✓
Elistina and Naemah	2011	Malaysia	✓		✓					✓	✓	
Chiu et al.	2011	Taiwan	✓		✓	✓				✓	✓	✓
Ahmed and Sanatullah	2011	Pakistan	✓	✓	✓		✓		✓	✓		✓
Samani et al.	2011	Malaysia	✓		✓		✓				✓	✓
Yieh et al.	2010	Taiwan	✓		✓		✓	✓			✓	
Yan and Mclaren	2010	South Africa	✓								✓	
Keshavarz et al.	2009	Iran	✓								✓	
Jian-Ling et al.	2008	China	✓		✓		✓		✓		✓	
Brito et al.	2007	Brazil	✓		✓			✓				
Bei and Chiao	2006	Taiwan	✓		✓		✓				✓	✓
Zerres	2004	NA	✓			✓			✓		✓	✓
INDIA												
Naru et al.	2024	India	✓		✓						✓	
Singh et al.	2023	India	✓							✓	✓	
Chandel et al.	2023	India	✓		✓		✓				✓	✓
Gupta and Raman	2022	India	✓		✓						✓	

Shetty and Solanki	2022	India	✓		✓	✓			✓	✓	✓	
Phule and Vyavhare	2022	India	✓								✓	
Malakar and Suwandee	2021	India	✓								✓	
Harsh and Tanmay	2021	India	✓								✓	
Govindarajan	2021	India	✓								✓	✓
Naveen and Pramod	2020	India				✓	✓				✓	✓
Robert and Rahul	2020	India	✓		✓						✓	
Fenny and Dharmaraj	2020	India	✓							✓	✓	
Amudha et al.	2018	India	✓								✓	
Subramani and Franklin	2017	India	✓								✓	✓
Krishnamurthi and Selvaraj	2017	India			✓	✓	✓				✓	✓
Yadav and Joseph	2017	India	✓								✓	
Kumar et al.	2017	India	✓	✓	✓				✓	✓		✓
Reddy et al.	2016	India	✓		✓					✓	✓	
Chatterjee	2015	India	✓		✓				✓		✓	

Selvabaskar and Athirathan	2015	India	✓								✓	
Amonkar	2015	India	✓		✓					✓	✓	
Rangarao	2013	India	✓	✓	✓				✓	✓	✓	
Ambekar	2013	India	✓								✓	
Jahanshahi et al.	2011	India	✓				✓				✓	✓
Sangode	2011	India	✓						✓	✓	✓	
Katarne et al.	2010	India	✓								✓	

The analysis of the literature review revealed that MCDM (Most Worst Method, Worst Method) has been used to prioritize or penalize factors in several applications, including business and economics, healthcare, IT, technology, education, and agriculture. Elahi et al. (2023) proposed a Best-worst case method emanate on sharp and triangular fuzzy numbers to evaluate the quality of automotive after-sales services. Jangre et al. (2022) aims to identify and assess factors affecting the commercial prospects of biomedical waste in developing countries using BWM. Wankhede and Vinodh (2021) identified barriers to Industry 4.0 adoption in the automotive industry and peruse these barriers to classify them for methodlogical adoption in the Indian automotive industry using BWM. Khan et al. (2021) proposed a BWM-based performance evaluation method to evaluate the overall accomplishment of an Indian steel industry company. Kaushik et al. (2020) used a Best-worst case method to more effectively prioritize and rank online revenue engines for clothing, etc. However, there are not many studies to prioritize and rank factors affecting CS-CL-AASSC using BWM.

3. Methodology

This section presents the methodology followed for data collection and for ranking the identified factors which are expected to influence the CS-CL-AASSC.

3.1 Methodology for Data Collection

The data is collected through the simple questionnaire exclusively developed for each of the MCDM methods: AHP and BWM. In this study, the questionnaire is circulated to four customers, and they were chosen based on the following criteria.

- Out of four customers, two are from Chennai and two are from Bangalore
- Customer, who has own vehicle, and his/her vehicle should be older than 2 years
- Customer, who has own vehicle, and the vehicle should have run more than 20000 kilometers
- Customer, who must belong to a different age group (<35, 36+)

3.2 Methodology followed for ranking the identified factors for CS-CL-AASSC

In this study there are two MCDM methods: AHP and BWM are individualisticconsidered to rank the identified factors for CS-CL-AASSC, mainly to triangulate and confirm the ranks obtained from two different methods. With this, the step-by-step details of each of the methods: AHP and BWM are presented as follows:

Step-by-Step Details of the AHPMethodology

Step1: Clearly define and state the objectives of a complex and ambiguous problem.Clearly characterize and state the goals of a complex and vague problem.

Step2:A multifaceted issue is separated into a progressive structure utilizing expert conclusion.The progressive structure is separated into afew levels. The top hierarchy speaks to the objective of the issue. This objective is divided into distinctive criteria (factors) at the following level. These factors can be further partitioned into sub-factor levels.

