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Identifying and Prioritizing Factors Affecting the Quality of After-Sales Services with a Hybrid FUCOM and ARAS Techniques Under Uncertainty (Case Study: Mobile Phone Industry)

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ABSTRACT

Organizations can no longer overlook customer expectations and should focus their efforts and resources on ensuring customer satisfaction. The aim of this research is to identify and prioritize the factors that impact the quality of after-sales services. To achieve this goal, a new hybrid method combining FUCOM and interval fuzzy ARAS has been utilized, with the mobile phone industry as the selected case study. A total of 16 evaluation criteria, based on key dimensions of the SERVQUAL model that significantly influence the quality of after-sales services, have been identified. These criteria, in order of importance, include assurance, reliability, responsiveness, empathy, and tangibility. Considering the importance of these factors and the ranking of service levels, it is recommended that service providers prioritize transparency, quality assurance, innovation, customer interactions, feedback mechanisms, online presence, and organizational values when designing their service offerings. When analyzing the evaluation criteria without factoring in service levels, the criteria of service guarantee, professionalism, and competence emerge as the most critical factors.

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1) Introduction

Customer satisfaction is a multidimensional and broad concept. A wide range of variables can directly and indirectly affect customer satisfaction and loyalty throughout the customer life cycle. Therefore, to achieve customer satisfaction, companies need to consider various factors and continuously evaluate and improve their various service activities, such as handling customer inquiries and complaints, meeting customer expectations and the like (Sivadas & Baker-Prewitt, 2000). Among the many factors that affect customer satisfaction, after-sales service is undoubtedly one of the key drivers and predictors of customer satisfaction and retention (Kurata & Nam, 2010). Providing after-sales service for durable products is not only a market requirement or a legal obligation but also an opportunity for companies to strengthen their competitive edge. The role of service quality is recognized as a critical determinant of an organization's success in today's competitive environment. Any decrease in customer satisfaction, due to a deterioration in service quality, is a cause for concern in organizations. Consumers have become more aware of the increasing standards of services and expectations. In other words, service quality aspects play a significant strategic role. This is not limited to the service sector but also applies to cases where services are a significant part of the products. In fact, the concept of service quality can be applied to all sectors, especially to those where products have tangible and intangible aspects (Fazlzadeh et al., 2011). Many large companies have advanced measurement programs that assess customer evaluations of service and product quality (Zeithaml et al., 1990). In recent years, smart devices, such as mobile phones and tablets, have become one of the fastest growing communication tools, with their market growing and developing rapidly (Economides & Grousopoulou, 2009). The rapid increase in the consumer community and the short lifespan of mobile phones due to technological advancements have led to a significant increase in the need for after-sales services to maintain and update mobile phones. The value of the mobile phone after-sales service market in 2024 is projected to be close to $1.1 billion (Global Market Insights, 2025). Given the high penetration rate of mobile phones and their multi-purpose use in all situations, the need for high-quality services is increasingly important. In order to maintain a relationship with satisfied customers, organization managers must understand how to provide high-quality services. Additionally, considering that the cost of acquiring new customers is higher than retaining the existing ones, providing services to retain old customers is crucial (Shafiei & Jamshidi, 2022).

Customers are the lifeblood of an organization; in other words, no business can survive without customers. Therefore, it is crucial for every organization to have a framework for understanding, analyzing, and evaluating the state of customer satisfaction. Today, only those organizations that attract and retain customers in sufficient numbers will be successful and continue to exist and achieve significant success. According to most experts, one of the most reliable ways to achieve success and development of an organization is to ensure customer satisfaction by providing high-quality products and services (Mok et al., 2013). In today's highly competitive business environment, providing high-quality after-sales service to customers is a key aspect of an organization's mission (Huang et al., 2019). After-sales service allows for higher value creation during the product and customer lifecycle (Dombrowski et al., 2011). For different levels in the supply chain, such as retailers, suppliers, and manufacturers, it is crucial to establish a reasonable after-sales policy that leads to the highest level of customer satisfaction. If manufacturing companies focus on key after-sales services, they can achieve up to four times the product sales level and more than three times the original purchase turnover rate during the product lifecycle. Therefore, identifying customer needs and providing after-sales services related to each customer is mandatory (Ahn & Sohn, 2009). Identifying the factors affecting the quality of after-sales services is crucial and affects the overall performance of the organization and ultimately customer satisfaction. Various models have been presented in the literature for evaluating service quality. In this study, the comprehensive Servqual model will be used as the basic model and the basis for development. The key innovation of the research is based on two aspects: the development of an evaluation model and a new hybrid decision-making method for prioritizing the factors and options under evaluation. The evaluation in the mentioned model will be based on the general framework of the dimensions of the Servqual model, including tangible factors, reliability, responsiveness, assurance, and empathy. The comprehensive sub-criteria in each dimension will also be identified and customized according to the research case study in the mobile phone after-sales service industry, using the Delphi method and based on the opinions of experts. Another aspect of the innovation of the model is based on the development of a combined fuzzy FACOM-ARS method. For this purpose, the ARS method has been expanded based on triangular fuzzy numbers with interval values.

- Tangible factors: Physical equipment, tools, and the appearance of employees in the environment.
- Reliability: The ability of a service organization to fulfill its promises accurately and consistently.
- Responsiveness: The ability of a service organization to provide services quickly and on time.
- Assurance: Includes competence (having the necessary knowledge and skills to provide service), courtesy (respect and friendliness of the organization's employees towards customers), credibility (reliability, acceptability, and trustworthiness of employees), security (low probability of doubt and hesitation in receiving services from customers).
- Empathy: Includes customer understanding (trying to identify customers and their specific needs), communication (keeping customers informed in a language they understand and truly listening to what they say), and accessibility.

The main questions addressed in this study, with the mobile phone industry as the case study, are: (1) What factors impact the quality of after-sales service in the mobile phone industry? and (2) How can the prioritization of these factors and desired service levels be determined using the combined FUCOM-Fuzzy ARAS method in the mobile phone industry? To achieve this, the study will first identify a comprehensive set of important and influential factors on the quality of after-sales services through the use of expert opinions and library research. Subsequently, these factors will be weighted using the FUCOM method, and ultimately prioritized using the interval fuzzy ARAS method.

2) Literature Review

In today's highly competitive business environment, every organization must prioritize satisfying its customers to survive (Rezaeenour & Deimazar, 2022). Service refers to an activity or a set of largely intangible actions that typically, though not necessarily, occur through interactions between customers and service employees, physical resources or goods, and service-providing systems. Services are primarily offered as solutions to customer problems (Gremler et al., 2020). They encompass economic activities that create value for customers at a specific time and place, resulting in a positive and desirable experience for the service recipient. In other words, service is a package of explicit and implicit benefits and advantages derived from the use of facilitating goods, supporting equipment, and facilities. Due to the diversity of services, defining them has always been challenging. This complexity is compounded by the intangible nature of most service data and outputs, making it difficult to understand and recognize how services are performed and delivered (Hosseini et al., 2020). The term has a broad range of meanings, leading to considerable ambiguity in management literature. Among the many definitions, the most widely accepted is that service quality involves meeting or exceeding customer expectations. Service quality is defined in various ways based on customer needs and expectations; one common definition describes it as the size and direction of the gap between customer perceptions of the service and their expectations (Shafiei & Jamshidi, 2022). Therefore, identifying and prioritizing the factors that affect the quality of after-sales services has long been a focus of research, with various methods employed to achieve this (Murali & Pugazhendhi, 2016). Emphasizing service quality offers several benefits, including increased customer satisfaction, which leads to greater loyalty and market share. Additionally, service quality enhances company profitability by attracting new customers and retaining existing ones (Gremler et al., 2020). It also improves the organization's reputation, customer retention, and profits by reducing costs, increasing demand for services, and generating positive word-of-mouth communication (Seiler et al., 2017).

