Benchmarking of airports service quality by a new fuzzy MCDM approach

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Abstract

Recent approaches to the service quality evaluation problem are focused on the employment of multi-criteria decision-making (MCDM) procedures, since processes related to service quality evaluation presentmeaningful communality elements to MCDM ones. Based on such assumption, in the present paper a new fuzzy MCDMapproach is developed tocomparatively evaluate passenger service quality of the international airports inSicily (Italy). In particular, by incorporating the respondents confidence level and degree of optimism on fuzzy assessments, quality scores of main airport service criteria are estimated, whereas ELECTRE multi criteria decision support methodis proposed to point out theservices quality rankingfor the considered airports, on the basis of which it is performed a strategic benchmarking of service quality. The developed approach represents an effective way to perform evaluation of airports service quality, sinceit can supportairportsmanagementto understand and to explain the relatedservice quality ranking in terms of qualityscores of service criteria.

Keywords: airport services quality; airport service quality structure; passenger satisfaction; ELECTRE III method; Fuzzy Sets Theory.

1. Introduction

Recent developments in air transport industries combined with increasing of domestic and international routes numbers and a substantial decreasing of air transport costs, havedetermined a strong increasing of passengers number that travel through airports. In such a context, service quality is becoming a crucial issue for the airport management to improve airport's competitive advantage (Lin and Hong, 2006; Correia et al., 2008; Graham, 2009).In fact, although passenger demand for airport services can be considered of inelastic typesincetravelers very often do not have a choice among airportsof a country(Doganis, 1992), particularly in the case of international travels, evaluation of a country from viewpoints of international tourist or business travelers is strongly related to their perceived value and image of the corresponding airport (Yeh and Kuo,2003).In particular, airport service quality has a direct impact on perceived airport value and related image as well as travelers' satisfaction, and an indirect impact on travelers' behavior: satisfied travelers are more likely to use the related airport againto promote infuture new international tourism or business activities in the corresponding countryand to recommend the airport to others travelers for their transfers(Park and Jung, 2011). Therefore, evaluation of airport service quality represents a main concern to deal in today airport context. In addition, airport service quality evaluation also allows to single out management problems regarding service efficiency (Transport Research Board, 1994) and it can be usefully

used as monitoring tool to on-going control service quality and to compare service quality over time and/or across space (De Borger et al., 2002).
In the literature were introduced a variety of methods regarding airport service qualityevaluation which can be basically classified into three main categories: stated importance methods, in which passengers are asked to rate each service aspect on a Likert-type importance scale; derived importance methods, in which importance measures of service aspectsare statistically derived considering relationships among performance of servicecriteria, sub-criteria and items with the overall satisfaction, and the more recent methodsfocused on the employment of multi-criteria decision-making (MCDM) procedures to point out service performance.Derived importance methods have been widely considered in the recent past 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 mean importance ratings. Several recent applications of derived importance methods based on passengers survey are described in: Humphreys and Francis, (2000); Adler and Berechman, (2001); Humphreys and Francis, (2002); Barros and Diseke, (2007); Correia et al., (2008); Chaudha, et al., (2011); Lubbe et al., (2011). However, service quality perception is a very complex multi - dimensional issue that involves both customers' perceptive and cognitive aspectsand which can be even characterized by a certain degree of heterogeneity(De Battisti et al., 2005;De Battisti et al., 2010). In addition, subjective judgments provided by customers using linguistic terms can be affected by possible uncertainty elements related to incompleteness for partial ignorance, imprecision for subjectivity and even vagueness.For such reasons, both derived and stated importance methods can be imprecise or even unreliable in handling and measuring quality of services (Chien et al 2011; Lupo 2013).
In general, as formulated in the Fishbein's model (Fishbein and Ajzen, 1975), the attitude of a customer towards a given service is based on a latent assessment of the service criteria weighted by the importance assigned tothese criteria. Such concept coincides with Multi-Attribute Decision-Making models based on multi-criteria value or utility theory (Dyer and Sarin, 1979; Keeney and Raiffa, 1993), as considered by more recent works (Kuo and Liang, 2011).Such an assumption allows the employment of MCDM procedures typicallyconsidered in a multi-decision-makers environment for evaluating and/or selecting service alternatives, such as:VIKOR technique (Opricovic, 1998; Opricovic and Tzeng, 2004); AHP method (Saaty, 1980; Saaty, 2008); PROMETHEE method (Brans and Vincke, 1985); TOPSIS method (Hwang and Yoon, 1981), etc. In particular, in the field of airport servicequality evaluation, some studies were focused on the deterministic nature of the multi-criteria decision process(Chen and Tzeng, 2004; Correia et al., 2008; Correia et al., 2008; Liou et al., 2011); while others were concerned about the uncertainty and imprecisenumeric values of decision data, considering also the condition of incompleteness data, as well thesubjectiveness and imprecision of humans behavior(Liang, 1999; Chen, 2000;Ding and Liang, 2005; Iraj et al., 2008; Wang et al., 2009;Sanayei et al.,2010).
Accordingly, in the present paper a new MCDM approach that considers in combined manner the Fuzzy Set Theory (FST) and the ELECTRE III multi criteria decision support method is proposed to comparatively evaluate airport service quality. In particular, FSTallows the mathematical representation and processing of information affected by some imperfection typically due to the use of the natural language (Zimmermann, 1985) and provide formalized tools for dealing with intrinsic imprecision of real life problems (Negoita, 1985; Zadeh,1996; Zadeh, 1975; Liang and Wang,1991). The FST has been applied in many fields of the management science, but it is still quietly used in the field of services quality assessment (Leung and Cao 2000; Wu et al 2009; Wang et al 2009; Sanayei et all 2010).On the contrary, ELECTRE method is herein considered to obtain a service quality ranking of the considered airport service alternativeson the basis of which to perform the comparative analysis of services quality.
ELECTRE (ELiminiation Et Traduisant la REalite) is a procedure that helps the decision-maker facing a complex problem with multiple usually conflicting qualitative and/or quantitative criteria (e.g. location or investment selection, projects ranking, and so forth). ELECTRE was devised in 1965, and later referred to as ELECTRE I (Electre One) (Roy and Susman, 1966). Such approach has evolved into a number of variants.