Step 3:A decision matrix can be used to make a pairwise comparison to illustrate the importance of one factor over another. The decision matrix is formed with the help of decision makers (customers) on the nine-point scale of Saaty (1994), which is presented in Table 2. In the hierarchical structure, the factors underlying a common node are compared, e.g. other factors of the same node. For illustration, if there are "n" factors under a node, there will be n (n-1)/2 comparisons under that node.

Table 2: Scale of Relative Preference for Pairwise Selection

Level of Preference	Explanations
1	Preferred equally
3	Preferred moderately
5	Preferred strongly
7	Preferred very strongly
9	Preferred extreme strongly
2,4,6,8	Intermediate preferred values

Let consider there are X_1, X_2, X_3, ..., X_n factors beneath the node "M" and their quntitative weights are w_1, w_2, w_3...w_n. The pairwise analogy of these factors in conferring with their relative weights are uncovered in the shape of a matrix, where Z is the comparison matrix (n * n) which constitute the pairwise comparisons among the factors X_1, X_2, X_3...X_n:

$$
Z = \begin{array}{c} \\ X_1 \\ X_2 \\ \vdots \\ X_n \end{array}
\begin{array}{c} \begin{array}{cccc} X_1 & X_2 & \dots & X_n \end{array} \\
\begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \vdots & \vdots & \vdots & \vdots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{bmatrix} \end{array}
$$

$$Z = \begin{array}{c} \\ X_1 \\ X_2 \\ \vdots \\ X_n \end{array} \begin{array}{c} \begin{array}{cccc} X_1 & X_2 & \dots & X_n \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \end{array}$$

where $a_{ij} = w_i/w_j$ (i, j =1,2...n) appear for themeasured relative importance between factorsXi and Xj. If i = j then aij = 1 and aji = 1/ aij for aij> 0 (i.e., a13 = 1 and a31 = 1/a13).

Step 4: After the origination of the decision-making matrix, the succeeding step is to recognize the need weights of the factors through the extreme eigenvectors and eigenvalues. Concurring to Saaty (1994), the eigenvector and eigenvalues are calculated by the taking after formula:

$$\lambda_{max} = \sum_{j=1}^{n} a_{ij} \frac{W_j}{W_i} \quad (1)$$

The eigenvectors can be computed with the formula:

$$Z.W = \lambda_{max} . W \quad (2)$$

where, W = eigenvector and λ_{max} = largest eigenvalue, of matrix Z.

Step 5: In this step, pairwise comparisons are checked for consistency. In pairwise comparisons,irregularityis measured by the consistency index (CI_AHP) and coherence is measured by the consistency proportion (CR_AHP) using the equation below

$$\text{CI\_AHP} = \frac{\lambda_{max} - n}{n-1} \quad (3)$$

$$\text{CR\_AHP} = \frac{\text{CI}}{\text{RI}} \quad (4)$$

where n is the number of factors in each level and RI is the random index. For diverse matrix sizes (n), the fittingvalues of RI are potrayed in Table 3 (Satty, 1980). The greatest satisfactory restrain for CR_AHP is 0.1 (Saaty, 1994). The values above 0.1 demonstrate that the pairwise comparison is inconsistent and subsequently rejected

Table 3: Consistency Ratio Random Number Index

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

Step-by-Step Details of the BWMMethodology

Step 1: Have the set of assessment factors (F_1, F_2, F_3,…., F_n)decided by the customers.

Step 2: Have the best F_B (e.g., the most powerful or critical) and the worst *Fw* (e.g., the least powerful or critical) factor decided by the customers.

Step 3: Determine the fondness of the best over all the other factorsutilizing the 9-point scale appeared in Table 4. The obtained Best-to-Others vector is: F_{B0}= (f_{B1}, f_{B2}, f_{B3}, …., f_{Bn}), where F_{Bj}speaks the fondness of the best factor $F_B$over other factor F_j, j= 1,2, ⋯, *n* .

Table 4: A 9-Point Scale used in BWM

The meaning of the score 1 to 9	
1	**Equal** importance
2	Somewhat between Equal and Moderate
3	**Moderately** important
4	Somewhat between Moderate and Strong
5	**Strongly** important
6	Somewhat between Strong and Very strong
7	**Very strongly** important
8	Somewhat between Very strong and Absolute
9	**Absolutely** more important

Step 4: Decide the inclinationsof all the factors over the worst factor using the 9-point scale shown in Table 4. The obtained Others-to-Worst vector is: $F_{ow}= (f_{1w}, f_{2w}, f_{3w}, \ldots, f_{nw})$, where F_{jW} represents the fondness of factor F_j over the worst factor F_W, j = 1,2, ···, n.

