



# Strategic Analysis of Transit Service Quality Using Fuzzy AHP Methodology

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## Abstract

Customer satisfaction analyses are deeply based on customers' judgments and as consequence, they can be characterized by a certain degree of uncertainty generally ascribed to coexistence of three relevant aspects: vagueness, imprecision and subjectivity.

In the present paper, a methodology able to handle such uncertainty, based on the ServQual discrepancy paradigm and that uses in combined manner the AHP method and the Fuzzy Sets Theory is proposed in order to overcome limitations of the traditional service evaluation approaches. Subsequently, by considering the Italian public transit service sector, a service quality analysis is conducted and the overall transit service quality structure is described. Finally, by using the developed methodology, the evaluation of customer satisfaction for the public urban transit service provided in the city of Palermo (Italy) is performed, and the prioritizing of its critical to quality service attributes is carried out.

The obtained results show that only few service attributes play an important role in performing a quality transit service.

*Keywords:* Transit Service Quality, Uncertainty Management, ServQual Model, AHP Method, Fuzzy Sets Theory, Customer Satisfaction Evaluation.

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## 1. Introduction

Performance of a service is not directly observable and consequently it cannot be evaluated by means of service direct measures. Typically, such an evaluation is performed by considering suitable and measurable service performance aspects, whose measures provide an indirect evaluation of the service performance level. For example, the evaluation of customer satisfaction (CS) represents an indirect measure of service performance, since it is performed with relation to proper service factors whose performance levels, quantified by means of the so called "manifest variables", are intended as "latent effects" of the service performance level (Ding, 2006). The relationship between manifest variables and latent effects can be formalized by means of specific conceptual models.

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In the literature, several conceptual models have been proposed and among these, as pointed out by Büyüközkan *et al.*, (2011), the ServQual model (Parasuraman *et al.*, 1985) is still the widely used model for measuring service quality. Several recent applications of the ServQual model in different service fields are described in: Ahn *et al.*, (2007); Cristobal *et al.*, (2007); Bai *et al.*, (2008); Song *et al.*, (2008); Chen *et al.*, (2009); Large *et al.*, (2009); Liu *et al.*, (2009); Lin, (2010); Büyüközkan *et al.*, (2011).

By considering the ServQual model, the evaluation of CS level is obtained by discrepancy or gap measures between customers' expectations " $P$ " and their perceptions " $E$ ", *i.e.*  $Gap = P - E$  (Parasuraman *et al.*, 1985). Therefore, customer's dissatisfaction is collected for the service aspects in which a negative Gap value is obtained.

In the present paper, the ServQual discrepancy paradigm is considered to evaluate the CS level. In particular, to estimate expectations' levels of service dimensions and attributes, the Analytic Hierarchy Process (AHP) method is herein considered (Saaty, 2000). In particular, AHP presents several advantages as: full differentiation among importance ratings, seeking consistency in judgments by means of the inconsistency ratio  $IR$ , easiness to use, etc. It also allows to structure complex problems in the form of a hierarchy or a set of integrated levels and can be combined with operations research techniques to handle more difficult problems.

AHP is a multi-criteria decision making (MCDM) method that helps the decision-maker facing a complex problem with multiple conflicting and subjective criteria (*e.g.* location or investment selection, projects ranking, and so forth). Several papers have compiled the AHP success stories in very different fields. For example, in Berritella *et al.*, (2008) AHP is proposed as tool to make group decisions, and in particular to involve a team of experts in an analysis regarding the transport field. In the Project management field, AHP has used for assessment and allocation of human resources. Dweiri *et al.*, (2006) propose a fuzzy decision making system (FDMS) for the evaluation of project management internal efficiency by considering as evaluation criteria the project cost, the project time and project quality and they suggest the use of AHP to find out the relative weights of criteria. Also Certa *et al.*, (2009) propose the use of AHP in the field of the project management. Recently, Certa *et al.*, (2013) summarize various engineering fields in which AHP has been applied. In the field of service quality assessment AHP has been recently suggested by Lupo *et al.*, (2008) to find out the relative importance weights of student requirements in higher educational sector. However, to our knowledge, there are not applications of AHP to the transit service sector as tool to evaluate the weights of its strategic attributes.

In order to adopt the AHP method for the aim of the present work, the first step concerns the identification of the service quality structure. The latter consists of several hierarchical levels: the first one includes the general objective or goal of the analysis, *i.e.* overall CS. In the second level the service quality dimensions, *i.e.* the service characteristics that are directly related with overall CS are reported. Subsequently, in the third level, the service attributes for each service dimension are identified. The number of the considered hierarchical levels depends on the detail degree that one wants to carry out with the analysis. The Fig 1 shows a general three levels hierarchical quality structure composed by  $w$  service dimensions,  $D_1, D_2, \dots, D_w$ , each one composed by  $C_1, C_2, \dots, C_w$  service attributes respectively. In particular, in the Fig. 1 the generic service attribute  $j$  of the service dimension  $i$  is denoted with the term  $A_{ij}$ .