As the competitive environment intensifies, organizations strive to maintain or expand their market share by offering a variety of services. Hosseini et al. (2020) examined the effects of perceived service quality and fair pricing on customer satisfaction, both directly and indirectly through company image. Their study focused on the users of Irancell services in Iran and Turkcell in Turkey, with samples selected via a random availability method. Data were collected using an electronic questionnaire designed with a five-point Likert scale, based on reliable sources; its reliability and content validity were tested and confirmed. The results indicated that perceived service quality positively and significantly influences customer satisfaction through company image both directly and indirectly. Additionally, perceived fair pricing had a positive and significant direct effect on customer satisfaction, but its indirect effect mediated by company image was not supported. In another study, Dombrowski et al. (2011) investigated the changes and challenges in after-sales service resulting from the shift to electric mobility in automobiles. The automotive after-sales market is crucial for the sustainable success of OEMs, suppliers, and service stations. However, the anticipated technological transition from internal combustion engines to electric vehicles will profoundly impact the entire after-sales market. Companies must adapt their business strategies to remain competitive and explore new business segments, as the growing share of electric vehicles significantly affects automotive after-sales services. Kurata and Nam (2010) analyzed competition in after-sales service within the supply chain for consumer durables, finding that after-sales service plays a vital role in customers' purchasing decisions. Manufacturers provide an initial warranty to all product customers, while retailers offer optional after-sales services available only to paying customers. By investigating the interaction of these two services across two customer segments and developing five analytical models, they found that profit-maximizing after-sales service programs do not align with the optimal service levels that maximize customer satisfaction. Ahan and Sohn (2009) proposed a framework incorporating fuzzy and canonical clustering to identify customer groups and their needs, aiming to discern customer patterns for after-sales service in manufacturing. Their results identified three customer groups: The first group exhibited high satisfaction, loyalty, and number of complaints; the second group showed very high satisfaction and loyalty with a low number of complaints; and the third group demonstrated medium levels of satisfaction, complaints, and loyalty.

In their study on service quality, Aboubakr and Bayoumi (2022) evaluated the quality of educational services for dental and nursing students using the SERVQUAL model. They employed a cross-sectional convenience sampling method to recruit dental and nursing students from both public and private sectors in Egypt and Saudi Arabia. The findings indicated that students' perceptions of the quality of educational services were above average. The field of study had the greatest impact on perceived service quality. Additionally, the academic year and educational departments significantly influenced the quality of educational services. Similarly, Shafiei and Jamshidi (2022) assessed the quality of after-sales services at Kia Motors dealerships in Tehran using the SERVQUAL model. The study population consisted of Kia Motors vehicle owners in Tehran. The results revealed that the dealerships in Tehran failed to meet their customers' expectations.

In another study, Javan Amani and Akbari (2022) examined the effect of banking service quality on customer satisfaction using the Servqual model in Tehran Maskan Bank by statistical analysis. The results indicate that tangible factors, empathy between bank employees and customers, bank guarantees and assurances, accountability, and physical and visual dimensions have an impact on customer satisfaction with service quality in Maskan Bank. Alizadeh et al. (2025) systematically reviewed the literature on the subject in the field of evaluating service quality in Iranian hospitals from the perspective of patients based on the Servqual model with a meta-analysis approach. Rabbad (2025) examined the effect of service quality on customer purchase intention and loyalty based on the Servqual model in the e-business environment, using statistical analysis approach. Satish Kumar et al. (2025) evaluated service quality based on the Servqual model using a statistical analysis approach in the Honda Motorcycle Manufacturing Company in India and found that responsiveness is the highest service gap, followed by reliability. Divandari and Torkashvand (2011) have identified the factors of after-sales service quality and examined the relationship between those factors and customer satisfaction in an informatics service company. The results after collecting information and performing the required statistical analyses indicate that there is a significant relationship between the aforementioned components and user satisfaction with the company's after-sales service. Based on the summary of prior studies, the key factors affecting the quality of after-sales service have been extracted, as shown in Table 1. The results of the study indicate that despite the importance of the issue of evaluating the quality of after-sales service from various functional aspects, there is still a need to develop a comprehensive model. This is while in addition to the comprehensiveness of the required model, adaptation to the specific characteristics required by each industry will also increase the necessity of developing customized models. Therefore, in the present study, a comprehensive model will be presented in terms of the scope of effective evaluation criteria for the mobile phone after-sales service industry.

Table 1) Factors Affecting the Quality of After-Sales Service

Factors	Components	Refrences
Tangibility	Availability of information and advice at the service center, proximity to the service center, modern-looking equipment and facilities, visually appealing service materials, convenient opening hours	Ahmed & Masud (2014); Kumar (2017); Shokouhyar et al., (2020); WhgShi & Shang (2020)
Reliability	Providing service as promised, availability of spare parts during service calls, availability of technical service personnel, consistency of service quality, selection and scope of services, good customer services during the warranty period	Van Birgelen et al. (2002); Shokouhyar et al. (2020); Wilson & Frimpong (2012)
Responsibility	Prompt identification of defects, time spent on service, time spent on complaint resolution, store employee provides prompt service to customers, reasonable warranty policy, response to customer complaints	Kansra & Jha (2016); Van Birgelen et al. (2002); Shokouhyar et al. (2020); Ahmed & Masud (2014)
Assurance	Competence and experience of staff, general attitude and behavior of technician, customer care, professionalism of service personnel, interpersonal behavior of service personnel	Shokouhyar et al. (2020); Wilson & Frimpong (2012)
Empathy	Personal interactions between service frontline and customers, personal attention of staff, availability of service personnel, service contract options	Badri et al. (2005); Naik et al. (2010); Yousapronpaiboon (2014); Manulik et al. (2016)

3) Researcg Method

In this study, a mixed qualitative-quantitative approach was employed to address the research questions (Figure 1). The initial identification of evaluation criteria was based on a literature review and expert interviews, followed by final identification and validation using the Fuzzy Delphi method (Habibi et al., 2015; Hasani et al., 2024). The initial phase of identifying factors affecting the quality of mobile phone after-sales services utilized purposive sampling, with the sample size determined to achieve saturation. In this phase, the sample comprised 19 experts from the mobile phone industry, academia, and prominent organizational consultants. Questionnaires for each Fuzzy Delphi round were distributed and collected electronically. In the first round, a list of factors and components influencing the quality of after-sales services, derived from the literature, was provided to all panel members to assess the importance of each factor. Panelists were also invited to suggest additional factors and components. Expert opinions were collected using a five-point Likert scale: "very high impact: 5," "high impact: 4," "medium impact: 3," "low impact: 2," and "very low impact: 1," with level 3 serving as the neutral midpoint. Accordingly, two ranges were defined: disagreement (1 to 3) and agreement (3 to 5). The corresponding triangular fuzzy numbers for this Likert scale are presented in Table 1.

Table 1)Equivalent Triangular Fuzzy Numbers for a Five-Point Likert Scale

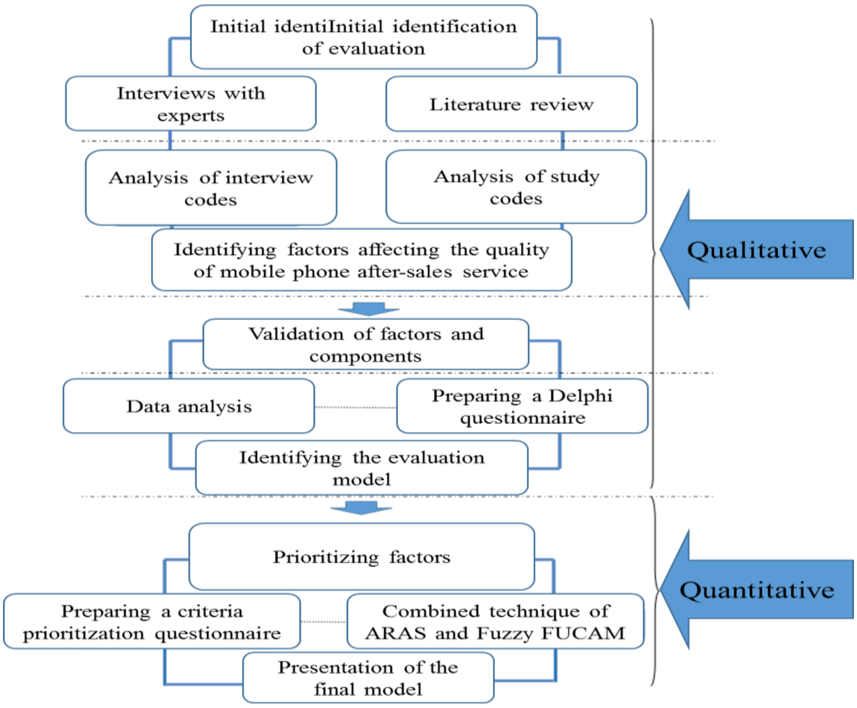
Language phrase (Likert scale)	Triangular fuzzy number

