Transportation Research Part A 106 (2017) 75–88

Contents lists available at ScienceDirect

Transportation Research Part A

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

Determinants of bus rapid transit (BRT) system revenue and effectiveness – A global benchmarking exercise

Rico Merkert*, Corinne Mulley, Md Mahbubul Hakim

Institute of Transport and Logistics Studies, The University of Sydney Business School, Sydney, NSW 2006, Australia

A R T I C L E I N F O

Keywords:
BRT
Effective bus service operation
Benchmarking
Performance measurement
DEA

A B S T R A C T

Bus rapid transit systems (BRT) have evolved in all shapes and sizes around the world in the last 30 years motivated by providing greater efficiency and value for money than potential alternatives. This paper aims to explore and compare the effectiveness (including its determinants) and revenue potential of 58 BRT systems globally. A key research question for this paper is to what extent there is a trade-off between long term capital expenditure and short term operating cost. The results suggest that BRT systems located in developing countries or countries that have high population densities are successful in generating higher revenues per passenger and unit of input than their conventional bus counterparts but are from a community perspective not more cost effective in doing so. Better BRT standards and hence higher capital expenditure, while significantly increasing patronage and input effectiveness do not have a significant impact on either yields or cost effectiveness. In contrast, public ownership and the number of stations are on average associated with higher cost effectiveness scores.

1. Introduction

The extent to which a transport system is considered to be cost inefficient and/or cost ineffective is of concern to transport operators, public transport (PT) authorities and regulators as PT systems play a significant role in the urban areas throughout the world (Mulley et al., 2014). Evaluating the operational performance of PT provides information on which to understand how potential improvements in efficiency, service quality/quantity (effectiveness) and financial plans can be implemented with potential implications for fare determination.

In common with other approaches to measuring performance, this paper compares multiple transport systems. However there is a specific emphasis on how the transport operator performs in terms of their service outputs relative to physical inputs and costs for the set of transport systems under consideration. Moreover, this paper is concerned with a comparison of the efficiency of Bus Rapid Transit (BRT) systems globally which is new to the literature in terms of mode and spatial coverage. The evaluation of BRT performance is important and timely as BRT systems have evolved from their early implementation in Lima (Peru) and Curitiba (Brazil) in the early 1970s to systems being built around the world in very different shapes and sizes. There are now over 190 cities with BRT systems of one form or another, carrying over 32 m passengers daily (BRTdata, 2015). Yet, many scholars still exclude BRTs when evaluating the use and performance of rapid transit systems (e.g., Shyr et al., 2017). This makes studying the efficiency of BRT systems both interesting and worthwhile as a basis for identifying best practice and providing opportunities for benchmarking.

* Corresponding author.
E-mail address: rico.merkert@sydney.edu.au (R. Merkert).

http://dx.doi.org/10.1016/j.tra.2017.09.010
Received 27 May 2016; Received in revised form 12 August 2017; Accepted 11 September 2017
0965-8564/ <outputStr5>

BRT is a rapid mass transit mode of PT which combines the speed and dependability of rail service through having access to dedicated infrastructure with the operating flexibility and cost effectiveness of a conventional/regular bus service[1] (Deng and Nelson, 2011). BRT systems have now emerged as a leading and popular mode of urban transport in many cities in the world (Darido, 2006; Wright and Hook, 2007; Hinebaugh and Diaz, 2009; Deng and Nelson, 2011; Vermeiren et al., 2015). As of August 2015, the cities implementing BRT have a combined total of 5112 km total system length (BRTdata, 2015). Beyond the cities already implementing a BRT system, there are many cities considering BRT as a cost effective and flexible way of rapid transit system given the lower initial capital cost, in relation to comparable rail based PT. However, significant differences exist among the BRT systems in terms of standard and practices. In particular, open systems have a framework where patronage is fed from neighbourhoods and funnelled onto dedicated trunk sections of the route (using the same bus) in contrast to a closed BRT system where passengers take conventional/regular buses to the dedicated BRT infrastructure and use interchanges to board vehicles using the dedicated trunk sections of the BRT system. Compared to conventional bus transport, BRTs are successful at offering speed, reliability and comfort improvements with these improvements being achieved by all or parts of the BRT trunk routes being operated on segregated infrastructure so that services are not affected by congested car traffic. Other elements of full BRT usually include high-frequency, high-capacity bus services, bus stop designs which emulate rail stations, off-vehicle fare payment and intelligent transportation systems both for informing passengers (e.g. real-time information), or for prioritising vehicles at junctions. These different levels of BRT characteristics come, of course, not only with benefits but also with costs. While BRTs cost more than conventional bus services, the cost is less than light rail solutions for equivalent contributions to the PT network. This is the rationale for considering BRT implementation (as compared to conventional bus) at different levels of infrastructure implementation so as to identify the determinants of BRT revenue generation and effectiveness. This work will support the work of ITDP (2014) which has attempted with their BRT Standard, underpinned by a scoring system, to provide a fairer and more transparent comparison of standards of different BRT systems.

