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DEVELOPMENT OF QUALITY ASSESSMENT MODELS USING TRAPEZOIDAL FUZZY NUMBERS WITH ASSOCIATED INDICATORS

Abstract

Developing evaluation methods for the service quality has become a priority in the society based on knowledge. In this article we will focus on the assessment process of service quality. Both declaratively (political assumptions, image promotion, etc.) and in an assumed manner (by laws, methodological rules, quality standards etc.), the quality of social services is a constant concern for the managers of the knowledge-based organization, and it directly concerns all the service providers and the beneficiaries of these activities. There is a debate within the knowledge-based society, concerning the fragile limit between what can be standardized and regulated.

From this point of view, the link between the need for nuancing in the assessment process and the degree of perishability of the quality features is straightforward and intuitive. By using the fuzzy numbers, we attempt to enrich the portfolio of instruments which can be used in the evaluation process of the services quality.

Keywords: *services quality, nuancing in the assessment process, fuzzy numbers*

1. The nuanced character of assessments concerning the quality of services

From our point of view the nuanced character of the quality assessment process is limited by the variability in the quality features between a reference level and a performance level. We refer to the reference level of service quality as those minimum quality standards regulated by specific rules. Starting from the law, the excellence of service is determined by the reference to the value of performance indicators that "exceed the reference level" and express a desirable standard at a given time. Most times these values are stipulated in the rules for the application of the law in force at a given time.

Thus, praxis, which usually exceeds the conceptualization in this area more than in many others, identifies and defines a reference level as a result of notable experiments, of statistical analysis relative to a certain specified period. We underline this aspect because we try to express the nuanced and relative character of these dimensions of quality.

When we refer to services it is necessary to point out the features that they define in general and thus to highlight the challenges to which a potential valuation model must respond to: the intangibility; the inseparability of production and consumption; the perishability / non-storing of the service; the strong client-provider interaction; the variability

The quality requirements for services must be clearly defined as variables easily observed and understood by the beneficiary and appreciated by reference to a system of standards / criteria.

We must emphasize that, epistemologically, there is a heated debate within the knowledge-based society, concerning the fragile limit between what can be standardized and regulated, on the one hand, and the practical low-homogeneity methods that services may materialize into in today's knowledge-based organization[2]. There is continuous pressure of the ethical and moral norms accumulated by a society at a given time on the concepts of quality and the reference standards on the one hand and expectations on the other. This directly impacts the principles, models and assessment tools thus greatly limiting the comparability over time. The perishability of quality features becomes the status quo.

The link between the need for nuancing in the assessment process and the degree of perishability of the quality features is straightforward. We believe that this relationship is defined both in terms of technical aspects (in conjunction with the technological development, the value of the indicators that regulate the minimum level of rights in a state of law, the new international commitments undertaken etc.) and morally speaking (in the direct correlation with the

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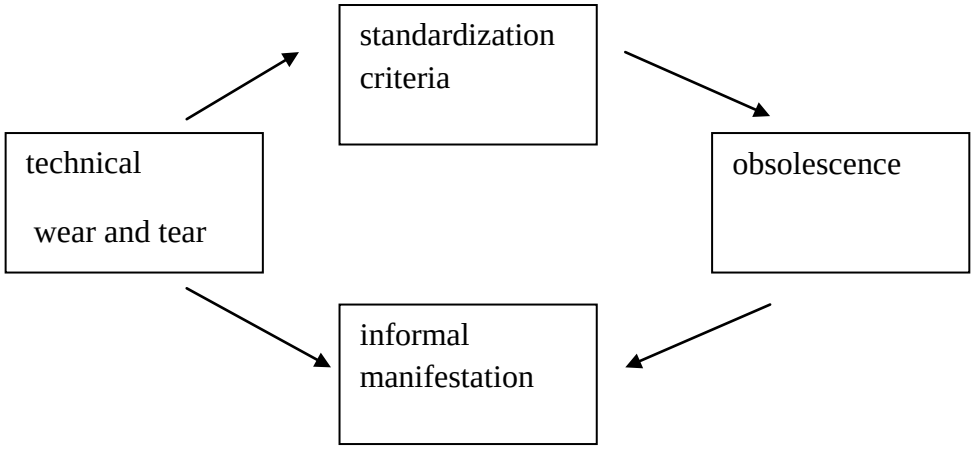
[2] Alecu Ionel Ciprian, *Utilizarea numerelor fuzzy in evaluarea calității serviciilor sociale,* in the *Symposion* magazine, under the auspices of the Romanian Academy Publishing House, Tome IX, No.2, 2011, Iasi ,pp 522