Today, the used applied versions are known as ELECTRE II (Roy &Bertier, 1973), ELECTRE III (Roy, 1978) ELECTRE IV (Roy and Hugonnard, 1982) and ELECTRE TRI (Yu, 1992). ELECTRE method has been widely used in the literature in very different research fields (Wang and Triantaphyllou, 2008; Papadopoulos and Karagiannidis, 2008; Montazer et al., 2009; Sevkli, 2010; Certa et al, 2013; Rouyendegh and Erkan, 2013). In the present work ELECTRE III is proposedsince, in contrast to other adopted MCDM procedures, it is not compensative, which means that a very bad qualityscore in one service criterion cannot be compensated by good qualityscores in other service criteria. In other words, the customer will not choose aservice alternative if it is very bad compared to another one, even on a single service criterion. Such a feature makes the ELECTRE III procedure more appropriate than other MCDM methodsfor the aims of the present paper(Ghobadianet al.,1994).
The remainder of the present paper is organized as follows: in the next Section the main steps of the developed fuzzy MCDM approach aredescribed; in Section 3, the comparative services quality analysis of theinternational airports inSicilyis performed with more detail and the related strategic considerations for the services quality improvement are given; finally, conclusions, with a summary and main findings, close the work.

2. Comparative service quality analysis

The herein developed approach is composed by the following fundamental steps: services quality structure description; evaluation of quality scores and importance weights ofmain service criteria,service quality ranking and comparative service quality analysis, as summarized in Fig. 1.

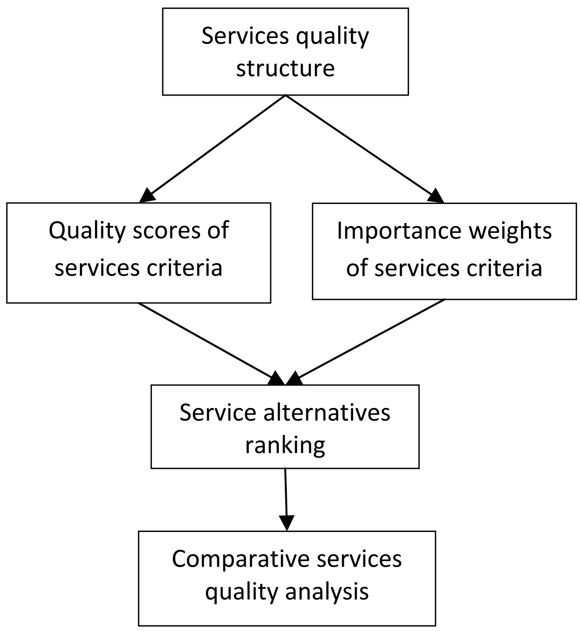

Figure 1: Fundamental steps of the developed Fuzzy MCDC approach

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 fundamental steps required by the developed MCDM procedure aredescribed.

2.1 Fuzzy Set Theory and Linguistic-Fuzzy evaluation Scales

The use of fuzzy numbers (Klir et al., 1999)represents an effective way to compare judgments in fuzzy environment (van Laarhoven et al., 1983; Chang, 1996; Cheng, 1996;Kwong et al., 2002). In the literature there is a number of methods to define fuzzy number parameters related to a linguistic variable. For example, Ayyub*et al.* (2006) provided a chart to define the lower and upper boundary for fuzzy numbers based on experts' assessment and Kaufmann and Gupta, 1988, adopt the Fuzzy Delphi method, that is a typical multi-experts procedure for combining views and opinions, to define the fuzzy boundaries of a fuzzy number.In the present work, linguistic variables used to represent respondents' evaluationsof service qualityare evaluated by positive triangular fuzzy numbers (TFNs), which can be denoted as $\widetilde{A} = (x_L, x_M, x_U)$ (see Fig. 2). By defining the interval of confidence level α(α-*cut*), a TFN can be characterized as:

$$\begin{aligned} &\widetilde{A}_\alpha = [a_L^\alpha, a_U^\alpha] = [(x_M - x_L)\alpha + x_L, -(x_U - x_M)\alpha + x_U] \\ &\forall \alpha \in [0,1] \end{aligned} \tag{1}$$

The term $x_M$represents the most possible value of the related linguistic variable and x_L and $x_U$the lower and upper bounds respectively used to reflect the fuzziness of the related linguistic variable. The confidence level $\alpha$is known to include the respondent's confidence over his/her preference score. In the case herein considered it incorporates the respondents' confidence and uncertainty over their judgments. A larger α value indicates that respondent's is more confident in choosing a crisp value interval to represent the corresponding fuzzy number.

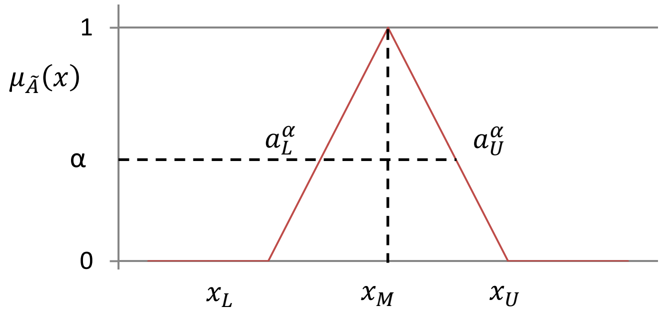

Figure 2: Positive triangular fuzzy number

Finally, the FST allows the extension of arithmetic operations from crisp numbers to fuzzy numbers. By considering the confidence levelα of positive fuzzy numbers, some main operations useful for the aim of the present work are given by the following expressions (Klir et al., 1999):