Step 5: Direct the weights (W_1*, W_2*, W_3*,…. W_j*) by tackling the taking after model:

Minξ

Subjected to

$|w_B - f_{Bj}\, w_j| \leq \xi$, for all j(5)

$|w_j - f_{jW} w_w| \leq \xi$, for all j

$$\sum_{j=1}^{n} w_j = 1$$

$w_j \geq 0$, for all j

Solving the mathematical model given in point (5) gives the ideal weights (W1*, W2*, W3*,…. Wj*) the optimal value ξ*. ξ* is characterized as the consistency degree of the reference framework. This impliesthat the closer ξ* is to zero, the more steady is the reference frameworkgiven by customers.

Once the weights are obtained after solving the mathematical model given in (5), the Consistency Ratio (CR_BWM) of the formulated problem is calculated using the following formula:

Consistency Ratio (CR_BWM)= ξ* / Consistency Index (CI_BWM)(6)

The consistency index can be computed from Table 5 and ξ* is the objective function value obtained from the mathematical model. The lower the consistency ratio,the more reliable the comparisons.For accepting the computed consistency ratio for the given model, Liang et al. (2020) introduced the threshold for the consistency ratio, and the same is given in Table 6.

Table 5:Consistency Index (CI)

F_{BW}	1	2	3	4	5	6	7	8	9	10
CI	0	0.44	1	1.63	2.3	3	3.73	4.47	5.23	5.96

Table 6: The threshold for the consistency ratio [Liang et al., (2020)]

Scale	Criteria						
	3	4	5	6	7	8	9
3	0.2087	0.2087	0.2087	0.2087	0.2087	0.2087	0.2087
4	0.1581	0.2352	0.2738	0.2928	0.3102	0.5154	0.3273
5	0.2111	0.2848	0.3019	0.3309	0.3479	0.3611	0.3741
6	0.2164	0.2922	0.3565	0.3924	0.4061	0.4168	0.4225
7	0.2090	0.3313	0.3734	0.3931	0.4035	0.4108	0.4298
8	0.2267	0.3409	0.4029	0.4230	0.4379	0.4543	0.4599
9	0.2122	0.3653	0.4055	0.4225	0.4445	0.4587	0.4747

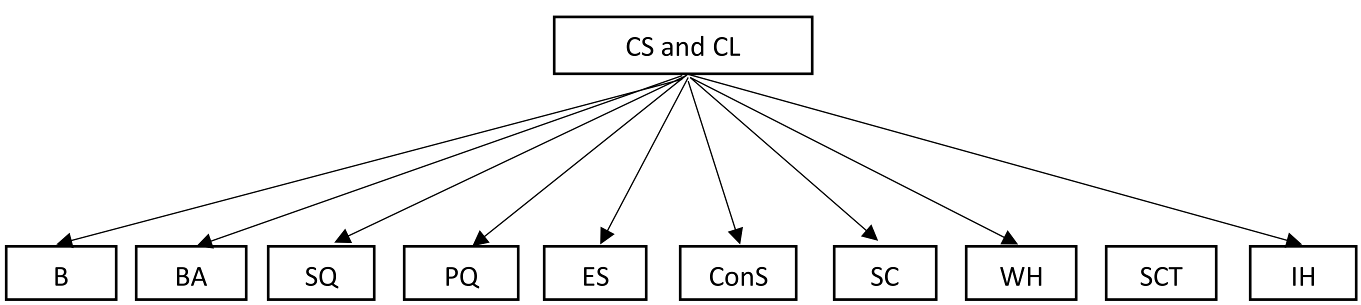
4. Result and Discussion

The collected data is appropriately given as input for implementing both MCDM methods. In the following section, the walkthrough of the AHP and BWM approach in determining the rank of the factors for CS-CL-AASSC is elaborated.

4.1 Rank Determination followingAHP

Step 1: Define the object or goal: The objective or goal of the ponder is to decide the ranking of the factors, which are identified and considered in this study and expected influence Customer Satisfaction (CS) and Customer Loyalty (CL) for the Automobile After-sales service centres (AASSC), from the perspective of customers.

Step 2: Decompose the objective or goal: Considering the identified factors, a two-level pecking order tree model has been shaped in this step. Accordingly, the top most objective of the problem is kept at the beat of the model, which is factors Customer Satisfaction (CS) and Customer Loyalty (CL). Then the ten unique factors identified for AAASSC influencing CS and CL are placed at the criteria-level of the model. These ten factors are Belief (B), Service Quality (SQ), Economic Service (ES), Service Capability (SC), Brand Awareness (BA), Warranty Handling (WH),Product Quality (PQ), Service Contract (SCT), Convenient Service (ConS), and Insurance Handling (IH). With this, the AHP framework was developed, for encouraging the study, and the same is presented in Figure 1.