Very high impact	(0.75,1,1)
High impact	(0.5,0.75,1)
Moderate impact	(0.25,0.5, 0.75)
Low impact	(0, 0.25,0/5)
Very low impact	(0,0,0.25)

In the analysis of the first-round questionnaires, the average responses to some questions did not fall within the agreement range. Consequently, certain factors and components were removed or added for the second round. In this round, each member's opinions from the previous round were shared with other members, who were then asked to reevaluate each element. After completing this round and reaching a consensus, the Fuzzy Delphi method was concluded, and the factors and components were finalized. Based on the data obtained from the Fuzzy Delphi rounds and the various sections of the questionnaire in each round, the average statistical index was calculated. The questionnaire distribution followed the Fuzzy Delphi method in two stages. In each stage, items with a mean score greater than 0.7 were included in the subsequent round, while components with a mean below 0.7 were eliminated. Additionally, consensus indices and the level of expert agreement were calculated for each round. The average responses of the panel members in both rounds were computed regarding the importance of the factors. Furthermore, the defuzzification value, measuring the level of expert consensus in the first round, was below 0.7 for some components affecting the quality of after-sales services. However, in the second round, the defuzzification value for the level of agreement and consensus among experts on the factors and components influencing after-sales service quality exceeded 0.7, indicating the alignment of opinions. Subsequently, the prioritization of evaluation criteria and options was performed using a novel combination of the Phacom weighting method and the interval fuzzy ARS multi-criteria decision-making approach. The advantage of the Phacom and ARS methods lies in reducing the number of pairwise comparisons and minimizing the need for extensive expert judgments. Phacom was employed to weight the criteria, while the ARS method was used to rank the options. The following outlines the implementation steps of these decision-making methods. As system analysis complexity increases, obtaining accurate and definitive data becomes challenging. In such cases, fuzzy set theory serves as a powerful tool for handling uncertain and ambiguous data (Ghasemi et al., 2022). The sampling method during the factor prioritization stage was purposive, with 10 experts available to implement the combined FUCOM-Fuzzy ARAS method in this study.

Weighting Method Based on Complete Consistency (FUCOM): The FUCOM weighting method relies on pairwise comparisons and accounts for deviations from maximum consistency. FUCOM requires only n-1 pairwise comparisons to assign weights to n criteria. The deviation from maximum consistency is used to validate the FUCOM results. The FUCOM implementation steps of FACOM are as follows (Božanić et al., 2020):

Figure 1) General Steps of the Research Method



Step 1: The set of target criteria $C = \{C_1, C_2, \ldots, C_n\}$ are initially ranked according to their importance (Relationship 1).

$$C_{j(1)} > C_{j(2)} > \cdots > C_{j(k)} \qquad \text{Equation (1)}$$

Step 2: The compared ranking criteria and the comparative priority $\varphi_{(k)/(k+1)}, k = 1,2,\cdots,n$ where k represents the order of the criteria. The criteria are determined according to the relation (2):

$$\Phi = \left(\varphi_{1/2}, \varphi_{2/3}, \cdots, \varphi_{k/(k+1)}\right) \qquad \text{Equation (2)}$$

Step 3: The weight coefficients of the target criteria $(w_1, w_2, \cdots, w_n)^T$ are calculated. These values must meet the following conditions:

1. The weight coefficients w_k are proportional to the comparative priorities φ_k:

$$\frac{w_{(k)}}{w_{(k+1)}} = \varphi_{k/(k+1)} \qquad \text{Equation (3)}$$

2. The following mathematical relationship must be observed among all comparative priorities φ_k:

$$\varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} = \varphi_{k/(k+2)} \qquad \text{Equation (4)}$$

Step 4: To calculate the optimal weight $(w_1, w_2, \cdots, w_n)^T$ of the target criteria, the following optimization problem must be solved.

Min X

s.t.

$$\left|\frac{w_{(k)}}{w_{(k+1)}} - \varphi_{k/(k+1)}\right| < \chi \quad , \forall_j$$

Equation (5)

$$\left|\frac{w_{(k)}}{w_{(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)}\right| < \chi \quad ,\forall_j$$

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

$$w_j \geq 0, \forall j$$

Interval Fuzzy ARS Multi-Criteria Decision Making Method: Acccording to Turskis and Zavadskas (2010), the ARS method has six general steps. They argue that the ratio of the sum of the scores of the normal and weighted criteria, describing the desired alternative, to the sum of the values of the normal and weighted criteria, describing the desired alternative, is the degree of optimum, which is achieved by the alternative in comparison. The ARS method allows to determine the level of performance of the alternative and shows the ratio of each alternative to the ideal.

Formation of the Decision Matrix: The decision matrix (relation 6) is used to evaluate the alternatives of the problem; therefore, it is a matrix whose rows are the alternatives (m) and its columns are the criteria (n) of the research. Moreover, each cell of this matrix is the evaluation of each alternative with respect to each criterion.

$$X = \begin{bmatrix} x_{01} & \cdots & x_{0j} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}; i = \overline{0, m}\,; j = \overline{1, n} \qquad \text{Equation (6)}$$

Determining the Hypothetical Ideal Value: The ideal value for positive criteria (B) will be equal to the highest value, while for negative criteria (C), it will be equal to the lowest value (Equation 7).

$$X_{0j} = \max X_{ij} \qquad \forall j \in B \qquad \text{Equation (7)}$$

$$X_{0j} = \min X_{ij} \qquad \forall j \in C$$

Normalizing the Decision Matrix: Positive and negative criteria must be normalized separately, which is done using the following relationships in this process.

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \cdots & \bar{x}_{0j} & \cdots & \bar{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{i1} & \cdots & \bar{x}_{ij} & \cdots & \bar{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mj} & \cdots & \bar{x}_{mn} \end{bmatrix}; i = \overline{0, m}\,; j = \overline{1, n} \qquad \text{Equation (9)}$$

$$\bar{X}_{ij} = \frac{X_{ij}}{\sum_{i=0}^{m} X_{ij}} \qquad \forall j \in B \qquad \text{Equation (9)}$$

$$\bar{X}_{ij} = \frac{\frac{1}{X_{ij}}}{\sum_{i=0}^{m} \frac{1}{X_{ij}}} \qquad \forall j \in C \qquad \text{Equation (10)}$$

Weighting the Decision Matrix: The weight calculated for the criteria using the Facom method is multiplied by the normalized criteria values to obtain the weighted matrix.

$$0 < \omega_j < 1 , \sum_{j=1}^{n} \omega_j = 1$$ Equation (11)

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \cdots & \hat{x}_{0j} & \cdots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} & \cdots & \hat{x}_{ij} & \cdots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{m1} & \cdots & \hat{x}_{mj} & \cdots & \hat{x}_{mn} \end{bmatrix}; i = \overline{0, m}\,; j = \overline{1, n}$$

$$\hat{x}_{ij} = \bar{x}_{ij}\omega_{ij}\,; i = \overline{0, m}$$

Calculating the Total Utility for Each Option: For this purpose, the weighted normalized numbers are added together in rows. The largest value of Si is the best, while the smallest is the worst. According to the calculated trend, the optimality function Si has a direct and proportional relationship with the values of xij and the weights of the examined criteria wj and their relative influence on the final result. Therefore, the largest value (value) of the optimality function Si is the most effective variable. The priorities of the options can be determined according to the value of Si. As a result, this method is suitable for evaluating and ranking decision-making options.

$$S_i = \sum_{j=0}^{n} \hat{X}_{ij} \qquad \forall i \in \{1,2,3, \ldots, m\}$$ Equation (12)

Calculating the Total Utility for Each Option: For this purpose, the weighted normalized numbers are added together in rows. The largest value of Si is the best and the smallest is the worst. According to the calculated trend, the optimality function Si has a direct and proportional relationship with the values of xij and the weights of the examined criteria wj and their relative influence on the final result. Therefore, the largest value (value) of the optimality function Si is the most effective variable. The priorities of the options can be determined according to the value of Si. As a result, this method is suitable for evaluating and ranking decision-making options.

$$K_i = \frac{S_i}{S_0}\,; i = \overline{0, m}$$ Equation (13)

In the following, an extension of the ARS method based on interval-valued triangular fuzzy numbers will be presented based on the model presented by Sheikh and Shambayati (2018) and Heydari Dahoui et al. (2018). The advantage of considering interval values is that it better represents the uncertainty and ambiguity present in the evaluation process compared to fuzzy analysis with non-interval values (Sheikh & Shambayati, 2018).