$$\begin{aligned} &\forall \alpha \in [0,1], \quad \forall a_L, a_U, b_L, a_U \in R^+, \quad A_\alpha = [a_L^\alpha, a_U^\alpha], \quad B_\alpha = [b_L^\alpha, b_U^\alpha] \\ &A_\alpha \oplus B_\alpha = [a_L^\alpha + b_L^\alpha, a_U^\alpha + b_U^\alpha] \\ &A_\alpha \Theta B_\alpha = [a_L^\alpha - b_L^\alpha, a_U^\alpha - b_U^\alpha] \\ &A_\alpha \otimes B_\alpha = [a_L^\alpha \times b_L^\alpha, a_U^\alpha \times b_U^\alpha] \\ &A_\alpha / B_\alpha = [a_L^\alpha / b_L^\alpha, a_U^\alpha / b_U^\alpha] \end{aligned} \tag{2}$$

2.2 Methodological approach

The four steps hereafter described compose the developed fuzzy MCDC approach.

Step 1: Service quality structure definition

The first stage to adopt the proposed approach concerns the description of the analyzed service quality structure, also mentioned as "value tree" or "value hierarchy" (Kirkwood, 1997). Such structure consists of several hierarchical levels: the first one includes the general objective or goal of the analysis, i.e. overall customer satisfaction. In the second level, service criteria, i.e. main distinctive service areas which are deeply related with customer satisfaction, are reported. Subsequently, in the third level service sub-criteria for each service criterion are identified. These satisfaction structure, which has to be operational, decomposable, and minimal (Keeney et al, 1993), should assure a consistent family of criteria, with the following properties: monotonicity, exhaustiveness, and non-redundancy (Roy and Bouyssou, 1993). Fig. 3 shows a general hierarchical service quality structure composed by *w*service criteria, C_1, C_2, …, C_W.

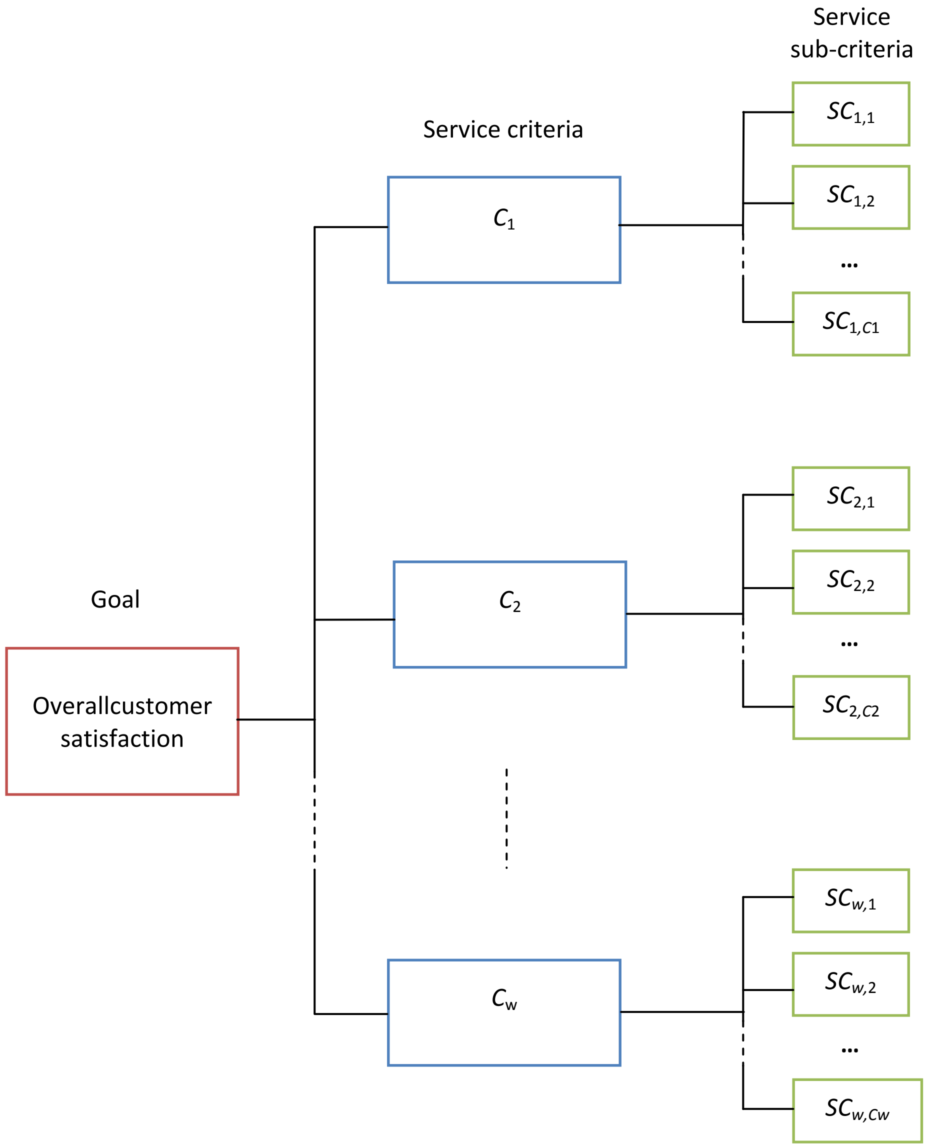

Figure 3: Service quality structure.

