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ANALYSIS OF PASSENGER'S SATISFACTION WITH THE QUALITY OF THE PUBLIC TRANSPORTATION MODE CHOICES IN BUCHAREST: A FUZZY APPROACH

Abstract. *This paper analyses the passenger's satisfaction towards the quality of existing public transportation mode choices in Bucharest. In order to eliminate the subjective factor from passenger's judgment, we have used fuzzy multicriteria analysis method. The criteria have been grouped in six groups of satisfaction determinants: convenience of service, comfort, service reliability, safety and security, communication with passengers and price and affordability. According to the criteria analyzed, although the surface transport network offers a wider range of services, the respondents show an overwhelming preference for travelling by underground.*

Keywords: *public transport; fuzzy method; quality; satisfaction; survey.*

JEL Classification: R41, R42

1. Introduction

Nowadays, most activities take place in cities, important economical and administrative locations developed around a transport system. As a result of economic development, growth of population and extension of urbanization, many cities and their inhabitants face increasingly mobility problems. In this frame, public transport is a part of everyday life in urban areas and it is considered the most efficient mode of transportation (Stathopoulos and Marcucci, 2014). It provides various services to the cities 'inhabitants who have the possibility of

travelling quickly in shared vehicles such as buses, trams, trolleys, underway, etc (Litman, 2016).

Public transportation becomes more important as cities become bigger. In smaller towns, public transport is used by people who cannot afford to buy a car (Ibarra-Rojas et al, 2015). However, as cities grow in size, it serves more the citizens who have financial possibilities for buying a car, but prefer to use public transport in order to reduce traffic problems and support more efficient land use patterns (Litman, 2016).

Many factors can affect public transport demand, including demographics, the quality of facilities (Huang et al, 2006), the price of alternatives (Litman, 2013) and land use patterns (Litman, 2016). The present article is focused around the concepts of quality and satisfaction. It is generally recognized that a higher quality for a product or service generates increased demand in any field. Therefore, a special attention should be paid to the quality of services in order to increase the attractiveness of public transport and reduce car use.

In the last decades the quality of transportation services has been in the attention of many researchers. Studies conducted in this field (Ekinci, 2003; Mouwen and Rietveld, 2013) showed that there is a strong relation between the quality of public transport and passenger's perception and satisfaction. The passengers' opinion represents a key element in assessing the quality of public transport. They are frequent users of this service and therefore they are the most able persons to make judgments about quality. The diversity of their reactions could be explained through quality of service, different perceptions on certain aspects, attitude toward transportation services, preferences and socioeconomic features. Even the literature in the field does not provide a consensus regarding the concept of passengers' satisfaction. According to some authors satisfaction is an outcome of the advantages obtained by using a service (Zeithaml, 2000).Other researches analyse this concept in relation to customer experiences across the transport services (Mokonyama and Venter, 2013). Moreover, sometime it isn't a clear distinction between the concepts of service quality and satisfaction. However, some empirical studies highlight the existence of a causal connection between service quality and satisfaction(Bezerra and Gomes, 2015).

As regards the quality of transport services, it is essential not to confuse the quality conformity with the perceived quality. The quality conformity is achieved when a service meets the requirements expected: time schedule, normal average daily passengers transported, number of vehicles in function. The perceived quality is studied in relation to customers' expectations (Morfoulaki et al, 2007) and requirements. Passengers perceive the quality of transport services by taking into account the following aspects: accessibility, reliability, safety, travel time and cost, capacity, cleaning and so forth (Grujičić et al, 2014). Moreover, the main objective of public transport consists in serving passengers at the highest level of their requirements.

Bucharest, the capital of Romania, is one of the cities experiencing many problems in public transport. The city has the largest network of public transport in Romania, which is also one of the largest in Europe. The explosive evolution of traffic vehicles in Bucharest capital led to increased problems in the public transport. As a result, the public transport takes place under very difficult conditions, both in terms of taking over passengers' flows and movement speed. Moreover, the traveling comfort has fallen and continues to fall below the permissible limits. In this context, the aim of this research is to analyse the passengers' satisfaction in relation to the mode of transport used and to identify the factors influencing their perception.

2. Literature review

The analysis of passenger satisfaction with public transportation is one of the most challenging themes in transportation research. The literature in the field provides a wide range of studies regarding the perceived quality and its relationship to passengers' satisfaction in the public transportation system in urban area. They analyze both the factors for quality measurement and the perceptions of public transport users and lead to very different conclusions as to what public transport systems are best overall. In this regard, this article uses customer satisfaction surveys to obtain a broad perspective over the quality of public transport system in Bucharest by using factors which bear influence on the passengers' satisfaction and perception.

Differences between perceived quality and desired quality have been analyzed by Dell'Olio et al (2011) in a study regarding public transport users in Santander, capital of Cantabria situated on the north coast of Spain. The methodology used consisted in customer satisfaction surveys method. The research has revealed that the different types of users value waiting time, cleaning and comfort. On the opposite pole, little importance was given to trip duration, vehicle occupancy and driver amiability. In a study conducted in 13 regions of Sweden using customer satisfaction surveys, Friman (2004) has concluded that satisfaction perceived by public transport users is influenced by the quality only up to a certain limit. The need to know the passengers' point of view regarding public transport quality as well as their level of satisfaction has been also emphasized by Olivkova (2010) who used customer satisfaction surveys in a study conducted in Ostrava, a city situated in Czech Republic. The same method has been applied by Antonucci et al (2014) in order to measure passengers' satisfaction with public city transport services and to determine the extent to which certain service characteristics could influence the perceived quality in Bari, Italy.

