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IMPROVING USERS' SATISFACTION BY IMPLEMENTING THE ANALYTIC HIERARCHY PROCESS IN THE PUBLIC TRANSPORTATION SYSTEM

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Abstract

This paper develops investigations in the field of analytic hierarchy techniques that could be applied in public transportation systems. The study focuses particularly on the public transport bus services in Bucharest, the capital of Romania. The research aims to investigate the methodological feasibility of the analytic hierarchy process to analyze and measure the perceptions and needs of the Romanian public transportation users. Towards this objective, the study presents the current state of the Bucharest bus network. Furthermore, an investigation is conducted based on one of the most used multiple criteria decision-making tool - Analytic Hierarchy Process (AHP). Unlike most of the previous studies, this analysis has a double approach: researching the essential total quality management principles in public transportation and simultaneously developing a one stage methodology used for measuring the quality of the Romanian public transportation system. This final step involves using the AHP methodology to determine the priority of service quality attributes. Our contribution to the literature focuses on the advantage of using an analytic hierarchy technique in evaluating complex decisions in terms of public transportation. This contribution provides an initial analysis of the public transportation field in the Capital of Romania. Additionally, the study develops the premises for our further research and concludes on the efficiency and sustainability of an AHP method assessment in the local transportation network.

Keywords: analytic hierarchy process, Bucharest, public transportation system, service quality

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1. Introduction

The increasing interest in the quality of public transport bus services has highlighted the need for identifying new methods and methodologies for continuous improvement. Of particular interest and complexity are the passengers' requirements, which are constantly changing. Specifically, quality in public bus transport networks has been extensively studied in recent years. In this context, the study presents what needs to be improved to increase users' satisfaction.

The current paper will present the main issues of public bus transportation on a three-level-hierarchical model (the first level is a general one, the second level is more specific, and the third level is very specific). According to the literature review, as of December 2019, the approach is considered to be innovative, productive and highly relevant for the topic of Bucharest public transport. As an illustration, the novelty of this research can be summed up as follows:

- Developing a general AHP model by actively analyzing the Bucharest's public bus transport quality;
- The weight determination is obtained by applying the general model and therefore various projects can be developed on random public transportation bus systems.

One of the most significant current discussions in public transportation is the quality management of the service provided, taken into consideration the fact

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that quality can be constantly improved (Spath, 2009). In detail, quality can be described as a set of criteria and objectives requested by the users, such as (travel time, transportation costs, comfort, available space, reliability etc.) designed to meet their expectations. As a result, nowadays recent studies suggest that quality is a particularly important factor in passenger transportation and also a representative key factor of the transport demand (Berežný and Konečný, 2017).

In the past decade, an increasing demand for transportation has been observed. As the international literature review points out that the interest in public transport services has been growing, several factors have influence which may vary from passenger to passenger. Nevertheless, little attention has been given to the public transport network in Bucharest, and how it can be improved using total quality management methodology. Despite its acknowledged importance, the issue of researching the local transportation system remains insufficiently explored. Previous research findings concerning the service quality of public transport in Bucharest have been inconsistent and contradictory (Androniceanu, 2016; Bugheanu, 2015; Nae and Turnock, 2011; Stoicescu et al., 2013).

In addition, over the last few years, in Romania, especially in Bucharest, the public transportation system became more and more preferred by users. Specifically, the STB (Bucharest Transport Corporation) bus network has a total route length of 1,374 kilometers and has the densest network in Bucharest. In present there are 85 bus lines, including 25 night routes, most of them operating in the Municipality of Bucharest. The Bucharest bus network still requires constant improvements. One of the main problems raised by the passengers is that the buses are not tracked by GPS. As a result, the information on the buses' ETA in the stations is not available. In response, this study applies the AHP technique in order to provide a comprehensive framework for analyzing the public bus transport service quality in Bucharest. Furthermore, the research has tended to focus on addressing the knowledge gap regarding the research on public transport quality and passengers satisfaction.

Taking these things into consideration, the study will identify certain methods that allow the use of quality management tools in developing a more sustainable public bus transport system in Bucharest, as well as determining the priority of service quality attributes using the AHP method.

In summary, the paper will focus on the following main objectives:

O1. Developing an efficient customer-oriented public bus transport system assessment tool;

O2. Determining the priority of service quality attributes from the users' point of view, using the AHP method;

O3. Integrating a part of Bucharest's public bus transportation challenges into a three-level-hierarchical model.

In this framework, the aim of the research was to investigate the role of passengers' perception regarding the bus network. To this end, a set of significant attributes were identified and used in the study. Based on these attributes, a consistent analysis was developed, which had as a main objective, to prioritize what matters the most for the bus users'.

2. Literature review

Due to its simplicity, flexibility and ease of use, the AHP methodology has been thoroughly analyzed and evaluated in numerous applications related to multiple criteria decision making since its appearance (Saaty, 1980). Given these points, a considerable amount of literature has been published in the topic of AHP technique applications in transportation. What is more, the analytic hierarchy process has the ability to cover strategic, tactical and operational issues of the analyzed transportation system (Duleba et al., 2012).

