8. EVALUATION OF DIMENSIONS OF SERVQUAL MODEL FOR DETERMINING QUALITY OF PROCESSES IN REVERSE LOGISTICS USING A DELPHI – FUZZY PIPRECIA MODEL

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Abstract

Determining a quality measure is a complex process that requires a large number of input parameters and extensive analysis. The purpose of this paper is to evaluate the dimensions of SERVQUAL model for its application in one of reverse logistics channels. A methodology that includes a combination of Delphi and PIPRECIA (PIvot Pairwise RElative Criteria Importance Assessment) method in a fuzzy form was applied. The Delhi method was applied in order for 112 users who filled in the SERVQUAL questionnaire to rank its five constituent dimensions according to significance. After that, based on the evaluation of five experts using the Fuzzy PIPRECIA method, the final values of the dimensions were obtained. Based on results, we could determine that the most significant dimension is C5 (responsiveness) with a weight coefficient of 0.259, followed by the reliability dimension (C1) with a weight of 0.228, slightly smaller than the responsiveness dimension. The assurance dimension and tangibles dimension follow with values (C2=0.207 and C3=0.183), while the empathy dimension is in the last position – C4=0.156. The obtained results show that certain improvement measures should be applied since certain dimensions do not meet the expectations of users to a greater extent. The originality of this research can be seen through the integration of a new Delphi – Fuzzy PIPRECIA model which is presented for the first

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time. In addition, reviewing other studies, it has been noticed that this is the first time that the SERVQUAL model or its dimensions are applied in the field of reverse logistics.

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1. Introduction

Reverse logistics as a relatively new concept (Dowlatshahi, 2000) is a part of integrated logistics and its basic task is to facilitate the organization of the process of returning a product from a customer to a manufacturer, to recycle the product and make it a new product, or separate components that can be used again (Garai & Sarkar, 2022; Wijewickrama *et al*., 2021). It is not always the case that the product is returned to the manufacturer, sometimes it is sent to companies whose main and only activity is recycling, restoration and the like. In addition to product renewal, reverse logistics also includes returning new, i.e. not much used products in order to be replaced for new ones, and the separation of materials and raw materials from returned products. One of the channels of reverse logistics is waste management (Ahmed & Zhang, 2021; Zielińska, 2020; Dias *et al*., 2016).

Waste management means waste collection from various places of its disposal, most often landfills and its return to manufacturing plants (Nanda & Berruti, 2021; Hantoko *et al*., 2021). In manufacturing plants, waste is separated, where completely new products are created from some components by their restoration, some components are used as spare used parts, and some parts that are in poor condition are returned to a landfill. Reverse logistics and municipal solid waste management is of great importance for the living environment as it strives to achieve sustainability through a familiar concept (3R): “reduce”, “reuse”, and “recycle” (Das *et al*., 2019). Its application enables the saving of energy, materials, raw materials, and thus purifies surroundings and creates a healthier living environment. Proper waste management not only creates a cleaner environment but can significantly affect the economic development of the country. If waste separation, proper storage and recovery is performed, great savings of energy, raw materials and materials are obtained, which reduces costs (Yıldız, 2020; Tomić & Schneider, 2020; Ferreira *et al*., 2017; Martinez-Sanchez *et al*., 2015).

Many countries care about the environment. Bosnia and Herzegovina does not belong to the developed countries like some European countries which annually invest a lot of money in ecology and environmental protection, but in accordance with capabilities, it is also paid attention to that here. With the help of research, such as this one, it is possible to try to eliminate some shortcomings that exist and start with the application of reverse logistics as much as possible. This research is one of the first studies that deals with this topic with the application of the SERVQUAL model.

The main objective of the research is to use the SERVQUAL model and its five dimensions, responsiveness, empathy, assurance, reliability and tangibles (Parasuraman *et al*., 1985; Udo *et al*., 2011; Naik *et al*., 2010), to determine the quality of service of the utility company "Komunalac" in Teslić, Bosnia and Herzegovina. The SERVQUAL model allows a survey to be conducted on a sample of *n* users, which provides a great opportunity for the survey to obtain quite good and accurate results. Quality measurement is an extremely complex task. In this paper, the focus is on evaluating the dimensions of the SERVQUAL model, which is later used for further calculations.

In addition to introductory considerations, the paper is divided into four sections. Section 2 presents the methods used. First, the steps of the Delphi method are shown and described, then the operations with triangular fuzzy numbers and the steps of the fuzzy PIPRECIA method. Section 3 provides basic information about the company and the current state of municipal logistics management in the utility company "Komunalac". In Section 4, the aforementioned model is integrated to determine the final values of the SERVQUAL model dimensions. The structure of the sample of respondents, the method of data collection and analysis are presented. The results of this part of the research are also shown. Section 5 presents concluding considerations with an emphasis on the contribution of the paper and the continuation of the research.