Barabino & Deiana (2013) used the SERVQUAL model for the evaluation of the service quality in public transport. In this regard, they have conducted a study in Cagliari in Italy in order to discover the extent to which the quality of public transportation system depends on the vehicle schedule. The conclusion was

that passengers are interested primarily in services with major frequency rate. The same method was applied by Agrawal et al. (2015)using the SERVQUAL model for assessing the quality of public transport in Delhi, India. Their study has highlighted that increasing the quality of public transport services could reduce the negative aspects related to pollution, traffic congestion, etc.

3. Case study: Bucharest's transportation network

Bucharest has one of the largest urban public transport systems in Europe, made up of an underground network and a very large surface transport network, made up by buses, trolleybuses and trams. The two networks are operated by two independent urban transport providers (RATB and METROREX). Although there are multiple connection points between the two urban transport networks, the citizens must use separate ticketing systems and fees to have access to urban transport services. It should be noticed that until the 14th of March 2014 there has been an agreement between the two companies that control the public transport in Bucharest concerning the validity of tickets and travel cards for both systems: surface and underground. Nevertheless, Metrorex decided to break the collaboration due to a high debt from R.A.T.B.

4. Research method

4.1 Identification of the determinants of passengers' satisfaction

The first step in the analysis of passengers' satisfaction with public transportation mode choices in Bucharest was the identification of the most important factors that have an influence on the user perception and satisfaction. Based on the literature review, we decided to analyse six groups of determinants. Each group was decomposed in corresponding criteria. Figure 1 presents the structure of the passenger satisfaction tree.

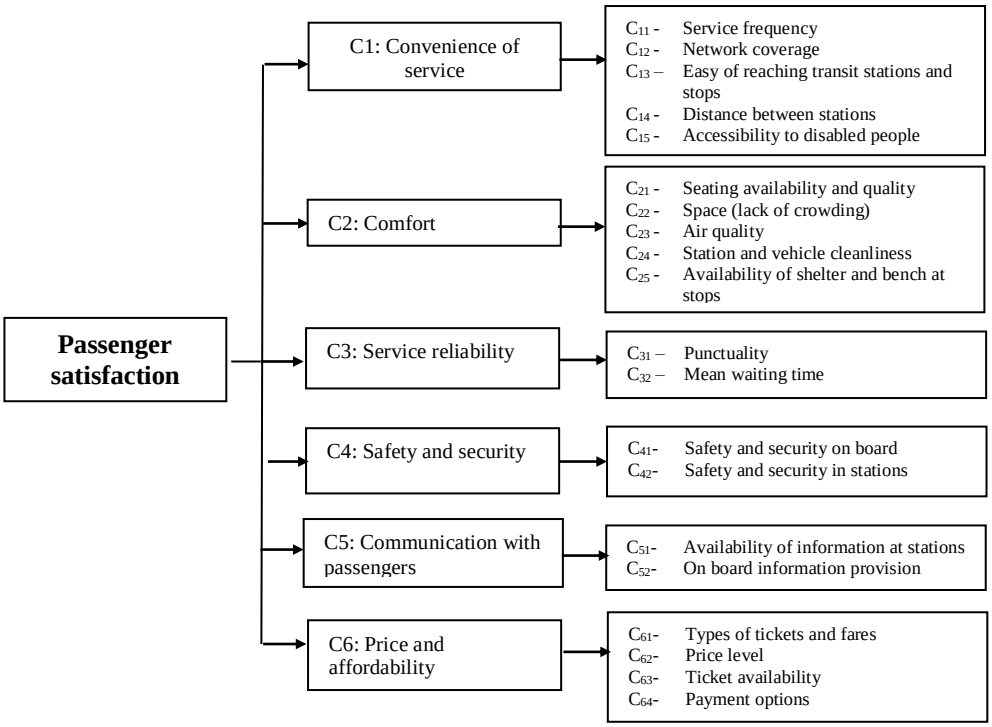

Figure 1. Passenger satisfaction tree

To gather data we have been selected 7 important subway, bus, tram and trolley stations from each sector of Bucharest, totally 168 centres. 5-7 passengers were interviewed randomly in each of the 168 sample centres. Finally, for the analysis we have obtained responses from 842 people, a representative sample for Bucharest. In order to eliminate the subjective factor from passenger's judgment, we have used fuzzy multi-criteria analysis method.

4.2. The fuzzy approach

Satisfaction does not have a physical dimension, it is very difficult to scale because the linguistic terms that people use to express their feelings are vague. To handle the vagueness and ambiguity of human thought, Zadeh (1965) first introduced the fuzzy set theory, which can effectively describe imprecise knowledge or human subjective judgment by linguistic terms.The membership function is the base element in the use of fuzzy sets. In a universal set X, a fuzzy subset A of X is defined by the membership function fA(x) and the degree to which an element belongs to a set is defined by a value 0 to 1. The greater fA(x) is, the greater is the grade of membership for x in A. As the present paper is focused on the passenger's satisfaction towards the quality of public transport in Bucharest, a fuzzy based methodology should be a valuable tool for analysis.

Each passengerhas it's own perceptions of the linguistic terms,so in the first part of the questionnaire each person has been asked to define the personal perception for each linguistic term in a 1-100 scale. Linguistic variables of "very low" to "very high" (5 scale) were used (Table 1).

Table 1. Scale for linguistic variables set by respondents

	Linguistic variable scale (0-100)				
Respondent	VL (Very Low)	L (Low)	N (Neutral)	H (High)	VH (Very High)
1	0 - 5	5 - 40	40- 60	60- 95	95 - 100
2	0 - 20	20-45	45-55	55-80	80-100
3	0 - 10	10- 35	35 - 65	65 - 90	90 - 100
…….	.....	.....	.....	.....	.....
842	0 - 5	5 - 30	30 - 70	70 - 95	95 - 100

Each set of responses was represented using histograms (Colesca et all, 2014) (Figure 2).

