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A tool for railway transport cost evaluation

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Abstract

After a compared analysis of different cost assessment methodologies with their mathematical formulations, the paper achieves a determination of cost functions (functions linking inputs with outputs) for an articulate estimation of regional railways investment and operating costs, in relation with existing and/or planned contexts, giving some example of reference points and orders of magnitude. The same methodology is then applied to compare calculated cost with some European regional operating costs (€/train-km).

Keywords: cost functions ; railway; investment costs; operating costs; €/TKM

1. Introduction

Besides its technical and infrastructural features, performance and environmental impact, the convenience of a given transportation technology must not leave out the correct assessment of its costs; this is by the way a priority when evaluating the efficiency, effectiveness and quality of an existing service, or calculating the needed resources to realize an action on system, or even when comparing different scenarios of a system's layout.

There are four characteristics of railways that make performance measurement particularly complex (Nash, 2000):

- multiplicity of outputs: an output needs to be described in terms of the provision of transport of a specific quality from a specific origin to a specific destination at a specific point in time. For a large national-scale railway, this means literally millions of products on offer and, of course, it is not possible to provide performance measures that separately identify each product;
- complexity of production process: rail technology is relatively complex, thus the production process includes multiplicity of inputs. Providing a rail service requires rolling stock, track, signalling, terminals and a variety

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of types of staff (train crew, signalling, track and rolling stock maintenance, terminals and administrations). A further problem related to this complexity is that of joint costs and economies of scale: for instance, a single track railway may carry both passenger and freight traffic, thus only some of the costs can be specifically attributed to one of the forms of traffic; the remaining costs are joint. Moreover railways are subject to economies of traffic density: putting more traffic on the same route generally reduces unit costs, unless the route is already heavily congested;
- geographic factors: gradient, climate and complexity of the network has a strong influence on railway performance through its impact on the nature of traffic carried;
- government intervention: for passenger service is not uncommon for governments to effectively control the timetable as far as the frequency of service on each route, either as part of a formal franchising agreement or via a public service obligation. In this situation the government becomes the customer, and the output the railway produces is a certain level of service, rather than transport for a number of people.

After a compared analysis of different railways cost methodologies, the paper proposes a set of cost functions for the articulate estimation of regional railways investment and operating costs in relation with existing and/or planned contexts. giving some example of reference points and orders of magnitude. The methodology is then applied to compare estimated cost with some European regional operating costs (€/train-km).

2. Literature cost models

Basically, a cost function *C* for a production level *y* (for example, the total amount of train kilometres per year, with an assumed capacity α of one train unit) can be determined as follows (Van Vuuren, 2002):

$$C(y) = c_0 + c_1 \text{ int } (y/\alpha) + c_2 y$$

where the three terms on the right-hand side correspond to sunk costs c_0, fixed costs c_1 and variable costs c_2, respectively, and for a given time horizon. Contrary to fixed costs, sunk costs cannot be eliminated, even at zero production level (examples are tracks and bridges). On the other hand, fixed costs are the kind of costs that are necessary for production, but do not vary with the output level (an example is the purchase of locomotives). In practice, it is not always clear whether costs should be categorized as sunk or fixed costs; the time horizon of the analysis is obviously crucial for this.

Knowledge of cost functions is essential for decision-making of transport companies and regulators of the public sector (Pels & Rietveld, 2000). The first ones need to achieve best results of companies objectives, whilst for the second ones, they have important implications for policies such as whether or not transport might qualify for subsidy, and whether the public sector should take special regulatory measures in markets to counter monopolistic tendencies.

Specialist literature concerning public transport systems proposes different ways to investigate costs (Tab. 1). Generally speaking, costs related with the production of a public transport service can be distinguished in *investment costs* (also known as *capital cost*), required for the realization or the purchase of components (for railways: infrastructure, rolling stock, installations, etc.) for the planned action, and *operating costs* (also known as *management costs)* including those for the operation and maintenance of transport service.

Amongst the studies particularly referred to railways and including both investment and operating costs, a paper from Baumgartner (2001) has to be mentioned. Moreover, a study about the reactivation of a railway line in central Italy (Santinelli, 2007) includes a basic indication of investment and operating cost for it. Ott (2001) compared infrastructure costs of road and rail. Mancuso and Reverberi (2003) studied operating cost and market organization in Italian railway services. A cost analysis for both investment and management costs in advanced public transport systems is proposed by Gattuso & Meduri (2006). Von Brown (2011) proposes a planning methodology for railway construction cost estimation in North America. A comparison of investment cost in