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Road and Rail Infrastructure V

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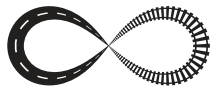
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SURVEY ON RAIL SERVICE QUALITY – CASE STUDY SERBIAN RAILWAYS

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Abstract

This paper presents one approach for determining the rail passengers' service quality. With the aim to increase the number of loyal passengers, and consequently revenue, rail companies around the world measure a service quality. Different approaches and methods for a service quality measurement are used in relevant literature. We proposed the multi-criteria decision making method which includes linguistic and imprecise values of inputs. Approximately 200 passengers of Swiss Stadler trains in Serbia were questioned, during 2016 and 2017. The survey was conducted to produce a real picture of passengers' satisfaction and to track a trend of the quality of rail service in the last two years. The developed model and obtained results could be useful for rail managers and rail experts in Serbia, but also in other countries. With some modifications proposed model could be applied in other industries as well.

Keywords: service quality, rail service, rail passengers, fuzzy logic, TOPSIS

1 Introduction

The aim of this paper is to provide a network-wide picture of customers' satisfaction with certain rail service, and to compare level of customer satisfaction over the years. There are different approaches to measure customers' satisfaction, i.e. the quality of service [1, 2]. Each methodology has its own benefits and constraints, so the particular methodology should be selected according to the purpose of the survey. Let us assume that we want to rank different services or to examine trend of customer satisfactions with the services. For that purpose it is suggested to calculate and then to compare all composite satisfaction indexes. Or, if we just want to get a wider picture of the quality of a service, than certain survey can be adequate approach, without calculating composite index. In this paper we calculated composite index in order to compare rail passenger satisfaction in different time period. The survey was conducted to produce a real picture of passengers' satisfaction and to track a trend of the quality of rail service during two years.

The survey involves 200 passengers in the Republic of Serbia, who travelled on the railway line "Belgrade–Niš" by Stadler train. Passengers' opinions about train services are collected during 2016 and 2017, from a representative sample of passenger journeys. Stadler trains are Swiss trains, known as "Fast Easy Innovative Trains", which provide the necessary comfort for passengers with modern interior, safe entry and an electronic automatic information system, with a maximum speed of 160 km per hour. Since 2015 Serbian Railways has 21 Stadler trains. The quality of service presents the level of customer's demands satisfaction. Related to this the company management has to measure customer's satisfaction in order to manage the quality of service. Considering the fact that acquiring a new customer is much more expensive than retaining a current customer, our focus group was the passengers that already use

the Stadler train service. In everyday life rail passengers mark rail service's attributes by descriptive phrases and how they are important to them by crisp values. In order to integrate descriptive phrases into mathematical model we used triangular fuzzy numbers and certain fuzzy arithmetic operations. The fuzzy multi-criteria decision making approach for calculating the composite satisfaction index is suggested. Fuzzy TOPSIS [3-6] is a traditional, simple technique that is easy to interpret and explain to managers, decision makers. Proposed method could be also used if there is a need to compare various rail services.

This paper is organized as follows. After Introduction, the second section is dedicated to the proposed methodology. In section 3 the obtained results are given. The last section presents conclusions and future research directions.

2 Proposed methodology

The proposed methodology for obtaining the overall rail service quality composite index (RSQ) is general. The only specificity of this model is in the fact that criteria are attributes. This is the consequence of calculation composite index for one rail service, but in different time period. It includes following three steps [4]:

The first step includes composing and carrying out a survey. All relevant data on passengers, their opinions about quality of rail service and its importance are collected by survey. In the text to follow the proposed questionnaire is shown.

- 1) Gender? Female / Male
- 2) How old are you? _____
- 3) What is your profession? Pupil / Student / Employed / Unemployed / Retiree
- 4) What are your monthly earnings? Up to 200 EUR / 200 – 400 EUR / Over 400 EUR
- 5) How often do you travel by train? 1-3 times a week / 10-20 times a month / over 20 times a month / 10-15 times a year
- 6) What is the purpose of your journey? School / Business / Touristic / Other
- 7) How do you rate following attributes and how they are important to you?

Attribute	Mark (Fuzzy values)			Importance		
	Low	Average	High	1	2	3
Punctuality						
Safety						
Comfort						
Frequency						
Journey time						
Ticket price						
Reliability						
Cleanliness						
Train staff						

Previous table presents the last and most important part of the questionnaire related to the train's service attributes (punctuality, safety, comfort, frequency, journey time, ticket price, reliability, cleanliness, train staff) expressed in linguistic variables and how much are they important for rail passengers expressed by crisp values. It can be seen that each respondent could mark satisfaction with rail service attributes using three linguistic variables (low, average or high). Crisp values 1, 2 and 3, are used to express importance of each attribute for the respondent, where 3 is the most important attribute.