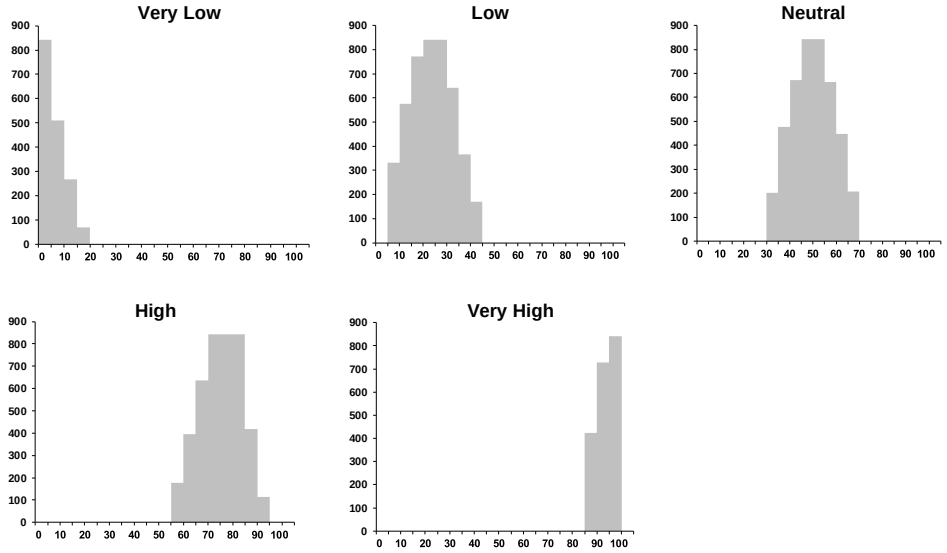

Figure 2. The histograms of each linguistic variables

Based on the histograms, the linguistic variables were characterized by trapezoidal fuzzy numbers. A trapezoidal number $\tilde{A} = (a, b, c, d)$ is a special type of fuzzy number defined by four ordered parameters (a≤b≤c≤d), with the membership function defined as (Taheri and all, 2010):

$$\mu_{\tilde{A}}(x)=\begin{cases}0 & ,x<a\\ \dfrac{x-a}{b-a} & ,a\le x<b\\ 1 & ,b\le x<c\\ \dfrac{d-x}{d-c} & ,c\le x<d\\ 0 & ,x>d\end{cases} \quad (1)$$

For fuzzyfication we have used the following rule: if $(L_i,U_i)_A$, is the response of the i[th] respondent for the $\tilde{A}$ linguistic term (i=1..n, n=number of respondents), then $a_{\tilde{A}}=\min_{i=1..n} L_i$, $d_{\tilde{A}}=\max_{i=1..n} U_i$, $b_{\tilde{A}}$ and $c_{\tilde{A}}$ equalled the minimum and maximum of the interval with the most number of responses.

The final calculations for the values of fuzzy membership function of each linguistic term are shown in Table 2. Figure 3 shows the graphical representation of the membership function for linguistic terms.

Table 2. Fuzzy numbers associated with linguistic terms

Linguistic term	Symbol	FN
Very Low	VL	(0, 0, 5, 20)
Low	L	(5, 20,30,45)
Neutral/Medium	N/M	(30, 45 , 55, 70)
High	H	(55, 70, 85, 95)
Very High	VH	(85, 95, 100, 100)

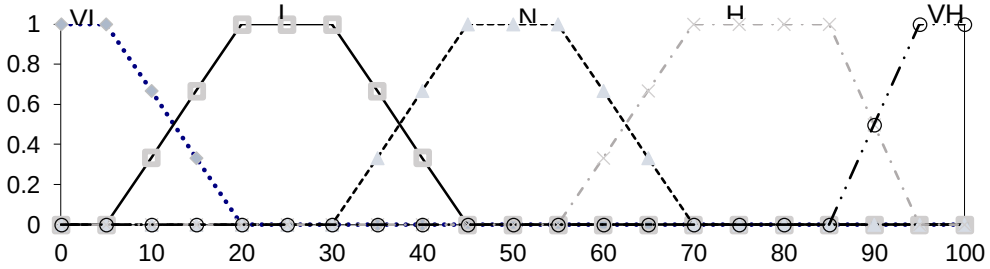

Figure 3. Graphical representation of the membership function for linguistic terms

The importance of each criterion was evaluated by each passenger using linguistic terms. Each response was converted on a fuzzy number $\tilde{w}_j^t$. If $\tilde{w}_j^t = (s_j^t, p_j^t, q_j^t, r_j^t)$ represents how person t rates the importance of criteria j (k represents the total number of respondents), the aggregated fuzzy number associated to the importance of criterion j could be calculated using the formula (Chen et al., 2006):

$$\widetilde{w_j} = \left(\min_{t=1..k}\left(s_j^t\right), \frac{\sum_{t=1}^{k} p_j^t}{k}, \frac{\sum_{t=1}^{k} q_j^t}{k}, \max_{t=1..k}\left(r_j^t\right)\right) \quad (2)$$

In order to normalize the trapezoidal fuzzy numbers associated to the importance of criteria, we have used the method presented in Chen et al (2006). The method is based on the concept that the best alternative should have the shortest distance from the fuzzy positive ideal solution and the longest distance from the fuzzy negative ideal solution, measured by a closeness coefficient. A larger value for the closeness coefficient indicates a better performance.

