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Guidance Provision for Increasing Quality of Service of Public Transport

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Abstract

Travellers formulate their optimal strategy to follow for their trip, every time they may shift to another mode. Trip generalized cost is perceived based on quality of service aspects and type of traveller. One of the most known models to assess service quality is the GAP model, proposed by Parasuraman *et al.* (1985), which considers both consumer and provider beliefs, expectations, perceptions and standards. The present paper deals with the fifth GAP of the model, known as the quality GAP, thus expected versus perceived quality of service, for the assessment of the transit service quality. This GAP has been estimated for the case of the transit system in Greece. An internet based questionnaire was used to collect user expectations and perceptions of 26 selected transit quality indicators, based on a 5 point likert scale. Then, a decision tree was developed, using the J48 algorithm, which linked user perceptions and expectations with the overall service quality assessment. The decision tree analysis depicts the importance of various quality components in the generalized cost estimation. Findings showed that the performance indicator “Availability of information by phone, mail”, was the most crucial parameter for the overall assessment of the service, while both performance and importance variables participated in the tree formulation. Tree paths provide guidance for transit operators and/or decision makers for increasing the quality of their services and at the same time enhance performance efficiency and operation profitability.

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Keywords: transit quality of service, gap model, decision trees, j48 algorithm

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1. Introduction

Transit Quality of Service (QS) seems to affect significantly transit choices and user perceptions. A lot of research has been conducted aiming to analyse user perceptions on Quality of Service of public transport operations (TRB, 1999; Tsami and Nathanail, 2014a; Tsami and Nathanail, 2014b). QS is commonly examined based on users' perceptions and evaluations. The difference between actual and perceived QS has been examined by a number of researchers (Tsami and Nathanail, 2012; Eboli and Mazzulla, 2007; Eboli and Mazzulla, 2008; Eboli and Mazzulla, 2011; De Ona *et al.*, 2010; Dell Olio *et al.*, 2010), but the perceived level of QS (Dell Olio *et al.*, 2010) seems to be the one that reflects the QS of a system from users' point of view.

Quality of Service parameters were also examined considering their impact on trip choices (Glerum *et al.*, 2011), usually focusing on users' perceptions and performance assessment. Tsami and Nathanail (2014) considered transit quality parameters influence on the "optimal strategies" users develop before transit choices, while Glerum *et al.* (2011) examined individuals' perceptions on quality parameters regarding their influence on travellers' mode preferences.

Tsami and Nathanail (2014) examined the level of significance users recognize on transit quality of service indicators, aiming at developing a framework of analysis of QS in a transit network, by investigating the key factors that influence travel choices based on the perceived general quality formulation of the users. In terms of this analysis a decision tree was developed classifying the quality indicators based on the security against crimes on bus indicator, which was the most crucial parameter affecting the decision making process in the overall quality of service assessment. The next two most important parameters in that analysis were the information by phone, mail and the cleanliness of bus exterior.

The socioeconomic characteristics of the travellers and their personal preferences formulate their perception regarding QS. User perceptions on transit quality of service were also analysed based on a gender classification proving that women travellers had higher expectations from quality parameters (Tsami and Nathanail, 2014c). It was also pointed out that stop location is the most important attribute to a gender classification of transit quality of service attributes, followed by the indicator of information by phone and mail.

2. Methodology

The quality of a service has mostly been studied in terms of marketing, as it comes from social and business sciences. One of the most known models to assess service quality is the GAP model, proposed by Parasuraman *et al.* (1985), to investigate the service quality gaps in an organization considering at the same time both costumers' and marketers'/operator's' beliefs, expectations, perceptions and standards. Five GAPs have been examined in terms of this model, between: 1) users' expectations and operators' perceptions of users' expectations, 2) operators' perceptions of users' expectations and service quality specifications, 3) service quality specifications and service actually delivered, 4) service delivery and the communications to users about service delivery and 5) users' expectations and perceived services. The present paper deals with the fifth GAP of the model, known as the quality GAP, and uses it as the attribute which leads users to the decision of selecting a transit service.

The data of the present study were collected in terms of an online Customer Satisfaction Survey (CSS) that took place during August 2012. A number of 211 completed questionnaires were collected and analysed.

