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A methodology for assessing the feasibility of fleet compositions with dynamic demand

Antonio Placido*, Luca D'Acierno

'Federico II' University of Naples, Department of Civil, Architectural and Environmental Engineering, via Claudio 21, Naples 80125, Italy

Abstract

In the last twenty years, European Union has promoted liberalisation and competition within the rail system under EC Directive 91/440 and the Railway Packages concerned, and all Member States now try to pursue the difficult task of considering both public (sustainability, accessibility, employment, etc.) and commercial interests (profit, return on investment, growth). In this context, it is necessary to carry out analyses about rail services so as to gain useful information for increasing efficiency, effectiveness and productivity. In many cases, great importance has been attached to Key Performance Indicators (KPIs) which do not usually consider customer needs. This paper aims to promote a Decision Support System (DSS) for assessing rail services taking both service quality and performance indexes into account. In particular, the procedure is based on a microscopic simulation model combined to an assignment tool for assigning dynamically passengers to services. Thus, demand peaks, temporary capacity variations, temporary over-saturation of supply elements, and formation and dispersion of queues can be considered providing a more precise analysis of rail services. An application on metro Line 1 in Naples (Italy) is presented in order to explain the workings of the model. Numerical results demonstrate that this approach is very useful for planning or managing rail systems in accordance with passenger satisfaction and operational efficiency.

Keywords: microscopic simulation, travel demand assignment, rail service management, service quality, operational efficiency.

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* Corresponding author. Tel.:+39-081-768-3356; fax: +39-081-768-3946
    E-mail address: antonio.placido@unina.it

1. Introduction

The use of private vehicles in many of the major cities in Europe generates several negative externalities such as congestion, environmental pollution and accidents. Public authorities have therefore focused on the possibility of reducing such externalities by promoting rail systems: since in several contexts (such as in the case of high utilisation) it is more efficient than other public transport, this transport mode is extremely important in areas of dense population where rail lines may become strong competitors of private cars. It is thus necessary to ensure a high service quality so as to increase the attractiveness of rail and to support a favourable modal split. The European Union has been encouraging all Member States since the passing of EC Directive 91/440 to adopt measures in favour of competitiveness, sound financial management and debt reduction. Such measures are basically designed to increase the efficiency of the sector after the decline of the rail market share and the poor financial situation of many European railways during the 1980s. Furthermore, the Railway Packages have contributed to opening up the market and promoting interoperability and service safety, also if the impact on safety has yet to be proven and the execution of the packages in some cases threatens functioning systems or is subject national incumbents misusing their power.

In this context, public authorities are increasingly interested in the effectiveness of their investments which means that, although accurate financial management is required, the main task is to 'capture' the highest number of passengers. This is no simple task since the rail system is a complex world in which the many participants have different aims. For example, passengers would like to have rapid low-cost transport on schedule while train operators are interested in maximising the ratio between passenger-kilometres (i.e. carried passengers-kilometres) and seat-kilometres (i.e. maximum number of transportable passengers-kilometres) . By contrast, infrastructure managers are keen to maximise sales of train-kilometres and, at the same time, public authorities want the best use of the provided resources. Therefore, several surveys were carried out to define performance criteria which could evaluate effectiveness, efficiency and productivity of rail systems. Lan and Lin (2006), for instance, proposed a stochastic distance function to make a valuation of the service of 39 worldwide rail systems over the period 1995-2002. Nash and Smith (2007) made a general description of rail performance models considering index number approaches, econometric approaches and efficiency-based approaches. Smith (2012), on the contrary, focused on the difficulties of obtaining comparable data across countries and over time, and proposed stochastic frontier panel models to determine the efficiency of Network Rail against international best practice. Other studies dealt with the most important technical and economic indicators for performance analysis through benchmarking such as Hansen et al. (2013). Nevertheless, although they are very easy to evaluate, most of the key performance indicators (KPIs) focus on the operational aspects and do not consider user satisfaction which is extremely important to produce guidelines for improving the service. Indeed, the transportation service experienced by passengers (i.e. waiting time, crowding, delay time) is not directly analysed, which sometimes means the system is not properly managed. Furthermore, in their evaluation of rail operators the public authorities increasingly attach importance to service quality by making specifications as part of the concession contract. In Italy, for example, after two national laws known as D.Lgs. 422/97 and DPCM 30th December 1998, all transport companies are obliged to draw up a 'Service Charter' which states the quality policy (such as safety, security, service availability and comfort).

In this context the aim of the paper is to present a micro-simulation approach for planning or managing the rail system in any kind of service conditions, taking into account both user satisfaction and operator criteria. In fact, in this way, it is possible to give indications about how to provide a high quality service trying to minimise also operational costs. An application on Line 1 of Naples is also performed so as to show the effectiveness of the proposed approach.

The paper is organised as follows. In the second paragraph, the European and Italian legislation on service quality is discussed so as to underline the importance public authorities give to this theme. Then, a detailed description of the proposed model is presented. The following section shows an application on metro Line 1 in Naples. Finally, conclusions and future research prospects are presented.

2. Legislation for quality-based planning of rail systems.

In a tendering situation, public authorities specify the various criteria which regulate the public transport service. The European Committee for Standardization (CEN) has introduced recommendations and contents of agreement