$w_j = \frac{CC_j}{\sum_{t=1}^{20} CC_j}$, where (3)

- w_j represents the the final weight of the subcriteria j

$CC_j = \frac{d_j^-}{d_j^+ + d_j^-}$, where (4)

- d_j^- represents the distance between the aggregated fuzzy weight and the fuzzy negative ideal rating (Very low)
- d_j^+ represents the distance between the aggregated fuzzy weight and the fuzzy positive ideal rating (Very high)

The distance between 2 trapezoidal fuzzy numbers has been calculated using the vertex method (Chen et al, 2006):

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{(x_1-y_1)^2+(x_2-y_2)^2+(x_3-y_3)^2+(x_4-y_4)^2}{4}}. \quad (5)$$

Table 3 presents the weights of importance for each criterion.

In another point of the questionnaire, each transportation mode choice has been assessed by each passenger using linguistic terms. The responses have been converted into trapezoidal fuzzy sets. If $\tilde{e}_{ij}^k = \left(a_{ij}^k, b_{ij}^k, c_{ij}^k, d_{ij}^k\right)$represents the evaluation of passenger *k* (*k=1..842*) towards alternative i (*1-underground; 2-bus; 3-trams; 4-troley)* under criterion *j (j=1-20),* the aggregated fuzzy rankings for each alternative and criterion $\tilde{e}_{ij} = \left(a_{ij},\ b_{ij}, c_{ij},\ d_{ij}\right)$could be calculated as (Chen et al, 2006):

$$\tilde{e}_{ij} = \left(\min_{t=1..k}\left(a_{ij}^t\right), \frac{\sum_{t=1}^{k} b_{ij}^t}{k}, \frac{\sum_{t=1}^{k} c_{ij}^t}{k}, \max_{t=1..k}\left(d_{ij}^t\right)\right) \quad (6)$$

The normalized fuzzy evaluation matrix $\tilde{N} = \left[\tilde{n}_{ij}\right]_{4*20}$can be represented as (Chen et al, 2006):

$$\tilde{n}_{ij} = \left(na_{ij}, nb_{ij},\ nc_{ij}, nd_{ij}\right) = \left(\frac{a_{ij}}{d_j^*}, \frac{b_{ij}}{d_j^*}, \frac{c_{ij}}{d_j^*}, \frac{d_{ij}}{d_j^*}\right), \quad d_j^* = \max_i d_{ij} \quad (7)$$

Table 3. The importance of each criterion

Criteria	Importance	d^-	d^+	cc	w
C11	$\tilde{w}_{11}$ = (55,87.46,95.48,100)	$d_{11}^- = 79.47$	$d_{11}^+ = 15.63$	$cc_{11} = 0.84$	$w_{11} = 0.067$
C12	$\tilde{w}_{12}$ = (30,84.37,93.5,100)	$d_{12}^- = 74.58$	$d_{12}^+ = 28.20$	$cc_{12} = 0.73$	$w_{12} = 0.058$
C13	$\tilde{w}_{13}$ = (55,87.34,95.4,100)	$d_{13}^- = 79.41$	$d_{13}^+ = 15.65$	$cc_{13} = 0.84$	$w_{13} = 0.067$
C14	$\tilde{w}_{14}$ = (30,89.83,96.69,100)	$d_{14}^- = 77.1$	$d_{14}^+ = 27.67$	$cc_{14} = 0.74$	$w_{14} = 0.059$
C15	$\tilde{w}_{15}$ = (0,20.68,30.62,95)	$d_{15}^- = 40.95$	$d_{15}^+ = 66.31$	$cc_{15} = 0.38$	$w_{15} = 0.030$
C21	$\tilde{w}_{21}$ = (0,46.37,55.61,100)	$d_{21}^- = 52.71$	$d_{21}^+ = 53.76$	$cc_{21} = 0.50$	$w_{21} = 0.040$

C22	$\tilde{w}_{22}$ = (5,58.81,69.47,100)	d_{22}^{-} = 59.24	d_{22}^{+} = 46.48	cc_{22} = 0.56	w_{22} = 0.045
C23	$\tilde{W}_{23}$ = (5,63.74,73.63,100)	d_{23}^{-} = 61.64	d_{23}^{+} = 44.92	cc_{23} = 0.58	w_{23} = 0.046
C24	$\tilde{w}_{24}$ = (0,57.61,67.78,100)	d_{24}^{-} = 58.44	d_{24}^{+} = 49.15	cc_{24} = 0.54	w_{24} = 0.043
C25	$\tilde{w}_{25}$ = (0,42.78,52.02,100)	d_{25}^{-} = 51.09	d_{25}^{+} = 55.35	cc_{25} = 0.48	w_{25} = 0.038
C31	$\tilde{w}_{31}$ = (55,89.3,96.58,100)	d_{31}^{-} = 80.29	d_{31}^{+} = 15.36	cc_{31} = 0.84	w_{31} = 0.067
C32	$\tilde{w}_{32}$ = (55,87.79,95.67,100)	d_{32}^{-} = 79.61	d_{32}^{+} = 15.58	cc_{32} = 0.84	w_{32} = 0.067
C41	$\tilde{w}_{41}$ = (55,84.49,93.69,100)	d_{41}^{-} = 78.15	d_{41}^{+} = 16.20	cc_{41} = 0.83	w_{41} = 0.066
C42	$\tilde{w}_{42}$ = (55,84.49,93.69,100)	d_{42}^{-} = 78.15	d_{42}^{+} = 16.20	cc_{42} = 0.83	w_{42} = 0.066
C51	$\tilde{w}_{51}$ = (0,26.10,35.11,95)	d_{51}^{-} = 42.46	d_{51}^{+} = 63.66	cc_{51} = 0.40	w_{51} = 0.032
C52	$\tilde{w}_{52}$ = (0,26.10,35.11,95)	d_{52}^{-} = 42.46	d_{52}^{+} = 63.66	cc_{52} = 0.40	w_{52} = 0.032
C61	$\tilde{w}_{61}$ = (30,60.80,72.57,100)	d_{61}^{-} = 62.37	d_{61}^{+} = 35.17	cc_{61} = 0.64	w_{61} = 0.051
C62	$\tilde{w}_{62}$ = (30,60.80,72.57,100)	d_{62}^{-} = 62.37	d_{62}^{+} = 35.17	cc_{62} = 0.64	w_{62} = 0.051
C63	$\tilde{w}_{63}$ = (0,46.98,56.06,100)	d_{63}^{-} = 52.95	d_{63}^{+} = 53.53	cc_{63} = 0.50	w_{63} = 0.040
C64	$\tilde{w}_{64}$ = (0,41.19,51.18,100)	d_{64}^{-} = 50.57	d_{64}^{+} = 55.91	cc_{64} = 0.47	w_{64} = 0.037