However, there were theoretical and practical aspects of the analytic hierarchy process that were disputed (one example comes from a discussion in (Belton and Stewart, 2002)), overall, it is widely applied and accepted in practice (Vaidya and Kumar, 2006)), being one of the most applied methods for decision support. For this purpose, in recent years, the AHP method was widely used in researches related to public transportation systems (Cai, 2008). In general, the method is characterized by mathematical simplicity and provides a reliable interpretation of the research, as well as being based on an additive weighting process, where certain relevant criteria are represented through their relative importance (Ghorbanzadeh et al., 2019). Another key point, its applications are widely used for both individual level and group decisions (Yuhua and Kai, 2004).

Even if the common AHP method does not imply evaluating uncertainty in its own inputs, there were a series of extensions which have been suggested for addressing this matter. As a result, several studies were conducted: by applying the fuzzy set theory (Boender et al., 1989; Buckley, 1985), arithmetic algorithms (Salo and Hämäläinen, 1995) and numerous stochastic techniques (Hauser and Tadikamalla, 1996; Saaty and Vargas, 1991).

One of the main advantages of the AHP method is represented by its use in a wide variety of application fields like: marketing (Mark, 2001; Wind and Saaty, 1980), energy (Pohekar and Ramachandran, 2004), medical and healthcare decision making (Liberatore and Nydick, 2008), research and development (R&D) project selection and resource allocation (Heidenberger and Stummer, 1999). Also, the AHP method has been intensively used in the field of public transportation planning (Cascetta et al., 2015; Le Pira et al., 2015).

An application developed by Tudela et al. (2006) made a comparison between the result of a cost-benefit and multi-criteria analyses for the urban transport investments. The resulted conclusion was that the decision-making process requires integrating other aspects, besides the economic ones. Moreover, another aspect that should be taken into consideration is the public opinion, especially for the decision-making, when the information about the projects that will influence them can be implemented in a precise manner. Also, in transportation investment studies, Caliskan (2006) analyzed decision-making like the AHP and the cognitive map - in the first place, the data achieved from the cognitive map were applied for determining the sub-criteria, and after that, the AHP method was implemented. Yoo and Choi (2006) adopted the AHP model for achieving significant factors in order to improve the passengers' security checks at the airport. Thus, for the Romanian public transportation system, a visible step forward would be to motivate the users to shift from private vehicle use to public transportation (Moslem et al., 2019).

Furthermore, the AHP tool needs a smaller cognitive effort since the respondents are asked to compare pair of attributes, rather than large bundles of attributes, and it also relies on a cognitive background (Zahedi, 1986). Similarly, the method usually adopts a simplistic choice heuristic (Moran et al., 2007; Swait and Adamowics, 2001). Besides applying to the finance and banking sector (Steuer and Na, 2003), the analytic hierarchy process was accepted in numerous domains such as education, industry, manufacturing, engineering, government, management, personal, political, social, or sports (Vaidya and Kumar, 2006).

3. Research methodology

A considerable amount of literature has been published on the topic of quality management and a complex decision based on mathematics in the field of public transportation systems.

With this in mind, the fundamental research question that guided this study can be stated as follows: "What should be changed in the public transportation system in Bucharest in order to improve the overall quality and the passengers' satisfaction?". As a result, taking into account that mobility is a major living standard (Malasek, 2016), we should make sure that the bus transport services boost the use of public and not private means of transportation. What we know about quality management in public transportation is largely based upon empirical studies that investigate how the public transports systems quality can be improved and what procedures should be used. Correspondingly, a large and growing body of literature has investigated the use of new management tools and advanced technologies with a positive influence upon the transport operators. For this reason, we decided to conduct a research on methods of evaluating complex decisions using mathematics and psychology. Fig. 1 introduce the steps of the present research methodology. The AHP technique is one of the Multi-Criteria Decision Making Methods that were originally developed by Saaty (1990). In short, it is a method to derive ratio scales from paired comparisons. The input can be attained from definite measurements like price or weight, or subjective opinions like satisfaction feelings and preferences. Under those circumstances, AHP allows a few small inconsistencies in judgment because the individual is not always consistent.