The second step considers determination of the criteria values. As we mentioned before, in our model 9 attributes present criteria which are relevant for calculating composite index. After all questionnaires are collected, average marks are obtained and attributes values are determined. This step is very significant for each rail company since it provides valuable information about service quality through each attribute.

The third step contains measurement of overall rail service quality, i.e. rail passengers' satisfaction with Stadler train on the railway line "Belgrade-Niš". This calculation is based on fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. Fuzzy TOPSIS is one of the well-known methods for multi-criteria decision making. Here is suggested the methodology presented in [5, 6].

$\tilde{A} = \tilde{a}_{ij}$ is a decision matrix with triangular fuzzy numbers $\tilde{a}_{ij} = (a_{ij1}, a_{ij2}, a_{ij3})$, where R_i is i -th respondent ($i = 1, 2, \dots, m$), and C_j is j -th criterion/attribute ($j = 1, 2, \dots, n$). The matrix \tilde{A} is developed after the survey was conducted. Rail service attributes are marked with three linguistic variables that are triangular fuzzy numbers: low ($\tilde{1} = (1, 2, 3)$), average ($\tilde{3} = (1, 3, 5)$) or high ($\tilde{5} = (3, 5, 7)$). There are benefit type criteria, which should be maximized, but also cost type criteria, that should be minimized. In our example, all criteria are benefit type.

$$\tilde{A} = \begin{matrix} & C_{1\dots} & C_{j\dots} & C_n \\ \begin{matrix} R_1 \\ \vdots \\ R_i \\ \vdots \\ R_m \end{matrix} & \begin{bmatrix} \tilde{a}_{11\dots} & \tilde{a}_{1j} & \tilde{a}_{1n} \\ \vdots & \vdots & \vdots \\ \tilde{a}_{i1} & \tilde{a}_{ij} & \tilde{a}_{in} \\ \vdots & \vdots & \vdots \\ \tilde{a}_{m1} & \tilde{a}_{mj} & \tilde{a}_{mn} \end{bmatrix} \end{matrix} \quad (1)$$

In order to normalize the fuzzy matrix \tilde{A} equations (2) and (3) are used, and fuzzy matrix (T) $\tilde{T} = [\tilde{t}_{ij}]_{m \times n}$ is generated.

For benefit criteria:

$$\tilde{t}_{ij} = \left(\frac{a_{ij1}}{a_{j3}^*}, \frac{a_{ij2}}{a_{j3}^*}, \frac{a_{ij3}}{a_{j3}^*} \right) \quad (2)$$

$$a_{j3}^* = \max_i a_{ij3}$$

For cost criteria:

$$\tilde{t}_{ij} = \left(\frac{a_{j1}^-}{a_{ij3}}, \frac{a_{j1}^-}{a_{ij2}}, \frac{a_{j1}^-}{a_{ij1}} \right) \quad (3)$$

$$a_{j1}^- = \min_i a_{ij1}$$

Using fuzzy arithmetic rules we calculated \tilde{e}_j , vector of average values of attributes:

$$\tilde{e}_j = \frac{\sum_{i=1}^M \tilde{t}_{ij}}{M}, j = 1, 2, \dots, n \quad (4)$$

Where M is number of respondents.

Next step in the proposed methodology is to calculate average values of normalized importance (weights) of each attribute, w_j . This is done according to common TOPSIS method with crisp values. The weighted normalized fuzzy decision vector $\tilde{V} = \{\tilde{v}_j\}$ is calculated as follows:

$$\tilde{v}_j = \tilde{e}_j \cdot w_j, j = 1, 2, \dots, n \quad (5)$$

Vector of ideal values is:

$\tilde{F}^- = (\tilde{f}_1^-, \tilde{f}_2^-, \dots, \tilde{f}_n^-) = ((0,0,0), (0,0,0), \dots, (0,0,0))$ and it contains all target values of all criteria,

while vector of anti-ideal values is: $\tilde{F}^+ = (\tilde{f}_1^+, \tilde{f}_2^+, \dots, \tilde{f}_n^+) = ((1,1,1), (1,1,1), \dots, (1,1,1))$.