2. Methods

2.1. The Delphi Method

The Delphi Method (Linstone and Turoff, 1975; Hirschhorn, 2019) does the study of and gives projections of uncertain or possible future situations for which we are unable to perform objective statistical legalities, in order to form a model, or apply a formal method. These phenomena are very difficult to quantify because they are mainly qualitative in their nature, *i.e.,* not enough statistical data about them exist that could be used as the basis for our studies. The Delphi Method is one of the basic forecasting methods, the most famous and most widely used expert judgment method. Methods of experts' assessments are significant improvement of the classical ways of obtaining the forecast by joint consultation of an expert group for a given studied phenomenon. In other words, this is a methodologically organized use of the experts' knowledge to predict future states and phenomena. A typical group in one Delphi session ranges from a few to thirty experts. Each interviewed expert, participant in the method, relies on knowledge, experience and his / her own opinion. The goal of the Delphi Method is to exploit the collective, group thinking of experts about certain field. The goal is to reach a consensus on an event by group thinking. This is a method of indirect collective testing but with a return link. It consists of eight steps (Vesković et al., 2018): 1. Selection of the prognostic task, defining basic questions and fields for it; 2. Selection of experts; 3. Preparation of questionnaires; 4 Delivery of questionnaires to experts; 5. Collecting responses and their evaluating; 6. Analysis and interpretation of responses; 7. Re-exams; and 8.Interpretation of responses and setting up final forecast.

The advantages of the Delphi Method are: It covers the large number of respondents; Expert's statements are objective because they do not know the statements of others until the end of the circle; It is possible to examine the opinion and attitude of an individual according to a task; The method strengthens the sense of community and encourages thinking about the future of the organization.

Delphi Method disadvantages: The success of the method depends exclusively on the participants in the expert panel; Complicated implementation process; Absence of the possibility to exactly identify the number of participants in the expert panel; Long duration of research.

According to the rules of the Delphi Method, the submitted forecasts of the first circle are statistically processed and sent to the experts again to make possible corrections if they consider other opinions. It is characteristic that most experts remain in their first-round prognosis.

2.2. Operations on Fuzzy Numbers

A fuzzy number $\overline{A}$ on R to be a TFN if its membership function $\mu_{\overline{A}}(x)$: R→[0,1] is equal to following Equation (1):

$$\mu_{\overline{A}}(x)=\begin{cases}\dfrac{x-l}{m-l} & l\le x\le m\\ \dfrac{u-x}{u-m} & m\le x\le u\\ 0 & otherwise\end{cases} \tag{1}$$

From Equation (1), *l* and *u* mean the lower and upper bounds of the fuzzy number $\overline{A}$, and *m* is the modal value for $\overline{A}$. The TFN can be denoted by $\overline{A}=(l,m,u)$.

The operational laws of TFN $\overline{A}=(l_1,m_1,u_1)$ and $\overline{A}=(l_2,m_2,u_2)$ are displayed as following equations (Petrović *et al*., 2019; Vesković, *et al*., 2020).

Addition:

$$\overline{A_1}+\overline{A_2}=(l_1,m_1,u_1)+(l_2,m_2,u_2)=(l_1+l_2,m_1+m_2,u_1+u_2) \tag{2}$$

Multiplication:

$$\overline{A_1}\times\overline{A_2}=(l_1,m_1,u_1)\times(l_2,m_2,u_2)=(l_1\times l_2,m_1\times m_2,u_1\times u_2) \tag{3}$$

Subtraction:

$$\overline{A_1}-\overline{A_2}=(l_1,m_1,u_1)-(l_2,m_2,u_2)=(l_1-u_2,m_1-m_2,u_1-l_2) \tag{4}$$

Division:

$$\frac{\overline{A_1}}{\overline{A_2}}=\frac{(l_1,m_1,u_1)}{(l_2,m_2,u_2)}=\left(\frac{l_1}{u_2},\frac{m_1}{m_2},\frac{u_1}{l_2}\right) \tag{5}$$

Reciprocal:

$$\overline{A_1}^{-1}=(l_1,m_1,u_1)^{-1}=\left(\frac{1}{u_1},\frac{1}{m_1},\frac{1}{l_1}\right) \tag{6}$$

2.3. Fuzzy PIPRECIA Method

The fuzzy version of the PIPRECIA method was developed by Stević *et al*. (2018) and used in different fields (Memis *et al*., 2020). The fuzzy PIPRECIA method is based on the earlier developed PIPRECIA method (Stanujkic *et al*., 2020; Stanujkic *et al*., 2017). Furthermore, Stanujkic *et al*. (2021) proposed also and a simplified PIPRECIA method (PIPRECIA-S). The fuzzy PIPRECIA method consisting of 11 steps is explained as below (Stević *et al*., 2018; Đalić *et al*., 2020):

Step 1. Forming a set of criteria and sorting the criteria according to marks from the first to the last, and this means that they need to be sorted unclassified.

Step 2. Each decision-maker individually evaluates pre-sorted criteria by starting from the second criterion.

$$\overline{s_j^r} = \begin{cases} > \bar{1} & if \quad C_j > C_{j-1} \\ = \bar{1} & if \quad C_j = C_{j-1} \\ < \bar{1} & if \quad C_j < C_{j-1} \end{cases} \tag{7}$$

$\overline{s_j^r}$ denotes the assessment of criteria by a decision-maker *r.*

Average mean is performed by averaging the matrix $\overline{s_j^r}$ in order to obtain a matrix $\overline{s_j}$. Decision makers evaluate the criteria via applying the defined scales in Tables 1 and 2.