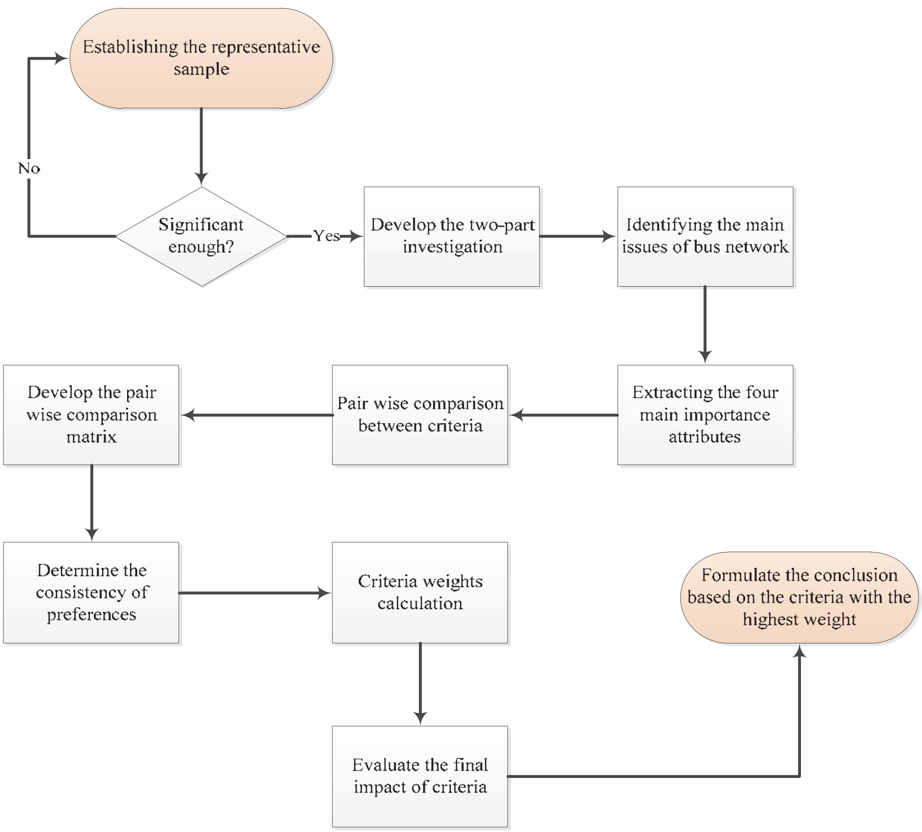

Fig. 1. Methodology research

As Štefancová et al. (2017) pointed out, a new perspective is required, which implies designing the public transport services by taking into consideration the passengers' needs and expectations. Therefore, the public network can achieve and maintain a privileged position in the top user's preferences. Users' satisfaction in public transport is a fundamental quality indicator. Chica-Olmo et al. (2018) argued that evaluating and therefore increasing the transport service quality is a key factor in increasing the demand. However, Paulsson et al. (2018) found that public transport services are strongly influenced by the collaboration in public governance. In particular, quality is highly impacted by the relationship between public transport operators and municipalities. As a result, the transport network will build a common identity with the public authority and future improvements projects can be established.

On the other hand, the lack of consciousness for the perceived quality and the absence of the quality management system is one of the fundamental causes of the poor quality of public transport services. Therefore, the objectives regarding quality in the public transport system should be properly established and should present the following characteristics (Juran and Godfrey, 1998):

1) Justified - they should have an incontestable official character;
2) Measurable - so that they can be communicated with precision;
3) Accessible - pointing out the fact that they have already been accomplished by other institutions;
4) Equitable - the objectives' accessibility level should be similar for individuals with similar responsibilities.

As the products and services evolve, the passengers' expectations tend to grow, such as what once was considered as being a quality product or service, today is only an ordinary one (Wallace, 2007). In addition, Hrelja et al. (2017) also emphasize the necessity for partnership approaches in order to stimulate the private transport operators and the public authorities. A point often overlooked, the coordination and collaboration among those previously mentioned could substantially improve the transport services quality.

3.1. Types of quality applied in the Bucharest public transportation system

In their book, Kano and Nobuhiku (1984) divided the quality into four main categories in order to better understand its relationship to competition. However, we consider that these four categories could be visible also for the public transportation system (Bhat, 2010):

a) Indifferent quality - specifies the quality that the passengers do not notice or appreciate.

b) Expected quality - specifies the quality that the passenger expects and demands and also, notices when is missing. For example, in Romanian public transportation system, people expect to travel in a safe and clean mean of transports.

c) One-dimensional quality - is also a type of quality that the passengers expect, but this time, it does not necessarily result in discontent if it is missing. For example, the increased price in transport pass would represent dissatisfaction for customers though they will continue to use public transport. Instead, if public transport is insecure, passengers might orient towards another way of transports. In this case, the increased price of transport passes represents a one-dimensional quality.

d) Exciting quality - represents the type of quality that exceeds passengers' expectations, pleasantly surprising them. For example, the passengers were excited when some buses introduced the air conditioning system.

3.2. Purpose and method research

The users' answers were collected (online and manually) and introduced in Excel. Next, the weight of the criteria was calculated through the help of the AHP software and the values were interpreted.

In support of this research, a two-part investigation was conducted regarding the users' satisfaction degree for the Bucharest public transport bus service (the first part of the investigation was meant for determining the main dissatisfactions that users have related to the bus service, whereas the second part presented four attributes - extracted from the first part- for which each respondent should express the importance level), during four months, starting from January 2019 until April 2019.

In terms of methodology, it was used a mix method, respectively both online and off-line mode of administration. The total sample size was 284 people, significant enough for the research. As a result, 178 answers were received online, and 106 from a traditional offline survey. Concerning the gender distribution, 48.59% of the respondents were males and 51.41% females. Even though all the 284 participants were involved in the AHP method, not all the answers were considered consistent. Due to the fact that sometimes it is difficult to measure the subjective judgment, almost 17% of the respondents' answers were not counted as consistent - the logic of preference was, in most of the cases, difficult to clarify. For example, a respondent preferred Safety to Cost – thus, safety has greater value than cost. Next, the same respondent preferred Cost to Clean - thus, cost has greater value than clean. Taking into account the two previous situations, if the respondent preferred next, clean to safety, then the answer become inconsistent). Thus, inconsistent results were excluded and the methodology's results were based only on the consistent answers.