assimilation of new principles that define the human development, with the gradual change of the perception of beneficiaries and the increasing of the beneficiaries expectations, etc.).

Drawing 1. Perishability factors of the quality features



All this represent a strong argument in developing a complex and continuous assessment system, allowing updates and periodic conceptual and methodological enrichment. It also requires the integration thereof in a quality management project clearly defined by policies with a greater time horizon (at least 5-10 years). From the stand point of view we advocate for the development of assessment models by using nuanced numbers to face such challenges.

2. Models of quality assessment

Within the quality management processes in the knowledge-based organization different methods and techniques for assessing the quality of services have been developed over several decades. They slowly integrate all the statistical tools for assessment and analysis of qualitative variables. We believe that these tools need new interdisciplinary adaptations through fuzzy techniques[3] aiming at ensuring a higher degree of comparability, transferability and integratability.

We list some of these methods and techniques that we consider as distinct in terms of the principles and methodologies used as well as the degree of operability in various different fields of activity:

The Critical Incident Technique (CIT)[4] – is very well known and appreciated in technical fields; it is based upon the analysis of critical incidents directly observed in the consumer's behavior of paramount importance concerning the studied issue that meet the methodologically defined criteria. This model is widely used within the services characterized by a high technological and informational level, where the human factor is replaced in most activities, the direct contact with the customer is limited to a rigorously structured interface (helpdesk, website, etc.).

Another special tool is the **Grönroos model**[5] which analyzes the technical quality compared to the functional quality, focusing on how the service is perceived by its direct beneficiary. The model proposes the comparison between the expectations with the actual performance of the service. This principle was the basis in the European models in particular. The "Image" that the customer acquires is based upon two elements: the technical quality (or the physical outcome) and the functional quality (or interactive of the process).

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[3] Alecu Ionel Ciprian, *Utilizarea numerelor, 526*

[4] Robert Johnston , *The determinants of service, quality: satisfiers and dissatisfiers*, International Journal of Service, Industry Management, Vol. 6 No. 5, 1995, pp. 53-71., MCB University Press

[5] Christian Grönroos , *Service management and marketing. A customer relationship, management approach*. Chichester: Wiley, 2000

The model proposed by **U.Lehtinen and J.R. Lehtinen** (1991) aims at developing a tool for analysis allowing for the overcome of the abstract dimensions of quality[6]. From this point of view within the model three main functions are pursued: the physical dimensions of quality (- take into account the environment and the tools used – the play-out space, the instruments utilized, the furniture, the forms to be filled, etc.), the quality of interaction between the service provider and the service beneficiary, the quality of the organization (envisages the image of the organization, focusing on the culture elements of the organization);

The SERVPERF model proposed by **Cronin and Taylor** (1992) - analyzes the main quality features of a service.

This approach allows for a high psychometric evaluation of the quality performance of a service, with an impact on the results of operations and the conceptual stability[7].

These attempts have somehow anticipated the future trends of the development of the methods and techniques of assessment and analysis of service quality.

We believe that somewhat different and complementary to the need for information and knowledge on the quality of services in the organization based on knowledge is the model developed by Kano and Taguchi who propose the dimensions of the quality for evaluation in relation to the customer satisfaction, namely the basic quality " the performance quality" and "the delight quality[8]".