Table 1. Scale 1-2 for the Assessment of Criteria

Linguistic Scale		Fuzzy Number				
			l	m	U	DFV
Almost equal value	Scale 1-2	1	1.000	1.000	1.050	1.008
Slightly more significant		2	1.100	1.150	1.200	1.150
Moderately more significant		3	1.200	1.300	1.350	1.292
More significant		4	1.300	1.450	1.500	1.433
Much more significant		5	1.400	1.600	1.650	1.575
Dominantly more significant		6	1.500	1.750	1.800	1.717
Absolutely more significant		7	1.600	1.900	1.950	1.858

Table 2. Scale 0-1 for the Assessment of Criteria

Fuzzy Number						Linguistic Scale
		l	m	u	DFV	
Scale 0-1	1	0.667	1.000	1.000	0.944	weakly less significant
	1/2	0.500	0.667	1.000	0.694	moderately less significant
	1/3	0.400	0.500	0.667	0.511	less significant
	1/4	0.333	0.400	0.500	0.406	really less significant
	1/5	0.286	0.333	0.400	0.337	much less significant
	1/6	0.250	0.286	0.333	0.288	dominantly less significant
	1/7	0.222	0.250	0.286	0.251	absolutely less significant

When the criterion is of greater importance in relation to the previous one, assessment is made using the above scale in Table 1. In order to make decision-makers easier to evaluate the criteria, the table shows the defuzzified value (DFV) for each comparison.

When the criterion is of less importance compared to the previous one, assessment is made using the above-mentioned scale in Table 2.

Step 3. Determining the coefficient $\overline{k_j}$

$$\overline{k_j} = \begin{cases} = \bar{1} & if \quad j = 1 \\ 2 - \underline{s_j} & if \quad j > 1 \end{cases} \tag{8}$$

Step 4. Determining the fuzzy weight $\overline{q_j}$

$$\overline{q_j} = \begin{cases} =\bar{1} & if \quad j=1 \\ \dfrac{\overline{q_{j-1}}}{\overline{k_j}} & if \quad j>1 \end{cases} \tag{9}$$

Step 5. Determining the relative weight of the criterion $\overline{w_j}$

$$\overline{w_j} = \frac{\overline{q_j}}{\sum_{j=1}^{n} \overline{q_j}} \tag{10}$$

In the following steps, the inverse methodology of fuzzy PIPRECIA method needs to be applied.

Step 6. Performing the assessment, but this time starting from a penultimate criterion.

$$\overline{s_j^r}' = \begin{cases} >\bar{1} & if \quad C_j > C_{j+1} \\ =\bar{1} & if \quad C_j = C_{j+1} \\ <\bar{1} & if \quad C_j < C_{j+1} \end{cases} \tag{11}$$

Step 7. Determining the coefficient $\overline{k_j}'$

$$\overline{k_j}' = \begin{cases} =\bar{1} & if \quad j=n \\ 2-\overline{s_j}' & if \quad j>n \end{cases} \tag{12}$$

Step 8. Determining the fuzzy weight $\overline{q_j}'$

$$\overline{q_j}' = \begin{cases} =\bar{1} & if \quad j=n \\ \dfrac{\overline{q_{j+1}}'}{\overline{k_j}'} & if \quad j>n \end{cases} \tag{13}$$

Step 9. Determining the relative weight of the criterion $\overline{w_j}'$

$$\overline{w_j}' = \frac{\overline{q_j}'}{\sum_{j=1}^{n} \overline{q_j}'} \tag{14}$$

Step 10. In order to determine the final weights of criteria, it is first necessary to perform the defuzzification of the fuzzy values $\overline{w_j}$ and $\overline{w_j}'$

$$\overline{w_j}'' = \frac{1}{2}(w_j + w_j') \tag{15}$$

Step 11. Checking the results obtained by applying Spearman and Pearson correlation coefficients.

3. Case Study

The "Komunalac" company for which the research was conducted has been operating as a joint stock company for many years, with the municipality of Teslić having a majority share of about 54%. The company is managed by a director general and one executive director who comes from the economic sector. So far, the company has about 7,000 registered users, of which 6,500 are natural persons and 500 are legal entities. In the beginning, waste collection and transport were performed only in urban and suburban areas, while in the last few years it has changed and expanded to rural areas of the municipality of Teslić, thus increasing the number of users.

3.1. Utility Company Services

Like any utility company, this company has the core activities that include collecting waste, transporting and disposing of it at the landfill. Waste collection in the urban zone is carried out twice a day, except on weekends, when waste collection is done once a day. Waste collection in rural areas is carried out once a week. Each rural settlement has a particular day when waste is collected.

In addition to collecting waste, the utility company, by the order of the Department of Housing and Communal Services of the Municipality of Teslić, carries out cleaning and arranging of green areas in the urban zone, and snow removal in the winter. Keeping the town clean is very important and is done daily, seven days a week. Mowing the grass is done as needed.

3.2. Personnel Structure

The "Komunalac" utility company has a total of 55 employees, i.e., 56 with the director, which classifies the utility company as a medium-sized company, according to the number of employees. About 15% of employees perform tasks related to the management of the company (legal sector, financial sector), 30% of employees perform transport and waste collection, 20% care about the cleanliness of the town, 20% about green areas and 15% are others (cash desk, kitchen, ...).

3.3. Reverse Logistics in the "Komunalac" Utility Company

Reverse logistics is a part of integrated logistics that deals with the flow of goods from users to manufactures. Flows do not always have to be directed towards the manufacturer, they can also proceed to a recycling center and the like. Reverse logistics differs from other logistics precisely in the direction of flow. What are features of reverse logistics are recycling, return of new products by consumers, as well as return of used products by consumers. Reverse logistics can bring great savings of money, materials, raw materials, energy, which enables better development of the country in which it is applied.

The basic function of the "Komunalac" utility company is waste management on the territory of the municipality of Teslić. Waste management in this case includes waste collection, transport and disposal at a landfill under the supervision of the utility company. The utility company collects and transports municipal, industrial, and commercial waste. The method of collection, time and price of the service differ depending on the type of waste.