Step 2: Qualityscoresof services criteria

In order to estimate quality scores of main service criteria the ServPerf service quality conceptual model is herein considered (Cronin and Taylor 1992). By considering such model, the expectation component can be discarded and only the perception component can be adopted for measuring quality scores of main service criteria.For such reason, the ServPerf model represents an efficient way to evaluate service quality,since it reduces by half the number of questionnaire to be considered in the survey and it represents a valid alternative to evaluate service quality in terms of analysis reliability and explanatory power (Cronin and Taylor, 1994; Brady et al. 2002; Zhou, 2004; Lee Kim, 2014). Based on such assumptions, the ServPerf paradigm is herein considered to evaluate quality score ofservice criteria. More in detail, considering the generic service criterion i composed by C_i service sub-criteria, $SC_{i,1}$, $SC_{i,2}$,…,$SC_{i,Ci}$, for the generic respondent the related quality score at the confidence level $\alpha \left(\tilde{P}^{\alpha}\right)_i$ can be estimated by aggregating perceptions related to its service sub-criteria by means of the following relationship (Lupo, 2013):

$$\left(\tilde{P}^{\alpha}\right)_i = \mu \cdot \frac{\sum_{j=1}^{Ci}\left(g_U^{\alpha}\right)_{i,j}}{C_i} + (1-\mu)\cdot \frac{\sum_{j=1}^{Ci}\left(g_L^{\alpha}\right)_{i,j}}{C_i} \qquad \forall \alpha \in [0,1] \tag{3}$$

in which $\left(g_U^{\alpha}\right)_{i,j}$ and $\left(g_L^{\alpha}\right)_{i,j}$ are respectively the upper and lower bounds of the fuzzy perception score at the confidence level *α,* with respect to the generic service sub-criterion j.Eq. (3)also takes into account the respondent's degree of optimism on fuzzy assessments. In fact, the index μ is employed to reflect the respondent's attitude towards risk, which may be optimistic, pessimistic or somewhere in between (Cheng et al., 1994; Chang, 1996; and Lee, 1999). An optimistic respondent is apt to prefer higher values of the crisp value interval derived from fuzzy assessments, while a pessimistic one tends to favor lower ones.

Finally, the arithmetic mean operator is considered for the aggregation of multiple respondents' perceptions.

Step 3: Importance weights of service criteria

Linguistic terms are used to indicate the relative importance of each service criteria pair and TFNs are considered to quantify concepts of linguistic expressions. In particular, considering service criteria C_1, C_2, …, C_W, the generic coefficient $\tilde{a}_{i,j}$ represents the fuzzy relative importance weight of the service criterion i^{th} *vs* the j^{th} one. Not all the C_w^2 pairwise comparison coefficients have to be directly estimated, but only C_w ($C_w - 1$)/2, given that it is valid the reciprocity property of the pairwise comparisons expressed by the following relationship:

$$\begin{cases} \tilde{a}_{i,j} = 1/\tilde{a}_{j,i} \\ \tilde{a}_{i,i} = 1 \end{cases} \qquad \forall i,j = 1,2,...,C_W \quad \forall i \neq j \tag{4}$$

The collected pairwise fuzzy comparison coefficients are used to construct the pairwise comparison matrix $\tilde{A}_W$, which is a fuzzy squared, reciprocal and positive matrix. For the aggregation of multiple respondents' judgments, the geometric mean is considered since it allows the respect of the AHP constraint expressed by Eq. (4) (Enea and Piazza, 2004).

Service criteria weights are computed by adopting the Lambda-Max method, initially introduced in crisp term with the AHP method by Saaty (1980), which was introduced in fuzzy form by Csutora and Buckley (2001):

$$\widetilde{A}_W \cdot \widetilde{k} = \widetilde{\lambda}_{\max} \cdot \widetilde{k} \tag{5}$$

in which $\widetilde{\lambda}_{\max}$ is the maximum fuzzy eigenvalue and $\widetilde{k}$ is a fuzzy vector ($Cw \times 1$) composed by $C_w$fuzzynumbers representing the importance weights of the service criteria. In particular, considering the relationships reported in Eq. (2), for the generic service criterion i^{th},Eq. (5) can be written as:

$$\left[\left(a_L^\alpha\right)_{i,1} \cdot \left(k_L^\alpha\right)_1, \left(a_U^\alpha\right)_{i,1} \cdot \left(k_U^\alpha\right)_1\right] \oplus \ldots \oplus \left[\left(a_L^\alpha\right)_{i,Cw} \cdot \left(k_L^\alpha\right)_{Cw}, \left(a_U^\alpha\right)_{i,Cw} \cdot \left(k_U^\alpha\right)_{Cw}\right] = \left[\lambda_L^\alpha \cdot \left(k_L^\alpha\right)_i, \lambda_U^\alpha \cdot \left(k_U^\alpha\right)_i\right] \tag{6}$$

in which:

$$\begin{aligned} &\widetilde{A}_w = \left[\widetilde{a}_{i,j}\right]; \ \widetilde{k}^t = \left(\widetilde{k}_1, \ldots, \widetilde{k}_{c_W}\right); \\ &\widetilde{a}_{ij}^\alpha = \left[\left(a_L^\alpha\right)_{i,j}, \left(a_U^\alpha\right)_{i,j}\right]; \ \widetilde{k}_i^\alpha = \left[\left(k_L^\alpha\right)_i, \left(k_U^\alpha\right)_i\right]; \ \widetilde{\lambda}_{\max}^\alpha = \left[\lambda_L^\alpha, \lambda_U^\alpha\right] \\ &\forall \alpha \in [0,1]; \ i,j = 1,2,\ldots,C_w \end{aligned} \tag{7}$$

As before said, the *α-cut* includes the respondents' confidence over her/his preferences. In this case it incorporates respondents' confidence and uncertainty over their judgments. Therefore, by considering the index of optimism μ, the crisp pairwise comparison coefficient at the confidence level α, $\widetilde{a}_{ij}^\alpha$ of the relative importance of the service criterion i^{th}*vs* the j^{th} one can be written as:

$$\begin{aligned} &\widetilde{a}_{ij}^\alpha = \mu \cdot \left(a_U^\alpha\right)_{i,j} + (1-\mu) \cdot \left(a_L^\alpha\right)_{i,j} \\ &\forall \alpha \in [0,1] \end{aligned} \tag{8}$$

and, when α is fixed after setting the index of optimism μ, the obtained crisp pairwise comparison matrix can be considered to estimate the importance weights of the considered service criteria.

