Transport Policy 45 (2016) 156–167

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Performance evaluation of public transit systems using a combined evaluation method

Chunqin Zhang [a], Zhicai Juan [a,*], Qingyu Luo [b], Guangnian Xiao [a]

[a] Antai College of Economics & Management, Shanghai Jiao Tong University, 200030 Shanghai, China
[b] College of Traffic, Ji Lin University, 130012 Changchun, China

ARTICLE INFO

Article history:
Received 10 September 2014
Received in revised form
10 August 2015
Accepted 10 October 2015

Keywords:
Public transit systems
Performance evaluation
Combined evaluation method
Super efficiency data envelopment analysis model
Information entropy theory
Passenger satisfaction

ABSTRACT

The goal of this paper is to evaluate the performance of public transit systems based on a combined evaluation method (CEM) consisting of information entropy theory and super efficiency data envelopment analysis (SE-DEA). Taking 13 transit operators in Yangtze Delta Region of China as the research object, we integrate the public transit industry regulations, transit operation and passenger requirements to construct an evaluation indicator system based on satisfaction and efficiency. The CEM is used to evaluate the performance. The results show significant differences in the efficiency scores between CEM and SE-DEA. The CEM can reduce the risks of SE-DEA affected by the dimensions of indicators, and improve its discrimination capability. The evaluation outcomes of the CEM seem to be more objective, therefore, provide a more suitable basis for decision-making related to public transit service performance, as well as for the study of operation and management.

© 2015 Published by Elsevier Ltd.

1. Introduction

Public transit systems play a vital role in modern society. In China, compared to the private travel modes (including private cars, electric vehicles, motorcycles and so on), the competitiveness of public transit system is insufficient. At present, the average share of the public transit system in major cities is about 20%, and in some small and medium-sized cities, it is less than 10%, which is lower than in most developed countries. Therefore, to improve the competiveness, it is quite essential to operate public transit services efficiently and effectively, from both the supply and demand perspectives. Regarding efficiency, transit operators typically aim at minimizing the operational costs conditional on meeting the daily travel demand by passengers. As a result, efficiency measures describe the relationship between resource inputs and produced outputs and include indicators of the overall cost efficiency, labor utilization, and vehicle utilization (Fielding et al., 1985). Regarding effectiveness, passengers should feel that transit systems are available to meet their daily travel requirements at lower costs. As a result, effectiveness can be measured by the service utilization (ridership), service quality, and service satisfaction (Fielding et al., 1985). Therefore, these two measures are required to be considered in public transit systems (Chu et al., 1992). Technical Efficiency, Total Factor Productivity, Service Satisfaction and Hensher Performance Model are usually used to measure the performance of public transit (Fielding et al., 1985; Hensher, 1987, 2001; Boitani et al., 2013).

Today, for its operation, every public transit system in China heavily relies on government subsidies. However, governments at all levels face significant budget deficits and public transit systems must compete with other public services for financial support. Therefore, as the level of government support for a public transit system declines, it becomes crucial to operate more efficiently (Tsamboulas, 2006). Many researchers have shown their interest in evaluating the performance of public transit systems. At the same time, most of the existing researches focus on evaluating the performance of transit operators from the management perspective (Benn, 1995; Taylor et al., 2000; De Borger et al., 2002), while little attention has been paid to consider the question from multiple perspectives, e.g. the government, transit operator and passengers perspectives, which are important for the performance evaluation.

This paper has thus set our study against this backdrop. The research presented in this paper is based on a case study of 13 transit operators in Yangtze Delta Region (YDR) of China. Our goal is to develop a combined evaluation method (CEM) to evaluate the performance of public transit systems from multiple perspectives. The approach can provide some propositions in management for public transit operators so that their performance and

* Corresponding author. Fax: +86 21 52301396.
E-mail addresses: zcq044@163.com (C. Zhang), zcjuan@sjtu.edu.cn (Z. Juan), 34436933@qq.com (Q. Luo), 243139335@qq.com (G. Xiao).

http://dx.doi.org/10.1016/j.tranpol.2015.10.001
0967-070X/© 2015 Published by Elsevier Ltd.

management can be improved.

An interesting feature of transit operators is their multi-products capability using multiple inputs. Transit operators provide public transit services, such as passenger-kilometers and vehicle-kilometers, using number of vehicles, fuel, employees, and other inputs such as oil and tires. Hence, many researchers adopted a concept of assuming public transit services as production, and its efficiency by comparing multiple inputs and outputs (Shalaby, 1999; Khasnabis et al., 2002; Roy and Yvrande-Billon, 2007; Ottoz et al., 2009; Boitani et al., 2013). There are several methods to measure and assess performance. The methods can generally be classified as parametric and non-parametric tests. Parametric techniques entail certain assumptions on the functional forms of the production or cost functions. This motivated researchers to use non-parametric approaches that entail fewer such assumptions (García Sánchez, 2009). The non-parametric technique known as Data Envelopment Analysis (DEA) has been widely used to measure public transit performance. DEA was introduced by Farrell (1957) and popularized by Charnes et al. (1978). DEA uses a linear programming technique to measure the relative performance of production.