Optimal Performance Ranking for Each Criterion: The optimal performance ranking for each criterion should be calculated as a fuzzy number with an interval value. Therefore, the fuzzy performance with the optimal interval value of the ranking can be determined as follows:

$$\tilde{x}_{0j} = \left[\left(l_{0j}, \acute{l}_{0j}\right), m_{0j}, \left(\acute{u}_{0j}, u_{0j}\right)\right]$$ Equation (14)

Where x ̃0j represents the fuzzy function ranking with the optimal interval value of criterion j.

Furthermore, other criteria are defined as follows:

$$l_{0j} = \begin{cases} \max\limits_i l_{ij}; j \in \Omega_{max} \\ \min\limits_i l_{ij}\,; j \in \Omega_{min} \end{cases}$$ Equation (15)

$$\hat{l}_{0j} = \begin{cases} \max_i \hat{l}_{ij}; j \in \Omega_{max} \\ \min_i \hat{l}_{ij}; j \in \Omega_{min} \end{cases}$$

$$m_{0j} = \begin{cases} \max_i m_{ij}; j \in \Omega_{max} \\ \min_i m_{ij}; j \in \Omega_{min} \end{cases}$$

$$\hat{u}_{0j} = \begin{cases} \max_i \hat{u}_{ij}; j \in \Omega_{max} \\ \min_i \hat{u}_{ij}; j \in \Omega_{min} \end{cases}$$

$$u_{0j} = \begin{cases} \max_i u_{ij}; j \in \Omega_{max} \\ \min_i u_{ij}; j \in \Omega_{min} \end{cases}$$

Calculating the Normalized Decision Matrix: To enable the use of these interval-valued fuzzy numbers, a normalization process is required (Equation 16).

$$\tilde{r}_{ij} = \begin{cases} \left[\left(\frac{a_{ij}}{c_j^+}, \frac{\acute{a}_{ij}}{c_j^+}\right), \frac{b_{ij}}{c_j^+}, \left(\frac{\acute{c}_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right)\right] ; j \in \Omega_{max} \\ \left[\left(\frac{\frac{1}{a_{ij}}}{a_j^-}, \frac{\frac{1}{\acute{a}_{ij}}}{a_j^-}\right), \frac{\frac{1}{b_{ij}}}{a_j^-}, \left(\frac{\frac{1}{\acute{c}_{ij}}}{a_j^-}, \frac{\frac{1}{c_{ij}}}{a_j^-}\right)\right] ; j \in \Omega_{min} \end{cases} \quad \text{Equation (16)}$$

Here, r̃ij is the optimal interval-valued fuzzy function ranking for the ith alternative on the jth variable; therefore,

$$a_j^- = \sum_{i=0}^{m} \frac{1}{a_{ij}} \text{ , } c_j^+ = \sum_{i=0}^{m} c_{ij} \text{ , } i = 0,1, \dots, m \quad \text{Equation (17)}$$

Calculating the Decision Matrix with Normalized Weighted Distance: In this step, the distance values will be calculated based on the rule of multiplication of triangular fuzzy numbers.

$$\tilde{\upsilon}_{ij} = \tilde{\omega}_j . \tilde{r}_{ij} \quad \text{Equation (18)}$$

Where $\tilde{\upsilon}$ ij is the normalized weighted interval-valued fuzzy performance ranking for the ith option on the jth criterion.

Overall interval-valued fuzzy performance ranking:

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{\upsilon}_{ij} \quad \text{Equation (19)}$$

Step 5: The utility of each alternative is calculated in this step. Since the result obtained from the previous step is presented as fuzzy numbers with an interval value, the calculation process is often more complicated with the overall degree of utility.

The following relations are proposed for the defuzzification of interval-valued triangular fuzzy numbers:

$$bnp = \frac{(1-\lambda)l + \lambda l + m + \lambda \acute{u} + (\acute{1} - \lambda)u}{5} \quad \text{Equation (20)}$$

In the above equation, λ is a coefficient between [0,1]; this coefficient gives more importance to the parameters.

The conversion to a non-fuzzy number of the degree of desirability is done using equation (21).

$$\tilde{Q}_i = \frac{\tilde{S}_i}{\tilde{S}_0} \qquad \text{Equation (21)}$$

Step 6: The alternatives are ranked and the most efficient ones are selected.

4) Results

The conceptual model of the research based on the findings of the initial criteria identification stage is presented in Figure 2. Descriptive analyses and overall results from data collection related to the opinions of the fuzzy Delphi panel are presented in Tables 1 to 4.

Figure 2) Initial Conceptual Model of the Research

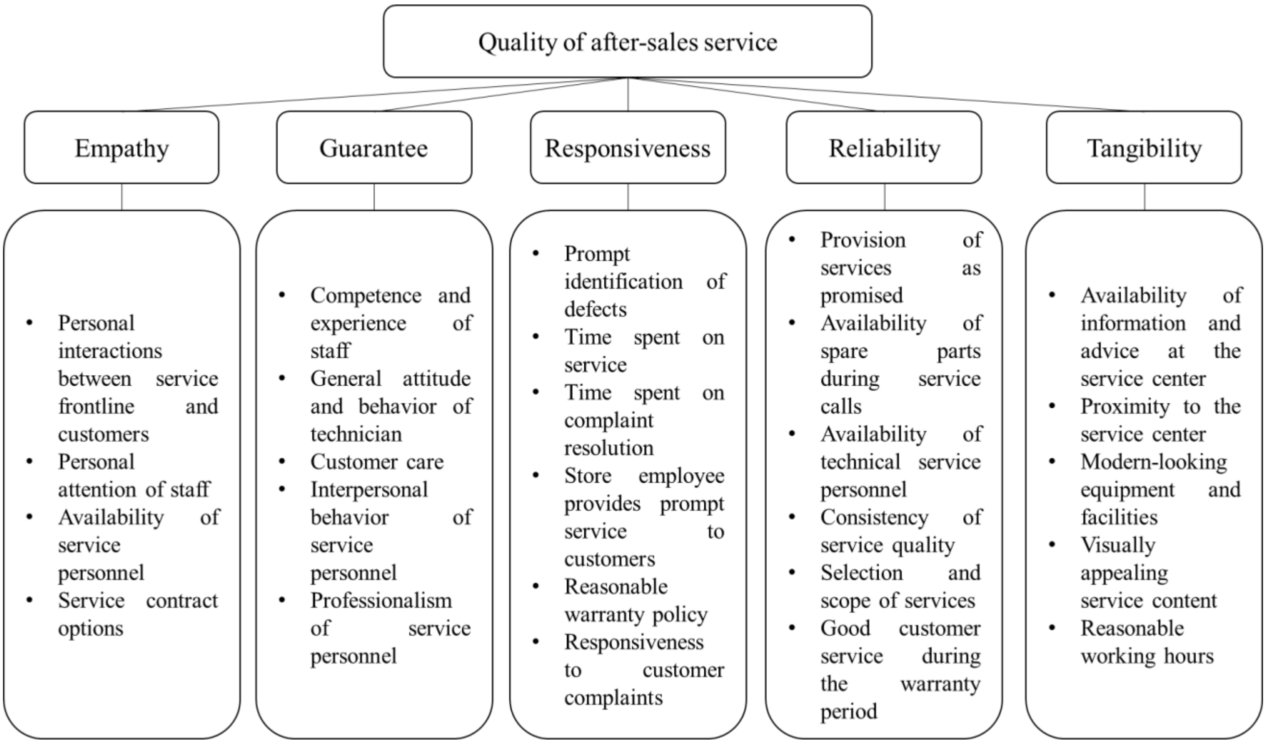


Table 1) Results of the First Round of Fuzzy Delphi

ID	Group	Subgroup	Recommended components	Number of responses	Average responses
1	Factors affecting the quality of after-sales service	Tangibility	Availability of information and advice at the service center	19	0.83
2			Proximity to the service center	19	0.80
3			Modern-looking equipment and facilities	19	0.93
4			Visually appealing service content	19	0.86
5			Reasonable working hours	19	0.93
6		Reliability	Provision of services as promised	19	0.86
7			Availability of spare parts during service calls	19	0.86
8			Availability of technical service personnel	19	0.93

