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# A customer satisfaction model based on fuzzy TOPSIS and SERVQUAL methods

Melike Erdoğan, Özge Nalan Bilişik, İhsan Kaya and Hayri Baraçlı

*Department of Industrial Engineering, Yildiz Technical University, Istanbul, Turkey*
*melike@yildiz.edu.tr; oznalan@yildiz.edu.tr; ihkaya@yildiz.edu.tr; hayri@yildiz.edu.tr*

**Abstract.** Service quality is one of the most important factors that increases the use of public transportation system (PTS). Many problems such as traffic congestion, air and noise pollution, and energy consumption can be solved by improvements of service quality in PTS. In this paper, a hybrid methodology which consists of SERVQUAL (Service Quality) method that categorizes evaluation criteria and fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method that ranks alternatives is suggested for evaluation of service quality in PTS. The suggested methodology is applied in a real case that analyzes the PTS in Istanbul. As a result, the public transportation company that provides the highest customer satisfaction is identified.

**Keywords:** customer satisfaction, fuzzy logic, multi-criteria decision making

## Introduction

The service can be defined as an event that is produced to meet requirements and currently consumed. Services are economic activities, they are offered one to by one party to another and employed time-based performances to bring about desired results in recipients themselves or in objects or other assets for which purchases have responsibility (Lovelock and Wirtz, 2007). Measuring the degree of satisfaction with service performance concerning a set of relevant criteria is a way to evaluate service quality. Passengers are the important elements for measuring and evaluating the service provided (Freitas, 2013). Service quality is one of the most important factors which extends the use of public transport (Fujii and Van, 2009). Public transportation is an activity type of service. The understanding the typical characteristics of the public transportation provides a high quality level that meets the needs and expectations of the passengers (Freitas, 2013).Evaluation of public transportation to increase productivity and improve customer satisfaction in terms of quality of service is very important. All public transport organizations assess the quality of service regularly.

Although various models developed for measuring service quality in service organizations, SERVQUAL is accepted as the basis for all of these models (Saravanan and Rao, 2007). The criteria used for measuring the quality of service are not only limited to quantitative, because service quality dimensions cannot be measured quantitatively (Awasthi et al., 2011), so as multi-criteria decision making approaches can be used successfully in this area. By the way, it is determined and evaluated in subjective and qualitative in nature and described linguistically. To handle with this, fuzzy logic is used as a mathematical way to represent and handle vagueness in decision-making (Tseng, 2011).

In this paper, an integrated methodology consists of SERVQUAL and fuzzy TOPSIS methodology for evaluation of service quality of public transportation systems (PTS) is proposed. As a real case application, the PTS in Istanbul is investigated and the public transportation company that provides the highest customer satisfaction is identified.

The rest of the paper is organized as follows: Section 2 includes a literature review on service quality in PTS. Section 3 gives information about the multi-criteria decision making (MCDM) methodology that is used in the proposed methodology. In Section 4, conducted real case application for public transportation in Istanbul is analyzed. The obtained results and future research directions are discussed in Section 5.