Step 4: Service quality alternatives ranking

As said before, ELECTRE III (Roy, 1990)is the multi-criteria method proposed for ranking service quality of the considered international airports. ELECTRE III is a multi-criteria decision-making method that reflects the respondents' preferences and it can be applied when a set of alternatives must be ranked according to a set of qualitative/quantitative criteria or when just the preferred one has to be selected. The method is based upon pseudo-criteria. More in detail, by using suitable thresholds, if the quality score difference between two service alternatives is minimal, according to a certain service criterion, such service alternatives can be considered indifferent according to that service criterion. Another peculiarity that differentiates ELECTRE III from other adopted MCDM procedures is that, as previously said in the Introduction, it is not compensative, which means that a very bad performance score in one service criterion cannot be compensated by good scores in the other one. In other words, the customer will not choose a service alternative if it is very bad compared to another one, even on a single service criterion. Such circumstance occurs if the difference between the performance scores of service criteria of two service alternatives is greater than a fixed veto threshold. Therefore, in ELECTRE III the concept of outranking relation is very important: a service alternative outranks another one if sufficient reasons exist to assert that the first is as good as the second and good reasons to reject such assertions do not exist. The outranking relation is based upon a concordance/discordance principle. This principle consists of the verification of the existence of a concordance of criteria in favour of the assertion that one solution is as good as another and that a verifiably strong discordance among the score values that may reject the previous assertion does not exist. For each considered service criterion, the following thresholds are introduced:

- *q* indifference threshold;
- p preference threshold;
- *v* veto threshold;

where q< p < v.

Those thresholds values can be expressed in term of percentage of the score differences assumed by the solutions, respect to the worst one under the considered criteria.In the Appendix A1 the ELECTRE III algorithm is described with more detail.Finally, on the basis of the obtained results in terms of service quality ranking and quality scores of service criteria,it can be performed the comparative service quality analysis, as shown in the empirical study below reported.

3. Empirical study

The developed fuzzy MCDM approach is consideredto comparatively evaluate passenger service quality of the international airports in Sicily (Italy): the Catania-Fontanarossa Airport, the Palermo-Punta Raisi Airport and the Trapani-Birgi Airport.

The Catania-Fontanarossa Airport (CTA), located on the southern outskirts of the Catania City territory, was on 2013 the sixth airport in Italy for passengers traffic. In particular, the Catania-Rome route is the nationally busiest and the fourth in Europe (Enac, Italian Civil Aviation Authority). The airport also handles a remarkable number of medium/long range connections within and outside Europe.

The Palermo-Punta Raisi Airport (PMO) is located at 35 km west of the City of Palermo. It is the third airport in southern Italy for the number of passengers after Catania and Naples Airports. Such airport, dedicated to Giovanni Falcone and Paolo Borsellino memory, allows the daily connection with the main Italian cities and many European and extra European destinations.

Finally, the Trapani-Birgi Airport (TPS), which is a military airport also recently opened to civilian traffic, is located along the coast of the Cities of Trapani and Marsala. The Airport is currently characterized by a strong air traffic growth which mainly consists of low cost domestic and international flights, since it carries out the hub function for a low-cost airline company. Such international airports, which passengers traffic is nationally the third while it is marginal the related cargo traffic (Enac, Italian Civil Aviation Authority), play a crucial role for the Sicily’s economy development. For such a reason, the European Commission (COM (2012) 556) identifies guidelines and normative measures in order to support the development of such airports focused on:

- airports capacity optimization, through the optimal trade-of between airport and “in-flight” capacities in order to avoid congestion;
- overall quality improvement of airport service.

The analysis subsequently reported represents a first but substantial step toward the direction to be pursued, in which passengers are considered the main driver to support service quality improvement.

3.1 Service quality structure

As before said, the first step of the developed approach is related to the service quality structure definition. For such reason, a comprehensive study involved a limited number of academics, domestic and international travelers, as well airport service experts (airport service decision makers) has been performed, and on the basis of the passenger service quality structure developed by Airport Council International (Airports Council International, 2000), widely considered in the literature for evaluating airport service quality (Yu-Hern Chang et al, 2003; Yeh and Kuo, 2003; Correia et al., 2008;Kuo and Liang, 2011), the relevant elements of the service quality structure for the under analysis airports has been described. Such structure, which identifies performance measure points that have to be under the control of airport management, consists of three levels: the highest level includes the overall passenger's satisfaction; in the second one, the airport main service criteria that are strongly related to passenger's satisfaction are reported: *Processing time* (C_1), *Convenience* (C_2), *Comfort* (C_3), *Information* (C_4), *Courtesy of the staff* (C_5) and *Safety and security* (C_6). Finally, in the third one, airport service criteria are broken down into 20 sub-criteria, as reported in Table 1.

	Criterion	***Sub-Criterion***
Passenger's satisfaction	*Processing time* (C_1)	**Total time required for:** Immigration processing ($SC_{1,1}$) Customs inspection ($SC_{1,2}$) Luggage claiming ($SC_{1,3}$)
	Convenience (C_2)	**Availability/accessibility of**: Washrooms ($SC_{2,1}$) Shops and restaurants ($SC_{2,2}$) Money exchange ($SC_{2,3}$) Luggage carts ($SC_{2,4}$) Rental facilities ($SC_{2,5}$)
	Comfort (C_3)	**Considering waiting areas/lounges and ambience of the airport as a whole:** Cleanliness ($SC_{3,1}$) Lighting ($SC_{3,2}$) Congestion level ($SC_{3,3}$)
	Information (C_4)	**Considering information for flights, airport facilities and signposting:** Clearness ($SC_{4,1}$) Frequency ($SC_{4,2}$) Positioning ($SC_{4,3}$)
	Staff (C_5)	Helpfulness ($SC_{5,1}$) Friendliness ($SC_{5,2}$) Courtesy ($SC_{5,3}$) Availability/reliability of staff ($SC_{5,4}$)
	Safety and security (C_6)	**Sense of security about:** Airport safety measures ($SC_{6,1}$) Security facilities ($SC_{6,2}$)

Table 1: Fundamental airport service quality structure (Airports Council International, 2000).