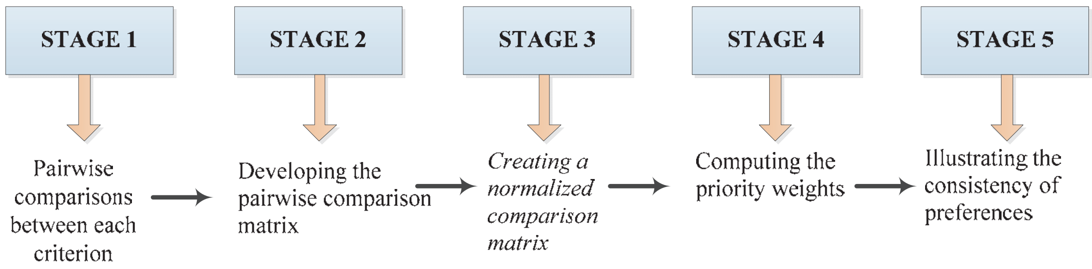

Fig. 2. Steps for developing the AHP methodology

Table 1. Scale for comparison (adapted from Saaty and Vargas, 1991)

Intensity of importance (numerical rating)	***Definition***	***Explanation***	***Reciprocal rating***
1	Equivalent importance	Two items contribute equitably to the assigned objective	**1**
3	Neutral importance	Both experience as well as judgment slightly favor one item over another	**1/3**
5	Significant importance	Both experience as well as judgment firmly favor one item over another	**1/5**
7	Very strong importance	One item is preferred very strongly over another, its dominance is demonstrated in practice	**1/7**
9	Intense importance	The confirmation favoring one item over another is of the highest possible order of affirmation	**1/9**

Note: 2,4,6,8 used for specifying intermediate values

3.3. First part of the investigation - Pareto chart

Next, the main issues addressed by the bus users have been collected and presented as a Pareto graph. These will be presented in Fig. 4 from the Results section.

3.4. Second part of the investigation - Analytic hierarchy process

Secondly, by applying this procedure, we evaluated the priority of each service quality attribute from the passengers' point of view. The main stages used for developing the AHP procedure are presented in Fig. 2:

- *Stage 1. Pairwise comparisons between each criterion*

The first step consists of a pairwise comparison capable of determining the relative importance of each criterion. As an example scale for comparison, it was used the one from Saaty and Vargas (1991).

By attributing values varying from 1 to 9, the relative importance of an alternative will be determined when compared with another alternative.

- *Stage 2 - Pairwise comparison matrix*

After that, Table 2 presents a comparison matrix created from the Saaty scale (Saaty, 1990).

The number of pairwise comparisons is then computed, with, $n(n-1)/2$, considering n the number of criteria. Because there are four comparisons, there will be a 4 by 4 matrix. The diagonal items of the matrix are constantly 1 and thus the upper triangular matrix is created. For completing the upper triangular matrix, the following rules were used:

1. *The **actual judgment** value will be placed only when the judgment value is on the **left** side of 1.*
2. *The **reciprocal** value will be placed only when the judgment value is on the **right** side of 1.*

The reciprocal values from the upper diagonal were used for filling the lower triangular matrix.

Table 2. Comparison Matrix (presuming that Criterion 2 dominates over Criterion 3 (adapted from Saaty, 1990)

	Criterion 2	***Criterion 3***
Criterion 2	1	Numerical rating
Criterion 3	1/Numerical rating (reciprocal)	1

Considering a_{ij} the item of row I column j of the matrix, the lower diagonal is filled using the following formula (Eq. 1):

$$a_{ji} = \frac{1}{a_{ij}} \qquad (1)$$

As mentioned above in the research, based on the developed questionnaire and the received answers, four attributes were considered when assessing the quality of the public bus transportation system: safety, low cost, speed, and cleanliness, presented in Fig. 3. Further on, the received answers from the second part of the investigation (the importance of each of the four attributes from the user's experience) were processed with the AHP methodology. Therefore, in order to better illustrate the concept, the answers of one participant are presented (we will call it *User A*) and then all participants' answers were processed by using the AHP software.

