



Invited Review

Efficiency and effectiveness in the urban public transport sector: A critical review with directions for future research



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ABSTRACT

This paper proposes a self-contained reference for both policy makers and scholars who want to address the problem of efficiency and effectiveness of local public transport (LPT), with special emphasis on urban transit, in a sound empirical way. Framing economic efficiency studies into a transport planning perspective, it offers a critical discussion of the existing empirical studies, relating them to the main methodological approaches used. The connection between such perspectives and Operations Research studies dealing with scheduling and tactical design of public transport services is also developed. The comprehensive classification of selected relevant dimensions of the empirical literature, namely inputs, outputs, kind of data analysed, methods adopted and policy relevant questions addressed, and the systematic investigation of their interrelationships allows us to summarise the existing literature and to propose desirable developments and extensions for future studies in the field.

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1. Introduction

The operation of public transport services has a significant impact on the budget of most territorial public bodies (central state, regions, provinces and municipalities). Moreover, in many cases only a small fraction of these costs is recovered through end user tickets and subscriptions. This expenditure of public money usually is justified both in terms of welfare efficiency and equity goals, given the pervasive socio-economic and environmental impact of transport. In terms of equity goals, a reasonable level of access to mobility services is unanimously considered an essential right in a democratic society. As far as efficiency goals are concerned, stakeholders are in fact usually interested both in the direct effects (improving the efficiency and the quality of the offer of the public transport system itself), and in the external effects such as reducing pollution and congestion and improving labour supply in urban centres. Most remarkably, these "external effects" often constitute the primary rationale for such interventions, both in the political arena, and in more technical analysis of the transport planning documents. The matter is not how much "output" one is able to produce given some input, but how the intervention impacts the transport system as a whole by modifying

environmental footprints, land use patterns or territorial accessibility and more generally, how the intervention affects a vector of social goals given its use of social resources. While this issue is usually considered when implementing strategic decisions, such as the construction of a new transport infrastructure, at the more tactical level this general vision is seldom implemented. Therefore, in the following we focus on such level, which on the other hand absorbs the majority of the resources that public bodies invest in public transport systems.

It should nevertheless be acknowledged that any evaluation method should consider this framework, in order to provide really useful indications to transport policy decision makers. We preliminary observe that at least two radically different approaches are used, both at the research and at the practitioner level, to make such kind of assessment, according to the disciplinary background of the analysts. Civil engineers and transport planners are usually conscious of the different implications that often underlie any investment in a public transport system and are interested in studying also the technical performances of the system itself. This generally leads to the definition of a set of indicators, since this method permits to jointly consider heterogeneous kinds of data (for example, public subsidies, commercial speed and decrease of pollutants emissions) in a rather straightforward way, on an analytical point of view, often involving simple mathematical operations. On the other hand, economists tend to apply efficiency analyses at a more aggregated level, using shadow

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prices of the social resources and a social welfare function to design intervention policies. Their methodologies are very insightful, allowing one to evaluate how well a Decision Making Unit (DMU) is operating, if, and how much the resources could be better used, and so on. As such, these tools are very useful for a public transport operator, like for any other firm, but from the more general point of view of the stakeholder need to be integrated according to the above described framework.

We believe that a promising avenue of research is to interface the analysis based on transport indicators, whose flexibility allows us to consider a wide range of data, such as cost drivers, output, levels of use and impact measures, with the efficiency analysis literature, a powerful analytical tool that is widely used in different fields both in the public and in the private sector to estimate possible improvements in the amount and mix of used resources and the trade-offs between output attributes. In other words, efficiency models could be enriched by considering as input and output variables some of the indicators that are used in the transport engineering field. For example, outputs could not only represent production amounts but measures of impacts, ranging from a decrease of emission of pollutants to an increase of territorial accessibility. To the best of our knowledge, a unified framework that jointly considers these two research areas is missing, and could provide insightful indications for researchers and policy makers.

To contribute in achieving this goal, our ambition is to provide a systematic analysis of the existing studies and elaborate a taxonomy of the main research questions, the main results and policy implications addressed in the literature by means of a careful study of the data, variables and methods applied in these growing fields of study. The most valuable output of our research will be a self-contained reference to researchers and policy makers interested in modelling and empirically investigating the local public transport (LPT) sector under their different perspectives and needs. We focus in the following on local public transport, since the operation of many long distance services (e.g. high speed trains, airline services or coaches) does not need public money in many countries, at least if we exclude infrastructures construction costs. On the other hand, most of local public transport services are provided in urban areas: therefore, we interchangeably use the two expressions “local public transport” and “urban public transport” in this paper.