## Literature review

Altuntas et al. (2012) used analytic hierarchy process (AHP) and analytic network process (ANP) to acquire the relationship and the level of the importance among service quality measurement dimension. Olsson et al. (2012) presented the Satisfaction with Travel Scale (STS) for measuring the service experience in public transport. They obtained that service experience is multidimensional, consisting of a cognitive dimension related to service quality and two affective dimensions related to positive activation, such as enthusiasm or boredom, and positive deactivation, such as relaxation or stress. Barabino et al. (2012) used modified SERVQUAL approach compliant with the EN13816, a European standard on service quality in public transport. Their aim was to provide a quality evaluation tool readily usable by transport operators willing to certify the service offered. Castillo and Benitez (2012) determined a methodology to identify and quantify the relationship between the ratings given to the overall satisfaction and those given to specific aspects of the service or specific ratings to measure the quality of public transport through user surveys by rating different aspects of the service. Carvalho and Brito (2012) presented the evaluation about the perceptions of users of public services in order to improve quality of public services. They aimed to answer the question about how to assess users' perceptions in order to improve public service quality. Awasthi et al. (2011) proposed a hybrid approach based on SERVQUAL and fuzzy TOPSIS for evaluating service quality of urban transportation systems. Their approach consisted of three steps. In the first step, they developed a SERVQUAL based questionnaire to collect data for measuring transportation service quality. Second step involved the linguistic ratings were combined through fuzzy TOPSIS to generate an overall performance score for each alternative and finally in step 3, they conducted a sensitivity analysis to evaluate the influence of criteria weights on the decision making process. Chou et al. (2011) proposed a fuzzy weighted SERVQUAL model for evaluating the airline service quality and applied a case study for Taiwanese airline. Hilmola (2011) aimed to evaluate public transportation efficiency in larger cities and developed four different DEA-based efficiency benchmarking models to evaluate the public transportation efficiency. Dell'Olio et al. (2011) explored a methodology used to study the quality of service desired by users of PTS. They expressed that desired quality was different from perceived quality because it was not represent the daily experiences of the users, but rather what they desired, hope for or expect from their PTS. Wang et al. (2010) presented an instrument based on SERVQUAL for measuring urban transport service quality from a stakeholder perspective. Pantouvakis and Lymperopoulos (2008) presented the relative importance of the physical and interactive elements of service on overall satisfaction, particularly when these elements were moderated by the point-of-view of repeat and new customers in transport sector. Wu et al. (2004) tested five dimensions of SERVQUAL for hospitals by using the fuzzy set theory to clarify the positioning of service quality in the healthcare market and suggested service strategy implementation priorities of service strategies.

## The proposed methodology

In this paper, criteria for the public transportation service quality are classified according to SERVQUAL dimensions. The criteria are categorized with respect to the SERVQUAL dimensions which are accepted in literature (Awasthi, 2011; Tseng, 2011; Liou, 2011). Then, fuzzy TOPSIS approach is used to rank the alternatives. The fuzzy set theory is applied to deal with uncertainty associated with the data and to gain more realistic results, thus the effectiveness of multi criteria decision making methods are increased. The methods that are used in this paper are briefly explained as follows.

### SERVQUAL Approach

SERVQUAL is a useful instrument for performing gaps analysis where a gap is measured as the difference between the customer expectations and customer perceptions. The dimensions of SERVQUAL are Tangibles, Service Reliability, Responsiveness, Assurance and Empathy. These dimensions are defined as follows

(Awasthi et al., 2011): Tangibles include the physical appearance of the service facility, the equipment, the personnel, and the communication materials, i.e., appearance of stations, lighting, etc. Service reliability relates to the ability of the service provider to perform the promised service dependably and accurately, i.e., arrival of trains at the right time. Responsiveness is the willingness of the service provider to be helpful and prompt in providing service, i.e., response of customer queries by railway personnel. Assurance refers to the knowledge and courtesy of employees and their ability to inspire trust and confidence, i.e., knowledge staff at information desks. Empathy refers to caring, individualized attention to customers, i.e., helping old age customers with ticket reservation at kiosks.

## Fuzzy TOPSIS

TOPSIS is a multi-criteria decision-making technique to rank different alternatives through numerical evaluations the decision maker performs with respect to certain criteria. Weights can also be specified for each criterion, in order to introduce a measure of the relative importance felt by the decision maker (Gamberini et al., 2006; Kahraman et al., 2009b). The method is based on the consideration that the chosen alternative should have the shortest distance from the positive- ideal solution and the farthest distance from the negative ideal solution. TOPSIS defines an index called similarity to the positive- ideal solution and remoteness from the negative-ideal solution. Then the method chooses an alternative with the maximum similarity to the ideal solution (Yoon and Hwang, 1995).

The fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. It was specifically designed to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many problems. By contrast, traditional computing demands precision down to each bit. Since knowledge can be expressed in a more natural way by using fuzzy sets, many engineering and decision problems can be greatly simplified. The decision maker can specify preferences in the form of natural language expressions about the importance of each criterion (Kahraman et al., 2004a). In this paper fuzzy TOPSIS approach is used to specify the ranking of alternatives according to aggregated decision matrix and weight vector as well as the individual decision matrices and weigh vectors.