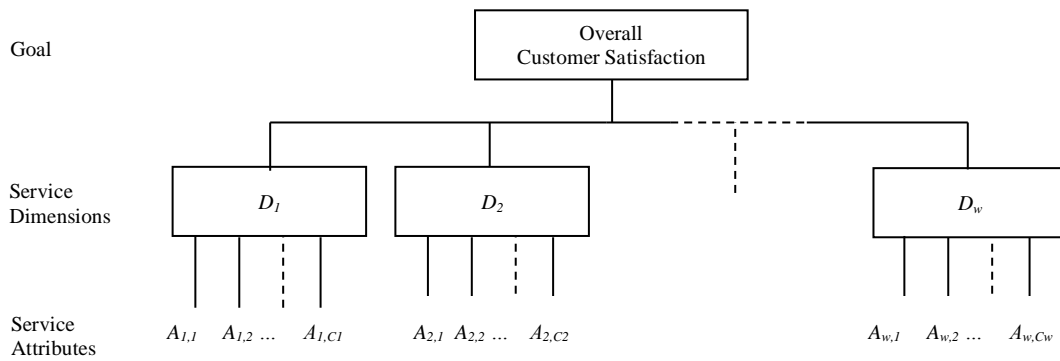


Figure 1: Hierarchical structure of service quality.

However, AHP in its original formulation can be unreliable in handling ambiguity of the concepts associated to the use of the human knowledge. In fact, unfortunately, the latter is often incomplete, inconsistent and even vague or imprecise and, as consequence, this introduces uncertainty in service performance analyses.

The choice of the technique to be used to minimize uncertainty effects is usually based on the type and nature of uncertainty (Ferdous *et al.*, 2012). However, since uncertainty related to service performance analyses is of epistemic type: it is generally ascribed to coexistence of three relevant aspects, *i.e.* vagueness, imprecision and subjectivity in customers' judgments (Curcurù *et al.*, 2012), the Fuzzy Set Theory (FST) (Zadeh, 1965) is herein considered to deal with such uncertainty type.

The FST allows mathematical representation of uncertainty and vagueness and provides formalized tools for dealing with intrinsic imprecision of many real-life problems. In particular, it is particularly useful in the quantification of linguistic categories since it allows representation for different "membership degrees" of a concept (Negoita, 1985). The FST has been applied in many fields of the management science (Büyüközkan *et al.*, 2011a and 2011b), but it is still quietly used in the service quality assessment field (Tseng, 2009a and 2009b).

In the light of the previous considerations, the purpose of the present work is to develop a ServQual based methodology with the aim to overcome the previously described limitations. For such motivation, an efficient combined procedure based on integration between the AHP method and the FST is herein proposed to effectively handle uncertainty in service performance analyses. In particular, the FST is considered to deal with such uncertainty, whereas the AHP method is adopted as tool to estimate importance weights of strategic service dimensions and attributes.

Subsequently, the strategic analysis of the public urban transport service delivered in Palermo (Italy) by using the proposed methodology is performed and the possible implications for the overall service improvement are given.

The remainder of the present paper is organized as follows: in the next Section a brief literature review on recent studies about measurements of transit service quality and CS is given; in the Section 3, the theoretical issues of the proposed composite methodology are described; in the Section 4, the Italian public transit service sector is analysed and its strategic service quality structure is described; in the Section 5 performance evaluation of public transit service delivered in Palermo is performed by means of the developed

composite approach and the obtained results are commented and, finally, the conclusions, with a summary and directions for future researches, close the work.

## 2. Literature review

Measurement of transit service performance represents a crucial activity with relation to various aspects. First of all, to assess community expectations and perceptions related to the main service attributes, and, secondarily, to point out management problems regarding costs of the service (Transport Research Board, 1994). In addition, service performance measures can be used as monitoring tool to on-going control the service quality level and to compare the obtained performance service level over time and/or across space (De Borger *et al.*, 2002).

In the literature, there is a variety of methods regarding the performance measures about the different transit service aspects, specifically applied to a local public transport and to possible methodological advantages. Such methods can be mainly classified as stated importance methods, in which customers are asked to rate each service attribute on an importance scale, or derived importance methods, in which the importance measure of each service attribute is statistically derived considering relationships among individual service attributes with overall satisfaction.

Derived importance methods are widely considered in the recent decade since, although stated importance methods are intuitive and simple to use, they require a significant increase in the length of the survey and can sometimes yield insufficient differentiation among importance ratings. Several recent applications of derived importance methods based on CS surveys are described in: Cavana *et al.*, (2007); Dell'Olivo *et al.*, (2010); Eboli *et al.*, (2007); Jen *et al.*, (2011); Joewono *et al.*, (2007); Nurul-Habib *et al.*, (2011); Pakdil *et al.*, (2007) and Weinstein, (2000).

From stated preference surveys, the most recent applications are described in: Cirillo *et al.*, (2011); Dell'Olivo *et al.*, (2011); Eboli *et al.*, (2008a, 2008b, 2010); Felici *et al.*, (2008); Gatta, (2006, 2008); Gatta *et al.*, (2007); Hensher *et al.*, (2002); Hensher, *et al.*, (2003); Marcucci, (2005); Marcucci *et al.*, (2006, 2007, 2012) and Valeri *et al.*, (2012).