9			Consistency of service quality	19	0.95
10			Selection and scope of services	19	0.93
11			Good customer service during the warranty period	19	0.86
12		Accountability	Prompt identification of defects	19	0.86
13			Time spent on service	19	0.91
14			Time spent on complaint resolution	19	0.89
15			Store employee provides prompt service to customers	19	0.91
16			Reasonable warranty policy	19	0.86
17			Responsiveness to customer complaints	19	0.86
18		Guarantee	Competence and experience of staff	19	0.91
19			General attitude and behavior of technician	19	0.92
20			Customer care	19	0.86
21			Interpersonal behavior of service personnel	19	0.86
22			Professionalism of service personnel	19	0.93
23		Empathy	Personal interactions between service frontline and customers	19	0.91
24			Personal attention of staff	19	0.91
25			Availability of service personnel	19	0.91
26			Service contract options	19	0.86

Table 2) Defuzzification of the Results of the First Round of Fuzzy Delphi

ID	Group	Subgroup	Recommended components	Defuzzfied	Status
1	Factors affecting the quality of after-sales service	Tangibility	Availability of information and advice at the service center	0.605	Disapproved
2			Proximity to the service center	0.588	Disapproved
3			Modern-looking equipment and facilities	0.737	Approved
4			Visually appealing service content	0.658	Disapproved
5			Reasonable working hours	0.746	Approved
6		Reliability	Provision of services as promised	0.632	Disapproved
7			Availability of spare parts during service calls	0.649	Disapproved
8			Availability of technical service personnel	0.754	Approved
9			Consistency of service quality	0.794	Approved
10			Selection and scope of services	0.746	Approved
11			Good customer service during the warranty period	0.640	Disapproved
12		Accountability	Prompt identification of defects	0.640	Disapproved

13			Time spent on service	0.702	Approved
14			Time spent on complaint resolution	0.706	Approved
15			Store employee provides prompt service to customers	0.711	Approved
16			Reasonable warranty policy	0.640	Disapproved
17			Responsiveness to customer complaints	0.640	Disapproved
18		Guarantee	Competence and experience of staff	0.702	Approved
19			General attitude and behavior of technician	0.759	Approved
20			Customer care	0.640	Disapproved
21			Interpersonal behavior of service personnel	0.640	Disapproved
22			Professionalism of service personnel	0.772	Approved
23		Empathy	Personal interactions between service frontline and customers	0.702	Approved
24			Personal attention of staff	0.737	Approved
25			Availability of service personnel	0.711	Approved
26			Service contract options	0.640	Disapproved

Based on expert opinions, some sub-criteria were removed after the first Delphi process, such as the immediate identification of defects. When repairing damaged mobile devices, defects can generally be categorized into two types. The first type includes clear and distinct defects, such as screen damage or no sound, which are straightforward issues that do not require a complex troubleshooting process. The second type involves cases like the device turning off or failing to transmit a signal, which can take longer to diagnose due to the wide range of potential causes. A successful repair process includes troubleshooting, parts procurement, and parts replacement. The latter two typically account for a small portion of the total repair time, while accurate fault diagnosis often requires the most time. Consequently, technicians prioritize achieving a correct diagnosis, even if it takes longer. From the customer's perspective, the total time spent on problem solving and completing repairs—including troubleshooting, parts procurement, and parts replacement—is what matters, not just the troubleshooting phase. Additionally, several issues arise regarding good customer service during the warranty period. In this context, the warranty provided to the customer applies only to the specific service performed. For example, if a phone had a sound problem, the warranty covers the repair of that issue, assuring the customer of the service quality. Therefore, the warranty service is limited and not comprehensive. In this study, for the reliability component, other options were considered more comprehensive and were approved by experts, such as confirming the selection and scope of services versus merely providing services as promised.

Table 3) Results of the Second Round of Fuzzy Delphi

ID	Group	Subgroup	Recommended components	Number of responses	Average responses		
1	Factors affecting the quality of	Tangibility	Staff attitude and appearance	19	0.91	0.74	0.49
2			Modern-looking equipment and facilities	19	0.93	0.76	0.51

3	after-sales service		Reasonable working hours	19	0.93	0.78	0.53
4		Reliability	Fair prices and fees	19	0.93	0.79	0.54
5			Availability of technical service staff	19	0.93	0.79	0.54
6			Consistency of service quality	19	0.95	0.84	0.59
7			Selection and scope of services	19	0.93	0.78	0.53
8		Responsivenss	Customer response time	19	0.91	0.72	0.47
9			Time spent resolving problems and completing repairs	19	0.89	0.74	0.49
10			Ability to personalize services	19	0.91	0.74	0.49
11		Guarantee	Competence, honesty, and reliability of staff	19	0.91	0.72	0.47
12			Service guarantee	19	0.92	0.80	0.55
13			Professionalism of service personnel	19	0.93	0.82	0.57
14		Empathy	Personal interactions between frontline service and customers	19	0.91	0.72	0.47
15			Feeling of value	19	0.91	0.78	0.53
16			Customers receive a sense of appreciation	19	0.91	0.74	0.49

Table 4) Defuzzification Results of the Second Round of Fuzzy Delphi Data

ID	Group	Subgroup		Recommended components	Defuzzfied	Status
1	Factors affecting the quality of after-sales service	Tangibility	A	Staff attitude and appearance (A1)	0.711	Approved
2				Modern-looking equipment and facilities (A2)	0.737	Approved
3				Reasonable working hours (A3)	0.746	Approved
4		Reliability	C	Fair prices and costs (C1)	0.754	Approved
5				Availability of technical service staff (C2)	0.754	Approved
6				Consistency of service quality (C3)	0.794	Approved
7				Selection and range of services (C4)	0.746	Approved
8		Responsivenss	B	Customer response time (B1)	0.702	Approved
9				Time spent resolving problems and completing repairs (B2)	0.706	Approved
10				Ability to personalize services (B3)	0.711	Approved
11		Guarantee	D	Service guarantee (D1)	0.702	Approved
12				Competence, honesty, and reliability of staff (D2)	0.759	Approved
13				Professionalism of service personnel (D3)	0.772	Approved
14		Empathy	E	Personal interactions between frontline service personnel and customers (E1)	0.702	Approved
15				Feeling of value (E2)	0.737	Approved
16				Customers receive a sense of appreciation (E3)	0.711	Approved

Experts' opinions were gathered to assess the importance of the final evaluation criteria using a seven-point Likert scale (Table 5).