Fuzzy TOPSIS was first presented in Chen and Hwang (1992), with reference to Hwang and Yoon (1981). The basic principle of the fuzzy TOPSIS is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative-ideal solution in a geometrical (i.e., Euclidean) sense (Hwang & Yoon, 1981). The steps of fuzzy TOPSIS can be summarized as follows (Chen, 2000; Aydın et al., 2012; Baysal et al., 2013):

**Step 1:** Form a committee of decision-makers, and then identify the evaluation criteria.
**Step 2:** Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for alternatives with respect to criteria. For this aim, Tables 1 and 2 can be used.

**Table 1.** Linguistic variables for the importance weight of each criterion

| | |
|---|---|
| *Very low (VL)* | ( 0.0, 0.0, 0.1 ) |
| *Low (L)* | ( 0.0, 0.1, 0.3 ) |
| *Medium low (ML)* | ( 0.1, 0.3, 0.5 ) |
| *Medium (M)* | ( 0.3, 0.5, 0.7 ) |
| *Medium high (MH)* | ( 0.5, 0.7, 0.9 ) |
| *High (H)* | ( 0.7, 0.9, 1.0 ) |
| *Very high (VH)* | ( 0.9, 1.0, 1.0) |

**Table 2.** Linguistic variables for the ratings

| | |
|---|---|
| *Very poor (VP)* | ( 0, 0, 1 ) |
| *Poor (P)* | ( 0, 1, 3 ) |
| *Medium poor (MP)* | ( 1, 3, 5 ) |
| *Fair (F)* | ( 3, 5, 7 ) |
| *Medium good (MG)* | ( 5, 7, 9 ) |
| *Good (G)* | ( 7, 9, 10 ) |
| *Very good (VG)* | ( 9, 10, 10 ) |

**Step 3:** Pool the decision makers' opinions to get the aggregated fuzzy rating $\tilde{x}_{ij}$ of alternative $A_i$ under criterion $C_j$ and aggregate the weights of criteria to get the aggregated fuzzy weight $\tilde{w}_j$ of criterion $C_j$ by using Eqs. (1) and (2), respectively.

$$\tilde{x}_{ij} = \frac{1}{K}\left[\tilde{x}_{ij}^{1}(+)\tilde{x}_{ij}^{2}(+)\cdots(+)\tilde{x}_{ij}^{K}\right] \quad (1)$$

$$\tilde{w}_j = \frac{1}{K}\left[\tilde{w}_j^{1}(+)\tilde{w}_j^{2}(+)\cdots(+)\tilde{w}_j^{K}\right] \quad (2)$$

where $K$ is the number of decision makers, $\tilde{x}_{ij}^{K}$ and $\tilde{w}_j^{K}$ are the rating and the importance weight of the $K^{th}$ decision maker.

**Step 4:** Construct the fuzzy decision matrix and the normalized fuzzy decision matrix as in Eqs. (3) and (4).

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m*n} \quad (3)$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right),\ j \in B; \quad \tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right),\ j \in C; \quad (4)$$

$$c_j^* = \max_i c_{ij} \ \text{ if } j \in B; \qquad a_j^- = \min_i a_{ij} \ \text{ if } j \in C.$$

where $B$ and $C$ are the set of benefit criteria and cost criteria, respectively,

**Step 5:** Construct the weighted normalized fuzzy decision matrix by Eqs. (5) and (6).

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n} \quad (5)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \quad (6)$$

**Step 6:** Determine fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS).

**Step 7:** Calculate the distances of each alternative from the FPIS (A*) and the FNIS (A-) as in Eq. (7), respectively.

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, ..., \tilde{v}_n^*), \quad A^- = (\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^-) \quad (7)$$

**Step 8:** Calculate the closeness coefficient of each alternative as in Eq. (8).

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^*),\ i = 1,2,...,m \qquad d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^-),\ i = 1,2,...,m \quad (8)$$

where d ( $d_i^*, d_i^-$ ) is the distance measurement between two fuzzy numbers.