In the next step, the normalized fuzzy evaluation matrix has been integrated with the weights of each criterion. If W is the vector of criteria weights, the fuzzy weighted value of the passenger satisfaction with transportation mode choices could be calculated with the formula $\tilde{R} = \tilde{N} * W,\ \tilde{R} = \left[\tilde{r}_{ij}\right], i = 1..4, j = 1..20$

$$\tilde{r}_{ij} = \left(na_{ij} * w_j, nb_{ij} * w_j, nc_{ij} * w_j, nd_{ij} * w_j\right) \quad (8)$$

The ranking of the transportation choice modes is based on the same concept of closeness coefficient. In this case the fuzzy positive ideal solution is (1,1,1,1) and the fuzzy negative ideal solution (0,0,0,0). If C_{ij} represents the closeness coefficient for the alternative i and criteria j, and C_i the closeness coefficient for alternative i, then :

$$C_{ij} = \frac{d_{ij}^{-}}{d_{ij}^{+} + d_{ij}^{-}} \quad (9)$$

$$d_{ij}^{+} = d(\tilde{r}_{ij}, (1,1,1,1)) \quad (10)$$

$$d_{ij}^{i} = d(\tilde{r}_{ij}, (0,0,0,0)) \quad (11)$$

$$d_i{}^{+} = \sum_{j=1}^{n} d_{ij}^{+} \quad (12)$$

$$d_i{}^{-} = \sum_{j=1}^{n} d_{ij}^{-} \quad (13)$$

$$C_i = \frac{d_i^{-}}{d_i^{+} + d_i^{-}} \quad (14)$$

The final results are presented in Table 4.

Table 4. Final results

Criteria	Subway	Buses	Trolleys	Trams
C_{11}	0.060	0.040	0.030	0.050
C_{12}	0.040	0.050	0.020	0.030
C_{13}	0.060	0.040	0.020	0.050
C_{14}	0.050	0.030	0.030	0.040
C_{15}	0.030	0.020	0.020	0.010
C_{21}	0.040	0.020	0.020	0.030
C_{22}	0.030	0.020	0.020	0.020

C_{23}	0.040	0.030	0.030	0.030
C_{24}	0.030	0.020	0.020	0.020
C_{25}	0.040	0.020	0.020	0.010
C_{31}	0.050	0.030	0.030	0.040
C_{32}	0.050	0.040	0.030	0.050
C_{41}	0.060	0.030	0.040	0.030
C_{42}	0.060	0.030	0.030	0.030
C_{51}	0.030	0.020	0.020	0.020
C_{52}	0.030	0.020	0.020	0.020
C_{61}	0.030	0.040	0.040	0.040
C_{62}	0.040	0.040	0.040	0.040
C_{63}	0.040	0.020	0.020	0.020
C_{64}	0.030	0.030	0.030	0.030
C_1	0.048	0.036	0.024	0.036
C_2	0.035	0.022	0.022	0.025
C_3	0.050	0.035	0.029	0.045
C_4	0.059	0.030	0.035	0.030
C_5	0.030	0.020	0.020	0.020
C_6	0.035	0.033	0.033	0.033
Total	**0.0417**	**0.0293**	**0.0263**	**0.0303**

5. Results and discussions

842 questionnaires (a representative sample for the population of Bucharest) were considered valid and used for the final analysis. Most respondents use the public transportation daily (72.57%), 22.45% weekly and 4.99% occasionally, therefore the study results are relevant for the analysis of travellers' perception about the quality of public transportation in Bucharest.

As previously said, the respondents evaluated each criterion using linguistic terms. Based on this evaluation (Table 3), service frequency, easiness of reaching transit stations and stops, punctuality and mean waiting time are considered the most important by the respondents, followed by safety and security on board and safety and security in stations.

The passengers in Bucharest require a short distance between stations and a good network coverage, but they don´t take care so much about availability of information at stations and on board information provision like other European passengers.

This difference could originate from Romanian system of public city transport when majority of passengers don´t come into contact with drivers. The passengers expect that their orientation during travelling is easy, so the information in the public transport vehicles has to be sufficient.

The results are in line with the research done by Antonucci et al (2014), Pawlasová (2015) and Mouwen (2015) in different European countries. Antonucci at al. (2014) found that the punctuality and regularity as well as short waiting time are very important factors determining the Italian passenger satisfaction. Mouwen (2015) founds that overall satisfaction with public city transport in Netherlands is influenced the most by service attributes such as on time performance, travel speed and service frequency, followed by personnel attributed (driver behaviour) and

vehicle cleanliness. Pawlasová (2015) founds station proximity, service continuity and frequency are the most important indicators of satisfaction for Czech passengers.