Recently, many Authors focused their attention on the heterogeneity of passengers' perception of various aspects of transit service (Cirillo *et al.*, 2011; Dell'Olivo *et al.*, 2010; Eboli *et al.*, 2008b; Eboli *et al.*, 2011; Marcucci *et al.*, 2012). In particular, such heterogeneity, mainly related to certain aspects of the service, the different attitudes passengers have toward the use of transit service, the social and economic characteristics of passengers and the different ways of viewing aspects of the service (Eboli *et al.*, 2011), can represent a further problem for many widely used techniques that intend to measure service quality.

In addition, as before said, judgments provided by customers can be affected by possible uncertainties related to incompleteness for partial ignorance, imprecision for subjectivity and even vagueness and, as consequence, the obtained results by these methods can be unreliable. The latter, can be also related to the commonly considered series disposition of service items in widely considered CS questionnaire structures, that can bring customers to simultaneously consider for judgment all the service items (Simon, 1983 and Miller, 1956). For such reasons, in order to overcome the previously described limitations, the methodology hereafter described is developed.

### 3. Design and methodological approach

In the next section a brief overview about FST and its theoretical principles useful for the aim of the present work are given. Subsequently, the considered methodological approach for the measurement of customers' importance weights and perception levels of service dimensions and attributes are described.

#### 3.1 Fuzzy Set Theory and Linguistic-Fuzzy Scales.

In the FST, the concept of convexity of a set differs from that applied in the classical set theory: a fuzzy set is said convex if and only if the degree of membership  $\mu_A$  of an element  $x_2$  between two elements  $x_1$  and  $x_3$  is not less than the minimum value among the membership degrees of  $x_1$  and  $x_3$ . More in detail, a fuzzy number  $\tilde{A}$  is a convex fuzzy set defined in  $R$  and such that:

1.  $\exists x_0 | \mu_A(x_0) = 1$
2. the membership function  $\mu_A(x)$  is continue.

In the present paper positive triangular fuzzy numbers (TFN) are considered, for which the membership function is given by the following relationship:

$$\mu_A(x) = \begin{cases} \frac{x-x_L}{x_N-x_L} & \text{for } x_L \leq x \leq x_N \\ \frac{x-x_U}{x_N-x_U} & \text{for } x_N \leq x \leq x_U \\ 0; & \text{otherwise} \end{cases} \quad (1)$$

Alternatively, by defining the interval of confidence level  $\alpha$  ( $\alpha$ -cut), a TFN can be characterized as:

$$\forall \alpha \in [0,1] \\ \tilde{A}_\alpha = [a_L^\alpha, a_U^\alpha] = [(x_N - x_L)\alpha + x_L, -(x_U - x_N)\alpha + x_U] \quad (2)$$

Service performance analyses often articulate customers' knowledge/judgments in term of linguistic variables such as: *very bad, poor, average, good, excellent*, etc. Ayyub *et al.*, (2006) provided a chart to define the lower and upper boundary for such variables based on experts' assessment. Considering the most likely value as an average of these two boundaries, TFNs can be used to represent such linguistic variables. The fuzzy boundaries of a TFN may also be defined by means of the Fuzzy Delphi method, which is a typical multi-experts procedure for combining views and opinions (Kaufmann *et al.*, 1988). Moreover, the FST allows the extension of arithmetic operations for real crisp numbers to fuzzy numbers. By considering the membership degree  $\alpha$  ( $\alpha$ -cut) of positive fuzzy numbers, some main operations useful for the aim of the present work are given by the following expressions (Klir, 1999):

$$\begin{aligned}
 \forall \alpha \in [0,1], \quad \forall a_L, a_U, b_L, b_U \in R^+, \quad \tilde{A}_\alpha &= [a_L^\alpha, a_U^\alpha], \quad \tilde{B}_\alpha = [b_L^\alpha, b_U^\alpha] \\
 \tilde{A}_\alpha \oplus \tilde{B}_\alpha &= [a_L^\alpha + b_L^\alpha, a_U^\alpha + b_U^\alpha] \\
 \tilde{A}_\alpha \ominus \tilde{B}_\alpha &= [a_L^\alpha - b_L^\alpha, a_U^\alpha - b_U^\alpha] \\
 \tilde{A}_\alpha \otimes \tilde{B}_\alpha &= [a_L^\alpha \times b_L^\alpha, a_U^\alpha \times b_U^\alpha] \\
 \tilde{A}_\alpha / \tilde{B}_\alpha &= [a_L^\alpha / b_L^\alpha, a_U^\alpha / b_U^\alpha]
 \end{aligned} \tag{3}$$

In the present study, linguistic terms are used to represent the customers' assessments and positive TFNs are considered for their evaluations. The methodological approach is described as follow.