3.2. Performance scores and importance weights of service criteria.

Performance scores and importance weights of service criteria have been evaluated by a survey process. In particular, a homogeneous group of respondents, able to rate the considered airports on a common comparative base, composed by domestic and international travelers, academics and a number of international travel agencies have been selected and interviewed between January-March 2014. Table 2 reports an extract of the adopted questionnaire.

(a)

Processing time (C_1) Mark the performance level of the following service attributes:	Very poor	Poor	Fair	Good	Very good
Immigration processing ($SC_{1,1}$)	□	□	□	□	□
Customs inspection ($SC_{1,2}$)	□	□	□	□	□
Luggage claiming ($SC_{1,3}$)	□	□	□	□	□

(b)

How importantis:

Compared with:

	Process. time (C_1)					*Convenience* (C_2)					*Comfort* (C_3)					*Information* (C_4)					*Staff* (C_5)				
Safety and security (C_6)	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b
	C	D		c	d	C	D		c	d	C	D		c	d	C	D		c	d	C	D		c	d
Staff (C_5)	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b					
	C	D		c	d	C	D		c	d	C	D		c	d	C	D		c	d					
Information (C_4)	A	B	=	a	b	A	B	=	a	b	A	B	=	a	b										
	C	D		c	d	C	D		c	d	C	D		c	d										
Comfort (C_3)	A	B	=	a	b	A	B	=	a	b															
	C	D		c	d	C	D		c	d															
Convenience (C_2)	A	B	=	a	b																				
	C	D		c	d																				

Please, mark in the questionnaire form the letters related to your judgements:

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

Table 2: Extract of the questionnaire adopted to estimate quality scores (a) and importance weights (b)

A total of 71 questionnaire forms have been selected for their completeness to perform such analysis, from a total of 83 obtained questionnaire forms. In such survey process the fuzzy-linguistic evaluation scales reported in Table 3 have been considered.

Performance evaluation scale		Importance evaluation scale	
Linguisticcategory	TFN	Linguistic category	TFN
Very poor (VP)	(0, 0, 30)	Equally important	(1, 1, 1)
Poor (P)	(10, 30, 50)	Moderately more important	(1, 3, 5)
Fair (F)	(30, 50, 70)	Strongly more important	(3, 5, 7)
Good (G)	(50, 70, 90)	Very strongly more important	(5, 7, 9)
Very good (VG)	(70, 100, 100)	Extremely more important	(7, 9, 9)

Table 3: Fuzzy-linguistic evaluation scales (Yeh and Kuo, 2003)

By applying the fuzzy ServPerf model previously described, fuzzy quality scores of service criteria have been obtained. Table 4 reports such values for the considered airports.

	Criterion					
	C_1	C_2	C_3	C_4	C_5	C_6
CTA	(47.8;69.5;86.2)	(45.0;66.7;83.2)	(46.5;67.8;84.7)	(48.9;71.3;86.6)	(45.1;66.8;83.1)	(48.4;70.2;86.6)
PMO	(42.0;63.2;80.9)	(39.9;61.1;78.1)	(42.5;63.4;80.9)	(47.4;69.7;85.2)	(42.4;64.1;80.7)	(46.5;68.2;84.7)
TPS	(47.2;69.5;84.9)	(35.4;55.7;74.3)	(44.2;65.7;82.7)	(44.8;66.8;82.9)	(45.5;67.7;83.3)	(43.2;64.4;82.1)

Table 4: Fuzzy quality scores.

More in detail, Fig. 4 summarizes the obtained crisp quality scores considering for both the confidence level α□and the index of optimism μ a value equal to 0.5. In particular, in such Fig. the symbol "X" denotes Catania-Fontanarossa Airport (CTA), "+" the Palermo-Punta Raisi Airport (PMO) and "°" the Trapani-Birgi Airport (TPS).

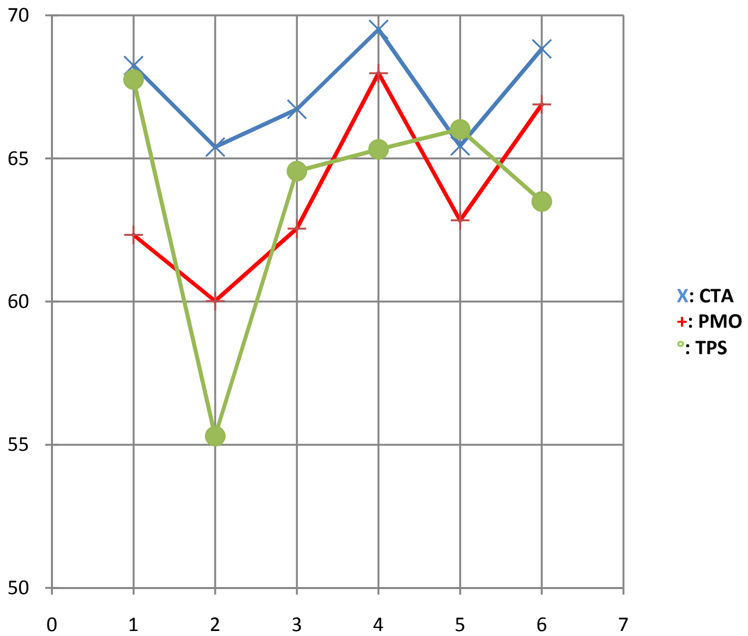

Figure 4: Quality scores of service criteria for the considered airports
(α□= 0.5; μ = 0.5)