Then a closeness coefficient is defined to determine the ranking order of all alternatives as in Eq. (9).

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-},\ i = 1,2,...,m \quad (9)$$

**Step 9:** According to the closeness coefficient, the ranking order of all alternatives can be determined.

## A real case application

In Istanbul, the public transportation is generally provided by buses, minibuses, taxis and private cars. The public transportation firms in Istanbul are Istanbul Electricity, Tramway and Tunnel General Management (IETT), Metrobus (BRT System), Private Public Transportation Busses (PPTB) and Otobus Inc.

The questionnaire used in this study is applied to totally 2006 passengers who get on and get off the busses at bus stops and Metrobus stations, and 800 of them at Metrobus stations and 1206 of them is hold at the bus stops. This sample size means the %95 ± 2.19 confidence levels. In this customer satisfaction research, 56 bus stops and 7 Metrobus stations are selected. The questionnaire consists of 59 questions. The first eighteen questions are about the demographic characteristics and so they are not used in the evaluation. The criteria used in this paper are composed of the questions in the customer satisfaction questionnaire. In conjunction with these criteria, TOPSIS method is applied to rank the alternatives according to satisfaction level.

The criteria weights are identified by experts' evaluations who are decision makers in Institution of Public Transport, as shown in Table 3. The fuzzy TOPSIS is applied to rank the alternatives. In the first stage, a decision matrix is constructed from normalized survey results according to the scale of 5-point Likert.

FPIS and FNIS are determined for all criteria. Then, the distances of each alternative from the fuzzy positive-ideal solution (FPIS, A*) and the fuzzy negative-ideal solution (FNIS, A-) are calculated as in Eq. (7). The weighted normalized fuzzy decision matrix is shown in Table 4.

**Table 3.** Criteria Weights

| Criteria | Weight | Criteria | Weight |
|---|---|---|---|
| ***Responsiveness*** | ***(0.1,0.3,0.5)*** | ***Tangibles and fee*** | ***(0.9,0.9,1)*** |
| Website information | (0.01,0.09,0.25) | The air conditioning system in the vehicles | (0.27,0.45,0.7) |
| Removal of cash usage in busses | (0.03,0.15,0.35) | The seats, holders and other equipment in the vehicles | (0.09,0.09,0.3) |
| Call center services | (0.01,0.09,0.25) | Inside and outside information of busses | (0.09,0.27,0.5) |
| ***Reliability*** | ***(0.5,0.7,0.9)*** | Information at bus stops | (0.09,0.27,0.5) |
| Vehicles leaving from bus stops punctually | (0.35,0.63,0.81) | The general look of vehicles | (0.09,0.27,0.5) |
| Vehicles arriving to the destination punctually | (0.25,0.49,0.81) | Outside cleaning of vehicles | (0.09,0.09,0.3) |
| Waiting time at the stations | (0.35,0.63,0.81) | Inside cleaning of vehicles | (0.09,0.27,0.5) |
| Vehicles arriving to the bus stops punctually | (0.25,0.49,0.81) | The environmentally-conscious vehicles (noise) | (0.09,0.09,0.3) |
| Easiness in transition | (0.05,0.07,0.27) | The environmentally-conscious vehicles (exhaust fumes) | (0.09,0.09,0.3) |
| Distance suitability of districts to access to the busses and stops | (0.15,0.35,0.63) | Suitability of vehicles for disabled | (0.45,0.63,0.9) |
| Istanbul Card/Akbil (Smart ticket) loading easiness | (0.05,0.21,0.45) | Suitability of bus stops for disabled | (0.45,0.63,0.9) |
| Istanbul Card providing easiness | (0.05,0.21,0.45) | Transportation Fee | (0.63,0.81,0.9) |
| The sufficiency of sitting areas in the vehicles | (0.15,0.35,0.63) | ***Assurance*** | ***(0.3,0.5,0.7)*** |
| The passenger density at the bus stations | (0.05,0.21,0.45) | The driving ability of drivers | (0.15,0.35,0.63) |
| The passenger density in the busses) | (0.35,0.63,0.81) | The knowledge of drivers/officers | (41395,0.25,0.49) |
| The security of the vehicles | (0.15,0.35,0.63) | ***Empathy*** | ***(0.5,0.7,0.9)*** |
| The security of the bus stations | (0.15,0.35,0.63) | The solution for passenger concerns and requests | (0.05,0.21,0.45) |
| Lost property finding easiness | (0.05,0.21,0.45) | Behavior of drivers/officers to the passengers | (0.25,0.49,0.81) |