The distances (d^+ and d^-) of weighted normalized fuzzy decision vector from the ideal value (\tilde{F}^+) and from the anti-ideal value (\tilde{F}^-) were calculated as Euclidean distance, as follows:

$$d^+ = \sum_{j=1}^n d_v \cdot (\tilde{v}_j; (1,1,1)) \quad (6)$$

$$d^- = \sum_{j=1}^n d_v \cdot (\tilde{v}_j; (0,0,0)) \quad (7)$$

Where $d_v \cdot (\tilde{v}_j; (1,1,1))$ is the distance measurement between these two fuzzy numbers [6].

The final step of fuzzy TOPSIS method is calculation of the relative closeness to the ideal solution:

$$RSQ = \frac{d^-}{d^- + d^+}, \quad 0 \leq RSQ \leq 1 \quad (8)$$

RSQ could vary within the range 0 to 1, so when $RSQ = 0$, it suggests that the attributes values are equal to the anti-ideal values, i.e. customer satisfaction is the least possible, whereas when $RSQ = 1$, it means that the attributes values are equal to the ideal values, i.e. customer satisfaction is the greatest possible.

3 Results and discussion

This paper presents the survey which purpose was to measure the rail passengers' satisfaction with Stadler trains in Serbia in 2016 and 2017, and to compare composite indexes for these two years. This survey will be continued in the next period in order to analyze trend in passenger satisfaction with the service quality. Here are shown the final results obtained by the questionnaires which are offered to passengers about to board a train at station.



Figure 1 Stadler trains, railway line “Belgrade – Niš”

The overall sample size for 2016 and 2017 survey was 100 passengers per year. In total, there were 60 % males and 40 % female respondents. The most of them are employed (cca. 35-40 %) and students (cca. 25-30 %), and then unemployed, retired or pupils. One third of them have monthly earnings up to 200 EUR, the second third of them have 200-400 EUR, and the rest over 400 EUR. Almost a half of respondents use the Stadler train services several times a week (1-3 times a week, cca. 42 %). The purpose of the journey for 55 % passengers is school and business, and for 10 % is touristic. There were nine relevant criteria evaluated for each year: punctuality, safety, comfort, frequency, journey time, ticket price, reliability, cleanliness, and train staff. Their final rank based on the average marks and importances are presented in Table 1.

Table 1 Rank and importance of service’s attributes

Attribute	Rank based on average marks		Importance	
	2016	2017	2016	2017
Punctuality	8	8	2.83	2.84
Safety	2	1	2.85	2.85
Comfort	3	6	2.70	2.71
Frequency	9	9	2.70	2.72
Journey time	7	7	2.85	2.80
Ticket price	1	3	2.90	2.85
Reliability	5	5	2.80	2.80
Cleanliness	6	4	2.80	2.82
Train staff	3	2	2.80	2.73

The best marked service’s attributes in 2016 were: Ticket price, Safety and Comfort, respectively. There were very small differences in 2017, when the first three attributes were: Safety, Trains staff, and Ticket price. The worst marked attribute in 2016, as well as in 2017, was Frequency. The most important service’s attributes in 2016 were: Ticket price, Journey time, and Safety. Once again, very small changes were in 2017, when the most important attributes were: Ticket price, Safety, and Punctuality. The least important attributes were Comfort and Frequency.

The overall rail service quality, RSQ, was calculated based on developed methodology presented in the Section 2. The composite satisfaction index, i.e. RSQ, for Stadler train was 0.80 in 2016 and 0.75 in 2017. This small decrease of the RSQ value is not significant at this moment, but it should be considered in the future. If it continues with the negative trend then the rail managers should analyze the causes that lead to this tendency. Considering 2016 and 2017, the rail managers can conclude that rail passengers who travel by Stadler trains are satisfied with this rail service.

4 Conclusion

There are many different approaches for service quality measurement. The most important factor in the process of choosing proper approach is the question what is the purpose of the analysis. Sometimes, management want to compare different services and then the overall satisfaction with certain route or with certain train company is enough, but if they want to improve concrete rail service than they need the passengers’ opinions about each service attribute.

The fuzzy MCDM model is developed in order to produce a real picture of passengers’ satisfaction and track a trend of the quality of rail service in the past period of time. The data are collected by survey, which aim is to highlight the strengths and weaknesses of Stadler train

services, i.e. the level of passengers' satisfaction with this rail service, in the Republic of Serbia. The obtained results show that passengers are satisfied with Stadler train services in 2016 and 2017, but there are always some possibilities for improvements.

Comprehensive approach will be considered in the further research. For instance, the model can be upgraded with station facilities' assessment. The station facilities are relevant for improvement of overall picture of train services and also for better position of rail service at the transport market generally.

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