Collection and transport of municipal waste on the territory of the municipality of Teslić is carried out daily according to established routes. Transport of industrial and commercial

waste is carried out by agreement, or as needed. Depending on the amount of waste generated during a day, it can be once a day, twice a day or once or twice a week.

The containers are located in accessible places, so that users can dispose of waste in a very easy and fast way. The number of containers and their volume at a location depends on the number of users located at the same place. Unfortunately, waste is not separated and the inscriptions are the remnants of a project that should have been implemented a few years ago intending to try to realize a recycling process in the municipality of Teslić in some way. Covered containers are set at three locations in the municipality of Teslić. Waste bins are mostly the same size and shape in all places. They are usually set next to promenades, benches, institutions, in parks and the like.

3.4. Setting up a Model for Determining the Quality of Reverse Logistics on the Territory of the Municipality of Teslić

This section presents the structure of the sample of respondents, the way in which the data were collected, as well as the statistical analysis. The main objective of this research has been to determine the level of service quality in the "Komunalac" utility company in Teslić, in order to enable the improvement of the service, as well as provide suggestions for further development and progress that is important not only for the company but for the whole municipality of Teslić. Through this paper, a part of the overall research is presented.

3.4.1. SERVQUAL Questionnaire – Dimensions

The SERVQUAL questionnaire was used in order to obtain the opinion of users about the services provided by the "Komunalac" utility company in Teslić. Based **on** the questionnaire, users were able to rate the level of service quality in the utility company. Users had the opportunity to fill in the questionnaire by the application "Google forms", as well as fill it in manually. The questionnaire consists of 21 questions for perceptions and 21 questions for expectations (Stević *et al*., 2021). The questions are created by five dimensions: reliability, assurance, empathy, responsiveness and tangibles. The questionnaire was filled in by 170 respondents, of whom 58 did not complete the questionnaire well, which means that 112 questionnaires could be analyzed in order for the results to be obtained.

Table 3 shows the questions from the questionnaire in terms of user expectations. The questions refer to the expectations of users about the services provided by the "Komunalac" utility company. The questions are divided into five basic dimensions, where questions 1 to 3 belong to the reliability dimension, from 4 to 6 relate to assurance, 7 to 13 form the tangibles dimension, from 14 to 16 relate to empathy and from 17 to 21 belong to the responsiveness dimension.

Table 3. Questionnaire Form in Terms of User Expectations

Reliability	The utility company will provide services in the expected time.	1	2	3	4	5
	The utility company will collect waste on a regular basis.	1	2	3	4	5
	The utility company will be able to collect waste without any difficulties.	1	2	3	4	5
Assurance	Workers will be careful when performing work tasks (they will pay attention to vehicles, pedestrians, property, etc.).	1	2	3	4	5
	The user will be notified of any changes in a timely manner.	1	2	3	4	5
	The price of the waste collection service will be fixed.	1	2	3	4	5
Tangibles	The price of the service will be acceptable.	1	2	3	4	5
	The utility company will not make noise when removing waste.	1	2	3	4	5
	Invoices will be clear to the user and delivered to the user's home address every month.	1	2	3	4	5
	The streets will be clean (no waste in inappropriate places).	1	2	3	4	5
	The containers will be placed close to the household, so that waste can be easily disposed of.	1	2	3	4	5
	There will be no unpleasant odors at waste disposal sites and in the immediate vicinity.	1	2	3	4	5
	Waste collection vehicles will be modern, with all the appropriate equipment.	1	2	3	4	5
Empathy	The utility company will be flexible in meeting individual additional customer requirements.	1	2	3	4	5
	The daily time of waste collection and disposal will be appropriate for users (it will not obstruct the activities of citizens).	1	2	3	4	5
	When billing, the company will take into account the categories of population (social status and temporary residence).	1	2	3	4	5
Responsiveness	Workers will act professionally in performing the waste collection process.	1	2	3	4	5
	The utility company will be ready to accept novelties and to be harmonized with them.	1	2	3	4	5
	The utility company will be ready to react adequately in unpredictable situations.	1	2	3	4	5
	Waste collection will be carried out quickly and adequately.	1	2	3	4	5
	The utility company will not obstruct the normal functioning of traffic.	1	2	3	4	5

Table 4 shows 21 questions used to create a questionnaire for the examination of the degree of user satisfaction in terms of perception. The questions are divided into five basic

dimensions, where questions 1 to 3 relate to reliability, 4 to 6 relate to assurance, 7 to 13 relate to tangibles, 14 to 16 relate to empathy, and 17 to 21 relate to responsiveness.