A special **model** is the one proposed by **Brady and Cronin**[9] (2011) which is based upon an hierarchical and multidimensional architecture, based around three axes: 1. the quality of interaction – seen as an analysis on three subgroups: attitude, behavior, expertise; 2. the physical quality of the environment – structured on the three subcategories of - ambient conditions, design and social factors; 3. The quality results – analyzed in terms of the following three elements sub-dimensions – tangible elements, waiting time, valences.

The multidimensional model **Dabholkar Shepherd and Thorpe**[10] is considering the reliability, personal attention, comfort and the features of the service offered to assess the ratio consumer / beneficiary on each component and on the whole[11].

One of the most used models is the one proposed by **Parasuraman, Zeithaml and Berry**. The most popular and widespread form of use is known under the generic name of SERVQUAL[12] (developed on the platform GASP or PZB[13]).

As it is widely used in practice, the SERVQUAL model was granted much more attention and a much broader debate; many authors were excited about the nature of the principles underlying the analysis of the quality features, the free and informal character of determining the composition of the development directions which enables a broader integration of ethical and moral rules of the society in the management of knowledge based organization. We also note the ease of the mathematical device, as it is being developed around the principle of arithmetic mean (sometimes not even weighted).

SERVQUAL is the most used method for assessing the service quality and was experienced in a variety of specific contexts (ex: professional services, health services, tourism services, transport services, electronic library services, computer services, telecommunications etc.) (Parasuraman 2000).

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[6] Gi-Du Kang, Jeffrey James, *Service quality dimensions: an examination of Gronroos's service quality model*, Managing Service Quality(2004), Volume:14, Issue 4

[7] Laura Martínez Caro, Ellen Roemer , *Developing a Multidimensional and Hierarchical Service Quality.Model for the Travel and Tourism Industry*., Bradford University School of Management, Working Paper No 06/18, July 2006

[8] A. Pugna, I. Tauceanu, G. Negru Străuți, *Kano`s tridimensional model for quality evaluation*, Buletinul AGIR, n 2-3, București, 2009

[9] Michael K. Brady, J. Joseph Cronin, Richard R. Brand, *Performance-only measurement of service quality:a replication and extension*, Elsevier Science , Journal of Business Research n.55,2002, p. 17– 31

[10] Dabholkar, P., Thorpe, D. I., & Rentz, J. Q. (1996). A measure of service quality for retail stores. Journal of the Academy of Marketing Science. 24

[11] Maive Suuroja, *Service quality-main conceptualizations and critique*, Tartu University Press, Tartu, 2003

[12] A.Parasuraman, V. Zeithaml and L. Berry, *SERVQUAL: a multiple item scale for measuring consumer perception of service quality*, Journal of Retailing, Volume 64, Number 1, 1988, p 12-40

[13] Alexandru Balog, Grigore Badulescu, *Modele conceptuale ale calitatii*, Theoretical and Empirical Researches in Urban Management, Year 3, Number 8, 2008

Although the SERVQUAL method was widely applied, the praxis resulted in widespread pragmatic criticism that were aiming at *the number of dimensions, the calculation of indicators*, ***the measurement scale used***, etc. Initially, the model was divided into 10 categories of features (tangible elements-1, reliability-2, responsiveness-3, competence-4, kindness-5, credibility-6, security-7 access-8, communication-9, consumer / beneficiary understanding -10). Following suggestions on how to practically conceptualize dimensions and criticism concerning the limits of the calculation method of indices, the model was redefined on 5 categories that we also cover as follows: tangible elements (tangibles): physical facilities, equipment, staff and advertising (physical evidence of service); reliability (reliability) the ability to perform the service properly, safely and always at the promised level of performance; responsiveness (responsiveness): the desire to assist customers and provide them with a prompt service; confidence (assurance): the ability to inspire safety and confidence to customers, as well as competence, respect and honesty to employees; empathy (empathy): treatment with the proper attention of each client, the ease of contact and communication with the client.