From the obtained results, it is possible to point out that the Catania-Fontanarossa Airport presents the highest values of quality scores on five criteria: *Processing time* (C_1), *Convenience* (C_2), *Comfort* (C_3), *Information* (C_4) and *Safety and security* (C_6). On the contrary, the Palermo – Punta Raisi Airport does not present dominance in any of the six considered criteria, while the Trapani-Birgi Airport is characterized by the highest value of quality score on the criterion *Staff* (C_5).On the contrary, the importance weights of service criteria have been obtained by using the fuzzy AHP procedure described in the Step 3 Section, and Table 5 shows the obtained aggregated fuzzy comparison matrix (a) and the related fuzzy criteria weights (b).

a)

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	(0.77;1.39;2.08)	0.45;0.74;1.37)	(0.37;0.53;0.96)	(0.47;0.78;1.32)	(0.18;0.26;0.48)
C_2	(1.28;0.72;0.48)	1	(0.43;0.68;1.15)	0.30;0.43;0.76)	(0.68;1.03;1.48)	(0.17;0.26;0.58)
C_3	(0.73;1.35;2.19	(0.86;1.46;2.30)	1	(0.50;0.83;1.28)	(0.47;0.77;1.52)	(0.20;0.31;0.68)
C_4	(1.03;1.86;2.67)	(1.29;2.31;3.34)	(0.77;1.20;3.34)	1	(1.43;2.64;3.82)	(0.40;0.52;0.72
C_5	(0.75;1.27;2.08)	(0.67;0.97;1.47)	0.65;1.28;2.12)	(0.26;0.37;0.69)	1	(0.34;0.61;1.16)
C_6	(2.04;3.74;5.30)	(1.73;3.87;5.91)	(1.47;3.21;4.78)	(1.37;1.90;2.46)	(0.85;1.62;2.90)	1

b)

	C_1	C_2	C_3	C_4	C_5	C_6
Fuzzy importance weight	(0.06;0.1;0.2)	(0.06;0.09;0.15)	(0.1;0.12;0.15)	(0.19;0.2;0.19)	(0.09;0.12;0.14)	(0.19;0.34;0.42)

Table 5: Fuzzy aggregated comparison matrix (a) and related fuzzy criteria weights (b)

As it can be seen from Table 4 b), from respondents perspective, the most important service criterion is *Safety and security* (C_6) followed by *Comfort* (C_3), *Staff* (C_5), *Convenience* (C_2), *Information* (C_4) and, finally, *Processing time* (C_1).

3.3 Comparative airports service quality analysis

The thresholds required by ELECTRE III method have been determined on the basis of a preliminary survey conducted to a limited number of airport service experts (airport decision makers and academics). In particular, such thresholds have been calculated as percentage of the maximum performance scores of the respective criteria: a difference less or equal to 3% has been considered indifferent, while preference and veto thresholds have been fixed to 6% and 12% respectively. The obtained fuzzy performance scores and importance weighs of service criteria (see Tables 3 and 4 b) constitute the ELECTRE III input which has given the service quality ranking for the considered airports,obtaining results reported in Table 6.

CTA	1
PMO	2
TPS	3

Table 6: Service quality ranking of the airports in Sicily(α□= 0.5; μ = 0.5)

As it can be seen from Table 6, the Catania-Fontanarossa Airport is the best one in Sicily in term of quality of delivered passenger service followed by the Palermo-Punta Raisi Airport and, finally, the Trapani-Birgi Airport.On the basis of the obtained results, strategic implications for service quality improvements can be pointed out by comparing the performance scores related to Palermo-Punta Raisi and Trapani-Birgi Airports *vs* the ones related to Catania-Fontanarossa Airport.In such a way, it is possible to highlight, in comparative manner, critical to quality service aspects that need to be improved for the Palermo-Punta Raisi and Trapani-Birgi Airports. Fig. 6 shows the obtained quality gaps.

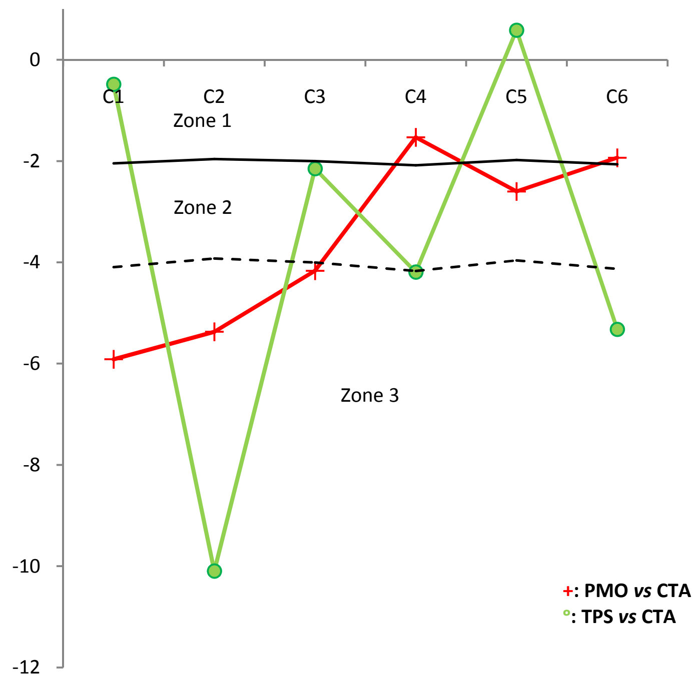

Figure 6. Performance gaps of service criteria (μ = 0.5; α = 0.5)

In particular, in Fig. 6 three zones can be defined:

- zone 1: the indifference zone within the limits [$-q_i$, 0];
- zone 2: the weak preference zone within the limits [$-p_i$; $-q_i$,);
- zone 3: the strong preference zone over the limit ($-p_i$).

in which i is the generic service criterion.
Clearly, service criteria which quality gaps are plotted within the zone 3 have to be primarily take into account for improvement actions, since they imply strong preference of the Catania-Fontanarossa Airport service; subsequently, service criteria related to quality gaps plotted within the zone 2. Finally, for service criteria which quality gaps are plotted within the zone 1, they can be secondarily considered for improvement actions.On the basis of the previous considerations, for the Palermo – Punta Raisi Airport, service aspects related to the following criteria need to be primarily improved: C_1 (*Processing time*), C_2 (*Convenience*) and C_3 (*Comfort*). On the contrary, for the Trapani-Birgi Airport the performed comparative service analysis highlights that criteria C_2 (*Convenience*), C_6 (*Safety and security*), and C_4 (*Information*), being characterized by significant negative quality gap values, should be improved in first instance in order to obtain an overall perceived quality improvement of the passenger service.