The survey was structured in three discrete parts. In the first one the sample socioeconomic characteristics were collected along with a question to address the overall service quality of the Greek transit systems. In part two, a 5-point likert scale evaluation of the importance level of 26 selected transit quality of service indicators took place, where the highest importance was indicated by the rating value of 5 and the lowest by the rating value of 1. Similarly, in the third part, respondents were asked to evaluate the performance of the same indicators (in a 5-point likert scale), where the lowest value of 1 reflected the lowest performance level and the value of 5 the highest. The data collected from the questionnaire parts 2 and 3 were used to develop a decision tree that considered the importance travellers recognize and their perceptions of the performed transit quality of service indicators in the overall quality of service assessment.

The decision tree was developed using the J48 classification algorithm using the Waikato Environment for Knowledge Analysis (WEKA) open data mining software.

J48 is a Java implementation of the C4.5 algorithm which is an advanced implementation of the ID3 algorithm of Quinlan (1993).The tree developed was a pruning tree using the default pruning value of 2.5. The pruning decision is needed to optimize the computational efficiency and the classification accuracy in such cases. Applying pruning in a tree, we aimed to reduce the size of it and at the same time avoid complexity (Breiman *et al.*, 1984).

The J48 algorithm was developed following a post-pruning method. Post-pruning is the process of evaluating the decision error (estimated % of misclassifications) at each decision junction and propagating this error up the tree. At each junction, the algorithm compared the weighted error of each child node versus the misclassification error if the child nodes were deleted and the decision node were assigned the class label of the majority class.

3. Results

The socioeconomic characteristics of the sample are presented in Table 1 and the 26 examined quality indicators in Table 2. In the second table, the selected quality indicators are represented with specific symbols that were used in the representation of the decision tree graph (Figure 1).

The tree developed through the J48 algorithm had a total size of 85 with 43 leaves (Figure 1). The time taken to build the model was 0.55 seconds and the time taken to test model on training data was 0.04 seconds. As it can be noticed in Table 3, the tree is considered as highly accurate with 89% correctly classified instances. The exact number of the correctly/not correctly classified instances is represented in the tree graph inside each parenthesis at the end nodes. Table 3 represents the main model output characteristics and Table 4 the detailed accuracy by classification class.

The performance of the indicator “Availability of information by phone, mail” seems to be the most important parameter in such a classification. If this indicator receives a score <=4 then the next parameter that needs to be examined is the importance transit users recognize in “Cleanliness of vehicle interior, seats and windows”. In cases travellers believe that the cleanliness of vehicle interior, seats and windows is below adequate important (rating <=2) then the performed “Reliability of runs that come on schedule” defines whether the overall quality assessment will be evaluated as bad (2) or medium (3).

If the importance of the indicator “Cleanliness of vehicle interior, seats and windows” is >2 and the performed “Service frequency” is perceived as very bad, the “Availability of schedule/maps on vehicle and announcements” is the next indicator that needs to be considered in the classification. If the rating of this indicator is <=4 the importance of the “Air conditioning” leads to a bad assessment of the overall service quality of the transit system in rating score >4 and a medium overall assessment in a rating score <=4. When the importance of the “Availability of schedule/maps on vehicle and announcements” has the highest evaluation score (>4), the “Air conditioning” importance classifies the sample on value 3, leading on a bad assessment of the overall quality (Importance of “Air conditioning” <=3), and a bad assessment (Importance of “Air conditioning” >3).

The tree is developed based on the correlations of the importance-performance quality indicators, starting from the most crucial nodes and ending to the overall assessment of the transit system scores.

Thus, the highest evaluation of the transit quality system is addressed by the following relation:

Travellers assess the performed “Availability of information by phone mail” as very good (>4), the performed “Service frequency” as >2, the importance of the “Safety and competence of drivers” as >3, the performed “Security against crimes on vehicles” as >2, the performed “Cleanliness of vehicle interior, seats and windows” as >4 and the importance of the same indicator as<=4 and the importance of “Levels of noise and vibrations” as <=2.

This path could be analysed in the opposite direction and provide the “know how” in a decision making process where for example operators aim to achieve the highest level of users’ assessment of the overall assessment of the transit quality of their services. This correlation of indicators could satisfy their target without the need to improve all 26 indicators, but only the actors of this path.

Similarly, according to the tree representation, there are 13 different paths to achieve a good overall quality of service assessment (=4). The crucial paths are those with the highest scores of correctly classified instances. In this case, decision makers should follow the path:

PIPI<=4 – IINC>2 –PREF >1 – IEXC >1 –PROU >2 –PINC >2 – PREF <=4 – PREL <=4 – PSBS <=2 – PREL >2 - ISEI >3 – IROU >3.