Table 4. Questionnaire Form in Terms of User Perception

Reliability	The utility company provides services in the expected time.	1	2	3	4	5
	The utility company collect waste on a regular basis.	1	2	3	4	5
	The utility company collect waste without any difficulties.	1	2	3	4	5
Assurance	Workers are careful when performing work tasks (they pay attention to vehicles, pedestrians, property, etc.).	1	2	3	4	5
	The user is notified of all changes in a timely manner.	1	2	3	4	5
	The price of the waste collection service is fixed.	1	2	3	4	5
Tangibles	The price of the service is acceptable.	1	2	3	4	5
	The utility company does not make noise when removing waste.	1	2	3	4	5
	Invoices are clear to the user and delivered to the user's home address every month.	1	2	3	4	5
	The streets are clean (no waste in inappropriate places).	1	2	3	4	5
	The containers are placed close to the household, so that waste can be easily disposed of.	1	2	3	4	5
	There are no unpleasant odors at waste disposal sites and in the immediate vicinity.	1	2	3	4	5
	Waste collection vehicles are modern, with all the appropriate equipment.	1	2	3	4	5
Empathy	The utility company is flexible in meeting individual additional customer requirements.	1	2	3	4	5
	The daily time of waste collection and disposal is appropriate for users (it does not obstruct the activities of citizens).	1	2	3	4	5
	When billing, the company takes into account the categories of population (social status and temporary residence).	1	2	3	4	5
Responsiveness	Workers act professionally in performing the waste collection process.	1	2	3	4	5
	The utility company is ready to accept novelties and to be harmonized with them.	1	2	3	4	5
	The utility company is ready to react adequately in unpredictable situations.	1	2	3	4	5
	Waste collection is carried out quickly and adequately.	1	2	3	4	5
	The utility company does not obstruct the normal functioning of traffic.	1	2	3	4	5

The questions in terms of perception define the real perception of users about the quality of the service provided.

3.4.2. Description of All Five Dimensions of the SERVQUAL Model

The reliability dimension is one of the five dimensions by which the questions of the SERVQUAL questionnaire are created. The reliability dimension in this research consists of

three questions, which relate to the time of the realization of the service, the accuracy of the service and the realization of the service without difficulties. Reliability is one of the most important dimensions for the user because it is very important for the user that the company performs the service at the agreed time, accurately and without difficulties.

The assurance dimension in this study consists of three questions. The first question refers to the reliability of workers when performing the service. This is of great importance not only for the users of the service, but also for all the inhabitants of the municipality. The behavior of workers when performing work tasks towards pedestrians, drivers, property is very important. If they do not pay attention to it, they can cause great material damage, but also minor or serious injuries to other people who have been nearby. The second question is whether the user will be notified of any changes that may occur, such as changes in waste collection times, price changes and the like. The third question refers to whether the price is always the same as agreed in the contract. In this case, the price is fixed and the same tariff is paid every month.

The tangibles dimension consists of seven questions. The questions are focused on price acceptability, delivery of invoices, cleanliness of streets, location of containers, noise made during waste transport, vehicle characteristics and the creation of unpleasant odors at waste disposal sites.

The empathy dimension consists of three questions. The first question refers to the fulfillment of additional services that the utility company provides to its customers and how much it is flexible in meeting some additional, specific user requirements. The second question refers to how satisfied the users are with the time period in which the waste is collected, whether the time is appropriate or overlaps with the peak hours and obstructs the activities of citizens. The third question related to empathy is the question that refers to taking into account the categories of population.

The responsiveness dimension consists of five questions. All questions are based on the ability of workers, adaptation to new situations, acceptance of novelties, quickness and accuracy of service delivery and the like. By the responsiveness dimension, it can be determined how much the utility company is interested in the progress and modernization of the services provided.

4. Results

4.1. Application of the Delphi Method

At the end of the questionnaire there is a table in which it is necessary to rate each of the aforementioned dimensions, *i.e*., users have determined which of the dimensions is most significant to them in percentage. The total sum of the rated dimensions should be 100%. During the evaluation, the users were guided by which of the stated dimensions had the greatest impact on the quality of the provided service of the utility company. Using the Delphi method, the initial values of the weight coefficients were obtained. Table 5 shows the initial values of the weight coefficients for each of the listed dimensions, which were obtained based on the users' responses. The values were obtained by filling in the table at the end of the questionnaire by each respondent and rating each of the dimensions, so that the sum of rates is 100. After that, the sum of all values for one dimension was divided by 11200 (the number of respondents multiplied by 100). The value of the coefficient for each dimension was obtained in the same way.

Table 5. Values of Weight Coefficients by Dimensions

W_1	0.204
W_2	0.199
W_3	0.191
W_4	0.190
W_5	0.216
Σ	1.000

Table 6 shows the percentage values of the weight coefficients for each given dimension. From the table, it is possible to see that the sum of all percentage values is 11200. The procedure by which the values of weight coefficients are obtained is as follows: the sum of percentage values of one dimension is divided by the sum of percentage values of all dimensions.

Table 6. Percentage Values of Five Dimensions in Terms of 112 Respondents

Customer	Reliability	Assurance	Tangibles	Empathy	Responsiveness	Σ
1	10	10	40	35	5	100
2	0	0	40	60	0	100
3	10	15	25	25	25	100
4	20	20	20	20	20	100
5	5	5	0	40	50	100
6	20	20	20	20	20	100
7	5	15	20	20	40	100
8	30	10	10	50	0	100
9	20	20	20	20	20	100
10	20	20	30	15	15	100
11	20	20	10	10	40	100
12	20	40	15	15	10	100
13	25	20	10	20	25	100
14	25	25	15	15	20	100
15	25	25	20	15	15	100
16	25	20	25	15	15	100
17	25	30	15	15	15	100
18	30	20	10	25	15	100
19	30	20	15	15	20	100
20	20	20	20	20	20	100
21	20	20	30	10	20	100
22	20	25	15	15	25	100
23	20	20	20	20	20	100
24	15	15	25	25	20	100
25	20	25	15	15	25	100
26	25	25	15	15	20	100
27	25	20	15	20	20	100
28	20	25	15	15	25	100
29	25	15	15	25	20	100
30	25	20	15	25	15	100