Table 5) Seven-Point Likert Scale (Linguistic Equivalent) and Associated Fuzzy Triangular Number

Linguistic variables	**Numeric value**	**Fuzzy triangle number**
Very high (VH)	7	(0.9,1,1)
High (H)	6	(0.7,0.9,1)
Moderate to high (MH)	5	(0.5,0.7,0.9)
Medium (M)	4	(0.3,0.5,0.7)
Moderate to low (ML)	3	(0.1,0.3,0.5)
Low (L)	2	(0,0.1,0.3)
Very low (VL)	1	(0,0,0.1)

The weight estimation of the criteria was conducted using the FUCOM multi-criteria decision-making method. Initially, experts' opinions were aggregated using the geometric mean. In the first step, the criteria were ranked, starting with the criterion expected to have the highest weight coefficient and continuing to the least important criterion. In the second step, the ranked criteria were compared by determining the priority of the kth criterion over the (k+1)th criterion. In the third step, the weight coefficients of the target criteria were calculated. Finally, the relative weight of each criterion in relation to the others was determined (see Table 6). In this study, to account for different conditions and preferences in service provision, four service levels with varying conditions, as detailed in Appendix 1, were offered to customers, who then selected their preferred level. Additionally, to integrate technical aspects with emotional marketing in the service levels, factors such as special product discount cards, bill payment terms, courier shipping and receiving, and provision of a replacement device during repairs were considered. Experts assigned scores to each criterion based on the selection of each service level separately. Further information on the Levels of Service (LOS), derived from market studies conducted by the company providing after-sales mobile phone services (used as a case study), is provided in Appendix 1.

Table 6) Final Weight of the Criteria Using the Phacom Method

Criteria	**Weight**	**Subcriteria**	**Relative weight**	**Final weight**		**Criteria**	**Weight**	**Subcriteria**	**Relative weight**	**Final weight**
A	0.061	A1	0.309	0.019		C	0.204	C3	0.181	0.037
		A2	0.355	0.0217				C4	0.134	0.027
		A3	0.336	0.020		D	0.459	D1	0.34	0.156
B	0.153	B1	0.439	0.067				D2	0.327	0.150
		B2	0.346	0.053				D3	0.333	0.153
		B3	0.215	0.033		E	0.123	E1	0.328	0.040
C	0.204	C1	0.291	0.06				E2	0.38	0047
		C2	0.394	0.08				E3	0.292	0.035

Table 7) Alternative Decision Matrix

	IA	**LOS 1**	**LOS 2**	**LOS 3**	**LOS 4**
A1	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.300,0.499),0.706,(0.883,1.000)}	{(0.3000,0.4994),0.706,(0.8834,1.000)}	{(0.5000,0.7057),0.883,(0.9S791,1.000)}	{(0.500,0.706),0.883,(0.9791,1.000)}
A2	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.300,0.483),0.688,(0.874,1.000)}	{(0.3000,0.4994),0.706,(0.8834,1.00)}	{(0.5000,0.6882),0.874,(0.9791,1.00)}	{(0.500,0.706),0.883,(0.9791,1.000)}
A3	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.300,0.483),0.688,(0.874,1.000)}	{(0.300,0.499),0.706,(0.883,1.000)}	{(0.500,0.688),0.874,(0.979,1.000)}	{(0.500,0.706),0.883,(0.979,1.000)}

B1	{(0.500,0.767),0.925,(0.990,1.000)}	{(0.500,0.730),0.906,(0.990,1.000)}	{(0.300,0.671),0.854,(0.955,1.000)}	{(0.500,0.767),0.925,(0.990,0.1 00)}	{(0.500,0.767),0.925,(0.990,1.000) }
B2	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.100,0.470),0.685,(0.854,1.000)}	{(0.700,0.774),0.939,(1.000,1.000)}	{(0.700,0.794),0.949,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}
B3	{(0.700,0.814),0.959,(1.000,1.000)}	{(0.300,0.459),0.665,(0.852,1.000)}	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.700,0.814),0.959,(1.000,1.000)}
C1	{(0.300,0.814),0.959,(1.000,1.000)}	{(0.700,0.814),0.959,(1.000,1.000)}	{(0.500,0.665),0.852,(0.969,1.000)}	{(0.500,0.665),0.852,(0.969,1.000)}	{(0.300,0.516),0.724,(0.893,1.000)}
C2	{(0.700,0.814),0.959,(1.000,1.000)}	{(0.100,0.281),0.499,(0.706,0.900)}	{(0.300,0.475),0.682,(0.861,1.000)}	{(0.500,0.688),0.874,(0.979,1.00 0)}	{(0.700,0.814),0.959,(1.000,1.000) }
C3	{(0.300,0.632),0.824,(0.945,1.000)}	{(0.100,0.411),0.632,(0.824,1.000)}	{(0.100,0.411), 0.632,(0.824,1.000)}	{(0.300,0.632),0.824,(0.945,1.000)}	{(0.300,0.632),0.824,(0.945,1.000)}
C4	{(0.700,0.835),0.969,(1.000,1.000)}	{(0.100,0.239),0.459,(0.665,0.900)}	{(0.300,0.459),0.665,(0.852,1.000)}	{(0.500,0.665),0.852,(0.969,1.000)}	{(0.700,0.835),0.969,(1.000,1.000)}
D1	{(0.700,0.835),0.969,(1.000,1.000)}	{(0.100,0.139),0.350,(0.553,0.700)}	{(0.300,0.499),0.706,(0.883,1.000)}	{(0.500,0.706),0.883,(0.979,1.000)}	{(0.700,0.835),0.969,(1.000,1.000)}
D2	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000) }
D3	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.300,0.499),0.706,(0.883,1.000)}	{(0.300 ,0.499),0.706,(0.883,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}	{(0.700,0.856),0.979,(1.000,1.000)}
E1	{(0.500,0.688),0.874,(0.979,1.000)}	{(0.500,0.688),0.874,(0.979,1.000)}	{(0.500,0.688),0.874,(0.979,1.000)}	{(0.500,0.665),0.852,(0.969,1.000)}	{(0.500,0.665),0.852,(0.969,1.000)}
E2	{(0.700,0.835),0969,(1.000,1.000)}	{(0.300,0.350),0.553,(0.755,0.900)}	{(0.500,0.553),0.755,(0.929,1.000)}	{(0.500,0.730),0.906,(0.990,1.000)}	{(0.700,0.835),0.969,(1.000,1.000)}
E3	{(0.700,0.835),0969,(1.000,1.000)}	{(0.500,0.633),0.835,(0.969,1.000)}	{(0.500,0.633),0.835,(0.969,1.000)}	{(0.700,0.835),0.969,(1.000,1.000)}	{(0.700,0.835),0.969,(1.000,1.000)}

Table 8) Normal Matrix

	IA	LOS 1	LOS 2	LOS 3	LOS 4
A1	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}
A2	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/060,0/097),0/138,(0/175,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/100,0/138),0/175,(0/196,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}
A3	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/060,0/097),0/138,(0/175,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/100,0/138),0/175,(0/196,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}
B1	{(0/100,0/153),0/185,(0/198,0/200)}	{(0/100,0/146),0/181,(0/198,0/200)}	{(0/060,0/134),0/171,(0/191,0/200)}	{(0/100,0/153),0/185,(0/198,0/200)}	{(0/100,0/153),0/185,(0/198,0/200)}
B2	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/020,0/094),0/137,(0/171,0/200)}	{(0/140,0/155),0/188,(0/200,0/200)}	{(0/140,0/159),0/190,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}
B3	{(0/140,0/163),0/192,(0/200,0/200)}	{(0/060,0/092),0/133,(0/170,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/100,0/141),0/177,(0/196,0/200)}	{(0/140,0/163),0/192,(0/200,0/200)}
C1	{(0/276,0/102),0/086,(0/083,0/083)}	{(0/118,0/102),0/086,(0/083,0/083)}	{(0/165,0/124),0/097,(0/085,0/083)}	{(0/165,0/124),0/097,(0/085,0/083)}	{(0/276,0/160),0/114,(0/093,0/083)}