### 3.2 Measurement of customers' expectations

As before said, in the present paper a composite approach between the AHP method and the FST is considered to effectively handle uncertainty related to service performance analyses. According to this purpose, in the literature several applications of fuzzy extensions of AHP are proposed in different research fields (Chamodrakas, 2010, Fu, 2006 and Huang, 2008). However, in the field of service quality assessment is still scarcely considered (Büyüközkan *et al.*, 2001 and Ayagç, 2005).

The four step-procedure of this approach is given as follow:

- Step 1: *Compare the performance score.*

Linguistic terms are used to indicate the relative importance of each pair of elements in the same hierarchy level (see Figure 1).

- Step 2: *Construct the fuzzy comparison matrix.*

By using TFNs via pairwise comparison, the pairwise comparison matrix is constructed. In particular, considering the service attributes of the generic service dimension  $k$ , the generic element  $\tilde{a}_{ij}$  of the pairwise comparison matrix  $\tilde{A}_k$ , represents the value, expressed in fuzzy form, of the pairwise importance comparison between the service attributes  $i$  and  $j$  respectively. In particular, for the generic service dimension  $k$ , not all the  $C_k^2$  pairwise comparison coefficients have to be detected, since:

$$\begin{aligned}
 \tilde{a}_{i,j} &= 1/\tilde{a}_{j,i} \\
 \forall i &\neq j
 \end{aligned} \tag{4}$$

and

$$\begin{aligned}
 \tilde{a}_{i,i} &= 1 \\
 \forall i, j &= 1, 2, \dots, C_k
 \end{aligned} \tag{5}$$

Therefore, only  $C_k (C_k - 1)/2$  pairwise comparison coefficients have to be detected by the customers' assessments.

For the aggregation of multiple customers' judgments, a number of methods, *e.g.*, max-min arithmetic averaging, symmetric sum, t-norm, etc., are available. The

geometric mean is herein considered as aggregator operator since, as pointed out by Enea *et al.*, (2004), it allows the respect of the AHP constraint expressed by Eq. (4). In fact, if  $\tilde{p}_{ijk}$  is the fuzzy preference of the generic  $k^{th}$  customer and  $t$  the number of judgments to be aggregated, it is possible to write:

$$\tilde{a}_{i,j} = \left( \prod_{k=1}^t \tilde{p}_{ijk} \right)^{1/t} \quad \tilde{a}_{j,i} = \left( \prod_{k=1}^t 1/\tilde{p}_{ijk} \right)^{1/t} \quad (6)$$

and consequently:

$$\tilde{a}_{i,j} = 1/\tilde{a}_{j,i} \quad (7)$$

Subsequently, also the pairwise comparison matrix for the upper hierarchy level of the service dimensions is constructed. The next step is related to the evaluation of the local importance weights of the service dimensions and attributes, by using the following computational procedure.

- Step 3: *Computing of both the maximum fuzzy eigenvalue and the related fuzzy eigenvector of  $\tilde{A}_k$ .*

The maximum fuzzy eigenvalue  $\tilde{\lambda}_{\max}$  of  $\tilde{A}_k$  is a fuzzy number solution of the following fuzzy relationship:

$$\tilde{A}_k \cdot \tilde{w} = \tilde{\lambda}_{\max} \cdot \tilde{w} \quad (8)$$

in which,  $\tilde{w}$  is a fuzzy vector ( $C_k \times 1$ ) composed by  $C_k$  fuzzy numbers  $\tilde{w}_i$  that represent the local importance weights of the  $C_k$  compared service attributes. Considering the relationships reported in Eqs. (2), for the generic service attribute  $i$ , the Eq. 8 can be written as:

$$\left[ (a_L^\alpha)_{i,1} \cdot (w_L^\alpha)_1, (a_U^\alpha)_{i,1} \cdot (w_U^\alpha)_1 \right] \oplus \dots \oplus \left[ (a_L^\alpha)_{i,n} \cdot (w_L^\alpha)_n, (a_U^\alpha)_{i,n} \cdot (w_U^\alpha)_n \right] = \left[ \lambda_L^\alpha \cdot (w_L^\alpha)_i, \lambda_U^\alpha \cdot (w_U^\alpha)_i \right] \quad (9)$$

in which:

$$\begin{aligned} \tilde{A}_k &= [\tilde{a}_{i,j}] \quad \tilde{w}^t = (\tilde{w}_1, \dots, \tilde{w}_{C_k}) \\ \tilde{a}_{ij}^\alpha &= \left[ (a_L^\alpha)_{i,j}, (a_U^\alpha)_{i,j} \right] \quad \tilde{w}_i^\alpha = \left[ (w_L^\alpha)_i, (w_U^\alpha)_i \right] \quad \tilde{\lambda}_{\max}^\alpha = [\lambda_L^\alpha, \lambda_U^\alpha] \\ \forall \alpha &\in [0,1]; \quad i, j = 1, 2, \dots, C_k \end{aligned} \quad (10)$$