Customer	Reliability	Assurance	Tangibles	Empathy	Responsiveness	Σ
31	25	15	25	15	20	100
32	15	15	15	15	40	100
33	18	12	30	20	20	100
34	20	10	30	30	10	100
35	15	15	40	15	15	100
36	20	25	15	15	25	100
37	15	15	30	20	20	100
38	17	13	40	15	15	100
39	20	20	20	20	20	100
40	25	20	10	20	25	100
41	10	20	30	30	10	100
42	20	25	15	15	25	100
43	20	25	15	15	25	100
44	0	0	30	20	50	100
45	10	20	30	20	20	100
46	20	25	15	15	25	100
47	15	25	15	15	30	100
48	20	20	20	20	20	100
49	20	25	15	15	25	100
50	25	20	20	15	20	100
51	30	25	15	5	25	100
52	20	20	20	20	20	100
53	20	25	15	15	25	100
54	20	25	15	15	25	100
55	20	25	15	15	25	100
56	20	25	15	15	25	100
57	0	0	50	50	0	100
58	20	25	15	15	25	100
59	25	25	15	15	20	100
60	20	25	15	15	25	100
61	20	25	15	15	25	100
62	20	20	20	10	30	100
63	20	25	15	20	20	100
64	30	10	10	20	30	100
65	30	10	10	15	35	100
66	10	20	30	20	20	100
67	20	20	20	20	20	100
68	20	30	5	15	30	100
69	20	25	15	15	25	100
70	30	15	20	20	15	100
71	10	20	20	0	50	100
72	30	30	10	10	20	100
73	30	30	20	10	10	100
74	25	15	20	15	25	100
75	50	10	20	10	10	100

Customer	Reliability	Assurance	Tangibles	Empathy	Responsiveness	Σ
76	20	20	20	20	20	100
77	20	20	10	20	30	100
78	25	25	30	10	10	100
79	25	15	20	10	30	100
80	20	20	20	20	20	100
81	20	25	15	15	25	100
82	20	20	20	20	20	100
83	25	15	15	20	25	100
84	20	20	20	20	20	100
85	15	10	10	40	25	100
86	20	20	20	20	20	100
87	15	30	10	30	15	100
88	40	20	30	5	5	100
89	25	25	15	20	15	100
90	15	10	20	40	15	100
91	35	5	30	20	10	100
92	25	25	15	15	20	100
93	20	30	10	10	30	100
94	15	20	20	25	20	100
95	20	20	20	20	20	100
96	20	25	15	15	25	100
97	20	25	15	15	25	100
98	20	25	15	15	25	100
99	20	20	20	20	20	100
100	20	20	20	20	20	100
101	25	15	15	20	25	100
102	20	20	20	20	20	100
103	20	20	20	20	20	100
104	15	20	15	25	25	100
105	20	20	20	20	20	100
106	20	20	20	20	20	100
107	15	25	20	20	20	100
108	35	20	18	12	15	100
109	20	20	20	20	20	100
110	20	20	15	15	30	100
111	15	15	25	20	25	100
112	15	25	15	15	30	100
SUM	2290	2225	2138	2127	2420	11200
Wij	0.204	0.199	0.191	0.190	0.216	1.000
Rank	*2*	*3*	*4*	*5*	*1*	

4.2. Application of the Fuzzy PIPRECIA Method to Obtain the Final Weights of the SERVQUAL Model Dimensions

The evaluation of the criteria has been performed using a linguistic scale that involves quantification into fuzzy triangular numbers. Table 7 shows the evaluation of the criteria for

fuzzy PIPRECIA and inverse fuzzy PIPRECIA by five decision-makers and the average values (AV) which are used for further calculation. It is important to note that, compared to the original method developed, the average value (AV) is used here to average decision-makers' preferences (Tomašević *et al*., 2020; Stanković *et al*., 2020), which in this specific case contributed to the more accurate input parameters of the model. Whether a geometric mean or an average value is applied depends directly on a particular case. Both methods of averaging are valid.

Table 7. Evaluation of the Main Criteria by DMs for the Fuzzy PIPRECIA and Inverse Fuzzy PIPRECIA Methods

PIPR.	C1			C2			C3			C4			C5		
DM1				0.500	0.667	1.000	0.667	1.000	1.000	0.500	0.667	1.000	1.300	1.450	1.500
DM2				0.667	1.000	1.000	0.667	1.000	1.000	0.400	0.500	0.667	1.400	1.600	1.650
DM3				0.667	1.000	1.000	0.500	0.667	1.000	0.667	1.000	1.000	1.200	1.300	1.350
DM4				0.500	0.667	1.000	0.667	1.000	1.000	0.500	0.667	1.000	1.300	1.450	1.500
DM5				0.667	1.000	1.000	0.400	0.500	0.667	0.667	1.000	1.000	1.200	1.300	1.350
AV				0.600	0.867	1.000	0.580	0.833	0.933	0.547	0.767	0.933	1.280	1.420	1.470
PIPR-I	C5			C4			C3			C2			C1		
DM1				0.333	0.400	0.500	1.100	1.150	1.200	1.000	1.000	1.050	1.100	1.150	1.200
DM2				0.286	0.333	0.400	1.200	1.300	1.350	1.000	1.000	1.050	1.000	1.000	1.050
DM3				0.400	0.500	0.667	1.000	1.000	1.050	1.100	1.150	1.200	1.000	1.000	1.050
DM4				0.333	0.400	0.500	1.100	1.150	1.200	1.000	1.000	1.050	1.100	1.150	1.200
DM5				0.400	0.500	0.667	1.000	1.000	1.050	1.200	1.300	1.350	1.000	1.000	1.050
AV				0.350	0.427	0.547	1.080	1.120	1.170	1.060	1.090	1.140	1.040	1.060	1.110