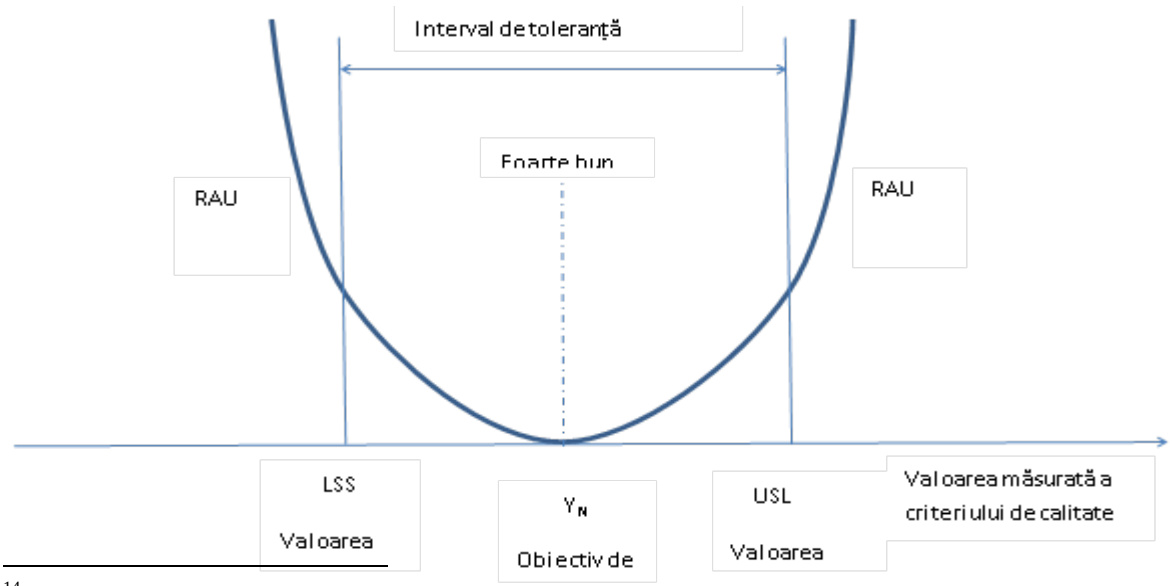
Based on a large number of experiments conducted and the information gathered from the practice of service assessment the relative importance of each dimension of service quality has been determined[14]: **tangible elements** 11% **reliability** 32%, **responsiveness** 22% **confidence** 19% and **empathy** 16% . Those shares are approximate and were obtained as average values from the experiments conducted by the authors of SERVQUAL. Depending on the type of service assessed and the experience of the evaluators in the field the service deals with, the shares may have different values.

3. The use of nuanced numbers in the quality assessment

One of the quality functions commonly used is the loss of quality function developed by Taguchi. Thus, it is considered that in case the quality features deviate from the optimal target, the costs expressed in monetary units increase in a quadratic manner (quadratic).

One can notice two convex functions on the two wings, and that the zero value is taken in the Yn point. It can be easily transformed into a fuzzy representation of a bell shape, triangular or trapezoidal. It appears as a mirror image compared to the original definition. The interpretation is similar but the membership functions in two distinct wings represent decreases in quality, deviations from the ideal value which the value 1 takes. We propose an approach by trapezoidal numbers to cover the need for a high degree of comparability in time, on the one hand, and on the other hand to meet the challenges of the low degree of homogeneity of services.

Drawing 2. The Taguchi quality loss function



[14] Revisoara Badulescu, Methods for evaluation of on-line public services, Theoretical and Empirical Researches in Urban Management, Year 3, Number 8, 2008

The trapezoidal fuzzy number that expresses the quality will be determined by the function of belonging μ_Q: R→[0,1], with the following format:

$$\mu_Q = \begin{cases} \mu_1(q), daca \quad LSS < q \le Y_n \\ 1, daca \quad x = Y_n \\ \mu_2(x), daca \quad Y_n \le q < USL \\ 0, daca \quad x \notin (LSS, USL) \end{cases}$$

The significance of service quality features and the categories of features may vary considerably depending on the nature of the services.