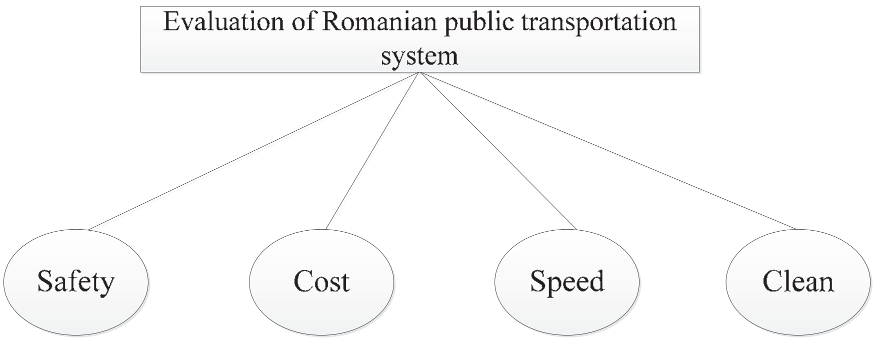

Fig. 3. Hierarchy structure of public transportation attributes

For the beginning, it is normal to assume that maybe for User A, the criteria listed above may not have the same importance (may not be equally important), perhaps safety is more important than having a low-cost subscription, or the bus speed is preferred to the low-cost subscription and so on. In the matrix below, it is clearly observed that User A prefers safety over cost, cost over speed and speed over cleanliness:

Table 3. Comparison matrix for User A

	Safety	***Cost***	***Speed***	***Clean***
Safety	**1**	2	4	9
Cost	½	**1**	5	7
Speed	¼	1/5	**1**	7
Clean	1/9	1/7	1/7	**1**

• *Stage 3 - Creating a normalized comparison matrix*

This kind of matrix is useful for making the values in the comparison matrix comparable. In order to achieve that, a normalized comparison matrix is created where each column in the pairwise comparison matrix is summed up and each entry is divided by column sum (after applying the normalization procedure, the total of each column should be equal to 1).

For creating this matrix, the formula below could be used (Eq. 2):

$$b_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} aij} \quad i= 1, 2,\ldots n;\ j= 1, 2,\ldots,n \qquad (2)$$

• *Stage 4 - Priority weights*

After creating the normalized comparison matrix, priority weights (w1,w2,…,wi) of each criterion are computed by the average of each row of the normalized matrix, by using the formula (the total of priority weight should be equal to 100%, Eq. (3):

$$W_i = \frac{\sum_{j=1}^{n} bij}{n} \quad i= 1, 2,\ldots n;\ j= 1, 2,\ldots,n \qquad (3)$$

• *Stage 5 - Consistency of preferences*

The resulting priorities calculated from the pairwise comparisons are based on the row geometric mean method (RGMM), the consistency ration (CR) and the possible calculation errors (+/-) that might appear during the process, as presented in Table 4. The *C*R is calculated to test the reliability of subjective judgments. It can be calculated with the formula below, where *CI* is the consistency index the random index will be marked as *RI* (Eq. 4):

$$CR = \frac{CI}{RI} \qquad (4)$$

Table 4. Consistency of preferences for User A

n	***Criteria***	***RGMM***	**+/-**
1	Safety	47.4%	13.9%
2	Cost	35.0%	14.7%
3	Speed	13.7%	6.8%
4	Clean	3.8%	1.7%
CR: 9%			

In order to have a reliable result, the *CR* should be below 10%. For User A the result was below 10%, thus the answers will be considered consistent.

In order to achieve a consistent reciprocal matrix, Saaty (2004) demonstrated that the largest Eigen value is equivalent to the number of comparisons, or $\gamma_{max} = n$. Then he associated a measure of consistency, respectively the Consistency Index, as degree of consistency or applying the following formula (Eq. 5):

$$CI = \frac{\gamma_{\max} - n}{n-1} \qquad (5)$$

Knowing the Consistency Index, it can be used by comparing it with the relevant one. The relevant Consistency index is marked as Random Consistency Index *(RI*). After randomly developed a reciprocal matrix by using the scale $\frac{1}{9}, \frac{1}{8}$, …, 1, …, 8, 9, Saaty (2004) achieved the *RI* to verify if its value is about 10% or less. Therefore, the average *RI* derived from a sample size 500 matrices is presented below in Table 5.

Table 5. Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Adapted from Saaty (2004)

As mentioned, the inconsistency is accepted if the value of *CR* is smaller or equal to 10%. On the contrary, the subjective judgment needs to be revised if the *CR* is greater than 10%.The same logic has been applied for all users; therefore, the research continues with the cumulative results. The *normalized comparison matrix* (Eq. 6) as well as the weighted geometric mean of participants for all users is shown below in Table 6. As mentioned before, the priority vector presents relative weights among the elements that we compare.

$$\begin{array}{c} \\ \text{Safety} \\ \text{Cost} \\ \text{Speed} \\ \text{Clean} \end{array} \begin{array}{c} \begin{array}{cccc} \text{Safety} & \text{Cost} & \text{Speed} & \text{Clean} \end{array} \\ \begin{pmatrix} 1 & 2\frac{3}{8} & 2\frac{2}{7} & 2\frac{5}{9} \\ \frac{3}{7}. & 1 & 1\frac{4}{7} & 1\frac{5}{7} \\ \frac{3}{7} & \frac{2}{3} & 1 & 1\frac{1}{2} \\ \frac{2}{5} & \frac{3}{5} & \frac{2}{3} & 1 \end{pmatrix} \end{array} \begin{pmatrix} 44.14\% \\ 23.44\% \\ 18.14\% \\ 14.28\% \end{pmatrix} \quad (6)$$