**Table 4.** The weighted normalized fuzzy decision matrix

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| IETT | (0.01,0.11,0.32) | (0.04,0.15,0.41) | (0.03,0.12,0.36) | (0.11,0.3,0.6) | (0.1,0.29,0.59) | (0.1,0.28,0.59) | (0.09,0.27,0.58) | (0.02,0.1,0.33) |
| OHO | (0.01,0.11,0.32) | (0.04,0.15,0.41) | (0.03,0.12,0.36) | (0.1,0.29,0.59) | (0.1,0.28,0.58) | (0.1,0.27,0.57) | (0.09,0.26,0.57) | (0.03,0.12,0.36) |
| OTOBUS INC. | (0.01,0.11,0.32) | (0.04,0.15,0.41) | (0.03,0.12,0.36) | (0.12,0.32,0.63) | (0.11,0.3,0.61) | (0.11,0.3,0.62) | (0.1,0.29,0.6) | (0.02,0.08,0.27) |
| METROBUS | (0.01,0.11,0.32) | (0.04,0.15,0.41) | (0.03,0.12,0.36) | (0.17,0.43,0.75) | (0.17,0.43,0.75) | (0.16,0.42,0.75) | (0.15,0.41,0.75) | (0.03,0.12,0.36) |

| | C9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 |
|---|---|---|---|---|---|---|---|---|
| IETT | (0.06,0.22,0.54) | (0.04,0.17,0.44) | (0.05,0.21,0.5) | (0.1,0.28,0.62) | (0.03,0.13,0.41) | (0.13,0.33,0.76) | (0.07,0.22,0.53) | (0.05,0.18,0.47) |
| OHO | (0.06,0.22,0.54) | (0.04,0.17,0.44) | (0.05,0.21,0.5) | (0.1,0.28,0.63) | (0.03,0.12,0.39) | (0.13,0.32,0.74) | (0.06,0.21,0.52) | (0.05,0.18,0.47) |
| OTOBUS INC. | (0.06,0.22,0.54) | (0.04,0.17,0.44) | (0.05,0.21,0.5) | (0.11,0.31,0.66) | (0.03,0.15,0.46) | (0.14,0.35,0.79) | (0.08,0.26,0.6) | (0.05,0.18,0.47) |
| METROBUS | (0.05,0.21,0.52) | (0.04,0.19,0.46) | (0.06,0.22,0.52) | (0.12,0.33,0.69) | (0.03,0.16,0.46) | (0.13,0.33,0.75) | (0.09,0.28,0.63) | (0.06,0.22,0.54) |

| | C17 | C18 | C19 | C20 | C21 | C22 | C23 | C24 |
|---|---|---|---|---|---|---|---|---|
| IETT | (0.04,0.17,0.48) | (0.12,0.3,0.63) | (0.05,0.15,0.41) | (0.03,0.16,0.4) | (0.03,0.13,0.36) | (0.03,0.08,0.27) | (0.03,0.05,0.24) | (0.05,0.2,0.45) |
| OHO | (0.04,0.15,0.45) | (0.12,0.29,0.62) | (0.05,0.15,0.41) | (0.03,0.16,0.39) | (0.03,0.13,0.36) | (0.03,0.08,0.27) | (0.03,0.05,0.24) | (0.05,0.19,0.44) |
| OTOBUS INC. | (0.03,0.16,0.48) | (0.16,0.39,0.75) | (0.05,0.17,0.45) | (0.04,0.19,0.43) | (0.03,0.13,0.36) | (0.04,0.11,0.32) | (0.04,0.06,0.27) | (0.06,0.23,0.51) |
| METROBUS | (0.04,0.16,0.48) | (0.17,0.41,0.77) | (0.06,0.18,0.46) | (0.04,0.21,0.47) | (0.04,0.15,0.41) | (0.05,0.12,0.35) | (0.04,0.07,0.28) | (0.07,0.25,0.53) |