Legend: **B** -Belief, **BA**-Brand Awareness, **SQ**-Service Quality, **PQ**-Product Quality, **ES**-Economic Service, **ConS**-Convenient Service, **SC**-Service Capability, **WH**-Warranty Handling, **SCT**-Service Contract, **IH**-Insurance Handling

Figure 1: An AHP Framework, Considering the Factors for CS-CL-AASSC

Step 3: Perform pair-wise comparisons: This step is concerned with data collection from the

customers to find the ranking of factors for AASSC.

To collect the required pair-wise data considering the factors shown in the AHP model (Figure 1), a questionnaire developed was circulated among 4 customers for collecting all therequired data. The pair-wise comparison among ten factors (that is, 45 comparisons) using a nine-point scale (Table 2) is collected from each of the four customers and shown in Annexure 1. For demonstrating the working mechanism of AHP, the data collected from customer 1 is used here. Accordingly, the pair wise comparison of factors w.r.t. customer 1 is converted to matrix and the same is presented in Table 7. That is, the data in Table 7 indicates how important the i^{th} factor is compared with the j^{th} factor for customer 1. From this point, for the ease of reading, the computation is shown only for customer 1. The other customers' computation is exactly like customer 1, so not provided.

Step 4: Develop a normalized matrix to identify the priority weights:After the formation of the pair-wise comparison data or matrix (that is, Table 7), the following step is to discover the priority weights of the factors through the greatest eigenvectors and eigenvalues. In this step divide each entry of the column j (where j = 2 to 11) of Table 7 by the aggregate of the entries in the respective column j. This leads to the normalized matrix and the same is presented in Table 8, in which the aggregate of the entries in each column is '1'.Further, considering each of the row 'i' (where i = 2 … 11) of Table 8, the priority weight (equal to eigenvector) w.r.t. each factor is computedby taking the average of the values in the respective row i of Table 8.The priority weight for customer 1 is shown in the last column of Table 8.

Table 7: Pairwise Comparison Data (matrix) for the Factors w.r.t. CS-CL-AASSC – Customer 1

	B	BA	SQ	PQ	ES	ConS	SC	WH	SCT	IH
B	1.00	3.00	1.00	7.00	1.00	7.00	8.00	9.00	9.00	7.00
BA	0.33	1.00	1.00	4.00	2.00	6.00	6.00	3.00	5.00	9.00
SQ	1.00	1.00	1.00	8.00	1.00	4.00	4.00	3.00	4.00	6.00
PQ	0.14	0.25	0.13	1.00	1.00	2.00	2.00	2.00	4.00	3.00
ES	1.00	0.50	1.00	1.00	1.00	6.00	4.00	4.00	5.00	5.00
ConS	0.14	0.17	0.25	0.50	0.17	1.00	2.00	6.00	4.00	2.00
SC	0.13	0.17	0.25	0.50	0.25	0.50	1.00	7.00	5.00	5.00
WH	0.11	0.33	0.33	0.50	0.25	0.17	0.14	1.00	1.00	1.00
SCT	0.11	0.20	0.25	0.25	0.20	0.25	0.20	1.00	1.00	2.00
IH	0.14	0.11	0.17	0.33	0.20	0.50	0.20	1.00	0.50	1.00
SUM	4.11	6.73	5.38	23.08	7.07	27.42	27.54	37.00	38.50	41.00

Table 8: Normalized Data (matrix) for the Factors w.r.t. CS-CL-AASSC – Customer 1

	B	BA	SQ	PQ	ES	ConS	SC	WH	SCT	IH	Row Sum	Priority Weights
B	0.24	0.45	0.19	0.30	0.14	0.26	0.29	0.24	0.23	0.17	2.51	0.25
BA	0.08	0.15	0.19	0.17	0.28	0.22	0.22	0.08	0.13	0.22	1.74	0.17
SQ	0.24	0.15	0.19	0.35	0.14	0.15	0.15	0.08	0.10	0.15	1.69	0.17
PQ	0.03	0.04	0.02	0.04	0.14	0.07	0.07	0.05	0.10	0.07	0.66	0.07
ES	0.24	0.07	0.19	0.04	0.14	0.22	0.15	0.11	0.13	0.12	1.41	0.14
ConS	0.03	0.02	0.05	0.02	0.02	0.04	0.07	0.16	0.10	0.05	0.58	0.06
SC	0.03	0.02	0.05	0.02	0.04	0.02	0.04	0.19	0.13	0.12	0.65	0.07
WH	0.03	0.05	0.06	0.02	0.04	0.01	0.01	0.03	0.03	0.02	0.28	0.03

SCT	0.03	0.03	0.05	0.01	0.03	0.01	0.01	0.03	0.03	0.05	0.26	0.03
IH	0.03	0.02	0.03	0.01	0.03	0.02	0.01	0.03	0.01	0.02	0.21	0.02

Exactly like the priority weights obtained for customer 1, the priority weight w.r.t. other customers (2, 3 and 4) considering date given in Annexure 1, is also computed. With this, the priority weight obtained for each of the customers is presented in Table 9. Further, the average priority weight for each of the factors is computed by considering the each of the four customers' priority weight of the respective factors and the same is presented in Table 9 (last but one column of Table 9). Using the average priority weight of each factors, rank is assigned (top most rank is given to the factor which has high average priority weight and the least rank is given to the factor which has least average priority weight) for each of the factors and presented the same in Table 9.