C2	{(0/143,0/166),0/196,(0/204,0/204)}	{(0/020,0/057),0/102,(0/144,0/184)}	{(0/061,0/097),0/139,(0/176,0/204)}	{(0/102,0/140),0/178,(0/200,0/204)}	{(0/143,0/166),0/196,(0/204,0/204)}
C3	{(0/060,0/126),0/165,(0/189,0/200)}	{(0/020,0/082),0/126,(0/165,0/200)}	{(0/020,0/082),0/126,(0/165,0/200)}	{(0/060,0/126),0/165,(0/189,0/200)}	{(0/060,0/126),0/165,(0/189,0/200)}
C4	{(0/143,0/170),0/198,(0/204,0/204)}	{(0/020,0/049),0/094,(0/136,0/184)}	{(0/061,0/094),0/136,(0/174,0/204)}	{(0/102,0/136),0/174,(0/198,0/204)}	{(0/143,0/170),0/198,(0/204,0/204)}
D1	{(0/149,0/178),0/206,(0/213,0/213)}	{(0/021,0/030),0/074,(0/118,0/149)}	{(0/064,0/106),0/150,(0/188,0/213)}	{(0/106,0/150),0/188,(0/208,0/213)}	{(0/149,0/178),0/206,(0/213,0/213)}
D2	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}
D3	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/060,0/100),0/141,(0/177,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}	{(0/140,0/171),0/196,(0/200,0/200)}
E1	{(0/100,0/138),0/175,(0/196,0/200)}	{(0/100,0/138),0/175,(0/196,0/200)}	{(0/100,0/138),0/175,(0/196,0/200)}	{(0/100,0/133),0/170,(0/194,0/200)}	{(0/100,0/133),0/170,(0/194,0/200)}
E2	{(0/143,0/170),0/198,(0/204,0/204)}	{(0/061,0/071),0/113,(0/154,0/184)}	{(0/102,0/113),0/154,(0/190,0/204)}	{(0/102,0/149),0/185,(0/202,0/204)}	{(0/143,0/170),0/198,(0/204,0/204)}
E3	{(0/140,0/167),0/194,(0/200,0/200)}	{(0/100,0/127),0/167,(0/194,0/200)}	{(0/100,0/127),0/167,(0/194,0/200)}	{(0/140,0/167),0/194,(0/200,0/200)}	{(0/140,0/167),0/194,(0/200,0/200)}

Table 9) Weighted Normal Matrix

	IA	LOS 1	LOS 2	LOS 3	LOS 4
A1	{(0/002,0/003),0/003,(0/004,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}
A2	{(0/002,0/003),0/004,(0/004,0/004)}	{(0/001,0/002),0/003,(0/004,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/002,0/003),0/004,(0/004,0/004)}	{(0/002,0/003),0/004,(0/004,0/004)}
A3	{(0/002,0/003),0/004,(0/004,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/001,0/002),0/003,(0/003,0/004)}	{(0/002,0/003),0/004,(0/004,0/004)}	{(0/002,0/003),0/004,(0/004,0/004)}
B1	{(0/007,0/010),0/012,(0/013,0/013)}	{(0/007,0/010),0/012,(0/013,0/013)}	{(0/004,0/009),0/011,(0/013,0/013)}	{(0/007,0/010),0/012,(0/013,0/013)}	{(0/007,0/010),0/012,(0/013,0/013)}
B2	{(0/007,0/009),0/010,(0/011,0/011)}	{(0/001,0/005),0/007,(0/009,0/011)}	{(0/007,0/008), 0/010,(0/011,0/011)}	{(0/007,0/008), 0/010,(0/011,0/011)}	{(0/007,0/009),0/010,(0/011,0/011)}
B3	{(0/005,0/005),0/006,(0/007,0/007)}	{(0/002,0/003),0/004,(0/006,0/007)}	{(0/003,0/005),0/006,(0/006,0/007)}	{(0/003,0/005),0/006,(0/006,0/007)}	{(0/005,0/005),0/006,(0/007,0/007)}
C1	{(0/017,0/006),0/005,(0/005,0/005)}	{(0/007,0/006),0/005,(0/005,0/005)}	{(0/010,0/007),0/006,(0/005,0/005)}	{(0/010,0/007),0/006,(0/005,0/005)}	{(0/017,0/010),0/007,(0/006,0/005)}
C2	{(0/011,0/013),0/016,(0/016,0/016)}	{(0/002,0/005),0/008,(0/012,0/015)}	{(0/005,0/008),0/011,(0/014,0/016)}	{(0/008,0/011),0/014,(0/016,0/016)}	{(0/011,0/013),0/016,(0/016,0/016)}
C3	{(0/002,0/005),0/006,(0/007,0/007)}	{(0/001,0/003),0/005,(0/006,0/007)}	{(0/001,0/003),0/005,(0/006,0/007)}	{(0/001,0/003),0/005,(0/006,0/007)}	{(0/002,0/005),0/006,(0/007,0/007)}
C4	{(0/004,0/005),0/005,(0/006,0/006)}	{(0/001,0/001),0/003,(0/004,0/005)}	{(0/002,0/003),0/004,(0/005,0/006)}	{(0/003,0/004),0/005,(0/005,0/006)}	{(0/004,0/005),0/005,(0/006,0/006)}
D1	{(0/023,0/028),0/032,(0/033,0/033)}	{(0/003,0/005),0/012,(0/018,0/023)}	{(0/010 ,0/017),0/023,(0/029,0/033)}	{(0/017 ,0/023),0/029,(0/032,0/033)}	{(0/023,0/028),0/032,(0/033,0/033)}
D2	{(0/021,0/026),0/029,(0/030,0/030)}	{(0/021,0/026),0/029,(0/030,0/030)}	{(0/021,0/026),0/029,(0/030,0/030)}	{(0/021,0/026),0/029,(0/030,0/030)}	{(0/021,0/026),0/029,(0/030,0/030)}
D3	{(0/021,0/026),0/030,(0/031,0/031)}	{(0/009,0/015),0/022,(0/027,0/031)}	{(0/009,0/015),0/022,(0/027,0/031)}	{(0/021,0/026),0/030,(0/031,0/031)}	{(0/021,0/026),0/030,(0/031,0/031)}
E1	{(0/004,0/006),0/007,(0/008,0/008)}	{(0/004,0/006),0/007,(0/008,0/008)}	{(0/004,0/006),0/007,(0/008,0/008)}	{(0/004,0/005),0/007,(0/008,0/008)}	{(0/004,0/005),0/007,(0/008,0/008)}
E2	{(0/007,0/008),0/009,(0/010,0/010)}	{(0/003,0/003),0/005,(0/007,0/009)}	{(0/005,0/005),0/007,(0/009,0/010)}	{(0/005,0/007),0/009,(0/009,0/010)}	{(0/007,0/008),0/009,(0/010,0/010)}

E 3	{(0/005,0/006),0/007,(0/007,0/007)}	{(0/004,0/004),0/006,(0/007,0/007)}	{(0/004,0/004),0/006,(0/007,0/007)}	{(0/005,0/006),0/007,(0/007,0/007)}	{(0/005,0/006),0/007,(0/007,0/007)}

Table 10) Final ARS Calculations with Interval Values and Alternative Rankings

Alternatives	S	BNP	Q	Rank
Ideal Alternative	(0.140,0.161),0.187,(0.194,0.195)}	0.1084	1	0
Service Level 1	{(0.067,0.098),0.133,(0.162,0.182)}	0.0786	0.4489	4
Service Level 2	{(0.088,0.121),0.156,(0.180,0.195)}	0.0915	0.5223	3
Service Level 3	{(0.119,0.152),0.181,(0.193,0.195)}	0.1052	0.6005	2
Service Level 4	{(0.140,0.160),0.188,(0.194,0.195)}	0.1095	0.6248	1

Table 11) Results of Ranking Options

Rank	Service level	Score
1	Gold +	0.6248
2	Gold	0.6005
3	Silver	0.5223
4	Bronze	0.4489

Table 12) Prioritization of Criteria Without Considering Service Levels

	S	BNP	Q	Rank
A1	0.0098	0.00195	0.1049	16
A2	0.011197	0.00224	0.1203	14
A3	0.010273	0.00205	0.1104	15
B1	0.03594	0.00719	0.3862	5
B2	0.030051	0.0061	0.3229	6
B3	0.0183	0.00366	0.1967	10
C1	0.01623	0.00325	0.1744	12
C2	0.045268	0.00905	0.4865	۴
C3	0.01777	0.00355	0.1910	11
C4	0.015448	00.00309	0.1660	13
D1	0.093053	0.0186	1.000	1
D2	0.085051	0.0170	0.9140	3
D3	0.086752	0.0172	0.9223	2
E1	0.020331	0.00406	0.2185	8
E2	0.026891	0.00538	0.2890	7
E3	0.019625	0.00392	0.2109	9