Within a Likert-type assessment, the standpoints can be assessed by using a scale of five degrees of comparability: very good, good, average, poor and very poor. From this standpoint we present a possible transformation of these standpoints using nuanced triangular numbers:

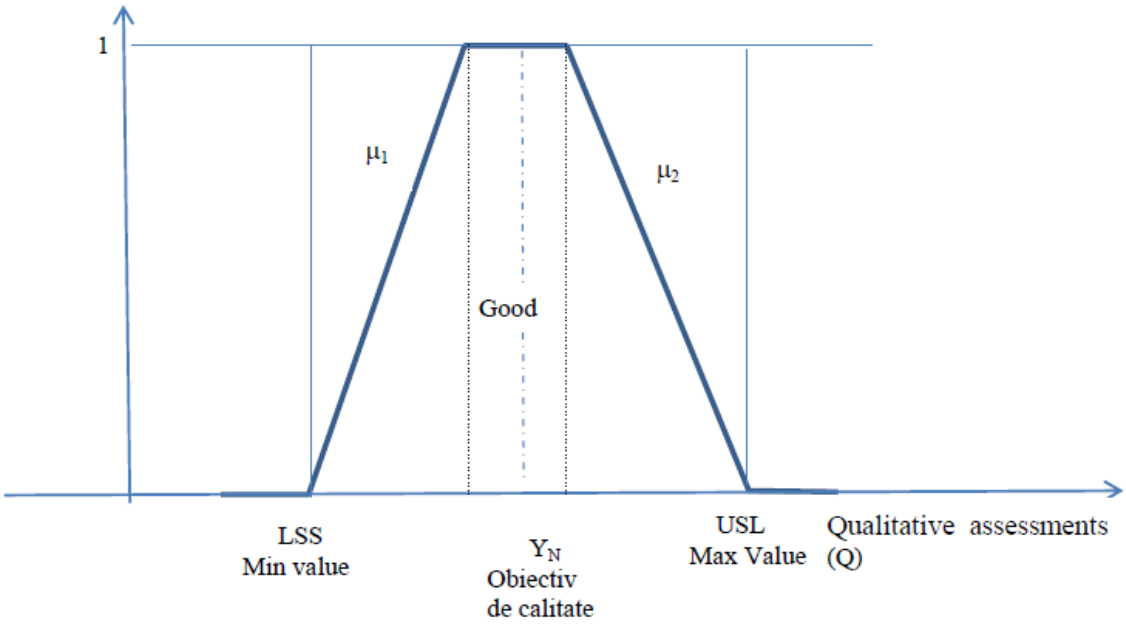
If linguistic variables are appealed to, we can obtain a representation if the following form:

- Very poor {0;00; 0,10; 0,30; 0.40; 0.60}
- Poor {0,10; 0,20; 0,40; 0.50; 0.70}
- Average {0,20; 0,30; 0,50; 0.60; 0.80}
- Good - {0,30; 0,40; 0,60; 0.70; 0.90}
- Very good {0,40; 0,50; 0,70; 0.80; 1.00}

Multiple item scales are proposed consisting of 7 or 11 elements in the nuanced developments. For the fuzzy subsets, scales of 11 elements are usually used, especially if logical operators are involved in the valuation model[15].

The mode of operation with trapezoidal nuanced assessments can be defined by specific mathematical operations of addition, multiplication, subtraction, division and multiplication by a scalar.