4. Conclusions

In the present paper a new approach able to evaluate in comparative manner service quality based on the ServPerf paradigm and that uses in combined manner the ELECTRE III method and the Fuzzy Sets Theory has been developed. The application of such approach has been shown in a strategic service quality analysis related to the international airports in Sicily (Italy). From such analysis, passenger service quality has been evaluated and a suitable "Gaps oriented" strategy for the overall airport service improvement has been identified. Moreover, the performed strategic service quality analysis has shown the effectiveness of the developed approach that can support airport management to identify, in comparative way, critical to quality passenger service aspects that need to be improved to obtain an overall airport value and image improvement.

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Appendix A1

As before said, by adopting the ELECTRE III method, for each considered service criterion the following thresholds have to be considered: q, indifference threshold; p, preference threshold and v, veto threshold, in which: $q<p<v$. By considering these thresholds, the following preference relations between service alternatives a and b may be established, referring to thequality scores $g_i(a)$ and $g_i(b)$ of the service criterion i:

(a.) $(a\ I\ b)_I$ – a is indifferent to b with respect to the service criterion i if $|g_i(a) - g_i(b)| \leq q_i$;
(b.) $(a\ WP\ b)_I$ – a is weakly preferred to b with respect to the service criterion i if $q_i < (g_i(a) - g_i(b)) \leq p_i$;
(c.) $(a\ SP\ b)_I$ – a is strongly preferred to b with respect to the service criterion i if $(g_i(a) - g_i(b)) > p_i$;
(d.) $(a\ NR\ b)_I$ – the assertion that a outranks b cannot be refused with respect to the service criterion i if $(g_i(b) - g_i(a)) \leq p_i$;
(e.) $(a\ WR\ b)_I$ – the assertion that a outranks b is weakly refused with respect to the service criterion i if $p_i < (g_i(b) - g_i(a)) \leq v_i$;
(f.) $(a\ SR\ b)_I$ – the assertion that a outranks b is strongly refused with respect to the service criterion i if $(g_i(b) - g_i(a)) > v_i$;

Moreover, concordance, indicated with $c_i\ (a, b)$, is equal to:

- 1, if relation (a.) is verified;
- 0, if $(g_i(b) - g_i(a)) \geq p_i$;
- $c_i(a,b) = \dfrac{p_i + g_i(a) - g_i(b)}{p_i - q_i}$ while if $q_i \leq (g_i(b) - g_i(a)) \leq p_i$

end discordance, indicated with $d_j\ (a,b)$, is equal to:

- 0, if relation (d.) is verified;
- 1, if relation (f.) is verified
- $d_i(a,b) = \dfrac{g_i(b) - g_i(a) - p_i}{v_i - p_i}$ while if relation (e.) is verified,

The concordance and discordance indices can be considered as measurements of dissatisfaction that a customer uses in choosing one service alternative over the other. For each service alternatives pairs a and b, the concordance values $c_i\ (a,\ b)$ with respect to each service criterion i, are aggregated in the *global concordance matrix*, by means of a weight k_i, assigned to each service criterion. The generic element of such a matrix can be expressed as:

$$C(a,b) = \sum_i k_i \cdot c_i(a,b) \tag{A1}$$

Following, the definition of *credibility* that "*a* outranks *b*", that summarizes the information expressed by *concordance* and *discordance*, is expressed as:

$$S(a,b) = \begin{cases} C(a,b) & \text{if } d_i(a,b) \leq C(a,b)\ \ \forall i \\ C(a,b) \cdot \displaystyle\prod_{\forall i | d_i(a,b) > C(a,b)} \frac{1 - d_i(a,b)}{1 - C(a,b)} & \text{otherwise} \end{cases} \tag{A2}$$

The next step is the so called descendent distillation that consists in ranking in descendent order the service alternatives on the basis of the credibility parameter. In such step, a further threshold is considered:

$$\lambda = \max_{\forall a,b} S(a,b) \qquad \text{(A3)}$$

A credibility level λ', less but close to λ, is established so that the related interval (λ□□□λ') can be considered as an indifference credibility interval. Consequently, a Boolean matrix is calculated as follows:

$$B(a,b) = \begin{cases} 1 & \forall a,b \mid S(a,b) > \lambda' \\ 0 & \text{otherwise} \end{cases} \qquad \text{(A4)}$$

As a final point, for each service alternative *j*, the difference *Q*(*j*) between the number of service alternatives *i* that are outranked by the service alternative *j* at level λ' of higher, that is the service alternatives *i* having *B*(*j*, *i*) = 1, and the number of service alternatives *k* that outrank the service alternative *j* at level λ' of higher, that is the alternatives *k* having *B*(*k*, *j*)=1, is calculated. The first distillates are the service alternatives *i* having:

$$Q(i) = \max_{\forall j} Q(j) \qquad \text{(A5)}$$

If the set containing all the service alternatives for which the previous relationships is verified, has a cardinality higher than 1, the described procedure is recursively applied until the set containing only one service alternative or a group of service alternatives that cannot be further differentiated. In such case, an ascending distillation can be applied, ranking the service alternatives in ascending order. This new ranking, coupled with that obtained by descending distillation, leads to a unique final ranking list.