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Improving transportation service quality based on information fusion

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ABSTRACT

How to improve transportation service quality and thus attract more passengers to use public transportation systems is an important concern for city governments around the world. In this study, we propose a novel information fusion model that addresses the dependent relationships among the various criteria for a method of non-additive weighted gap analysis aimed at evaluating and improving the service quality of transport systems. The hybrid model remedies prior shortcomings and should be more applicable to real-world situations. The proposed model is applied to a real case study of Taipei city bus companies to demonstrate its usefulness. The resulting analysis and the managerial applications for improving the bus service quality are also discussed with regards to the current policies of Taipei city.

1. Introduction

Service quality has been proven to have a positive effect on passengers' behavioral intentions (Lai and Chen, 2011). The service quality of a transportation system is a key factor that affects the willingness of citizens to choose to use the public transportation system rather than drive their private vehicles. The measurement of service quality in any transportation system has been and will continue to be an important issue when allocating resources between competing transit agencies. The problem of evaluating the service quality of a transportation system has been investigated in several studies and great contributions have been made (Hensher et al., 2003; Yedla and Shrestha, 2003; Iseki and Taylor, 2008; Said, 2002; Lai and Chen, 2011; Awasthi et al., 2011; Hu and Jen, 2006; Joewono and Kubota, 2007; Tripp and Drea, 2002; Paquette et al., 2009; Agarwal, 2008; Stuart et al., 2000; Eboli and Mazzulla, 2007; Nathanail, 2008; Nurul-Habib et al., 2009; Tyrinopoulos and Antoniou, 2008; Yeh and Kuo, 2003). Some researchers have applied statistical hypothesis testing to demonstrate the relationships between service quality and its related constructs. Some have used multiple criteria decision-making (MCDM) methods which assume that the criteria are independent to evaluate transportation service quality, but in the real world, the criteria are not independent. Others have considered the interdependence among criteria, but have still used additive models (i.e., the simple additive weight method (SAW), grey relations, VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS)) to obtain an aggregated performance score (Lin et al., 2010; Liou and Chuang, 2010; Yang and Tzeng, 2011). However, these methods are inconsistent with the assumption that the criteria are interdependent. This inconsistency can be avoided by applying an information fusion technique (e.g., non-additive fuzzy integrals) to integrate interdependent performance values.

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Our proposed model considers multiple criteria and uses the graph theory-based Decision-Making Trial and Evaluation Laboratory (DEMATAL) method in combination with the Analytical Network Process (ANP) approach (DANP or DEMATEL-based ANP) to construct the relationship and weights of the criteria. The DEMATEL technique confirms the relationship between various perspectives, which enhances our understanding of these complex evaluation systems. The ANP method is currently used to address normalization in the supermatrix by assuming that each cluster has equal weight. Although the supermatrix normalization method is simple, the assumption of equal weight appears to be irrational because different criteria have different degrees of influence (Ou Yang et al., 2008). The DANP method eliminates this problem. Therefore, this study utilizes a hybrid MCDM model that combines the DEMATEL with the ANP method to resolve the dependence and feedback problems, and thus, more accurately reflect real-world situations. We also replace the traditional performance evaluation with gaps between aspiration levels that better enable managers to measure and realize their aspiration-level gaps and to set priorities for improvement. Most importantly, applying non-additive fuzzy integrals so that the interdependent gap values can be integrated remedies the problem of inconsistency due to assuming that the criteria are interdependent, but entails the use of additive models.

This hybrid model offers a more useful strategy for evaluating and improving transportation service quality. This study contributes by offering a quantitative model that can help practitioners to not only rank/select alternatives but also improve their performance. The proposed hybrid model improves upon prior shortcomings and more closely reflects real-world situations. We use data from the Taipei city bus system to demonstrate the use of this model in practice. The derived management implications are discussed with the current policies of the city of Taipei. The remainder of this paper is organized as follows: A literature review appears in Section 2. The proposed hybrid model is illustrated in Section 3. Section 4 describes our problem and the data while the analysis procedures are presented in Section 5. Section 6 includes a discussion and some conclusions are offered in Section 7.

2. Literature survey of transportation service quality

Earlier research studies regarding transportation service have focused on the measurement of productivity and performance (Alter, 1976; Fielding and Anderson, 1983; Fielding et al., 1985; Carter and Lomax, 1992; Pullen, 1993; Hensher and Daniels, 1995). In fact, transit performance includes efficiency, effectiveness, productivity and service quality (Eboli and Mazzulla, 2011). Efficiency is the relationship of inputs to the produced service (e.g., vehicle kilometers), while effectiveness is the relationship of inputs to the consumed service (e.g., passenger kilometers) (Hensher, 2007). What is important and vital in the performance and delivery of a transit service depends significantly upon perspective. Traditional cost efficiency indicators (e.g., operating expenses per vehicle revenue kilometer and/or hour) and cost effectiveness indicators (e.g., operating expense per passenger kilometer and/or passenger trip) can be considered as performance measures from the transit agency perspective, although they are not linked to customer-oriented and community issues, which are also fundamental perspectives (Transportation Research Board, 2003). In other words, the customer's point of view is the most relevant for evaluating transit performance. Only customers can truly define service quality in public transport systems.

Several later studies have refocused on the measurement of service quality by customers (Hensher et al., 2003; Hu and Jen, 2006; Eboli and Mazzulla, 2011; Awasthi et al., 2011). Hensher et al. (2003) established a way to measure and calculate an overall service quality index, which includes 13 attributes, such as bus travel time, bus fare, time walking to the bus stop, seat availability, information, driver attitude, etc. Based on focus group interview, Hu and Jen (2006) developed a scale that contains four dimensions and 20 items related to bus service quality. The four dimensions comprise interaction with passengers, tangible service equipment, convenience of service and operating management support. Eboli and Mazzulla (2011) proposed a methodology which provides a way to evaluate transportation service quality that considers both subjective and objective measures of service performance. The judgment of passengers' perception is considered a subjective measure of service quality, while the performance measures provided by transit operators are considered an objective measure of service quality. Non-academic monitoring of passenger satisfaction on transit systems is already ongoing in several cities around the world (e.g., the quality of service of London buses is regularly observed based on 11 indices, such as safety, crowding, reliability, staff behavior, etc.).

Parasuraman et al. (1985) developed a framework that defines service quality as the degree and direction of the discrepancy between customers' expectations and perceptions. Their model was further developed and became known as SERVQUAL. It contains five dimensions with 22 attributes of service quality (Parasuraman et al., 1988). However, traditional gap analysis does not consider the weight of the criterion and the overall performance value. Furthermore, some researchers (Carman, 1990; Cronin and Taylor, 1992; Triplett et al., 1994) have argued that these five dimensions and the 22 items were inappropriate for some service businesses. This seems to suggest that the concept of service quality is context-dependent. Its measurements should thus reflect the operational environment being investigated.

Although most studies have used traditional statistical techniques to test hypotheses, others have applied MCDM models to investigate transportation service quality and to make suggestions for improvement. Yeh et al. (2000) presented a fuzzy multi-criteria analysis approach for the evaluation of the performance of bus companies. Tsaur et al. (2002) used the MCDM model to conclude that the most important attributes of air transport services are courtesy, safety and comfort. Based on SERVQUAL and fuzzy TOPSIS, Awasthi et al. (2011) proposed a model for evaluation of the service quality of the Metro in Montreal. Those models have assumed that the criteria are independent. In the real world, criteria are seldom independent