The  $\alpha$ -cut is known to include the customer's confidence over his/her preferences. In the case herein considered it incorporates the customer's confidence and uncertainty over their judgments. Therefore, by considering the index of optimism  $\mu$  (Lee, 1999), the pairwise comparison coefficient of the importance between the service attributes  $i$  and  $j$  at the confidence level  $\alpha$  can be written as:

$$\begin{aligned} \tilde{a}_{ij}^{\alpha} &= \mu \cdot (a_U^{\alpha})_{i,j} + (1 - \mu) \cdot (a_L^{\alpha})_{i,j} \\ \forall \alpha \in [0,1] \end{aligned} \quad (11)$$

When  $\alpha$  is fixed, after setting the index of optimism value  $\mu$  the following matrix (12) can be obtained and considered to estimate the local importance weights of the considered service attributes.

$$\tilde{A}_k = \begin{bmatrix} 1 & \tilde{a}_{1,2}^{\alpha} & \dots & \tilde{a}_{1n}^{\alpha} \\ \tilde{a}_{21}^{\alpha} & 1 & \dots & \tilde{a}_{2n}^{\alpha} \\ \dots & \dots & \dots & \dots \\ \tilde{a}_{n1}^{\alpha} & \dots & \dots & 1 \end{bmatrix} \quad (12)$$

- Step 4: *Computing the global importance weights.*

The last step is to determine the global importance weights of the service attributes. The latter can be obtained by multiplying the local importance weights of each service attribute by the importance weight or the related service dimension (Saaty, 2000).

### 3.3 Measurement of customers' perceptions

The fuzzy perception level related to the service attribute  $i$  of the generic service dimension  $k$ , at the confidence level  $\alpha$  ( $\alpha$ -cut),  $(\tilde{P}_{\alpha})_{k,i}$ , can be obtained with refer to the judgments satisfaction degree. The latter is estimated by the index of optimism  $\mu$ . The larger value of the index  $\mu$  indicates the higher degree of optimism. As before said, such index is a linear convex combination defined as:

$$\begin{aligned} (\tilde{P}_{\alpha})_{k,i} &= \mu (p_U^{\alpha})_{k,i} + (1 - \mu) \cdot (p_L^{\alpha})_{k,i} \\ \forall \alpha \in [0,1] \end{aligned} \quad (13)$$

in which in Eq. 13,  $(p_U^{\alpha})_{k,i}$  and  $(p_L^{\alpha})_{k,i}$  are the upper and lower bounds of fuzzy aggregated judgments at the confidence level  $\alpha$  ( $\alpha$ -cut), considering as aggregator operator the arithmetic mean. While  $\alpha$  is fixed, after setting the index of optimism value  $\mu$ , the Eq. 13 gives the crisp value of the customers' perception level for the considered service attribute.

## 4. Quality in Italian transit service sector

The Italian transit service sector presents a significant economic size with about the 24.9% of the population over 14 years that uses transit services for their displacements. The related market is affected by complex interactions among different economic subjects that give a particular configuration to its structure:

- a main national operator that assumes a legal monopoly position;
- a series of secondary operators connected with the main operator;
- many small operators organized, in general, in trade associations;



- supply chains;
- Regulatory Authorities in the sector.

The Italian public transit sector is characterized by a crisis condition that by now persists by several years. Over the last five years, the reduction of the users' number is equal to 19% and, at the same period, the increasing of the kilometres number performed by means of private vehicles is equal to 28%. There are not doubts that the widespread increasing of the life quality has contributed to establish such situation. In addition, such crisis condition can be also associated to the fact that customers, on average, perceive public transports characterized by a low overall quality level (EC 2011). To the contrary, the excessive use of private vehicles has led to the traffic congestion phenomenon with other harmful consequences such as: increased number of accidents, air and noise pollution, energy consumption and therefore with meaningful consequences also for the environment. For these reasons, the regulations at European Union (EU), national and local levels, encourage the development of policies that discourage the use of private vehicles and that aim to the improvement of the public transit service quality.

In Italy, public transit service transformation is mainly related to the deep normative reform that is affecting the entire sector. As pointed out by Marcucci *et al.*, (2007), the relevant key factors of such transformation concern:

- *customers' expectations identification*, with respect to both those explained out by customers and those implicitly considered satisfied by the service;
- *service delivery design*, in order to correctly "translate" customers' expectations in service specifications;
- *service delivery system*, that comprises operations standardization and the continuous control of the critical to quality service factors;
- *internal and external communication of achieved quality results*, with the aim to involve stakeholders in the continuous improvement process of the service;
- *service performance evaluation*.

The latter is characterized by significant aspects of complexity, given that service performance evaluation has necessarily to reflect the point of views of different service stakeholders: the transport company, the local community, directly or indirectly involved in the transit service and customers.

The company point of view essentially tends to focus on costs efficiency/effectiveness (Bertini, 2003). A measure of cost efficiency is typically defined as produced services (*e.g.* vehicle kilometres), while a measure of service effectiveness is defined as consumed service (*e.g.* passenger kilometres).

On the contrary, the community point of view is affected by matters related to equipment, in terms of quantity, quality and safety, and the environmental impact of the service.