In the business planning process, evaluating the best option using multi-criteria decision-making models can effectively address complex problems influenced by uncertainty, conflicting goals, diverse information types, multiple interests, and varying perspectives (Mokhtari et al., 2022). This study employed an extension of the ARS method for interval data analysis to prioritize options. First, qualitative evaluation values were converted into quantitative values, and initial decision tables were created for each expert. Next, fuzzy values were assigned in the experts' initial decision matrices. Subsequently, the initial matrices from all experts were aggregated to form the alternative decision matrix, as shown in Table 7. In the second step, the decision matrix was normalized (Table 8). In the third step, the normalized matrix was weighted by multiplying each criterion by its respective weight (Table 9). Finally, the decision options were ranked (Tables 10 and 11). Based on these results, the ranking of options is LOS4 > LOS3 > LOS2 > LOS1, with service level 4 ranked first, service level 3 second, service level 2 third, and service level 1 fourth. Additionally, when analyzing the criteria without considering service levels, the interval fuzzy ARS relations yielded the results presented in Table 12: D1 > D3 > D2 > C2 > B1 > B2. This analysis determined that the three criteria within the assurance dimension hold the highest priority from the decision makers' perspective.

5) Conclusion and Suggestions

Prioritizing factors that affect service quality is a multi-criteria decision-making problem. Due to the presence of multiple quantitative and qualitative criteria, this process is complex and uncertain. Therefore, it is essential to use efficient multi-criteria decision-making methods under uncertainty to prioritize factors influencing the quality of after-sales services, as demonstrated in this case study. For this purpose, the combined FACOM-ARS method will be employed. The advantage of the FACOM and ARS methods lies in reducing the number of pairwise comparisons and minimizing the need to collect extensive expert judgments. The FUCOM method will be used to weight the criteria, while the interval ARAS method will rank the options under evaluation. To address the first research question, which involves identifying factors affecting the quality of mobile phone after-sales services, 26 factors were initially identified through a literature review and expert opinions. These factors were then examined using the Fuzzy Delphi method, resulting in the confirmation of 16 key factors. These include employee attitude and appearance, modern equipment and tools, convenient working hours, customer response time, time spent solving problems and completing repairs, the possibility of personalizing services, fair prices and costs, consistency of service quality, selection and scope of services, availability of technical service staff, service warranty, competence, honesty and reliability of employees, professionalism of service personnel, personal interactions between frontline service staff and customers, sense of value, and sense of gratitude. The findings of this assessment align with studies conducted by Murali and Pugazhendhi (2016), Seiler et al. (2017), Gremler et al. (2020), and Hosseini et al. (2020), which evaluated service quality in home appliance manufacturing, e-business, telecommunications, and after-sales service industries. This consistency suggests the favorable generalizability of the findings of the present study to assess after-sales service quality in other industries. To address the second research question, the study prioritized the factors affecting the quality of mobile phone after-sales services using the FUCOM and ARAS methods in two ways. In the first case, based on service levels and the results obtained from the analysis, the key priorities are as follows: first priority: golden service level +, with a score of 1.0413; second priority: golden service level, with a score of 1.0009; third priority: silver service level, with a score of 0.8704; and fourth priority: bronze service level, with a score of 0.7481.

At the Gold Service Level+, customers benefit from expert repair of any type of mobile phone breakdown by a skilled technician, backed by a six-month warranty. Additionally, they receive a discount card offering up to 30% off and have the option to pay in installments. This service level also provides a replacement device during repairs and free delivery of the customer's device to their doorstep via a complimentary courier service. The combination of these ideal conditions for technical services, along with offerings that exceed customer expectations, positions this service level as the top priority. In the second scenario, when evaluating criteria without considering service levels—that is, comparing only the criteria themselves—the ranking is: D1 > D3 > D2. Examining the criteria by weight yields the order: D > C > B > E > A, reflecting the relative importance of each dimension. However, not all sub-criteria align perfectly with this priority sequence; the observed order is: D1 > D3 > D2 > C2 > B1 > B2 > E2 > E1 > E3 > … Overall, the results indicate that the three criteria of service guarantee, professionalism of service personnel, and competence are more important than other factors. Following these are the availability of technical service personnel, customer response time, and the time spent resolving problems and completing repairs. It is important to note that, over time, as consumer expectations and preferences evolve, a new set of criteria and sub-criteria with different priorities may emerge within Conagon businesses. Furthermore, the design of after-sales service packages significantly influences their prioritization, depending on varying business environments. Considering the factors identified as most important, it is recommended that service companies build greater customer trust by cultivating a positive brand image and properly training employees to enhance their interaction and empathy with customers. To achieve this, companies can implement the following strategies:

Transparency: Providing customers with clear and accurate information about the company's products, services, and processes, and encouraging them to familiarize themselves with the company's clearly stated terms and conditions.

Quality Assurance and Innovation: Delivering high-quality services and ensuring customer satisfaction.

Up-to-dateness and Innovation: Building customer trust through innovative and creative products and services.

Customer Interaction and Service: Ensuring a prompt and efficient response to any questions or issues raised by customers through a robust and effective customer support system that facilitates easy communication between customers and the company.

Feedback and Surveys: Requesting customers to share their opinions and feedback, analyzing and reviewing their responses, and providing them with updates on how their input has contributed to improving services and products.

Online Presence in Cyberspace and Social Media: Build customer trust by providing educational and valuable content about your products and services, engaging effectively with customers on social media, and promptly responding to their feedback and inquiries.

Corporate values: Clearly articulate the company's values and mission, and consistently strive to uphold these principles in practice. Additionally, enhance the brand image through socially responsible activities that demonstrate a commitment to the community.

An analysis of the parameters for each service level revealed that offering emotional and engaging services, such as discount cards, alternative devices, and flexible payment terms, can significantly influence customer choice. Since the objective of these services is to foster positive emotions and deepen customer connections, it is recommended that companies focus on enhancing and expanding these offerings by identifying and leveraging key factors. Although this study aimed to provide a comprehensive solution, the dynamic complexities of the decision-making environment suggest that further development of the proposed evaluation model is possible. Additionally, the qualitative and ambiguous nature of many evaluation criteria underscores the need to improve multi-criteria decision-making methods under uncertainty. Future research should expand the range of parameter levels in the design of after-sales services by considering a broader set of influential factors. Moreover, given the inherent uncertainty in evaluating criteria and service levels due to their qualitative nature, alternative multi-criteria decision-making methods, such as missed opportunity analysis under uncertainty, should be employed. In this study, the prioritization of evaluation criteria was measured solely based on the direct effects between criteria (relative preferences). However, criteria such as assurance, reliability, responsiveness, empathy, and tangibility may also exert indirect effects on one another. Incorporating both direct and indirect influence networks among criteria using a fuzzy mapping approach could provide more effective methods for analyzing the prioritization of criteria affecting service quality, accounting for the complexity of their interrelationships in future research.

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Appendix 1)Service Levels

Service Level	Bronze LOS1	Silver LOS2	Gold LOS3	Gold⁺ LOS$
Service Level Selection Limits	None	None	None	Special for loyal customers
Repair Level Required for Phone (1)	Level 1	Level 1&2	Level 1&2&3	Level 1&2&3
Technician	Beginner	Semi-skilled	Skilled	Skilled
Service Time	By appointment	According to quick turn-taking	According to quick turn-taking	VIP
Replacement Device Provided During Repair	None	None	Yes	Yes
Service Warranty	48 hour deadline for testing	1 month deadline for testing	3 month deadline for testing	6 month deadline for testing
Shipping and Receiving by Courier	Not free	Not free	Free	Free
Special Product Discount Card	Up to 5% discount	Up to 10% discount	Up to 15% discount	Up to 30% discount

Bill Payment Terms	Cash	Cash	Up to 1 installment	Up to 3 installments

Levels of Repair Required for the Phone:

Level One: Replacement of parts such as speaker, microphone, screen, touch screen, battery, frame

Level Two: Replacement of non-adhesive ICs

Level Three: Replacement of adhesive ICs