An integrated MCDM approach to evaluate public transportation systems in Tehran

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ABSTRACT

Public transportation is one of the most important systems in transportation, especially in big and crowded cities. As a result, evaluation of public transportation systems is a strategic decision-making problem for both private and public sections. In this paper, the problem of public transportation passengers in Tehran is addressed and their satisfaction levels are assessed by using passenger satisfaction survey. An integrated MCDM approach is proposed for evaluation of public transportation systems based on Delphi method, group analytic hierarchy process (GAHP) and preference ranking organization method for enrichment of evaluations (PROMETHEE). The proposed model provides more reliable and realistic results and introduces directions for future improvements of public transportation service quality. A sensitivity analysis is applied to investigate the influence of criteria weights on the decision making problem. As a conclusion, the most important public transportation systems in Tehran orderly are: metro, taxi, BRT, bus and van. Therefore, Tehran Municipality and policy makers should encourage and support the previously mentioned systems.

1. Introduction

During the past twenty years, developing countries have experienced very huge population growth (Buhaug and Urdal, 2013). The increase in population in Iran has led to the increase in the demand for urban transport in megacities, especially in the capital city of Tehran. Although the importance of public transportation is increasing with rapid growing population of Tehran, the transport infrastructure is not appropriate for the current transport demand. This has caused serious traffic congestion on the streets of the city that overloads the public transport in rush hours; this increases the queue length and waiting time for passengers. Under these conditions, a large part of people are compelled to use their private cars in contrast to their preference to use the public transportation, which plays a crucial role in facilitating the mobility of citizens (Lodovici and Torchio, 2015). By using more private cars, the transportation system's situation becomes worse because these cars are the main reason for congestion on the roads and the increase of environmental pollution.

Understanding the behavioral intentions of public transit passengers is critical (Lai and Chen, 2011), and ensuring a high customer satisfaction level in public transportation system is a fundamental mission for the managers and authorities (Aydin et al., 2015). Therefore, Municipality of Tehran and some transport companies have become more knowledgeable of the important role played by customer satisfaction in order to increase the utilization of public transport and decrease the private transport. As a result, improvements can attract more users to use public transportation.

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In this paper, the problem of public transportation customers in Tehran is discussed and the customer satisfaction survey is used to evaluate their satisfaction levels. For this purpose, Delphi-GAHP-PROMETHEE integrated approach for ranking public transportation modes in Tehran is introduced, and the implementation process is explained with a real world case.

The aim of using the Delphi method is to know the most important criteria via experts' opinions and questionnaires. It can be applied to iteratively process opinions of experts until a general agreement is reached on the subject under investigation (Emovon et al., 2015), and also to forecast and identify critical issues (Ramos et al., 2016).

The group AHP method is used to analyze the structure of the public transportation passengers' problem with the help of a panel of experts and determine the weight of the criteria. Group decision making has become a crucial and intensely important part of multiple criteria decision making (Ahmad et al., 2014; Wang et al., 2014; Yu and Lai, 2011), and a group can better overcome the complexity of the problem than a single decision maker (DM) (Grošelj et al., 2015). The advantages of AHP over other multi-criteria methods, as often cited by its proponents, are its flexibility, intuitive appeal to the decision-makers (experts), and finally its potency to test the inconsistencies in judgments (Saaty, 2000).

Finally, PROMETHEE method is employed for final ranking of public transportation modes. This is followed by a geometrical analysis for an interactive aid (GAIA) plane to identify conflicts among the criteria and to group the alternatives, as well as the sensitivity analysis of different scenarios by changing the criteria weights. The simultaneous consideration of quantitative and qualitative criteria is the advantage of PROMETHEE method. Moreover, PROMETHEE permits the decision-maker to take unclear, incomplete, incomparable or even contradictory information and thus preferences into consideration since it has the possibility to define threshold values, strict preference indefinite preferences and indifferences (Meier, 2013). Another benefit of applying PRO-METHEE over other non-compensatory methods, is simplifying the preference modeling, since as often cited by its proponents the decision makers find it easy to understand the concepts and parameters inherent in the method. (Silva and Schramm, 2015). The PROMETHEE method with its tools (GAIA plane, walking weights, stability intervals, multiple comparisons and preference flows) enables the decision-makers to better control the process using real data of the alternatives.

In spite of the existence of some integrated MCDM models that used Delphi, AHP and PROMETHEE simultaneously (Mousavi et al., 2013), but to the best of our knowledge, there is no study to evaluate public transport modes integrating Delphi, GAHP and PROMETHEE techniques. Hence, the integrated novel MCDM proposed in the present study benefits from the advantages of all methods by combining Delphi, GAHP and PROMETHEE. So, the results of the evaluation of public transportation system by MCDM methods can be used by Tehran Municipality for more realistic decision-making situation and more reliable investment appraisal.

The remainder of this paper is organized in the following manner. In Section 2, the literature review on customer satisfaction and MCDM methods in public transportation systems are presented. In Section 3, a brief introduction of Delphi, GAHP and PROMETHE along with the proposed methodology are given. The applicability of the proposed method on public transportation systems in Tehran is described in Section 4. The GAIA and sensitivity analysis of the results are given in Section 5. Conclusions and directions for future research are dealt with in Section 6.

2. Literature review

This section aims to review the customer satisfaction as well as the application of MCDM in public transportation.

2.1. Customer satisfaction in public transportation

Evaluation of the transportation service quality is the first step of increasing customer satisfaction in any system (Awasthi et al., 2011). There are many studies that focus on customer satisfaction in public transportation, understanding how to positively it influences public transit users' behavioral intentions for the future, and thereby influences users' loyalty (van Lierop and El-Geneidy, 2016; Stelzer et al., 2016; Mouwen, 2015; Lai and Chen, 2011; Shiftan et al., 2015).

Celik et al. (2014) proposed a framework which assesses the five rail transit lines in Istanbul (Turkey) for 2012. The study of Tyrinopoulos and Antoniou (2008) aimed to evaluate and understand better passenger attitudes toward public transport modes. This study explains the loyalty model and demonstrates its use in transportation using a case study of a choice between two modes, rail and bus. Friman and Fellesson (2009) analyzed the relationship between the objective performance measures of public transport services and the passenger satisfaction. Lai and Chen (2011) evaluated the relationships between the behavioral intentions of public transit passengers and the various factors that influence them. The paper aims to address the importance of the involvement of public transit services in passengers, behavioral intentions. Fellesson and Friman (2012) compared the perceived service satisfaction with public transport in eight European countries. This paper recognizes the four satisfaction dimensions of system, comfort, staff, and safety, which were present in most, but not all, of the cities. These findings demonstrate that there are disagreements in how public transport is perceived. Also Nathanai (2008) present a framework expanded for helping railway operators into monitoring and controlling the quality of services provided to the railway passengers.

Del Castillo and Benitez (2012) offered a methodology to identify the aspects that mostly affect the perception of the overall quality of service. The paper aimed to define and quantify the relationship between the ratings given to the overall satisfaction and those given to the specific aspects of the service or specific ratings. Hassan et al. (2013) suggested a multi-level framework in order to measure public transit service performance. The paper allows for the opinions of the various stakeholders of public transit services to join a multi-criteria evaluation process. Mouwen and Rietveld (2013) analyzed the public transportation in the Netherlands to search whether competitiveness raises the customer satisfaction in public transportation. They suggested that new vehicles highly influence the customer satisfaction. An evaluation for the efficiency of public transport operations undertaken in Swedish counties by the