Table 6. The weighted geometric mean of participants

	1	***2***	***3***	***4***
1		2.38	2.29	2.56
2	0.42		1.57	1.7
3	0.44	0.64		1.47
4	0.39	0.59	0.68	

Then each element of the matrix was divided by the sum of its column and each column's sum equaled 1 (Eq. 7):

$$\begin{pmatrix} 0.45 & 0.52 & 0.41 & 0.38 \\ 0.19 & 0.22 & 0.28 & 0.25 \\ 0.19 & 0.22 & 0.28 & 0.25 \\ 0.17 & 0.13 & 0.12 & 0.15 \end{pmatrix} \quad (7)$$

Sum 1 1 1 1

The normalized principal Eigenvector has been obtained by averaging across the rows. Thus in our example, we have $\gamma_{max} = 4.03$ and four comparisons, or n=4, thus the consistency index is (Eq. 8):

$$CI = \frac{\gamma_{\max} - n}{n-1} = \frac{4.0384 - 4}{4-1} = 0.0128 \quad (8)$$

For the present example, the *CI* equals 0.0128 and *RI* for n=4 is 0.9, so we will have (Eq. 9):

$$CR = \frac{0.0128}{0.9} * 100 = 1.42\% < 10\% \quad (9)$$

4. Results

By introducing the current study on the Bucharest' public transport system we aimed to investigate the role of passengers' perception regarding the bus network. As a result, based on the questionnaire survey and on the AHP methodology the following results were obtained (Table 7). Next, we will present below in Fig. 4 the major complaints that decrease passengers' satisfaction while using the bus as a public transport vehicle.From the above figure we can conclude the following:

- A total of 30.28% of complaints, coming from the bus users, are caused by a lack of an exact bus schedule (buses experience frequent delays, sometimes of around 20 minutes between each other).
- Therefore, the three main issues that cause 85.56% of problems and dissatisfaction, and should be corrected are: lack of an exact bus schedule, low safety level and an insufficient number of buses.

All things considered, the Romanian public transportation system has some major issues, like the ones listed above that decrease passengers' satisfaction. Therefore, if not solved, these deficiencies could lead to an increased percentage of people using their own cars, or taxis, which, in the end, will lead to traffic congestion. After seeing the main users' complaints and extracting the answers from the questionnaire, four main attributes were considered for increasing users' satisfaction: safety, low cost, speed and level of cleanliness.

Table 7. Research sample size

	Column Labels					
	on the field		***online***		***Total people***	***Total % people***
Row Labels	***people***	***% people***	***people***	***% people***		
Female	**56**	**52.83**	**90**	**50.56**	**146**	**51.41**
<20	3	2.83	2	1.12	5	1.76
20-30	8	7.55	21	11.80	29	10.21
30-50	32	30.19	49	27.53	81	28.52
50+	13	12.26	18	10.11	31	10.92
Male	**50**	**47.17**	**88**	**49.44**	**138**	**48.59**
<20	4	3.77	2	1.12	6	2.11
20-30	10	9.43	15	8.43	25	8.80
30-50	22	20.75	50	28.09	72	25.35
50+	14	13.21	21	11.80	35	12.32
Grand Total	**106**	**100.00**	**178**	**100.00**	**284**	**100.00**

Based on the normalized principal Eigenvector's (called also priority vector) results it can be stated that the users prefer safety 1.88 times more than low cost, and they also prefer safety 3.09 times more than clean (as seen in Fig. 5). The above figure presents an overview of the results obtained based on the Eigenvector, by computing the criterions' weights and their afferent absolute errors (+/-), where:

- *GCI - geometric consistency index;*
- *Psi - ordinal inconsistency;*
- *CR - consistency ratio;*
- *MRE - mean relative;*
- *Lambda - the highest Eigenvalue of the matrix.*

Besides the relative weight, the answers were also verified in terms of consistency level. In order to do that, the *Principal Eigenvalue* was used (obtained by summing the attributes between each element of Eigenvector and the sum of columns from the reciprocal matrix).

Thus, the evaluation based on quality attributes preferred by the public transportation system's users is consistent, as presented in Fig. 6.As a rule of thumb, a *CR* value of 10 or less is considered acceptable (Saaty, 2004). Our project demonstrates a *CR* of 1.4 which demonstrates that the results are reliable and consistent, therefore acceptable for further research. Also, as expected, the criteria 1 (safety) has the highest weight - 44.1 which makes it the most important attitude for the public transportation system.