Table 9: Priority weight of the Factors w.r.t. CS-CL-AASSC with Ranking of the Factors

	Customer 1	**Customer 2**	**Customer 3**	**Customer 4**	**Average**	**Rank**
B	0.251359497	0.23428683	0.267362652	0.224693851	0.244425707	1
BA	0.173925901	0.19952223	0.170993539	0.154905609	0.174836819	3
SQ	0.168856805	0.14239506	0.182605252	0.19919768	0.175263699	2
PQ	0.065669506	0.14050574	0.109331731	0.10008129	0.103897066	5
ES	0.141255934	0.11305792	0.103661798	0.123834007	0.120452415	4
ConS	0.057522294	0.0438227	0.052071933	0.057872629	0.052822388	7
SC	0.065429731	0.04474725	0.046202543	0.064284296	0.055165956	6
WH	0.028429647	0.03685065	0.026688039	0.027525569	0.029873477	8
SCT	0.026057291	0.02323248	0.020922574	0.022873234	0.023271396	9
IH	0.021493394	0.02157914	0.020159939	0.024731835	0.021991077	10

Step 5: Check the consistency in the pair-wise comparison: This step discovers whether the pair-wise comparison data for the factors are having any inconsistency or not. That is, it is feasible that, through pair-wise comparisons, customers may be conflicting in their scores given. For that, the consistency ratio test needs to be carried out. That is, the consistency ratio (CR_AHP) test is utilized to examine whether the pairwise comparison data given for each of the factors are consistent and the same could be used for decision-making. For that the CR_AHP is calculated concurring to the taking after condition:

$$\text{CR\_AHP} = \frac{\text{CI\_AHP}}{\text{RI}} \qquad (4)$$

where RI is the Random Index and CI_AHP (Consistency Index) is obtained by the following equation:

$$\text{CI\_AHP} = \frac{\lambda_{max} - n}{n-1} (3)$$

where 'n' is the number of factors and λ_{max} is the eigenvalue.

For the data considered in Table 7, the eigenvalue (λ) for each factor is calculated and shown in Table 10. To obtain the eigenvalue (λ), the following sub-steps were performed.

<u>Step 5.1:</u>**Compute 'δ':** For obtaining 'δ' for each factor, we need to multiply the pair wise comparison data (that is, Table 7) by the computed priority weight (that is, the last column of Table 8), as shown below:

$$\begin{vmatrix} 1 & 3 & 1 & 7 & 1 & 7 & 8 & 9 & 9 & 7 \\ 1/3 & 1 & 1 & 4 & 2 & 6 & 6 & 3 & 5 & 9 \\ 1 & 1 & 1 & 8 & 1 & 4 & 4 & 3 & 4 & 6 \\ 1/7 & 1/4 & 1/8 & 1 & 1 & 2 & 2 & 2 & 4 & 3 \\ 1 & 1/2 & 1 & 1 & 1 & 6 & 4 & 4 & 5 & 5 \\ 1/7 & 1/6 & 1/4 & 1/2 & 1/6 & 1 & 2 & 6 & 4 & 2 \\ 1/8 & 1/6 & 1/4 & 1/2 & 1/4 & 1/2 & 1 & 7 & 5 & 5 \\ 1/9 & 1/3 & 1/3 & 1/2 & 1/4 & 1/6 & 1/7 & 1 & 1 & 1 \\ 1/9 & 1/5 & 1/4 & 1/4 & 1/5 & 1/4 & 1/5 & 1 & 1 & 2 \\ 1/7 & 1/9 & 1/6 & 1/3 & 1/5 & 1/2 & 1/5 & 1 & 1/2 & 1 \end{vmatrix} * \begin{vmatrix} .25 \\ .17 \\ .17 \\ .06 \\ .14 \\ .05 \\ .06 \\ .02 \\ .02 \\ .02 \end{vmatrix} = \begin{vmatrix} 3.12 \\ 2.12 \\ 2.08 \\ 0.78 \\ 1.68 \\ .67 \\ .70 \\ .31 \\ .28 \\ .24 \end{vmatrix} = \delta$$

Step 5.2: **Compute the Eigenvalue of ‘λ’:** The value of ‘λ’ is obtained for each of the factors using the following formulae given below [that is, the value of ‘λ’ for each of the factors will be obtained by computing the factor wise the value δ obtained in Step 5.1 is divided by the respective factor wise the priority weight computed and presented in Table 8] and the details of the same are shown as below in Table 10:

$$\boldsymbol{\lambda} = \frac{\mathrm{i^{th}entry\ in\ \delta}}{\mathrm{i^{th}\ entry\ in\ priority\ weight}} \qquad (7)$$