Based on the evaluation of the criteria and their averaging, Equation (7), a matrix *sj* is formed.

$$s_j = \begin{bmatrix} \dots \\ 0.600, 0.867, 1.000 \\ 0.580, 0.833, 0.933 \\ 0.547, 0.767, 0.933 \\ 1.280, 1.420, 1.470 \end{bmatrix}$$

Applying Equation (8), those values are subtracted from number 2. Following the rules of operations with fuzzy numbers, the *kj* matrix

$$k_j = \begin{bmatrix} 1.000, 1.000, 1.000 \\ 1.000, 1.133, 1.400 \\ 1.067, 1.167, 1.420 \\ 1.067, 1.233, 1.453 \\ 0.530, 0.580, 0.720 \end{bmatrix}$$

is obtained as follows:

According to Equation (8), the value $\overline{k_1} = (1.000, 1.000, 1.000)$

$$\overline{k_2} = (2-1.000, 2-0.867, 2-0.600) = (1.000, 1.133, 1.400)$$

Applying Equation (9), the value *qj*

$$q_j = \begin{bmatrix} 1.000, 1.000, 1.000 \\ 0.714, 0.882, 1.000 \\ 0.503, 0.756, 0.938 \\ 0.346, 0.613, 0.879 \\ 0.481, 1.057, 1.658 \end{bmatrix}$$

is obtained as follows:

$$\overline{q_1} = (1.000, 1.000, 1.000)$$

$$\overline{q_2} = \left(\frac{1.000}{1.400}, \frac{1.000}{1.133}, \frac{1.000}{1.000}\right) = (0.714, 0.882, 1.000)$$

$$\sum_{j=1}^{n} \overline{q_j} = (3.044, 4.309, 5.475)$$

Applying Equation (10), the relative weights are calculated:

$$\overline{w_1} = \left(\frac{1.000}{3.044}, \frac{1.000}{4.309}, \frac{1.000}{5.475}\right) = (0.183, 0.232, 0.329)$$

and then it is necessary to defuzzify the obtained value by using the expression $df_{crisp} = \frac{l + 4m + u}{6}$ obtaining the number df_{crisp} as follows:

$$df_{w1-crisp} = \frac{0.183 + 4 \times 0.232 + 0.329}{6} = 0.240$$

In order to determine the final weights of the criteria, it is necessary to apply Equations (11)–(15) or the methodology of the inverse fuzzy PIPRECIA method. Based on the evaluation by the decision-makers and the application of the average value, the matrix *sj'* is obtained.

$$s_j' = \begin{bmatrix} 1.040, 1.060, 1.110 \\ 1.060, 1.090, 1.140 \\ 1.080, 1.120, 1.170 \\ 0.350, 0.427, 0.547 \\ \ldots \end{bmatrix}$$

Applying Equation (12), the values of matrix *kj'* are obtained:

$$k_j' = \begin{bmatrix} 0.890, 0.940, 0.960 \\ 0.860, 0.910, 0.940 \\ 0.830, 0.880, 0.920 \\ 1.453, 1.573, 1.650 \\ 1.000, 1.000, 1.000 \end{bmatrix}$$

$$\overline{k_5}' = (1.000, 1.000, 1.000)$$

$$\overline{k_4}' = (2 - 0.547, 2 - 0.427, 2 - 0.350) = (1.453, 1.573, 1.650) \text{ etc.}$$

Applying Equation (13), the following values are obtained:

$$q_j' = \begin{bmatrix} 0.730, 0.844, 1.083 \\ 0.701, 0.794, 0.964 \\ 0.659, 0.722, 0.829 \\ 0.606, 0.636, 0.688 \\ 1.000, 1.000, 1.000 \end{bmatrix}$$

$$\overline{q_5}' = (1.000, 1.000, 1.000)$$

$$\overline{q_4}' = \left(\frac{1.000}{1.650}, \frac{1.000}{1.573}, \frac{1.000}{1.453}\right) = (0.606, 0.636, 0.688)$$ etc.

$$\sum_{j=1}^{n} \overline{q_j}' = (3.696, 3.996, 4.564)$$

After that, it is necessary to apply Equation (14) to obtain relative weights for the fuzzy Inverse PIPRECIA method.

$$\overline{w_5}' = \left(\frac{1.000}{4.564}, \frac{1.000}{3.996}, \frac{1.000}{3.696}\right) = (0.219, 0.250, 0.271)$$

and then it is necessary to defuzzify the obtained value by using the expression $df_{crisp} = \frac{l + 4m + u}{6}$ obtaining the number df_{crisp} as follows:

$$df_{w5'-crisp} = \frac{0.219 + 4 \times 0.250 + 0.271}{6} = 0.248$$

The results of the applied methodology are presented in Table 8. Applying Equation (15), the final weights of the criteria are obtained. Table 8 shows the complete previous calculation, and the last column shows the defuzzified values of the relative weights of the criteria.