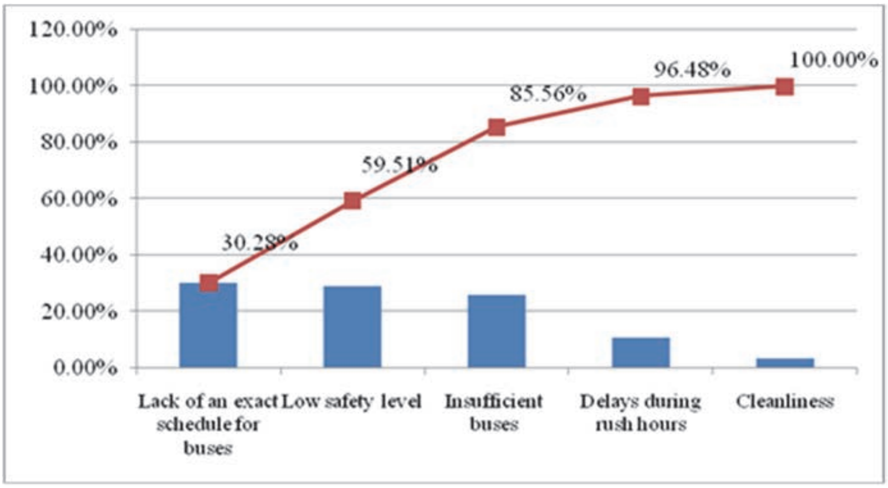

Fig. 4. Main complaints that decrease passengers' satisfaction while traveling by bus

	Criterion	Comment	Weights	Absolute errors +/-
1	Safety	Security agents, safety regarding the thieves, etc.	44.1%	8.1%
2	Cost	Ticket fee, subscription fee.	23.4%	4.0%
3	Speed	Driving style, waiting time, etc.	18.1%	2.5%
4	Clean	Inside cleaning, garbage baskets, etc.	14.3%	2.0%

Eigenvalue					Lambda:	4.038			MRE:	16.0%
Consistency Ratio	0.37	GCI:	0.05		Psi:	8.3%	CR:	1.4%		

Fig. 5. Results based on Eigenvector

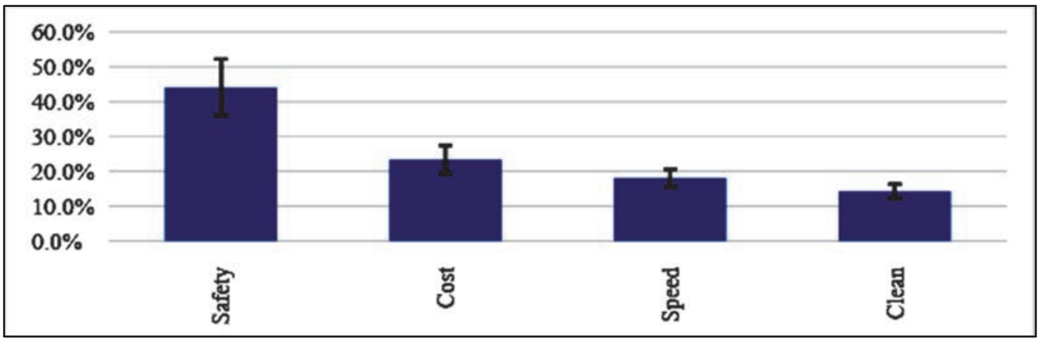

Fig. 6. Calculated weights with error indication

5. Discussions

The present study represents an ongoing research, so for the moment, the main objective was to present the Bucharest bus public transportation system's need for a management tool that could improve its efficiency, as well as, passengers' satisfaction.

In conclusion, in Bucharest we believe that if a total quality management system would be implemented, it could lead to achieving objectives such as:

✔ Higher productivity. With a well-planned system, the Romanian public transport system would avoid wasting resources. Every employee would know exactly the job he/she has to provide, in order to assure users' satisfaction;

✔ Lack of defects and waste. One of the most intrigued kinds of wastes is the waste of time. Public transport users have to stay to wait for the bus or metro sometimes even more than 20 minutes (especially for buses). Applying the TQM method, there could be initiated an automated software that could be available to users on mobile (basically, a mobile app) for avoiding crowds and diminish waiting time.

✔ Increase users' loyalty. A satisfied user would always prefer public transport and would also be willing to pay a higher price on the transport pass (with the condition that it would benefit from a qualitative public transport system).

✔ Increase employees' satisfaction. A more organized public transport system, assuring modern procedures, is welcomed by everyone.

We can say that the objectives serve for many purposes (Scott, 1998), being integrated into the majority of aspects and in exercising of the managerial functions, no matter the organizational level. Given these points, Romania could even assist in a change from total quality management to total quality transport.

6. Limitations of the study and future research

Of course, as with the majority of research papers this study is subject to limitations. For instance, a possible limitation of the current paper is the lack of previous research into the topic of public transportation in Bucharest, in particular as concerns service quality and sustainable development.

Additionally, the insufficient sample size for statistical measurement could also be a relevant issue. Equally important is the fact that the current AHP model which has been used in the study cannot analyze and clarify causalities. Likewise, the ranking of the AHP technique can be proven inadequate in certain situation and can be subject to various influences according to the decision-makers selection and their perception.

Nevertheless, after acknowledging our study's limitations we plan ourselves to address them in our future analysis. As a result, we intend that in our future research to focus on those mentioned above, with the intention to upgrade future research and ultimately impact the service quality of the public transport system and increase the users' satisfaction.

During the last few years, in Romania, especially in Bucharest, the public transportation bus system became more and more preferred by users. The aim of the current research was to investigate the role of passengers' perception regarding the bus network. Therefore, a set of significant attributes were identified and used in the study. In addition, future research will focus on using other well-known Multiple-criteria decision-making (MCDM) methods like Fuzzy AHP, Best Worst Method (BMW) or Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), with the main purpose of comparing and validating the findings from the current AHP study.