Table10: Priority Weight and Eigenvalue for the Factors w.r.t. CS-CL-AASSC

Factor	**Factor Wise the Value of**		
	δ	**Priority Weight**	**Eigenvalue (λ)= (δ / Priority Weight)**
B	3.12	0.25	12.41
BA	2.13	0.17	12.24
SQ	2.08	0.17	11.64
PQ	0.78	0.07	11.88
ES	1.68	0.14	11.91
ConS	0.67	0.06	11.69
SC	0.70	0.07	10.76
WH	0.31	0.03	10.85
SCT	0.28	0.03	10.63
IH	0.24	0.02	11.17
Average			11.52

Considering the computed Eigenvalue (λ) value for each of the factors,the average value of the Eigenvalue (λ) is computed (= 11.52) and the same is used instead of the maximum value of the Eigenvalue (λ) (= 11.52) to obtain the CI_AHP score. With this, as per the equation 3, the computed Consistency Index (CI_AHP) is 0.168 (n=10). Further, the value of CR_AHP is obtained (that is equal to 0.073), considering the value of RI (= 1.51 as per Table 3) for 10 factors, using equation4. As per the concept of the Consistency Ratio test for having consistency in the pairwise data, the computed value of CR_AHP should be less than 0.10. Here the computed value of CR_AHP is satisfying the condition. So, we conclude that the pairwise data considered for determining the relative importance of the factors (that is relative ranking of the factors) which are expected to influence CS-CL-AASSC from the perspective of customer 1, using an MCDM method AHP is a valid one. Similarly, the pairwise comparison for the other customers is found consistent. Theconsistency ratio (CR_AHP) for customer 2,3 & 4 is 0.09, 0.06 and 0.05 respectively. So, the rank obtained and presented in Table 9 for each of the identified factors is the final rank as per AHP methodology.

4.2 Rank Determination following AHP

In BWM, initially in ***step1***, 10 factors were identified from the literature are used for the analysis. Then in ***step 2***, the selected 4 customers were asked to identify the Best Factor (**BF**) and Worst Factor (**WF**) from the given 10 factors. The **BF** and **WF** were chosen by each of the 4 Customers approached of the data collection are given in Table 11.

Table 11: Customer wise, the Best Factor (BF) and Worst Factor (WF) for CS-CL-AASSC

Customer	Customer wise BF and WF	
	Best Factor (BF)	Worst Factor (WF)
1	Service Quality	Convenience service
2	Belief	Economic Service
3	Service Quality	Brand Awareness
4	Economic Service	Service Contract

In ***step 3***, Considering the best factor identified in the step 2, in this step each of the 4 customers was asked to benchmark the best factor to all other factors to generate a score, called as F_{BO} (Best-to-Other), using the 9-point scale. These collected scores (that is, F_{BO}) are given in Table 12.

Table 12: Customer wise, the comparison score between the Best Factor (BF) and to other Factors (OF)

Customer	Best Factor (BF)	Customer comparison Score between BF and the Other Factor (OF)									
		Belief (F1)	Brand Awareness (F2)	Service Quality (F3)	Product Quality (F4)	Economic Service (F5)	Convenience Service (F6)	Service Capability (F7)	Warranty Handling (F8)	Service Contract (F9)	Insurance Handling (F10)
1	Service Quality	1	8	1	2	1	9	4	7	5	6
2	Belief	1	4	5	1	2	3	6	8	7	8
3	Service Quality	1	3	1	1	5	1	2	3	1	5

4	Economic Service	5	8	1	4	1	5	6	5	6	5

In ***step 4***, Like Step 3, each of the 4 customers was asked to compare the Other Factors (OF) with the Worst Factor (WF) to generate a score, using the 9-point scale, called F_{OW} (Other-to-Worst). These collected scores (that is, F_{OW}) are given in Table 13.

In ***step 5***, using all the required inputs collected from each of the 4 customers for BWM (as presented in Tables 11,12, and 13), the mathematical model presented in (5) is developed for obtaining weights for each of the factors w.r.t. each of the 4 customers. Each of these 4 models is solved using LINGO and the optimal weight obtained for the factors is presented in Table 14.

Once the optimal weights for each of the factors w.r.t. each of the customers are obtained using the mathematical model, the consistency of the model is checked using equation (6) for each of the customers. For computing the value of CR_BWM, we need to get the Consistency Rate (ξ) and the Consistency Index (CI_BWM). The proposed mathematical model provides the value of the consistency rate (that is, the objective function value obtained from the proposed mathematical model). The CI_BWM value will be obtained using Table 5 (and this is equal to 5.96 considering 10 factors considered in this study for CS-CL- AASSC). Substituting these values in equation (6), the consistency ratio (CR_BWM) of the BWM for all the customers is given in Table 15.

