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A systems approach to access charges in unbundling railways

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ABSTRACT

This article presents a systems approach to access charges in unbundling railways where an infrastructure manager charges services to operators on an open market. The motive for this research is the fact that until now no universal model of access charges has been defined. We define a universal access charges model for an essential service package for a mid- and small-size network based on a systems approach to recovering the costs that are incurred as a result of the operation of a train. System elements are a railway network, trains and costs. Having in mind the system complexity a combination of an analytical and engineering approach has been used for access charges modelling. The model has been developed for a Serbian mid-size railway network and tested on real data. The numerical results of model application indicate that with charges defined in this way it is possible to track cost and cost management by services.

1. Introduction

The European Union (EU) railways have decided to open the railway market (directive 1991/440 as an act of EU) and to introduce competition among the operators on the railway infrastructure. This is, at the same time, a way to respond to the EU's demands for increased railway system efficiency and for a higher share of this system in modal share. With the reform of railways that requires a separation of historical railway companies into an infrastructure manager (IM) and an operator, the railway infrastructure ceases to be only a technical system and a cost category in the traffic management and operation of rail service. It becomes a special system which should be managed on a commercial basis. Now operators have to pay the access charges (AC) for railway infrastructure use to infrastructure managers. At the same time, these charges represent the infrastructure managers' instrument for achieving business operations efficiency.

Under EU directives (Directive 2001/14), types of services in railway infrastructure use are standardized. These are: essential service package (include charges for a minimum access package and charges for track access to the service facilities and supply of services), additional service and auxiliary service. An essential service package might include charges: for the scarcity, reservation, environment and others. However, access charges modelling are not restricted by either European transport policy or EU regulations. Each country is allowed to specify freely its access charges model, including the choice of an economic principle of charges. The marginal costs (MC), full costs (FC), full cost minus (FC−), marginal cost plus mark-up (MC+) and marginal cost + Ramsey (MC + Ramsey) principles has been recommended by European Conference of Ministers of Transport (ECMT, 2005).

Although twenty years have passed since the introduction of access charges, no generally acceptable universal model of charges has 'proved' to be recommendable for several reasons. One among the key reasons includes different sizes and complexities of railway networks, which are classified into small, medium and large, according to World Bank (2011) and Eurostat (2012).

In an attempt to eliminate some of the drawback from previous work, this research first reviews the access charges elements and cost modelling and application reported in the literature and then develops an access charges modelling algorithm based on a systems approach. As a result of systems approach, our access charges model consists of three modules: cost, network and traffic. An analytical approach, a combination of bottom-up allocation method and statistical distribution method, is used for cost module due to system complexity and data collection. Based on statistical data analysis of train serving in the node and direct attribution of traffic by train type and traction category to the nodes and sections, the traffic module is determined. The network is presented by an un-oriented graph where links and nodes represent specified network segments. The first objective of the access charges model is to formulate a relation of costs to a train type, traction category

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and network segments for an essential service package. The second objective is to permit the access charges model structured in this way to enable infrastructure cost management by services. The model has been developed for a Serbian mid-size railway network.

The model has been tested on real data collected on Serbia's railway network. Output results include the values of access charges for various passenger and freight train categories and weights, on various paths. A comparative analysis of the obtained access charges values by model and other European railway networks is given. The effect of a change in traffic volume and mark up on the coverage of total infrastructure cost is analyzed. The numerical results confirm that the defined universal model can serve as a tool for managing the coverage of total costs by revenues from charges for a mid- and small-size network.

An advantage of systems approach is that it observes the network characteristics, traffic volume and access charges principles as elements that influence modelling and recovering the costs in the framework of essential service package. In addition, it is not necessary to remodel access charges with increase of network efficiency and with changed economic principles. In this study, we restrict our attention to model advantages and applicability under European conditions. To become applicable to non-European railway networks, the model should be studied much more extensively.

The remainder of the article is organised as follows. In the second section, a literature review pertaining to access charges elements, cost management for network systems, cost modelling and access charges implementation is provided. The proposed access charges modelling framework is presented in the third section. This is followed by a detailed description of the model and its all three modules for the Serbian Railways which represent a mid-size network. In the fifth section, the application, results and discussion of the proposed model are given. Finally, conclusions and possible future research directions are presented.

