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Estimating the marginal cost of railway track renewals using corner solution models

Mats Andersson [a], Andrew Smith [b,*], Åsa Wikberg [a], Phill Wheat [b]

[a] Swedish National Road and Transport Research Institute, Department of Transport Economics, Box 920, 781 29 Borlänge, Sweden
[b] Institute for Transport Studies, University of Leeds, Leeds LS2 9JT, UK

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ABSTRACT

Economic theory advocates marginal cost pricing for efficient utilisation of transport infrastructure. A growing body of literature has emerged on the issue of rail marginal infrastructure wear and tear costs, but the majority of the work is focused on costs for infrastructure maintenance. Railway track renewals are a substantial part of an infrastructure manager's budget, but in disaggregated statistical analyses they cause problems for traditional regression models since there is a piling up of values of the dependent variable at zero. Previous econometric work has sought to circumvent the problem by aggregation in some way. In this paper we instead apply corner solution models to disaggregate (track-section) data, including the zero observations. We derive track renewal cost elasticities with respect to traffic volumes and in turn marginal renewal costs using Swedish railway renewal data over the period 1999–2009. This paper is the first attempt in the literature to apply corner solution models, and in particular the two-part model, to disaggregate renewal cost data in railways. It is also the first paper that we are aware of to report usage elasticities specifically for renewal costs and therefore adds important new evidence to the previous literature where there is a paucity of studies on renewals and considerable uncertainty over the effects of rail traffic on renewal costs. In the Swedish context, we find that the inclusion of marginal track renewal costs in the track access pricing regime, which currently only reflects marginal maintenance costs, would add substantially to the existing track access charge. EU legislation requires that access charges reflect the 'costs directly incurred as a result of operating the train service', which should include a marginal renewal cost component. This change would also increase the cost recovery ratio of the Swedish infrastructure manager, thus meeting a policy objective of the national government.

1. Introduction

Marginal cost pricing of transport infrastructure wear and tear is of great importance from an economic efficiency standpoint. Over the last decade, research on the subject has gradually increased for all modes of transport (Nash and Sansom, 2001; Nash, 2003; Thomas et al., 2003; Nash and Matthews, 2005; Wheat et al., 2009). One of the reasons for the renewed interest in the marginal cost of rail infrastructure costs has been the move in European railways towards vertical separation of rail infrastructure from train operations, driven by successive European legislation. This legislation requires countries to set rail infrastructure charges based on the direct cost of running different services, including: additional "wear and tear" costs of running more trains; scarcity charges; and environmental charges. Non-discriminatory mark-ups are also permitted.

* Corresponding author. Tel.: +44 0 113 34 36654.
E-mail address: a.s.j.smith@its.leeds.ac.uk (A. Smith).

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The changed model for organising rail transport in Europe has therefore created a key research need; namely to estimate the direct cost of running extra traffic on the network.

Sweden was the first country to undertake such a separation in 1988, with the rest of Europe following later, to a greater or lesser extent (see Nash and Matthews, 2009). The Swedish Railway Act stipulates two types of charges for the use of infrastructure (Banverket, 2009). Firstly, special charges, either covering the fixed costs of the infrastructure, or costs occurring when new infrastructure has been built as a special project. The second type is based on short run marginal costs. In turn, there are three different types of marginal cost based charges; the track charge, the accident charge and the emission charge. The first, and for our purposes most interesting, is the track charge, which mirrors the maintenance costs incurred by one additional tonne movement as a result of wear and tear on the network.

Importantly, to date, the wear and tear track charge has not taken into account incremental renewal costs. EU legislation requires that access charges reflect the 'costs directly incurred as a result of operating the train service', which should include a marginal renewal cost component. A renewal is an activity that will restore the infrastructure to its original standard. Renewals and maintenance are linked in such a way that lack of maintenance will force the infrastructure manager to renew at an earlier stage than if maintenance were undertaken properly and vice versa. An optimally managed railway track has a mix of maintenance and renewal in time over the life cycle and excluding renewals from the total picture of marginal infrastructure costs is therefore misleading.

More generally, most research on railway infrastructure wear and tear has focused on the relationship between maintenance costs and traffic, while controlling for infrastructure characteristics (see, for example, Wheat and Smith, 2008). The lack of empirical evidence concerning the size of marginal renewal costs has therefore recently drawn some attention in the literature and amongst policy makers (see Nash, 2005; Wheat et al., 2009).

Data on rail maintenance and renewal costs, outputs and network characteristics are typically recorded by rail infrastructure managers at the level of individual track sections. In the rail marginal cost estimation literature, a track section represents the most disaggregate level at which cost data are recorded. In the case of this study, it is defined by the national track information system (BIS), administered by the Swedish Transport Administration (Trafikverket). However, as track renewals have long life cycles and therefore are rare events, disaggregate renewal cost data contain many zero observations – that is, no renewal is undertaken for a given track section in a given year.

In the small number of previous econometric studies on marginal renewal costs, this problem has been addressed by combining maintenance and renewal costs to create a measure of total costs (thus eliminating the zeros); see Andersson (2006, 2007a), and Marti et al. (2009). Alternatively, modelling has proceeded at a less disaggregate level (regional or even national, for a number of countries), thus eliminating zero renewal costs; see Wheat and Smith (2009), Smith (2008) and Smith et al. (2008), though again maintenance and renewals have been combined in the reported, preferred models. Both types of aggregation merely mask the problem of zero renewals. The result is that renewal cost elasticities have to be inferred from models based on maintenance and renewals combined, and there is therefore currently much uncertainty over the range of appropriate values to be used.

As an alternative way of circumventing the problem, Andersson and Björklund (2012) applies survival analysis to estimate a deterioration elasticity with respect to traffic (tonnage) running on the network. Marginal costs are calculated as the change in the present value of renewal costs from premature renewal following increased traffic volumes. One disadvantage of this approach is that it requires an assumption to be made about unit renewal costs in order to compute marginal costs. The latter is non-trivial given the considerable unit cost variation associated with different types and volumes (as unit costs vary with scale) of renewal work.

Given the lack of previous evidence on marginal renewal costs, and the associated methodological problems experienced in previous studies, new approaches to the problem and new evidence are called for. In this paper we utilise an alternative set of econometric models that are workable even for disaggregate data with a large proportion of zero renewals (Tobit, Heckit and the two-part model). These approaches derive marginal costs directly from the econometric cost model, based on actual cost data (avoiding the aforementioned problems associated with survival analysis), whilst ensuring that the zero data observations are utilised and modelled appropriately to ensure consistent estimates of the model parameters (a more satisfactory approach than simply aggregating the data). We explore the results of these alternative approaches using Swedish railway track renewal cost data.

This paper is the first attempt in the literature to apply corner solution models, and in particular the two-part model, to disaggregate renewal cost data in railways (characterised by a data structure comprising a large fraction of zero values for the dependent variable) and thus derive usage elasticities specifically for renewal costs.[1] We consider this to be an important addition to the literature, particularly given the paucity of studies on marginal renewal costs in general and the importance of this cost category in the context of setting track access charges in vertically separated rail systems. The methods used in this paper, whilst not previously applied in the context of rail renewals marginal cost estimation, have been widely applied in transport applications more generally (see for example, Train, 1986; Mannering and Hensher, 1987).

The paper is organised as follows. In Section 2, we introduce the modelling approach followed by a description of the data set in Section 3. Section 4 covers the econometric specifications and results, while in Section 5 we discuss the results and draw some conclusions.

[1] The term 'usage elasticity' was first used by Wheat et al. (2009) to refer to the elasticity of cost (be it maintenance and/or renewal) with respect to traffic.