Drawing 3. Nuanced trapezoidal representation of the Taguchi quality loss function



[15] Antonio Maturo., (2009).. *Alternative Fuzzy Operations and Social Sciences., in International Journal of Intelligent Systems,*. Vol.24, p 1234-1264

By the use of the fuzzy numbers in shaping qualitative assessments, theoretical developments brought from Zadeh (1975), V. Georgescu (1995), Tamura Hatono and M. Umano (1998), Gil Aluja and Teodorescu (1998), Lazzari and Martinez Panero (2001), Garcia-Lampresta and L. Lamazares (2003), O. Gherasim (2006) can be highlighted.

We briefly introduce elementary trapezoidal fuzzy numbers with associated indicators with indicators and the operations to which within our numerical example (Gherasim, 2005).

Whether two trapezoidal fuzzy numbers u, v ∈Trp, $u = (a_u, c_u, d_u, b_u)$, and $v = (a_v, c_v, d_v, b_v)$,

Elementary associated indicators

$$G(u) = \ < u > \ = N(u) + \frac{S^R(u) - S^L(u)}{2} \in R) \tag{2}$$

Variable associated indicators

Operations

I. Multiplication by a scalar $$tu = \begin{cases} (ta,tc,td,tb) & ,t \geq 0 \\ (tb,td,tc,ta) & ,t < 0 \end{cases}, t \in R, \tag{3}$$

II. Addition $$u + v = (a_u + a_v,\ c_u + c_v,\ d_u + d_v,\ b_u + b_v) \tag{4}$$

III Multiplication : $$uv \overset{\text{def.}}{=} \frac{u < v > + < u > v}{2} \tag{5}$$

IV. Subtraction : $$u - v \overset{\text{def.}}{=} u + (-v) = u + (-1) \cdot v, \tag{6}$$

V. Reverse : $$v^{-1} \overset{\text{def.}}{=} \frac{v}{\langle v \rangle^2} \tag{7}$$

VI The division *:* $$\frac{u}{v} \overset{\text{def.}}{=} u \cdot v^{-1} = \frac{uv}{< v >^2} = \frac{u < v > + < u > v}{2 < v >^2} \tag{8}$$

4. The using of trapeze nuanced assessments within the SERVQUAL model

The procedure for the quality measurement and assessment by using nuanced assessments within the method SERVQUAL consists of the following main steps.

Stage 1. Identification of the requirements for service quality

Depending on the particularities of the service, five dimensions of quality defined in the SERVQUAL model are identified for the performed analysis. It is also now that the optimal principles pursued within the quality analysis are set.

Stage 2. Identification of the nuanced features of quality - now identify the attributes / features that are being assessed effectively within the questionnaires for each dimension / category of quality of the service category previously defined are identified. The objective of this stage is to obtain the matrix of the dimensions and features of the analyzed service quality.

Stage 3. Data collection based upon survey

In order to collect the data, two questionnaires are applied, by using the survey technique to query the customer expectations and perceptions.

We will thus have two categories of results concerning the quality:

- *"The customer expectations" assessed by the first questionnaire*
- *"The customer perceptions" analyzed by the second questionnaire*

In its most simple form in terms of costs and dedicated time, the questionnaires are sent to subjects in electronic form or on paper, with instructions for completion and use of the questionnaires, as well as the conceptual developments on the significance of quality features which are the subject of the research. On the completion of the first survey, the person being questioned must appreciate whatever the quality of that particular service based on his/her own experience as a user of the service means to him/her. The aim is to identify and appreciate the degree to which the service should meet the specified quality attributes. The responses imply the granting of qualifiers by 5.7 or 9 degrees of intensity, depending on the chosen degree of sensitivity.

Given the limitations, we recommend the use of the Delphi technique for a better identification of the real expectations and to avoid the obtaining of a spectrum of standpoints more or less focused on the dimensions of quality pursued.

After the synthesizing of the answers two quality assessment matrices will be obtained on the two directions - expectations and perceptions.