Accessibility to disabled people, are not so important for passengers in Bucharest. This result can be explained by the fact that the disabled people were not among the respondents.

Analysis of respondents' evaluation for the 20 criteria that have resulted from the six quality criteria shows some interesting trends on public transportation methods in Bucharest and explains how travellers perceive the services provided by the two urban transport operators: Metrorex and RATB.

Convenience of service. In terms of **service frequency**, participants at the survey consider that the underground network has the best frequency, followed in order by tram, buses and trolleys. Users' opinion is generally accurate, if we consider that the subway has a very strict timetable, which is not influenced by other external factors like private vehicles, usually the most influential factors in other means of transportation. For example, Bucharest subway trains have a frequency between three and 20 minutes depending on the hours: peak hours, week-end, with an average between 5-10 minutes (METROREX).

On the contrary, buses and trolleybuses fail to provide the formally established frequency due to traffic congestion and busy traffic at peak hours. Next, tram ranks second in the respondent's opinion because it has his/its own special path on the road. Although this may be true, in Bucharest it often happens that private vehicles block these pathways.

As regards the **network coverage**, the bus system is the favourite way of transportation for respondents. This is due to the high density of the network. For instance, in 2014 the bus network had travelled 48.912.154 km in comparison with the tram network which had recorded 18.212.547 km. Meanwhile, the trolleybus network recorded 9.974.169 km. Additionally, when referring to the network length, the bus is again leading by 417 km double track, followed by tram with 139 km and trolley with 67 kilometres of double track.

As has been noted, the subway, which has a much lower density network with only 4% of the total length of transport routes in Bucharest, ranks second in respondents preferences. A possible explanation could be that the perception of users on the network coverage includes the length of the system and also the number of daily passengers. For this reason, the volume of passengers transported by subway represents about 20% of the total number of those who use public ways of transportation, approximately 600.000 passengers daily (METROREX).

Quite unexpected are the responses concerning **the easy to reach the transit stations and stops** as well as about **distance between stations**. Overall, the underground network is ranked first in both cases, with an average distance of 1.5 km between stations, compared with the surface transport where stations are situated at significantly lower distances: 0.5-0.7 km. Respondents' opinion can be

explained by the fact that users perceive the distance between stations depending on the speed they travel and time spent among stations. It is absolutely natural for a passenger who frequently uses underground transport to subconsciously perceive a shorter distance among stations because of the higher speed of the subway compared to the surface network.

Concerning the **accessibility for disable people**, the underground system ranks first, immediately followed by the bus and trolley networks. In the last years the preoccupation of local authorities for investing in facilitating the access of disabled people to public transport has increased. Thereby, in the case of underground transport, from a total of 51 subway station, 42 stations are adapted for people with special needs. As a result, 93 indoor and outdoor elevators were installed in 42 stations. Additionally, 138 escalators were put into service in 41 stations. With this in mind, for the remaining stations the work is in progress, company representatives declaring that they invested so far about 49 million euros in adapting the stations to the legislative norms.

Although this may be true, investments in the surface transportation network facilities for people with special needs have focused mostly on purchasing vehicles with low platforms. Currently, only 20.78% of trams and 48.79% of the total number of trolleys are equipped with low floor platforms, which may favour access for disabled people.

Comfort. The underground network is the favourite way of transportation for respondents not only in terms of **seating availability** but also for **space/lack of crowding**. This is due primarily to the fact that the new generations of subways (BM2 and BM21 trains) can provide 216 seats per compartment and a maximum of 2184 standing places. Under these criteria tram network was ranked second, a tram compartment ensuring 22, 28 or up to 34 seats depending on the model and up to 160-250 standing places under a high load; in other words, up to six people/square meter. On the negative side, bus and trolley were ranked on the last positions due to a smaller number of compartments when compared to the subway or tram. In particular, this leads to an increased congestion for the users.

On the subject of **air quality**, passengers rank first the conditions provided by the subway, in detriment of the surface transport. This can be explained by the small size of the surface vehicles, unlike the underground trains. Furthermore, in the case of ground transport there is a higher congestion on peak hours which decreases the quality for the transport conditions.

It is important to mention that in 2014 Metrorex invested almost 120 million euros in new subway trains which are fitted with performance air conditioning systems. As regards the surface network, the vehicles fleet is old, and most air conditioning systems that equip the vehicles are no longer functional. Presently, the fleet has a technical wear of about 70-80% for trams, 90% for trolleys and roughly 65% for buses. In conclusion, a number of potential users avoid the public transport during the summer due to high temperatures, which is a direct effect of the deficiency of air conditioning systems (METROREX).

Station and vehicle cleanliness represent a major concern. The research results ranks again the subway as favourite in the respondents' opinion. In Bucharest, a total of 2396 surface stations for urban transport have been recorded at the end of 2014. As compared to this, the underground network has a total of only 51 stations. In these circumstances, it is obvious why comfort in subway stations is superior. The number of vehicles and stations in the underground is much lower, therefore the companies in charge with cleaning services can perform their work more efficiently.

An additional problem in surface transport is homeless people who use the public transport vehicles to spend their time in stations. For this reason, one can observe a negative impact on cleanliness in general and that the passengers are disturbed.

A lot of aspects need to be improved to complete the **availability of shelter and bench at stops**. At the present time, from a total of 2396 surface stations, 490 stations have pedestrian refuges with roof and walls of glass or transparent plastic. Furthermore, 241 stations have full shelters for travellers.

On the positive side, the subway is the mode of transportation preferred by most of the passenger because all stations are covered and weather condition does not affect the users.

Service reliability. In general, the subway runs extremely punctually, thus ranking first, followed by trams, bus and trolley. In addition, subway train delays can easily be recovered by increasing the average speed.