In general, the CR value represents the degree of consistency, and the degree of consistency is accepted if the calculated value of CR is less than 0.1 (Rezaei 2015) or if the CR is below the threshold of the consistency ratio given in Liang et al. (2020). Here the calculated value of all CR_BWM is < 0.1 as per Rezaei et al. (2015) [also the calculated value of CR_BWM is < 0.4747 as per Liang et al., (2020)]. Therefore, the weights obtained and presented in Table 14for each of the factors using the data related to all the four Customers are valid.

Table 13: Customer wise, the comparison score between other factors (OF) with worst factor (WF)

Other Factor (OF)	Comparison Score between OF and the Worst Factor (WF)			
	Customer 1	Customer 2	Customer 3	Customer 4
	WF: Convenience service	*WF: Economic Service*	*WF: Brand Awareness*	*WF: Service Capability*
Belief (F1)	7	4	4	5
Brand Awareness (F2)	2	2	1	5
Service Quality (F3)	9	6	5	9
Product quality (F4)	7	8	7	6
Economic Service (F5)	8	1	3	9
Convenience service (F6)	1	3	5	6
Service capability (F7)	6	1	5	1

Warranty Handling (F8)	4	7	1	5
Service Contract (F9)	6	5	3	1
Insurance Handling (F10)	5	5	1	5

Table 14: Customer wise the optimal weight for the factor with their ranks

Factor	Optimal weight obtained from the proposed mathematical model for the data related to Customer				Average Weights of the Factor	Rank of the Factor
	1	**2**	**3**	**4**		
Belief	0.1825888	0.1927657	0.1542934	0.06411398	0.59376188	3
Brand Awareness	0.03423541	0.08335814	0.02683363	0.04007124	0.18449842	10
Service Quality	0.2191066	0.06668651	0.1274597	0.3098842	0.72313701	2
Product quality	0.1369416	0.3334326	0.1744186	0.08014248	0.72493528	1
Economic Service	0.2008477	0.02604942	0.03488372	0.2350846	0.49686544	4
Convenience service	0.01825888	0.1111442	0.1744186	0.06411398	0.36793566	5
Service capability	0.06847082	0.05557209	0.0872093	0.02493321	0.23618542	7
Warranty Handling	0.03912618	0.04167907	0.05813953	0.06411398	0.20305876	8
Service Contract	0.05477665	0.04763322	0.1274597	0.05342832	0.28329789	6
Insurance handling	0.04564721	0.04167907	0.03488372	0.06411398	0.18632398	9

Table 15: Consistency Rate and Consistency Ratio for all the customers

Indicator	**Customer**			
	1	**2**	**3**	**4**
Consistency Rate (ξ)	0.05477665	0.1406669	0.04695886	0.08548531
Consistency Ratio (CR_BWM)	0.00919	0.023602	0.0788	0.014343

Further, using the optimal factor weights obtained w.r.t. each of the 4 customers, the average optimal factor weight is computed and the same is given in the last but one column of Table 14. Using the 'average optimal factor weight', the rank of the factor (the factor which has maximum 'average optimal factor weight' is assigned as the topmost rank of the factors considered in the study) is obtained and the

same is presented in the last column of Table 14.

4.3Statistical Verification of the Ranking Determined using AHP and BWM for the Factors

The relativesignificance of the factors (that is ranking of the factors) for CS-CL-AASSC, obtained from two MCDM methods: AHP and BWM is verified statistically by conducting Kendall's tau test (τ) of correlation (Haas et al., 2004, Azadeh et al., 2009). The correlation coefficient is calculated to test the correlation between ranks prevailed from two different methods. Generally, when data are not normally spread out or have ordered categories, Kendall's tau test is used to measure the association between ranks.Accordingly, the statistical test: non-parametric correlation test - Kendall's tau test (τ) is carried out using IBM SPSS Software, and the results comes about gotten are appeared in Table 16. The analysis of the results given in Table 16, verifies that the finding is significant (i.e.) there exists a direct relationship between AHP and BWM ranks.

Table 16: Non-parametric Correlation Test on the 'Ranking of the Factors' Obtained from the Methods

			BWM	AHP
Kendall's tau	BWM	Correlation Coefficient	1.000	.556*
		Sig. (2-tailed)	.	.025
		N	10	10
	AHP	Correlation Coefficient	.556*	1.000
		Sig. (2-tailed)	.025	.
		N	10	10
*. Correlation is significant at the 0.05 level (2-tailed).				