Table 1. The quality matrix of expectations for the k category

S_{ubject} / $F_{eatures\ of\ quality}$	S_1	S_2…….	S_n
F_1	$[A]_{11}$	$[A]_{12}$	$[A]_{1n}$
F_2	$[A]_{21}$	$[A]_{22}$	$[A]_{2n}$
. .	. .	. .	. .
F_m	$[A]_{m1}$	$[A]_{m2}$	$[A]_{mn}$

Table 2. The quality matrix of perceptions for the k category

S_{ubject} / $F_{eatures}$ of quality	S_1	S_2…….	S_n
F_1	$[P]_{11}$	$[P]_{12}$	$[P]_{1n}$
F_2	$[P]_{21}$	$[P]_{22}$	$[P]_{2n}$
. .	. .	. .	. .
F_m	$[P]_{m1}$	$[P]_{m2}$	$[P]_{mn}$

Also the importance coefficients for each feature and rated topic can be defined.

Table 3. Matrix of the importance /share coefficients

S_{ubject} / $F_{eatures}$ of quality	S_1	S_2…….	S_n
F_1	α_{11}	α_{12}	α_{1n}
F_2	α_{21}	α_{22}	α_{2n}
. .	. .	. .	. .
F_m	α_{m1}	α_{m2}	α_{mn}

Stage 5. Determination of the quality indicators

a) *Determining of the quality of service for each dimension*

The indicator is calculated as the standard deviation between the "perception" (perceptions) and "expectations" (expectations) for each dimension of service quality.

$$Q_k = (\Sigma\ [P]ij - [A]ij)/n \qquad (9)$$

Where:

Q_k the quality of service for the category k, k=1.5

[P]ij - the trapezoidal nuanced qualitative perceptions for the subject j questioned according to the appropriate quality features of i

[A]ij - the trapezoidal nuanced qualitative expectations for the subject j questioned appropriately for the quality features of i

n- Number of the subjects surveyed.

b) The calculation of the overall quality (un-weighted) of the service

The indicator is calculated as the average value of the service quality.

If the importance indicators of quality groups were defined then *a weighted average for obtaining of the overall quality Q will be applied.*

The indicator is calculated taking into account the weights given by the assessor to each dimension of the service quality.

Stage 4. The presentation and interpretation of results

The results of the evaluation process covered by a synthetic evaluation report.

Usually, it contains all the documents prepared during the previous stages, as well as a series of summary tables and graphs based on the data from the said documents and that are used for the interpretation of the results.

The interpretation of the final outcome of the assessment – the "quality" indicator expressed as the difference between perceptions and expectations – will be achieved based upon the following scheme:

- the positive values indicate a higher quality level than expected;
- the negative values indicate a poor quality level;

the zero value or significantly towards zero indicates a satisfactory level of quality. Nuanced trapezoidal reports can be defined to allow the identification of various degrees of quality satisfaction as the ratio between expectations and perceptions. Their substantiation will be achieved based upon the experience of the experts correlated with long-term strategic objectives.

5. Conclusions

By combining a fuzzy number to a variable quality feature as an ordinal variable-type or interval-type to include other complementary elements of research, we believe that the definition and characterization of a more complex image with a higher degree of comparability can be achieved. The quality analysis of the services in the multitude of its complexity can be seen as an expression of the evolution of the quality of life, man and society.

Given the major debates on the concept of quality of services (from the nature of the quality as the perception of comfort or discomfort to the shape of the model of the central indicator used single or aggregate – an expression of many technical or psychosocial features), the fuzzy numbers meet the need for a complex assessment, leading to a homogenization of the knowledge and an increase of the comparability degree over time.

The challenge is to obtain a nuanced assessment based on principles specific to the quality management. Working with nuanced values obtained is very easy[16] and it becomes very easy to apply using specific programs. Weighted averages can calculated, ordinal variables can be combined with the interval-type or report-type ones, nonparametric correlation coefficients can be determined.

From these standpoints mentioned above we can hope to achieve unity in the quality management of services.

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