2. Literature review

When reviewing literature in the field of access charges, one can note that the number of scientific research studies exceeds the number of publications in journals. The reasons are multiple and the most important are: the topic is very complex and requires a multidisciplinary approach; it requires research which needs extensive work and financial support; it concerns an area within railways to which until now no great attention has been paid. Studies in the journals which addresses problem of access charges can be systematized as the one that deals with the problem of defining access charges components, cost allocation scheme and infrastructure costs management and, implementation and structure of the access charge on the railway market.

In the literature treating the problems of components which might be the elements of access charges, the emphasis has been placed on the use of sophisticated econometric methods to estimate and determine infrastructure marginal or variable costs as a function of traffic volume (Andersson, 2011; Franklin, Nemtanu, & Teixeria, 2013; Gaudry & Quinet, 2009; Link et al., 2007; Thomas, Dionori, & Foster, 2003; Tisionas, Baltas, & Chionis, 2011; Wheat & Smith, 2008) or on describing and defining the costs of maintenance and renewal (Andersson, Smith, Wikberg, & Wheat, 2012; Gaudry & Quinet, 2009; Nash, 2005; Thomas et al., 2003) or on the estimation of mark up regarding different services (Gaudry & Quinet, 2009). In these researches the cost aggregate data and theoretical economic curves are used for defining a functional relationship between costs and traffic volume. Consequently, the application of these models and combination with others has an empirical difficulty in maintaining a high degree of freedom, so that these parametric approaches cannot produce a unique or general cost scheme. Gaudry and Quinet (2009) conclude that the application of regression curves for defining the relation costs – traffic volume is good method. But what about countries that have not tracked cost data for a long period? What concept to use? Some authors consider (Feldman & Shtub, 2006; Roy, Kelvesjo, Forsberg, & Rush, 2001) that there are three well-recognized cost allocation methods: analogous, bottom-up and top-down method. The application of these methods is guided by the type and complexity of a service, the precision required and data availability. Compare to the solution approaches reported in mention literature, our system approach integrate all costs, traffic and network elements to produce access charges scheme.

Over the last few decade many of papers has been devoted to operators' cost allocation whereas some infrastructure cost coverage was calculate or treated as a fixed value in that frame. Claessens, van Dijk, and Zwaneveld (1998) operator's cost allocation problem formulate as an integer nonlinear programming model and used infrastructure cost as fixed value. Tehrani Nejad Moghaddam and Michelot (2009) for joint cost allocation apply a linear programming approach and treat some of the infrastructure costs. Norde, Fragnelli, Garcia-Jurado, Patrone, and Stef Tijs (2002) use a game theoretical approach for cost allocation of infrastructure facilities. Butler and Williams (2006) use integer programming methods for the allocation of facilities fixed costs among a number of users. Lusby, Larsen, Ehrgott, and Ryan (2011) have begun to consider cost allocation problem in the context of timetable optimisation problems. A system approach based on statistical and engineering methods considered in our research enables all infrastructure costs allocation based on a current situation.

The literature that deals with the access charges implementation problem and its effects on a natural monopoly network, (Boskovic & Bugarinovic, 2011; Calvo & Oña, 2012; Clark & Easaw, 2007; Nash, Coulthard, & Matthews, 2004; Nikolova, 2008) gives reviews and analyses of the applies of access charges principles and access charges structures. Authors point out that the categorization of infrastructure elements is generally based on expert recommendations and access charges structures are very complex and often incomparable. Quite a few papers, however, have actually treated access charges structure development and it is shown in Table 1. As may be seen, there is a difference in the number of network elements as well as a considerable difference among the models developed. Network elements have been categorized according to desired network segmentation rather than according to network characteristics concerning cost homogeneity as considered in our research. Cost-based models have been developed for specific services and are adapted to the method of cost record keeping. Formulae do not reflect all costs that are incurred as a result of the operation of a train, so management of infrastructure based on costs is hard to realize. Therefore, the proposed AC structures in these papers are not directly applicable to the problem considered in our research.

Access charges for the use of railway infrastructure have been applied over the longest time in Sweden, Great Britain and Germany, so it is easy to understand why these countries have the widest experience in this area. To other countries, regarding the time/temporal gap in solving an issue of access charges, incomplete structured cost data, it is hard to compare their own models with the mentioned countries and to transpose their models, especially when small- and mid-size networks are in question. This conclusion is supported from the other aspects, definition of cost functions. For example, some authors in papers (Nash, 2005; Thomas et al., 2003; Andersson et al., 2012) deal with certain railway infrastructure cost in their countries and also explain that transposition of known cost functions are not appropriate because no extensive time series data are available, and there are instances