In this way, the validity and the long-term relevance of the current study will increase. Also, for a more comprehensive approach of the study, we aim to extend our research to the entire transportation system (metros and trams).

7. Conclusions

In the current economy, metropolitan areas face various problems regarding public transportation, in terms of excessive congestion, travel speed or service comfort. As a result, the present study has tended to focus on finding appropriate solutions to the situation in Bucharest, rather than general recommendations. Public transportation and decision-making methods proved to be an appropriate application area for the AHP, which is a widely used decision-making methodology that has seen widespread applications across various fields.

Therefore, some authors claim that the users' perception of service quality results from the comparison of consumer expectations and their perception of the service performance. However, other authors do not take expectations into consideration and focus only on the perceptions of passengers or transport companies.

The current study reveals that quality in the public transport services is a significant factor, with major influence on the transport demand. Increasing the quality level should be a long-term objective for transport operators and public administration in order to meet the passengers' expectations. Even so, service quality represents a complex concept, fuzzy and sometimes abstract, mainly due to the three properties of services: intangibility, heterogeneity, and inseparability.

The fundamental objective of this research was to present the main challenges addressed by the passengers who use the buses as public transport means, and to highlight a management method that, if implemented, could solve a part of these problems.

The AHP has seen considerable and continuous practice in the evaluation of public transportation system, as well as capital and information systems strategies. Lately, it has been an enlarged concern in its application for assessing public transportation facilities.

Given these points, AHP as an evaluation tool has a vast range of application and could be successfully used in public transportation networks.

APPENDIX

ANALYTIC HIERARCHY PROCESS QUESTIONNAIRE

Part I

1. On a daily basis, do you prefer using your personal car (if you owe one) or the bus?
 Car
 Bus

2. How often do you use the public bus transportation system?
 Daily
 Several times per week
 Weekly
 Several times per month

3. From your perspective, which are the most significant issues in the public bus transportation system from Bucharest?
 Lack of an exact bus schedule
 Numerous delays during rush hour
 Low safety level
 Lack of cleanliness
 Insufficient busses

4. From a scale of 1 (very dissatisfied) to 5 (very satisfied), please rate the following attributes related to public bus transportation:

Please mark your answers:

	Very dissatisfied				Very satisfied
Lack of an exact bus schedule	1	2	3	4	5
Numerous delays during rush hour	1	2	3	4	5
Low safety level	1	2	3	4	5
Lack of cleanliness	1	2	3	4	5
Insufficient busses	1	2	3	4	5

On a scale of 1 to 5 (1 – very dissatisfied; 5 – very satisfied), please express your satisfaction's degree regarding the following aspects when traveling with a bus in Bucharest:

Subscription fee	1	2	3	4	5
Ticket fee	1	2	3	4	5
Single ticket (applied only for the bus, without other means of transport)	1	2	3	4	5
Driving style	1	2	3	4	5
General tidiness	1	2	3	4	5
Video cameras	1	2	3	4	5
Inside temperature	1	2	3	4	5
Inside cleaning	1	2	3	4	5
Chairs' cleanliness	1	2	3	4	5
Controllers' empathy	1	2	3	4	5
Controllers' respect for passengers	1	2	3	4	5
Number of existent buses	1	2	3	4	5
Digital screens (which display the buses' schedule)	1	2	3	4	5
Security agents in the buses	1	2	3	4	5
Places for people with disabilities	1	2	3	4	5
Marked bus stations	1	2	3	4	5
Smell	1	2	3	4	5
Waiting time	1	2	3	4	5
Safety regarding the thieves	1	2	3	4	5
Garbage baskets	1	2	3	4	5

Part II

Which criterion is more important for you in each pairwise comparison and by how much?
(please check the numbers which suits best for representing the intensity of importance)

	Intense	Very strong	Signi- ficant	Neutra l	Equi- valent	Neutra l	Signi- ficant	Very strong	Intense	
safety	9	7	5	3	1	3	5	7	9	***speed***

	Intense	Very strong	Signi- ficant	Neutral	Equi- valent	Neutral	Signifi- cant	Very strong	Intense	
safety	9	7	5	3	1	3	5	7	9	***cost***

	Intense	Very strong	Signific ant	Neutral	Equival ent	Neutral	Signifi- cant	Very strong	Intense	
safety	9	7	5	3	1	3	5	7	9	***clean***

	Intense	Very strong	Significa nt	Neutral	Equivale nt	Neutral	Signifi- cant	Very strong	Intense	
cost	9	7	5	3	1	3	5	7	9	***speed***

	Intense	Very strong	Signifi cant	Neutral	Equiva lent	Neutral	Signifi -cant	Very strong	Intense	
cost	9	7	5	3	1	3	5	7	9	***clean***

	Intense	Very strong	Signifi- cant	Neutral	Equi- valent	Neutral	Signi- ficant	Very strong	Intense	
speed	9	7	5	3	1	3	5	7	9	***clean***

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