Finally, the customers' point of view is related to their perceived quality level of the delivered service and can be considered the main driver of the investment choices to improve service quality. In fact, apart from certain essential aspects of the service, the investment choices should strategically take into primary consideration the customers' point of view, considering their needs with the related importance levels. Therefore, it is clear the need to define the quality structure of the transit service, *i.e.* the set of the critical to quality service dimensions and attributes, with respect to which to evaluate the CS level and to consider the use of the other quality cycle tools (Figure 2), in order to allow an effective and efficient quality improvement of the service.

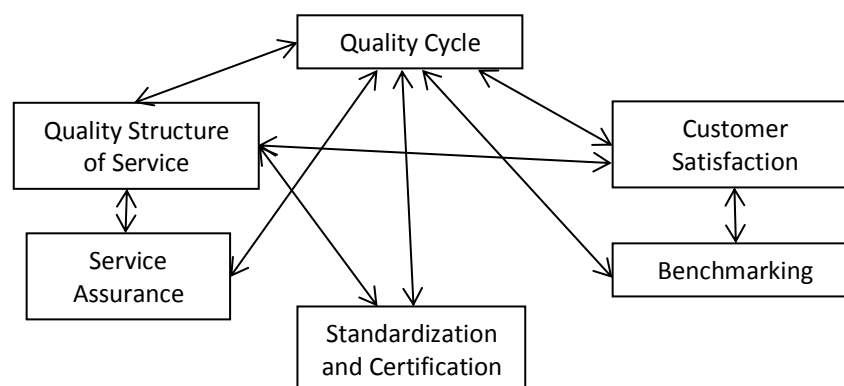


Figure 2: The Quality Cycle

The Table below shows such quality structure with refer to the public transit service sector in Italy.

Table 1: Overall structure of Italian public transit service quality.

| <i>Service dimension</i> | <i>Service Attribute</i>                         |
|--------------------------|--|
| Route Characteristics    | Path   |
|                          | Number of bus stops                              |
|                          | Distance between bus stops                       |
| Service Characteristics  | Bus stops location                               |
|                          | Service frequency                                |
| Service Reliability      | Daily service time                               |
|                          | Reliability of the scheduled runs                |
| Information              | Punctuality of the runs                          |
|                          | Availability of schedule/maps on bus             |
|                          | Availability of schedule/maps at bus stops       |
| Personnel                | Availability of information by phone-internet    |
|                          | Personnel appearance                             |
| Customer Service         | Personnel helpfulness                            |
|                          | Easiness of purchasing a ticket                  |
| Comfort                  | Administration of complaints                     |
|                          | Bus crowding                                     |
|                          | Comfort of bus seats                             |
|                          | Air condition on bus                             |
|                          | Level of vibration on bus                        |
| Safety and Security      | Availability of shelter and beaches at bus stops |
|                          | Bus reliability                                  |
|                          | Competence of drivers                            |
|                          | Security against crime on bus                    |
| Cleanliness              | Security against crime at bus stop               |
|                          | Cleanliness of bus interior, seats and windows   |
|                          | Cleanliness of bus exterior                      |

Eboli 2007.

The previously described transformation process is also affecting the public transit service delivered in Palermo. Such service is one of the most important and critical public services provided in Palermo and it is currently characterized by a process of facilities modernization and quality improvement. For such reasons, the analysis reported below has been performed.

### 5. Palermo transit service performance.

The transit service delivered in Palermo is supplied by the Palermo Public Urban Transport Company (AMAT S.p.a.) and covers the entire urban territory by means of about 90 bus lines distributed over 20 service hours for day. The daily customers' basin is of about 600.000 potential customers, mainly composed by citizens.

The overall structure of the public transit service quality stated in the Table 1 has been considered to single out the relevant elements of the quality structure of the under analysis service (see Table 2). In particular, such elements have been selected from the overall structure by using the Critical Cases Approach (Cronin, 1992) on the basis of preliminary interviews to both service experts (decision makers group) and a limited number of customers.

Table 2: Relevant elements of the Palermo transit service quality structure.

| Goal:              | Customer Satisfaction                              |   |   |   |   |
|--------------------|--|---|---|---|---|
| Service Dimension: | <i>D<sub>1</sub></i><br>Route Characteristics      | <i>D<sub>2</sub></i><br>Information                                   | <i>D<sub>3</sub></i><br>Personnel             | <i>D<sub>4</sub></i><br>Comfort   | <i>D<sub>5</sub></i><br>Safety and Security                 |
| Service Attribute: | <i>A<sub>11</sub></i> : Path                       | <i>A<sub>21</sub></i> : Availability of Schedule/Maps on Bus          | <i>A<sub>31</sub></i> : Personnel Appearance  | <i>A<sub>41</sub></i> : Bus Crowding  | <i>A<sub>51</sub></i> : Bus Reliability                     |
|                    | <i>A<sub>12</sub></i> : Number of Bus Stops        | <i>A<sub>22</sub></i> : Availability of Schedule/Maps at Bus Stops    | <i>A<sub>32</sub></i> : Personnel Helpfulness | <i>A<sub>42</sub></i> : Comfort of Bus Seats  | <i>A<sub>52</sub></i> : Competence of Drivers               |
|                    | <i>A<sub>13</sub></i> : Distance Between Bus Stops | <i>A<sub>23</sub></i> : Availability of Information by Phone-Internet |   | <i>A<sub>43</sub></i> : Air Condition on Bus  | <i>A<sub>53</sub></i> : Security Against Crime on Bus       |
|                    | <i>A<sub>14</sub></i> : Bus Stops Location         |   |   | <i>A<sub>44</sub></i> : Level of Vibration on Bus<br><i>A<sub>45</sub></i> : Availability of Shelter and Beaches at Bus Stops | <i>A<sub>54</sub></i> : Security Against Crime at Bus Stops |