Table 8. Calculation and Results Obtained by the Application of Fuzzy PIPRECIA and Inverse Fuzzy PIPRECIA for the Main Criteria

P.	$\overline{s_j}$			$\overline{k_j}$			$\overline{q_j}$			$\overline{w_j}$			DF
C1				1.000	1.000	1.000	1.000	1.000	1.000	0.183	0.232	0.329	0.240
C2	0.600	0.867	1.000	1.000	1.133	1.400	0.714	0.882	1.000	0.130	0.205	0.329	0.213
C3	0.580	0.833	0.933	1.067	1.167	1.420	0.503	0.756	0.938	0.092	0.176	0.308	0.184
C4	0.547	0.767	0.933	1.067	1.233	1.453	0.346	0.613	0.879	0.063	0.142	0.289	0.154
C5	1.280	1.420	1.470	0.530	0.580	0.720	0.481	1.057	1.658	0.088	0.245	0.545	0.269
SUM							3.044	4.309	5.475				
P-I	$\overline{s_j}'$			$\overline{k_j}'$			$\overline{q_j}'$			$\overline{w_j}'$			DF
C1	1.040	1.060	1.110	0.890	0.940	0.960	0.730	0.844	1.083	0.160	0.211	0.293	0.216
C2	1.060	1.090	1.140	0.860	0.910	0.940	0.701	0.794	0.964	0.154	0.199	0.261	0.201
C3	1.080	1.120	1.170	0.830	0.880	0.920	0.659	0.722	0.829	0.144	0.181	0.224	0.182
C4	0.350	0.427	0.547	1.453	1.573	1.650	0.606	0.636	0.688	0.133	0.159	0.186	0.159

P.	$\overline{s_j}$			$\overline{k_j}$			$\overline{q_j}$			$\overline{w_j}$			DF
C5				1.000	1.000	1.000	1.000	1.000	1.000	0.219	0.250	0.271	0.248
SUM							3.696	3.996	4.564				

Figure 1. Final Values of the Criteria Obtained Using the Fuzzy PIPRECIA Method

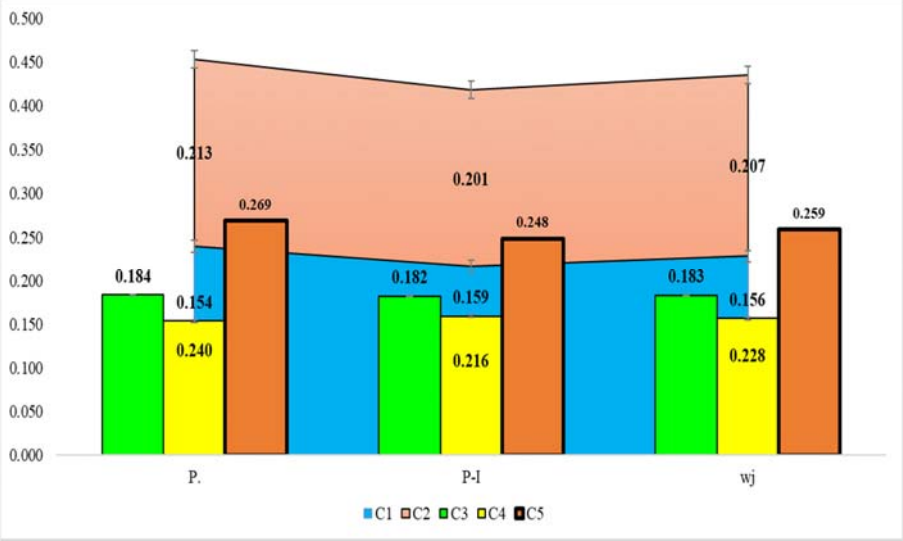

Figure 1 shows the final results of the procedure for determining the individual significance of each of the dimensions of SERVQUAL model. As explained above, based on the personal preferences of the five experts, the significance of the observed criteria was obtained using the Fuzzy PIPRECIA method. Then, the defuzzification of the values was carried out to obtain the final weights of dimensions of SERVQUAL model, and, based on them, we could determine that the most significant dimension is C5 (responsiveness) with a weight coefficient of 0.259, followed by the reliability dimension (C1) with a weight of 0.228, slightly smaller than the responsiveness dimension. The assurance dimension and the tangibles dimension follow with values (C2=0.207 and C3=0.183), while the empathy dimension is in the last place – C4=0.156.

Spearman's correlation coefficient (Božanić *et al*., 2020; Arsu, Ayçin, 2021) for the ranks obtained with fuzzy PIPRECIA and Inverse fuzzy PIPRECIA is 1.00, which means that these ranks are in complete correlation. Additionally, Pearson's correlation coefficient has been calculated for the weights of the criteria obtained using these approaches and is 0.994.

5. Conclusion

This paper presents an original integrated Delphi - fuzzy PIPRECIA methodology applied to determine the weights of the SERVQUAL model dimensions in reverse logistics. First, 112 respondents who filled in the SERVQUAL questionnaire determined the percentage significance of the dimensions: reliability, assurance, tangibles, empathy and

responsiveness. Then, weighted values were identified using the Delphi method and the rank of dimensions was determined. After that, five decision-makers evaluated the dimensions ranked in the previously mentioned manner. The fuzzy PIPRECIA method was applied and the final dimension values were obtained, which show that the fifth dimension, responsiveness, is the most significant for the users who participated in the research. The responsiveness dimension consists of five questions that are based on the ability of workers, adaptation to new situations, acceptance of novelties, quickness and accuracy of service delivery and the like. By the responsiveness dimension, it can be determined how much the utility company is interested in the progress and modernization of the services provided.

After defining the weights of the dimensions, it is needed to calculate the Cronbach's alpha coefficient as a factor of reliability of the SERVQUAL questionnaire, i.e. the questions within all five dimensions. Then, the obtained weight values should be integrated with the analyzed averaged values of perceptions and expectations. Finally, it is needed to determine the difference between perceptions and expectations of the SERVQUAL model, which is a measure of quality.

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