Table 1. Sample socioeconomic characteristics.

		N	%
Gender	Male	96	45.5
	Female	115	54.5
		211	100.0
Age	<=20	21	10.0
	21-40	139	65.9
	41-65	49	23.2
	>65	2	0.9
		211	100.0
Occupation	Private sector employee	28	13.3
	Public sector employee	50	23.7
	Freelancer	50	23.7
	Student	64	30.3
	Pensioner	5	2.4
	Unemployed	14	6.6
		211	100.0
Mode usually used	Urban bus	152	72.0
	Trolley	3	1.4
	Metro	41	19.4
	Suburban rail	13	6.2
	Tram	2	.9
		211	100.0
Aim of travel	Work	76	36.0
	Study	42	19.9
	Markets/Shopping	20	9.5
	Entertainment	26	12.3
	Doctor/Hospital	3	1.4
	Personal issues	31	14.7
	Other	13	6.2
		211	100.0
Travel Frequency with Public Transport	Daily (>= 5 days/week)	56	26.5
	Many times in a week (3-4 times/week)	49	23.2
	Some days in a week (1-2 times/week)	50	23.7
	Occasionally (1-3 times/ month)	36	17.1
	Rarely (<1 time/ month)	20	9.5
		211	100.0
General assessment of the PT QoS	Very bad	6	2.8
	Bad	37	17.5
	Medium	101	47.9
	Good	59	28.0
	Very Good	8	3.8
		211	100.0

Table 2. List of examined transit Quality of Service indicators.

Variable	Importance		Performance
Route		IROU	PROU
Number of stops and distance between stops	INOS		PNOS
Stop location		ISLO	PSLO
Service frequency		IREF	PREF
Daily service time		ITIM	PTIM
Reliability of runs that come on schedule	IREL		PREL
Punctuality (runs that come on time)	ICON		PCON
Crowding		ICRW	PCRW
Comfort of seats		ICMI	PCMI
Air conditioning		IAIR	PAIR
Levels of noise and vibrations	INVI		PNVI
Availability of shelter and benches at stop	ISBS		PSBS
Cleanliness of vehicle interior, seats and windows	IINC		PINC
Cleanliness of vehicle exterior		IEXC	PEXC
Ticket cost		ITIC	PTIC
Availability of schedule/maps on vehicle, and announcements	IIOV		PIOV
Availability of schedule/maps at stops	IIAS		PIAS
Availability of information by phone, mail.	IIPI		PIPI
Safety and competence of drivers	ISFD		PSFD
Security against crimes on vehicle	ISEI		PSEI
Security against crimes at stops	ISES		PSES
Personnel appearance		IPEA	PPEA
Personnel helpfulness		IPEH	PPEH
Ease of purchasing the ticket	IEBT		PEBT
Administration of complaints		IACO	PACO
Use of ecological vehicles		IECO	PECO

Table 3. WEKA J48 output.

Correctly Classified Instances	89.1509%
Incorrectly Classified Instances	10.8491%
Kappa statistic	0.8316
Mean absolute error	0.0663
Root mean squared error	0.1821
Relative absolute error	25.0604%
Root relative squared error	50.1814%
Coverage of cases (0.95 level)	100%
Mean rel. region size (0.95 level)	34.6226%

One important notice in the above path is that the indicator “Performed Reliability of runs that comes on schedule” (PREL) is classified two times in different steps of the path, the first time considers an evaluation <=4 and the second time an evaluation >2. Considering that the evaluation of individuals happens once, this indicator in the path needs to have a score of 3 or 4 in order to satisfy all the constraints.