A suitable questionnaire structure based on the service quality structure has been developed. In particular, the latter is composed by two parts; in the first one, customers are asked to indicate the relative importance of all the pairwise comparisons of service dimensions and attributes. Instead, in the second one, customers are asked to assess their

perceptions related to service attributes. In both the questionnaire parts, customers point out the levels of their judgments by using suitable linguistic-fuzzy evaluation scales. The Table 3 shows the first and the second part of the questionnaire related to the service dimension *Information*.

Table 3: Extract of the questionnaire related to the service dimension *Information*.

First part:

|                                      |  | <b>How important is:</b>                      |   |   |   |   |   |   |   |   |   |
|--------------------------------------|--|---|---|---|---|---|---|---|---|---|---|
|                                      |  | Availability of<br>schedule/maps at bus stops |   |   |   |   | Availability of information by<br>phone-internet; |   |   |   |   |
| <b>When it is<br/>compared with:</b> | Availability of<br>schedule/maps on bus          | A   | B | = | a | b | A   | B | = | A | b |
|                                      | Availability of<br>schedule/maps at bus<br>stops | C   | D | = | c | d | C   | D | = | C | d |
|                                      | //   |   |   |   |   |   | A   | B | = | A | b |
|                                      |  |   |   |   |   |   | C   | D | = | C | d |

- D: *Extremely more important*
- C: *Very strongly important*
- B: *Strongly important*
- A: *Moderately important*
- = *Equally important*
- a: *Moderately less important*
- b: *Strongly less important*
- c: *Very strongly less important*
- d: *Extremely less important*

Second part:

| Information:   |                          |                          |                          |                          |                          |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Indicate the performance level of the following<br>service attributes: | Very bad                 | Poor                     | Average                  | Good                     | Excellent                |
| Availability of schedule/maps on bus                                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Availability of schedule/maps at bus stop                              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Availability of information by phone-internet                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Finally, for both, the index of optimism  $\mu$  and the confidence level  $\alpha$  ( $\alpha$ -cut) have been assumed a value equal to 0.5 and the linguistic-fuzzy scales reported in the Table below have been considered.

Table 4: Linguistic-fuzzy evaluation scales.

| <i>Perception evaluation scale</i> |                         | <i>Importance evaluation scale</i> |                         |
|------------------------------------|-------------------------|------------------------------------|-------------------------|
| Linguistic category                | Triangular fuzzy number | Linguistic category                | Triangular fuzzy number |
| Very bad                           | (1, 1, 3)               | Equal importance                   | (1, 1, 3)               |
| Poor                               | (2, 3, 5)               | Moderate importance                | (1, 3, 5)               |
| Average                            | (3, 5, 7)               | Strong importance                  | (3, 5, 7)               |
| Good                               | (5, 7, 9)               | Very strong importance             | (5, 7, 9)               |
| Excellent                          | (7, 9, 9)               | Extremely more importance          | (7, 9, 9)               |

The CS survey has been conducted for three months, between May and July 2012, on about 300 random customers during the service delivering or the awaiting at the bus stops. The Table below reports the obtained results.

Table 5: Performance levels of the Palermo transit service.

| Service Dimension | Dimension Importance Weight | Attribute | Local Importance Weight | Global Importance Weight | Perception Level | Customer Satisfaction Level (Gap) |
|-------------------|-----------------------------|-----------|-------------------------|--------------------------|------------------|-----------------------------------|
| $D_1$             | 0.404                       | $A_{11}$  | 0.314                   | 0.127                    | 0.073            | -0.054                            |
|                   |                             | $A_{12}$  | 0.226                   | 0.091                    | 0.072            | -0.019                            |
|                   |                             | $A_{13}$  | 0.295                   | 0.119                    | 0.071            | -0.048                            |
|                   |                             | $A_{14}$  | 0.165                   | 0.067                    | 0.074            | 0.007                             |
| $D_2$             | 0.137                       | $A_{21}$  | 0.163                   | 0.022                    | 0.033            | 0.011                             |
|                   |                             | $A_{22}$  | 0.503                   | 0.069                    | 0.044            | -0.025                            |
|                   |                             | $A_{23}$  | 0.334                   | 0.046                    | 0.074            | 0.028                             |
| $D_3$             | 0.126                       | $A_{31}$  | 0.335                   | 0.042                    | 0.076            | 0.034                             |
|                   |                             | $A_{32}$  | 0.665                   | 0.084                    | 0.044            | -0.040                            |
| $D_4$             | 0.118                       | $A_{41}$  | 0.258                   | 0.030                    | 0.041            | 0.011                             |
|                   |                             | $A_{42}$  | 0.203                   | 0.024                    | 0.063            | 0.039                             |
|                   |                             | $A_{43}$  | 0.073                   | 0.009                    | 0.061            | 0.052                             |
|                   |                             | $A_{44}$  | 0.142                   | 0.017                    | 0.031            | 0.014                             |
|                   |                             | $A_{45}$  | 0.324                   | 0.038                    | 0.034            | -0.004                            |
| $D_5$             | 0.215                       | $A_{51}$  | 0.114                   | 0.025                    | 0.088            | 0.063                             |
|                   |                             | $A_{52}$  | 0.195                   | 0.042                    | 0.077            | 0.035                             |
|                   |                             | $A_{53}$  | 0.301                   | 0.065                    | 0.022            | -0.043                            |
|                   |                             | $A_{54}$  | 0.39                    | 0.084                    | 0.022            | -0.062                            |