Benchmarking reports for BRT systems around the world (such as Menckhoff, 2010; LeighFischer, 2011 or Nabavi and Leurent, 2011) have not delivered a comprehensive empirical performance analysis of BRTs that combines various inputs and outputs of such systems, with a particular focus on capital and ongoing costs and changes to revenue potential that comes with improved BRT standards/scores associated with higher standard systems. This means that there is no opportunity for systems within the set under consideration be able to learn from best practice. The analysis of BRTs to date is in the main based on published data, primarily the published data collected by the Observatory of the BRT Centre of Excellence (BRTdata, 2015), supplemented with data from other sources in the public domain and confidential data provided by the operators. The paper aims to identify what data is available and to contribute to the development of a methodological framework (extending Fielding's, 1985 work) that provides stakeholders with an opportunity to achieve international performance benchmarking of BRTs, including a better understanding of the determinants of BRT system effectiveness.

From a policy perspective, such benchmarking is important as, at the end of the day, it reveals whether stakeholders benefit from value for money. Particularly relevant are questions around the extent (if any) to which improved BRT standards generate additional revenues/patronage and how effectiveness gains can be made by a trade-off between one-off capital (fixed) costs of infrastructure and on-going revenue generating (variable) cost.

The paper is organised as follows. Section 2 presents the literature review and the identified gaps in the literature addressed by this paper. This is followed by the methodology and details of the sample used in this paper in Section 3. Section 4 discusses the results with Section 5 summarising the findings of the analysis and offering policy recommendations.

2. Literature review

In recent years, a considerable amount of research has been carried out in the area of efficiency and effectiveness of different transit systems (e.g. Chu et al., 1992; Kerstens, 1996; Viton, 1997; Mulley, 2003; Karlaftis, 2004; von Hirschhausen and Cullmann, 2010; Jarboui et al., 2015; Munoz et al., 2013; Tsai et al., 2015). At the early stage of PT performance research, Tomazinis (1977) measured the performance of PT systems by using simple indicators and evaluation of efficiency, productivity and quality of services. Fielding et al. (1978, 1985) adopted a framework and set service indicators (inputs, outputs and consumption) to evaluate the efficiency and effectiveness of PT performance as schematically shown in Fig. 1 (see next section). Efficiency in this framework refers to the total service outputs, usually measured by car-km travelled or car-hour operated with respect to service inputs (labour, fuel consumption, or operating cost) for rail-based systems, whereas effectiveness represents the service consumption by passengers, such as number of passengers, or passenger-km against service inputs. Cost efficiency is also referred to as supply-side efficiency in contrast to cost effectiveness which is also referred to as demand side efficiency. The ratio of service consumption to service outputs is defined as service-effectiveness, with the distinction between efficiency and effectiveness highlighting the different aspects of performance evaluation from the operator and consumer perspective, respectively. In a recent literature review on performance evaluation research in the context of PT Daraio et al. (2016) presented a similar framework confirming the importance of both efficiency and effectiveness in the sense of accounting for the relevance of different viewpoints of producers (efficiency), users (quality) and the community (effectiveness).

In terms of performance measurement approaches, scholars (e.g., Windle and Dresner, 1992) have used Partial Productivity Measures (PPM) which are intuitively easy for policy decision makers to understand and or communicate since they revolve around a

[1] In the remainder of the paper we use the term conventional buses which is interchangeable with the term regular buses and essentially represents bus operations that are not BRT.