| | C25 | C26 | C27 | C28 | C29 | C30 | C31 | C32 | C33 |
|---|---|---|---|---|---|---|---|---|---|
| IETT | (0.02,0.1,0.3) | (0.04,0.13,0.35) | (0.15,0.33,0.71) | (0.14,0.32,0.7) | (0.23,0.49,0.79) | (0.09,0.27,0.61) | (0.08,0.27,0.62) | (0.04,0.16,0.48) | (0.09,0.26,0.61) |
| OHO | (0.02,0.1,0.3) | (0.04,0.13,0.34) | (0.14,0.31,0.68) | (0.14,0.32,0.7) | (0.23,0.49,0.79) | (0.09,0.26,0.59) | (0.07,0.26,0.59) | (0.04,0.16,0.48) | (0.08,0.24,0.57) |
| OTOBUS INC. | (0.04,0.14,0.37) | (0.06,0.17,0.42) | (0.19,0.43,0.83) | (0.14,0.32,0.7) | (0.23,0.49,0.79) | (0.1,0.28,0.63) | (0.08,0.28,0.63) | (0.04,0.16,0.48) | (0.09,0.27,0.62) |
| METROBUS | (0.04,0.15,0.4) | (0.07,0.2,0.46) | (0.19,0.44,0.84) | (0.16,0.38,0.78) | (0.26,0.55,0.84) | (0.11,0.33,0.69) | (0.1,0.34,0.7) | (0.04,0.16,0.48) | (0.12,0.33,0.7) |

Finally, the closeness coefficient of each alternative is calculated as in Eq. (8) and the results are shown in Table 5. According to obtained results as shown in Table 5, the bus rapid transit system, Metrobus, is identified as the most satisfied public transportation company in Istanbul. Otobus Inc. is following it as a second alternatives and IETT and PPTB has close degrees relatively third and fourth alternatives.

**Table 5.** Ranking of Alternatives

| *Alternatives* | *CCİ* | *Rank* |
|---|---|---|
| IETT | 0.455 | 3 |
| PPTB | 0.452 | 4 |
| OTOBUS INC. | 0.466 | 2 |
| METROBUS | 0.490 | 1 |

It is not surprisingly that Metrobus is the best, because this new public transportation vehicle is quick, comfortable and confidential. However next to all of these, it is usually crowded and this affects the satisfaction of customers. Any improvement about the intensity of passengers at buses and bus stops criteria for Metrobus will get up customer satisfaction more. For the remaining alternatives, other criteria should also be improved to provide higher customer satisfaction and service quality such as sufficiency of sitting areas in the vehicles or leaving/arriving of vehicles from bus stops punctually.

## Conclusion

Service quality is one of the most important factors that increase the usage of PTS. Service quality improvements can solve many problems. In this paper, an integrated methodology consists of SERVQUAL and fuzzy TOPSIS methodology for evaluation of service quality of PTS is presented. The suggested methodology is applied for the PTS in Istanbul and the public transportation company that provides the highest customer satisfaction is clarified. By the way, the companies are ranked with respect to the degree of customer satisfaction. The ranking of alternatives is Metrobus-Otobus Inc.-IETT-PPTB. However, any improvement about the intensity of passengers at buses and bus stops criteria for Metrobus will get up customer satisfaction more. To have higher customer satisfaction, providing Istanbul Card process should be made easier, the distance of districts between busses and stops should be decreased, the security/safety in vehicles and at bus stations should be improved and finally finding of lost property should be facilitated for all public transportation companies.

As future suggestion, the weights of criteria can be calculated by using a fuzzy MCDM technique to obtain more comparative and sensitive results. Also, the obtained results can be evaluated with respect to a sensitivity analysis.

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