Though both methods resulted similar types of importance of the factors considered in this study, the weights obtained for the factors using BWM are very much distinct from one another, therefore, BWM can be used instead of AHP in this case. Hence, we could use the rank obtained by the BWM to understand the relative importance of the factors for AASSC. Accordingly, from Table 14, one can suggest to the AASSC that the factors: Product Quality, Service Quality, Belief are the most important factors for achieving CS and CL, and the factors: Warranty Handling, Insurance Handling, and Brand Awareness are the least important factors. The Factors: Economic Service, Convenience Service, Service Contract, and Service Capability are moderately important factors for achieving CS and CL at AASSC.

5. Conclusion

This study aimed to prioritize the factors influencing customer satisfaction and customer loyalty (CS-CL) in automobile after-sales service centers (AASSC). A comprehensive literature review was conducted to identify a complete set of relevant and unique factors. Two multi-criteria decision-making (MCDM) methods—Analytic Hierarchy Process (AHP) and Best Worst Method (BWM)—were then employed to determine the relative importance of these factors by assigning weights to each.To validate the consistency between the two methods, Kendall's tau (τ), a non-parametric correlation test, was performed. The results indicated no statistically significant difference in the rankings derived from the two methods. However, the BWM provided more differentiated weight distributions across the factors compared to AHP, offering clearer insights into their relative importance.

Based on the BWM rankings, the following conclusions were drawn:

- **Most important factors:** Product Quality, Service Quality, and Belief emerged as the top three factors significantly influencing CS and CL in AASSC.
- **Moderately important factors:** Economic Service, Convenience Service, Service Contract,

and Service Capability showed a moderate level of influence.

- **Least important factors:** Warranty Handling, Insurance Handling, and Brand Awareness were identified as the least influential in driving CS and CL.

These insights provide a valuable foundation for AASSC managers and practitioners to prioritize their efforts and resources toward enhancing customer satisfaction and loyalty by focusing on the most impactful factors.

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Annexure 1:Data Collected for the AHP Model

S. No	Factor **Vs.** Factor	Pairwise Comparison Score as per the Respondent (Customer)			
		1	2	3	4
1	Belief V**s.** Brand Awareness	3	3	5	2
2	Belief **Vs.** Service Quality	1	1	2	1
3	Belief Vs. Product Quality	7	7	4	3
4	Belief Vs. Economic Service	1	4	3	1
5	Belief Vs. Convenient service	7	8	6	4
6	Belief Vs. Service Capability	8	7	4	7
7	Belief Vs. Warranty Handling	8	4	6	8
8	Belief Vs. Service Contract	9	7	9	9
9	Belief Vs. Insurance Handling	7	9	9	9
10	Brand Awareness Vs. Service Quality	1	2	1	1
11	Brand Awareness Vs. Product Quality	4	6	5	2
12	Brand Awareness Vs. Economic Service	2	1	1	1
13	Brand Awareness Vs. Convenient service	6	9	7	5
14	Brand Awareness Vs. Service Capability	6	7	7	3
15	Brand Awareness Vs. Warranty Handling	3	6	6	5
16	Brand Awareness Vs. Service Contract	5	6	5	6

17	Brand Awareness Vs. Insurance Handling	9	6	9	6
18	Service Quality Vs. Product Quality	8	7	6	6
19	Service Quality Vs. Economic Service	1	1	2	2
20	Service Quality Vs. Convenient service	4	8	7	5
21	Service Quality Vs. Service Capability	4	2	6	3
22	Service Quality Vs. Warranty Handling	3	3	5	5
23	Service Quality Vs. Service Contract	4	3	6	5
24	Service Quality Vs. Insurance Handling	6	3	5	4
25	Product Quality Vs. Economic Service	1	4	3	1
26	Product Quality Vs. Convenient service	2	8	4	2
27	Product Quality Vs. Service Capability	2	7	5	3
28	Product Quality Vs. Warranty Handling	2	3	4	4
29	Product Quality Vs. Service Contract	4	3	5	5
30	Product Quality Vs. Insurance Handling	3	3	4	6
31	Economic Service Vs. Convenient service	6	4	2	2
32	Economic Service Vs. Service Capability	4	4	4	3
33	Economic Service Vs. Warranty Handling	4	2	4	4
34	Economic Service Vs. Service Contract	5	7	5	6
35	Economic Service Vs. Insurance Handling	5	7	8	3
36	Convenient Service Vs. Service Capability	2	1	1	1
37	Convenient Service Vs. Warranty Handling	6	2	3	4
38	Convenient Service Vs. Service Contract	4	2	5	3

39	Convenient Service Vs. Insurance Handling	2	6	4	3
40	Service Capability Vs. Warranty Handling	7	2	1	4
41	Service Capability Vs. Service Contract	5	3	4	5
42	Service Capability Vs. Insurance Handling	5	3	5	4
43	Warranty Handling Vs. Service Contract	1	2	1	1
44	Warranty Handling Vs. Insurance Handling	1	2	1	2
45	Service Contract Vs. Insurance Handling	2	1	1	1