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# A hybrid approach based on SERVQUAL and fuzzy TOPSIS for evaluating transportation service quality

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ABSTRACT

Managing service quality is vital to retain customer satisfaction and augment revenues for any business organization. Often it is difficult to assess service quality due to lack of quantifiable measures and limited data. In this paper, we present a hybrid approach based on SERVQUAL and fuzzy TOPSIS for evaluating service quality of urban transportation systems. The proposed approach consists of three steps. The first step involves development of a SERVQUAL based questionnaire to collect data for measuring transportation service quality. The participants provide linguistic assessments to rate the service quality criteria and the alternatives. In step 2, the linguistic ratings are combined through fuzzy TOPSIS to generate an overall performance score for each alternative. The alternative with the highest score is finally chosen. In step 3, sensitivity analysis is conducted to evaluate the influence of criteria weights on the decision making process.

The strength of the proposed approach is its practical applicability and ability to provide solution under partial or lack of quantitative information. An application of the proposed approach for evaluation of service quality of metro in Montreal is provided.



## 1. Introduction

Evaluation of service quality of urban transportation systems is vital to improve productivity, gain profits and increase customer satisfaction. All transportation organizations carry evaluation of their service quality on a regular basis. This involves assessment of various parameters related to service quality for example, efficiency, reliability, safety, comfort, etc. against their desired target values by the decision makers. The evaluation can be done by customers, service personnel, transportation experts, etc. for important time intervals related to service for example, weekdays vs weekends, peak vs off-peak hours, etc. The goal of all organizations is to achieve high customer satisfaction by providing high quality service at all times to all customers.

### 1.1. Existing state of the art

The problem of evaluating service quality of urban transportation systems has been investigated by several researchers (Apostolopoulou, Nellas, Ganoudis, & Marinaki, 2000; DuPlessis, 1984; Iseki & Taylor, 2008; Miller, 1995; Pullen, 1993; Said, 2002; TRB, 1999). The commonly used approaches can be classified into:

- Survey studies and Interviews.
- Statistical analysis of collected data.
- Multicriteria decision making.

The first category of techniques is based on survey studies and interviews. The survey studies involve introducing a questionnaire to participants to seek their opinion on service quality attributes. In interviews, the participants are questioned face to get answers. One of the most commonly used survey instrument for evaluating service quality is SERVQUAL (Parasuraman, Zeithaml, & Berry, 1988). SERVQUAL is based on 22 items related to measuring five dimensions of service quality namely tangibles, reliability, responsiveness, assurance and empathy. Cavana Robert, Corbett Lawrence, and Lo (2007) extend SERVQUAL instrument to evaluate passenger rail service quality in Wellington, New Zealand by adding three more dimensions namely comfort, connection, and convenience. Fick and Ritchie (1991) use SERVQUAL to measure service quality in the travel and tourism industry. Tripp and Drea (2002) conducted a survey study of Amtrak riders, and found that

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the core service elements of on-board conditions, cafe car conditions, and on-time performance were most strongly related to attitude toward the service. Paquette, Cordeau, and Laporte (2009) classifies three principal approaches to define quality service quality in dial-a-ride operations: the customer-based approach (customer perceptions), the technical approach (specifications), and the philosophical approach (excellence).

The second category of techniques is based on statistical analysis of data for evaluating service quality. These involve regression models (Agarwal, 2008), logit models (Hensher, Stopher, & Bullock, 2003; Tyrinopoulos & Antoniou, 2008), structural equation modeling, stated preference method (Eboli & Mazzulla, 2008; Swanson, Ampt, & Jones, 1997), etc. Regression and logit models are used to study the causal relationship between the dependent variable (service quality) and the independent variables (service quality attributes like reliability, comfort, security, etc.). In regression models, it is assumed that the relationship exists between the dependent and the independent models while in logit models, uncertainty exists. Agarwal (2008) used factor and regression analysis to identify the effect of customers' perception about the quality of performance of various factors on customer satisfaction and found that employee behavior has the maximum effect on satisfaction level of customers with Indian Railways as a whole. Tyrinopoulos and Antoniou (2008) use factor analysis and ordered logit models to evaluate public transit user satisfaction. In stated preference techniques, individual respondents' statements about their preferences in a set of transport options are collected to estimate utility functions. The options are typically descriptions of transport situations or contexts constructed by the researcher (Kroes & Sheldon, 1988). A stated preference experiment for measuring transit service quality can be found in Eboli and Mazzulla (2008).