The first step that we accomplish here is a critical review of the research carried out so far and dealing with efficiency analysis, in order to underline its common points with the research stream on transport indicators, to analyse in what they differ and to prospect how these two approaches could be improved and then integrated at best. To this purpose we collected and deeply analysed 124 papers, also extending and updating previous reviews examining economic efficiency studies in urban public transit (Brons, Nijkamp, Pels, & Rietveld, 2005).

Secondly, we analyse in detail the research questions, methods applied, input and output variables definitions, main results and policy implications of existing studies in order to present a general structure of the literature. This comprehensive frame will allow us to characterise the state of the art in the assessment of public transport systems efficiency and effectiveness.

The paper ends by enlarging the perspective of the study to another disciplinary field that is of primary interest for this Journal's readership, namely Operations Research (OR) and its applications to the tactical design of urban public transport services. Such methods can be seen as the counterpart of efficiency studies that are the main focus of the present review, since they are primarily used for the design rather than the evaluation of a service. It is however apparent that both aspects should take similar objectives and viewpoints for consistency reasons: therefore, we deemed it important to make a comparative assessment of the two fields within the framework sketched above.

The paper unfolds as follows. In Section 2 we describe the methodology of the review. In Section 3 we introduce the theoretical background of the analysis, whilst Section 4 discusses in details the main inputs, outputs and other variables used in the surveyed studies. Section 5 offers a schematic view on the main methods used in the empirical works and link them to the main variables analysed. Section 6 outlines the analysed data and Section 7 extends the perspective to the tactical planning of urban transit services. Finally, Section 8 concludes the paper outlining directions for future research.

2. Methodology of the review

Given the ambition of the present research of interfacing different disciplinary fields according to the above described framework, the bibliographic search aimed at retrieving the relevant papers both in the transport engineering and planning literature and among works dealing with efficiency analyses. However, we soon noted a connection between the latter group and an additional set of papers in the economic literature that are also of interest, since they deal with the impact of relevant issues such as deregulation processes on the efficiency of public transport services. The papers of interest for the present review have been therefore classified in the following three (broad and not completely fixed) preliminary categories, or lists:

- (A) *Evaluation of urban public transport systems through indicators.* Given the focus of the present research, we do not consider here papers dealing with strategic evaluation processes as explained in Section 1. Papers falling in this first list are mainly taken from the transportation engineering literature. We also privilege the stakeholder rather than the customer viewpoint, therefore not reviewing papers focused on service quality or customer satisfaction, even if indicators have been proposed also to deal with these latter aspects. Public transport quality issues are in fact more integrated in the economic efficiency analysis, and considering them would make this review overwhelmingly long and complex.
- (B) *Efficiency analyses of urban public transport systems,* usually found in the economic efficiency analysis literature.
- (C) *Other economic analyses* dealing with aspects related to the efficiency of urban public transport systems: *productivity, economic performances, cost structures, cost functions, subsidies, deregulation and privatisation, scale and scope.* Papers dealing with these issues are a lot, but we systematically disregarded those that do not discuss implications on efficiency, such as those merely describing deregulation and competition processes or designing and analysing pricing structures without reporting empirical evidences.

A search of the literature was carried out and a systematic search of the bibliographic references was also done, updated at the end of April 2014, on the Scopus database, by using a list of 33 relevant keywords (see Appendix A). The final number of papers retrieved for the analysis has been of 124, the oldest ones in each list (reported above as A, B and C) having been respectively published in 1974, 1977 and 1970. Each bibliographic item has been classified according to a grid that highlights the main relevant aspects of the analysed work to facilitate the systematic analysis of the different approaches, methods used and the comparison of the obtained results. More in detail, the fields in the grid summarise the information and classify each reference considering the following aspects:

- Paper reference.
- Objectives of the study.
- Method.
- Kind of data—this class includes eight sub-classes regarding the kind of data gathered (cross section, time series, panel) the size of the sample, the nationality and the geographical extension of the analysis.

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