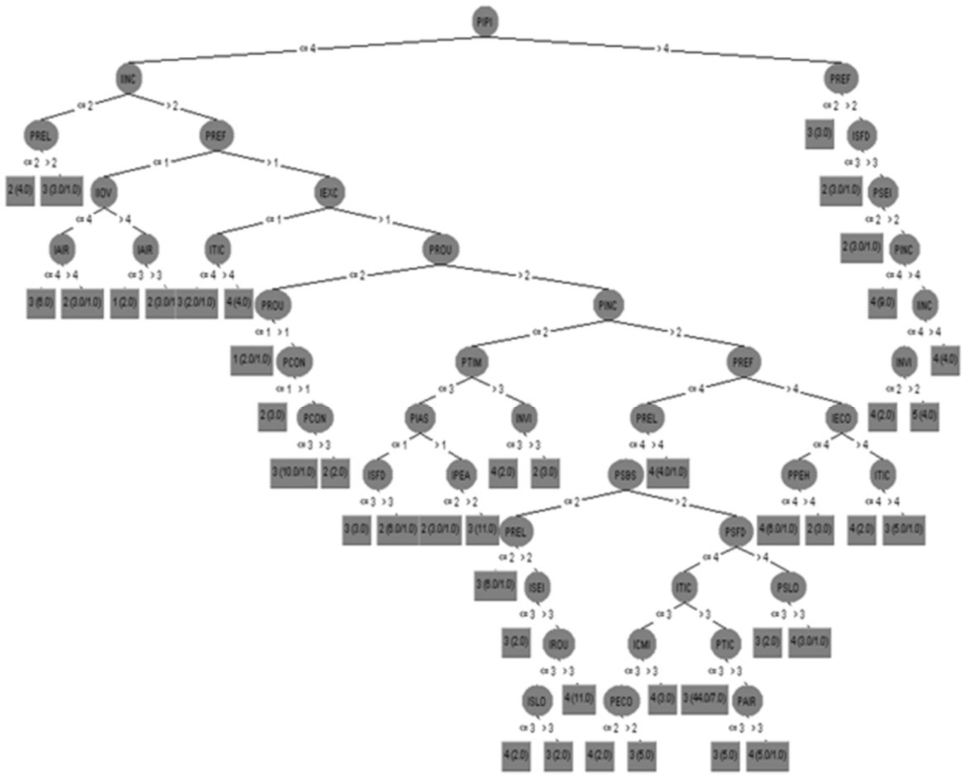

Fig. 1. J48 *decision* tree.

Table 4. WEKA J48 detailed accuracy by class.

Class	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area
1	0.500	0.005	0.750	0.500	0.600	0.604	0.987	0.688
2	0.811	0.034	0.833	0.811	0.822	0.785	0.966	0.861
3	0.951	0.109	0.890	0.951	0.919	0.842	0.967	0.948
4	0.932	0.026	0.932	0.932	0.932	0.906	0.987	0.965
5	0.500	0.000	1.000	0.500	0.667	0.700	0.990	0.795
Weighted Avg.	0.892	0.066	0.892	0.892	0.887	0.838	0.974	0.924

Another worth mentioning notice from the tree analysis representation is the fact that the performance level of quality indicators was used to classify the instances 23 times (23 performance nodes), while the importance level of quality indicators was used 19 times (19 importance nodes). This leads to the conclusion that the performance assessment is more crucial in the overall quality of service formulation assessment.

4. Conclusions

In terms of the present paper a decision tree was developed to address the GAP among perceived and expected quality of service attributes considering the overall quality assessment of the Greek transit system. Using a classification tree approach this research points out that both importance and performance assessments are important for the overall quality assessment formulation.

The tree paths are linked with the overall scores of transit quality and thus the present methodology could be very useful for decision makers and transit operators in order to increase their provided level of services. The performed indicator "Availability of information by phone, mail" was proved to be the most important indicator in terms of the present analysis.

Another important finding is the fact that the performance of the selected indicators seems to affect more the overall quality assessment than the importance users recognize for these indicators. Still, both evaluations need to be taken into account in order to cover the existing quality GAP.

The highest evaluation of the transit quality system is addressed by the tree path where travellers assess the performed "Availability of information by phone mail" as very good (>4), the performed "Service frequency" as >2, the importance of the "Safety and competence of drivers" as >3, the performed "Security against crimes on vehicles" as >2, the performed "Cleanliness of vehicle interior, seats and windows" as >4 and the importance of the same indicator as<=4 and the importance of "Levels of noise and vibrations" as <=2.

This path could be followed by decision makers in order to address the quality factors of intervention in order to achieve the highest overall assessment of their services.

This research used 211 responses to classify users' assessment regarding the importance and performance scores of 26 transit quality indicators. By increasing the number of data probably the J48 tree will grow differently. Still the high accuracy of the tree makes the analysis of the present paper proper for the aim of the present study.

Further research includes the collection of more responses in order to increase the accuracy and the validity of the tree. Similarly data could be collected and analysed in order to address the other 4 Gaps of the Gap model, considering operators' responses as well.

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