From the brief overview above, it is clear that previous studies used basic DEA model (including the CCR model and BCC model) to evaluate the performance of transit operators. The basic DEA model has not the desirable feature of differentiating between some of the efficient decision-making units (DMUs) that have identical efficiency scores equal to one. However, the super efficiency data envelopment analysis (SE-DEA) model addresses this issue (Seiford and Zhu, 1998). Based on the SE-DEA model that evaluates the performance of public transit operators, the dimensions of the input–output indicators are more closely related to the evaluation results. The number of the input–output indicators significantly affects the discrimination capability of the SE-DEA model. The excessive number of the input–output indicators causes an increase in the number of efficient DMUs and results in the lower model's discrimination capability. At the same time, using a small number of input–output indicators, the model is not able to reflect the performance evaluation adequately (Jenkins and Anderson, 2003). Therefore, the information entropy theory can be used to measure the degree of miscellaneous information supplied, where the greater the information entropy, the smaller the amount of information supplied. The smaller the role of a DMU in evaluating the efficiency, the smaller the weight should be assigned, and vice versa. Therefore, methodologically, the approach presented in this paper integrates the information entropy theory and SE-DEA model, we propose the combined evaluation method to reduce the risk of the SE-DEA model being affected by the dimensions of indicators, improve the method's discrimination capability, and obtain more objective evaluation results. Once these issues are resolved, the best performers as well as inefficient transit operators can be identified, and recommendations on strategies for public transit authorities can be made.

The efficiency results are highly dependent on the selection of inputs and outputs. Therefore, it is important to pay special attention to the choice of the indicators corresponding to the objectives of analysis. There are many indicators influencing the performance of transit operators. Any variable related to public transit systems can be taken as a potential indicator to evaluate their efficiency. The traditional inputs of public transit systems are capital, labor, and energy (Kerstens, 1996; De Borger and Kerstens, 2000; Odeck, 2006; Barnum et al., 2008; Sahoo et al., 2014). The outputs used to measure efficiency are usually vehicle-km, seat-km, passenger-km, passengers and operating revenue (Cowie and Asenova, 1999; De Borger et al., 2002; Karlaftis, 2004; Odeck, 2008; Sahoo et al., 2014). However, public transit systems may affect their stakeholders in many different ways. For example, transit operators strive to work within certain financial constraints, and passengers are concerned with their travel time and travel expenses. The approach presented in the paper has captured concurrently the multiple perspectives (e.g. the transit operator's and passenger's perspectives), which are very important for the evaluation of public transit system performance. Therefore, this paper integrates the public transit industry regulator, transit operators and passenger travel requirements to construct an evaluation indicator system based on satisfaction and efficiency to measure public transit service performance.

This research contributes to the literature on public transit service performance in the following ways. (1) The application of the CEM integrating information entropy and the SE-DEA model to measure public transit service performance is relatively undeveloped in the sense that few researchers have attempted to focus on these applications. (2) This paper takes into account various stakeholders of public transit system, and constructs an evaluation indicator system based on satisfaction and efficiency to measure public transit service performance. This research provides a comprehensive framework with the ability to account for various indicators and stakeholders simultaneously.

The remainder of this paper is organized as follows. Section 2 introduces the SE-DEA model and information entropy theory, and proposes the CEM, followed by a mathematical description of the basic idea of the CEM. Taking into account two perspectives (e.g. the transit operator's and passenger's perspectives), an evaluation indicator system based on satisfaction and efficiency to measure public transit service performance is provided in Section 3. Section 4 introduces the method of measuring passenger satisfaction, which serves as the outputs for the evaluation method. In Section 5, an illustrative example is presented together with the comparison of the two different evaluation methods. Finally, conclusions are addressed in Section 6.

2. Methodology

2.1. Overview of SE-DEA

The DEA is a non-parametric approach to measure efficiency based on Farrell (1957) article and extensions by Charnes et al. (1978) and Banker et al. (1984). The original model, proposed by Charnes et al. (1978) was called the CCR (Charnes, Cooper and Rhode) model. The original CCR is not flexible enough in the sense that it assumes constant returns to scale (CRS) in its production possibility set. In many applications, the researchers are interested in exploring the assumption of increasing returns to scale (VRS) other than constant. The VRS formulation of Banker et al. (1984) (BCC) was used in the study. The DEA is an analytical technique for measuring the relative efficiency of organizational or production units. It has been widely acknowledged for its strength of (1) capturing multiple inputs and outputs, (2) combining multiple performance dimensions, and (3) computing performance measurements that integrate data/information across multiple dimensions and input/output resources (Gattoufi et al., 2004).

The DEA identifies the empirical frontier that is constituted by the best practice units, and provides an efficiency/inefficiency score for each individual DMU. When the relative efficiency of the DMUs is measured based on the basic DEA model (including the CCR and BCC), it is possible to obtain the results where the multiple DMUs are relatively efficient at the same time. However, the basic DEA model cannot differentiate and rank them. The SE-DEA model (first provided by Andersen and Petersen (1993) and improved by others (Adler et al., 2002)) addresses this inadequacy and makes further comparisons and ranks the multiple efficient DMUs.

Download English Version:

https://daneshyari.com/en/article/7497543

Download Persian Version:

https://daneshyari.com/article/7497543

Daneshyari.com