The average waiting time for the subway ranges between six to 20 minutes depending on the line and apart from peak times. On the contrary, in peak hours, the subway operates on a three to 16 minutes daily schedule.

At the same time, punctuality is greatly influenced by vehicles defects and safety recalls, which cause delays and traffic congestion. Secondly, traffic accidents involving public transport units influences the normal schedules. Due to traffic events, in 2014 a vehicle immobilization time of 8565.33 hours for surface transport units has been recorded. This has a direct influence on departure-arrival times and average waiting time for passengers. As an illustration, the number of technical flaws delays for the surface transportation system recorded a significant increase in 2015 compared to 2014. In detail, a major problem is associated with buses and trolleys, which registered increases of 36.03% and 33.19% compared to the previous year.

Safety and security. According to the survey, the subway is perceived safer than surface transport by passengers. This could be explained by the partnership of Metrorex with a company specialized in security and protection in order to ensure the security of the network.

Security agents are present in every vehicle and compartment to prevent the occurrence of thefts, and also to significantly reduce the number of passengers who travel without a ticket.

This partnership ensures the safety of users while increasing the quality perceived by travellers concerning the transport system. Furthermore, subway trains are electronically monitored between stations by video surveillance.

Surface transportation recorded a total of 2739 traffic events in 2015. From these, 1702 cases were traffic collision, down 6.59% compared to 2014. From the total, 17.33% accidents were caused by urban transport vehicles drivers. Moreover, 114 accidents involving people who resulted in 24 serious injuries and five fatal accidents have been recorded.

Additionally, a significant problem for the public transport in Bucharest is related to thefts incidents and pick-pocketing. According to a press release from the General Directorate of Bucharest Police, the most common type of theft in surface transportation system is pick-pocketing, followed by thefts of personal items left unattended. In particular, the same statement shows that is much safer to travel by subway, because thefts committed in subway stations are considerably fewer, all the stations being equipped with surveillance systems and security guards.

Communication with passengers. Availability of information at stations is not an essential criterion for public transport users (Table 3). The underground system ranks first in respondents' opinions. Higher ranking for the subway is due to an information system which provides for travellers real-time details such as: last train departure time, arrival time for the next train, waiting minutes until the arrival of a new transportation mode.

Both in case of the underground network and in the surface transport, users have access to on board information provision such as: arrival time, next station, connection with other transport lines. Unfortunately the information is not very detailed, thus having a negative influence on the travellers' perception. However, under these circumstances buses and trolleys surpasses the trams in terms of access to information. The results could be explained by the fact that some buses and trolleys units display transportation details, and also provides GPS applications on a TV screen, being more attractive and accessible.

Price and affordability. As regards price and affordability, the underground and surface networks are ranked equally. If one gains in the field tickets availability, the other exceeds in the field of types of tickets and fares

The average price level of a single trip in the underground network is 0.4 euro and it provides access to any route as long as you do not leave the subway area. With only 0.4 euro you can travel the entire length of the subway line, different from other European cities, where the ticket is valid only one or two hours The price of a single trip for the surface network is 0.29 euro, but the ticket availability is reduced to just one trip and only one route. As surface lines are significant smaller than the underground lines, to reach the same destination are necessary minimum two surface transportations vehicles and the overall cost is greater compared to the case when it is used the subway.

When considering types of tickets and fares, the underground system offers a limited range of choices. Tickets with 2, 10 or 62 trips are available.

Additionally, customers may use daily passes, weekly or monthly passes with unlimited trips.

Comparatively, in terms of transport passes options**,** RATB provides a larger offer of services:

- passes available for one day, seven or 15 days for all the lines;
- monthly passes available for one or two lines;
- monthly passes available for the entire network;
- the possibility to pay the trip with an e-wallet.

Among the most innovative payment methods we notice payment by mobile phone or payment with bank cards that require only proximity contactless, available on both underground and surface systems.

It should be noted that in the case of surface transportation, not all the stations are equipped with ticket offices or vending machines. For example, from a total number of 2117 stations in Bucharest, only 97 stations feature ticket desks (RATB).

The study reflects the overwhelming preference of respondents for travelling by underground network in detriment of surface transportation modes. In essence, both transport networks have advantages, offering a wide range of choices.

6. Conclusions

The transportation system in Bucharest is facing significant issues and challenges because of the increase growth in population, intense urban development and public budget constraints. In this study we have used fuzzy multicriterial analysis method in order to analyse passenger's perception regarding the quality of public transport system in Bucharest.

After processing the research results, we can reach the conclusion that the underground system is considered the highest quality transport network by the majority of respondents, ranking first in the users' preferences in Bucharest.

The tram network ranked second in the respondents' options. Compared to the bus, vehicles punctuality and average waiting time in tram stations represent significant advantages. The tram has also its own runway, which is partially modernized, while the bus remains often blocked in crowded traffic, especially at peak hours. On the other hand, in the last year the tram fleet has experienced a positive trend: the number of units increased from 481 in 2013 to 483 in 2014, while the number of new buses in circulation increased with only one unit, from 1146 to 1147 (RATB). Furthermore, the existing routes for vehicles circulation are of particular importance in the quality of public transport system. Thus, according to the last annual report, tram network has achieved a rate of 99.22% effective/planned races in 2014 compared to 98.65% in 2013, while buses have achieved only 98.78%, (RATB).

The differences between buses and trolleys are not significant, each network having both advantages and disadvantages. That is why the users' opinions are impartial. The bus system is better evaluated in terms of service frequency, network coverage, mean waiting time and easy of reaching transit stations and stops

However, future researches are required in order to create a methodology for promoting sustainable development of public transport and reducing quality differences between the underground transport network and the surface system: buses, trams and trolleys. Such researches could have a great contribution in reducing the consumers' desire for other forms of transport like personal vehicles.