The third category of approaches involve multicriteria decision making. The commonly used multicriteria decision making approaches for service quality assessment of public transit systems are based on weighted scoring. In multicriteria decision making approaches, the alternative is evaluated against multiple weighted criteria and an aggregate performance score is determined. If the alternative performs above a pre-defined threshold limit, the service quality is deemed to be good. In case of multiple alternatives, the alternative with the highest score is chosen as the best alternative. Yeh, Deng, and Chang (2000) present a fuzzy multicriteria analysis approach for performance evaluation of bus companies. Yedla and Shrestha (2003) propose a multi-criteria approach based on AHP (Saaty, 1980) for the selection of alternative options for environmentally sustainable transport system in Delhi. Yeh and Kuo (2003) present a fuzzy multiattribute decision making approach for evaluating passenger service quality of 14 major Asia–Pacific international airports. Nathanail (2008) proposed a multicriteria evaluation framework for measuring the quality of service for passengers on the Hellenic railways. The criteria chosen were itinerary accuracy, system safety, cleanness, passenger comfort, servicing, and passenger information. Hensher et al. (2003) propose a service quality index in the provision of commercial bus contracts. Eboli and Mazzulla (2009) proposed an index based on customer perspective for evaluating transit service quality.

### 1.2. Motivation for this research

Managing service quality is vital to retain customer satisfaction and improve business profitability. Despite implementation of sound service quality initiatives, it is often difficult to measure their performance due to lack of quantifiable measures and limited data. In realistic situations, customers may not provide quantitative or numerical evaluations. Rather, they may be comfortable providing qualitative assessments such as good, very good, poor, very poor, etc. The reasons can be many including no prior experience with similar products, higher comfort level with qualitative ratings than discrete numbers, etc. Besides, the criteria used for judging service quality should not be only limited to quantitative ones since some of the service quality dimensions such as responsiveness, empathy, assurance cannot be measured quantitatively. Most of the existing studies in service quality literature rely on numerical data which may not often be practically available. Therefore, studies that are able to treat both qualitative and quantitative criteria and extract maximum information out of limited numerical data are required for improving service quality.

In this paper, we present a hybrid approach integrating SERVQUAL and fuzzy TOPSIS for evaluation of service quality of urban transportation systems. Fuzzy set theory is used to model vagueness and uncertainty in decision making processes arising due to lack of quantitative information (Zadeh, 1965). For example, it is much easier to represent the quality of service in organizations in linguistic terms such as good, very good, poor, very poor, etc. than in numbers. In fuzzy set theory, linguistic terms are used to represent decision maker preferences. This is the reason why we have used linguistics terms in seeking questionnaire responses from respondents.

The rest of the paper is organized as follows. In section 2, we present preliminaries of fuzzy set theory and fuzzy TOPSIS. In section 3, we present our solution approach for evaluating service quality of urban transportation systems. Section 4 presents an application of our approach on evaluation of service quality for metro service in Montreal. In the fifth and the last section, we present the conclusions and future work.

## 2. Preliminaries of fuzzy set theory

Some related definitions of fuzzy set theory adapted from (Buckley, 1985; Dubois & Prade, 1982; Kaufmann & Gupta, 1991; Klir & Yuan, 1995; Pedrycz, 1994; Zadeh, 1965; Zimmermann, 2001) are presented as follows.

**Definition 1.** A fuzzy set $\tilde{a}$ in a universe of discourse $X$ is characterized by a membership function $\mu_{\tilde{a}}(x)$ that maps each element $x$ in $X$ to a real number in the interval [0,1]. The function value $\mu_{\tilde{a}}(x)$ is termed the grade of membership of $x$ in $\tilde{a}$ (Kaufmann and Gupta). The nearer the value of $\mu_{\tilde{a}}x$ to unity, the higher the grade of membership of $x$ in $\tilde{a}$.

**Definition 2.** A triangular fuzzy number (Fig. 1) is represented as a triplet $\tilde{a} = (a_1, a_2, a_3)$. Due to their conceptual and computation simplicity, triangular fuzzy numbers are very commonly used in practical applications (Klir & Yuan, 1995; Pedrycz, 1994). The membership function of $\mu_{\tilde{a}}x$ triangular fuzzy number is given by:

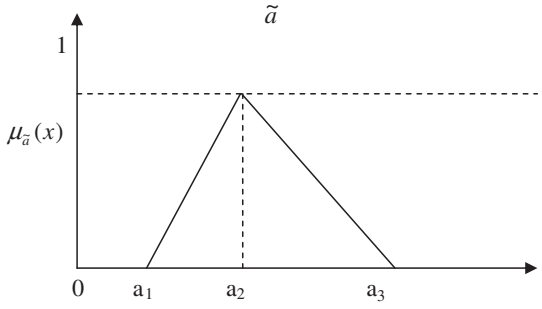


**Fig. 1.** Triangular fuzzy number $\tilde{a}$.