As it can be seen from Table 5, the most important service dimension is *Route Characteristics* ( $D_1$ ), and *Path* ( $A_{11}$ ), is its most important service attribute, followed by *Distance Between Bus Stops* ( $A_{13}$ ). Subsequently, the second service dimension for importance is *Safety and Security* ( $D_5$ ) and *Security Against Crime at Bus Stops* ( $A_{54}$ ) is its most important attribute. Lastly, the other service dimensions are characterized by a similar importance level.

The same Table shows also service attributes perception levels: the most powerful service attribute is *Bus Reliability* ( $A_{51}$ ), followed by *Competence of Drivers* ( $A_{52}$ ) and *Personnel Appearance* ( $A_{31}$ ). The service attributes *Availability of Information by Phone-Internet* ( $A_{23}$ ), *Bus Stops Location* ( $A_{14}$ ), *Path* ( $A_{11}$ ), *Number of Bus Stops* ( $A_{12}$ ) and *Distance Between Bus Stops* ( $A_{13}$ ) are characterized by similar perception levels. Follow the other service attributes with gradual decreasing of the perception levels.

Finally, by considering the CS level, *i.e.* the ServQual Gap =  $P - E$ , it emerges that the most satisfied service attributes are: *Bus Reliability* ( $A_{51}$ ), *Air Condition on Bus* ( $A_{43}$ ), and *Comfort of Bus Seats* ( $A_{42}$ ). The first one is the most important and also the most powerful service attribute. On the contrary, the second and the third attribute are characterized by a medium perception level and a low important level. Conversely, the service attributes that provide the highest contribution to customer dissatisfaction are in order: *Security Against Crime at Bus Stops* ( $A_{54}$ ), *Path* ( $A_{11}$ ), *Distance Between Bus Stops* ( $A_{13}$ ) and *Security Against Crime on Bus* ( $A_{53}$ ) which are characterized by low perception and high importance levels.

The strategic implications for the overall service improvement should take into account the service dimensions *Route Characteristics* and *Safety and Security* and, more in detail, the following service attributes: *Security against crime at bus stops*, *Path*, *Distance between bus stops* and *Security against crime on bus*.

On the base of the obtained results, to increase the attractiveness of the public transit service delivered in Palermo, the provider could implement the following measures:

- A. to expand and to simplify the public transit network;
- B. to improve safety in bus stations, bus stops and on vehicles to protect users and drivers, as well as the infrastructure equipment, for example, by:
  - implementing a safety strategy (e.g. installing cameras at bus stops and on bus);
  - creating safer conditions at the bus stations and adjacent areas (e.g. better lighting);
  - providing training on safety and security.

## 6. Conclusions

In the present paper a methodology able to evaluate the CS based on the ServQual discrepancy paradigm and that uses in combined manner AHP and the Fuzzy Sets Theory has been developed. With the considered combined approach it is possible to effectively handle uncertain that can characterize the employment of linguistic-numerical evaluation scales adopted by widely considered service evaluation approaches. In particular, the study aims to offer a meaningful contribution in a research field quietly considered by researchers by proposing a methodology able to perform reliable service quality assessments.

The application of such methodology has been shown in a strategic transit service analysis related to the public urban transit service delivered in Palermo (Italy). From such analysis, service performance has been evaluated and a suitable “Gaps oriented” strategy for the overall service improvement has been identified.

However, some considerations have to be done about the considered service quality attributes; it could be interesting to consider them in comparison with the cost of service: customers can be inclined to accept a lower service quality if a ticket price is seen cheap or very cheap. This kind of connections between the service attribute "cost of service" and other service attributes can deserve a further future study to obtain more reliable results.

In addition, future researches concerning transit service analyses will involve: (i) the evaluation by means of the proposed methodology of quality perceptions of transit service from non-users standpoint, to single out the service improvement configuration to make it attractive for more user-categories; (ii) the further development of the proposed methodology, by adopting the Fuzzy Logic approach.

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