REFERENCES

[1] **Agrawal, V., Tripathi, V., and Agrawal, A.M. (2015),** ***Methodology for Evaluating Service Quality of Public Transport: Case of Delhi, India*****;** *Journal of Supply Chain Management Systems*. 4(1&2):88-100;

[2] **Antonucci, L., Corrado, C.,d'OvidioF.D., Toma E. (2014),** ***Passenger Satisfaction: A Multi-group Analysis*****;** *Quality and Quantity*, 48(1):337-345;

[3] **Barabino, B. and Deiana, E. (2013),** ***On the Attributes and Influencing Factors of End-users Quality Perceptions in Urban Transport: An Exploratory Analysis*****;** *Procedia - Social and Behavioral Sciences*, 87:18-30;

[4] **Bezerra, G.C.L. and Gomes,C.F. (2015),** ***The Effects of Service Quality Dimensions and Passenger Characteristics on Passenger's overall Satisfaction with an Airport.*** *Journal of Air Transport Management*, 44-45:77-81;

[5] **Chen, C.T., Lin, C.T., Huang,S.F. (2006),** ***A Fuzzy Approach for Supplier Evaluation and Selection in Supply Chain Management*****;** *International Journal of Production Economics*, 102(2):289–301;

[6] **Colesca, S.E., Ciocoiu, C.N., Popescu, M.L. (2014),** ***Determinants of WEEE Recycling Behaviour in Romania: A Fuzzy Approach*****;** *International Journal of Environmental Research*, 8(2):353-366;

[7] **Dell'Olio, L., Ibeas, A., Cecin, P. (2011),** ***The Quality of Service Desired by Public Transport Users*****;** *Transport Policy*", 18(1):217-227;

[8] **Ekinci, Y. (2003),** ***An Investigation of the Determinants of Customer Satisfaction;*** *Tourism Analysis*, 8(2):193-196;

[9] **Friman, M. (2004),** ***Implementing Quality Improvements in Public Transport*****;** *Journal of Public Transportation*, 7(4):49-65;

[10] **Grujičić, D., Ivanović, I., Jović, J., Đorić, V. (2014), Customer** ***Perception of Service Quality in Public Transport*****;** *Transport*, 29(3):285-295;

[11] **Huang, Y.C., Wu, C.H., Hsu, J.C.J. (2006),** ***Using Importance-Performance Analysis in Evaluating Taiwan Medium and Long Distance National Highway Passenger Transportation Service Quality*****;** *Journal of American Academy of Business*, 8(2):98-104;

[12] **Ibarra-Rojas, O.J., Delgado, F., Giesen, R., Munoz, J.C. (2015),** ***Planning, Operation, and Control of Bus Transport Systems: A Literature Review*****;** *Transportation Research Part B: Methodological*, 77:38-75;
[13] **Litman, T. (2013),** ***Understanding Transport Demands and Elasticities: How Prices and Other Factors Affect Travel Behavior*****;** Available at: http://www.vtpi.org/elasticities.pdf [Accessed 20 Sept. 2015];
[14] **Litman, T. (2016),** ***Evaluating Transportation Land Use Impacts. Considering the Impacts, Benefits and Costs of Different Land Use Development Patterns*****,**Available at: http://www.vtpi.org/landuse.pdf[Accessed 21 June 2016];
[15] **Mokonyama, M. and Venter, C. (2013),** ***Incorporation of Customer Satisfaction in Public Transport Contracts – A Preliminary Analysis*****;** *Research in Transportation Economics*, 39(1):58-66;
[16] **Morfoulaki, M., Tyrinopoulos, Y., Aifadopoulou G. (2007),** ***Estimation of Satisfied Customers in Public Transport Systems: A New Methodological Approach*****;** *Journal of the Transportation Research Forum*, 46(1):63-72;
[17] **Mouwen, A. andRietveld, P. (2013),** ***Does Competitive Tendering Improve Customer Satisfaction with Public Transport? A Case Study for the Netherlands;****Transportation Research Part A: Policy and Practice*. 51, 29-45;
[18] **Mouwen, A. (2015),** ***Drivers of Customer Satisfaction with Public Transport Services*****;***Transportation Research Part A*, 78, 1–20;
[19] **Olivkova, I. (2010),** ***Evaluation of Quality Indicators Public Transport*****;** Available at: http://pernerscontacts.upce.cz/20_2010/Olivkova.pdf [Accessed 17 June 2015];
[20] **Pawlasová, P. (2015),** ***The Factors Influencing Satisfaction with Public City Transport: A Structural Equation Modelling Approach*****;** *Journal of Competitiveness*, 7(4), 18 – 32;
[21] **Stathopoulos, A. andMarcucci, E. (2014),** ***Special Issue on Measuring Service Quality and Local Public Transport Performance*****;** *International Journal of Sustainable Transportation*, 8(1), 1-4;
[22] **Taheri, S., Hesamian, G., Viertl, R. (2010),** ***Contingency Tables with Fuzzy Categories. Report No SM-2010-2,*** Vienna, Vienna University of Technology;
[23] **Transportation Research Board. (2003),** ***Transit Capacity and Quality of Service Manual.*** **2nd Edition,**Available at: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp100/part%200.pdf [Accessed 11 Feb. 2013];
[24] **Zadeh, L.A. (1965),** ***Fuzzy Sets*****;** *Information and Control*, 8(2), 338-353;
[25] **Zeithaml, V.A., Parasuraman, A., Berry, L.L. (1990),** ***Delivering Quality Service. Balancing Customer Perceptions and Expectations,***New York, NY, The Free Press.