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Effects of timetable related service quality on rail demand

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ABSTRACT

This paper is concerned with the suitability of and component weightings within the composite index Generalised Journey Time (GJT). GJT is used to model rail demand in Britain and is composed of station-to-station journey time, service headway and a penalty for the need to change trains. We analyse a large data set of rail ticket sales data to explore three features of GJT. The first is to determine how GJT impacts on rail demand, including interactions with distance and value for money and exploring the effects of the size and sign of the change in GJT, distinguishing between short run and long run effects. The new evidence obtained was important given concerns over the elasticities previously recommended for use in the rail industry in Britain. Secondly, we provide evidence as to whether the weights associated with headway and interchange in GJT are appropriate. Our analysis indicates that more influence should be attached to interchange. Finally, the rail industry in Britain's approach of using GJT and fare is quite unique. We have tested how it compares with the more traditional approach of generalised cost and with the specification of separate elasticities to the component parts of GJT. This indicates that the GJT approach is preferable to the more conventional approach although there would seem to be value in further pursuing separate elasticities to the components of GJT.

1. Introduction

Generalised Journey Time (GJT) is a concept unique to the railway industry in Britain and from the earliest forecasting applications in the 1970s it has been used as a means to represent the overall timetable related service quality of a train service. GJT is made up of: station-to-station journey time, including any time involved in interchange[1]; a frequency penalty, reflecting the inconvenience of not being able to travel at the desired time; and a penalty for each change of train during the course of a journey. Its background stemmed from an identified need to be able to represent overall attractiveness across diverse train services with, say, a mix of limited through services, connecting services of varying speeds and numbers of required connections, and highly irregular service intervals. Whilst service patterns are now generally much more homogenous across journey time, interchange, and departure times, GJT remains an important representative measure.

The rail industry in Britain has long adopted an apparently unique practice of using separate fare and GJT terms in forecasting demand as set out in its Passenger Demand Forecasting Handbook (PDFH). The latter document (ATOC, 2013), first introduced in 1986, is perhaps unique amongst rail organisations worldwide in recommending a comprehensive forecasting

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[1] Unlike standard transport planning practice, this connection time does not have some premium weighting but is treated the same as on-train time, and this can be seen as a shortcoming of the approach. The reason for this is historic; in the early years of application, distinguishing connection time from station-to-station time was not feasible in the computer models dealing with a large number of flows offering very diverse service patterns.

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framework and associated demand parameters based on a distillation of best available evidence to provide a consistent basis for strategic business planning and the appraisal of important pricing and investment decisions.

The purpose of this paper is to investigate the functional form and weight estimates for GJT using sales data for non-season tickets and for station-to-station movements not involving London. We build an econometric panel data error correction model and divide our analysis into three parts.

- First, we examine the GJT elasticity in somewhat more detail than is customary, examining whether the response to changes in GJT differs depending on the size and sign of the GJT change and if the response is a function of trip distance and value for money of travel (in terms of fare).
- Second, we consider whether the current formulation of GJT specifies the appropriate weights by estimating a model with freely varying weights.
- Third, we consider whether it is better to dispense with the GJT concept and either replace it with separate components (no index function) or alternatively add GJT to fare via some exogenous or endogenous weight to form a Generalised Cost model.

Therefore this paper is concerned with how timetable related service quality - namely journey time, frequency and interchange - impact on rail demand, in terms of the extent that the current index function, GJT, is appropriate. It does not consider the influence on demand of other service attributes, such as crowding, rolling stock and travel time reliability, as these enter outside of GJT index. Whilst the results are derived for GJT in the British context, there is wider applicability to the use of indices, the most common of which is generalised cost, that are widely used in transport planning practice.

The structure of this paper is as follows. Following this introduction, Section 2 details the railway context of GJT (Section 2.1), previous research into the elasticity associated with GJT and the weights comprising it (Section 2.2) and new research needs to which this paper addresses (Section 2.3). Sections 3 and 4 outline the data and methodology respectively for our study. Section 5 discusses the results and Section 6 concludes.

2. Background

2.1. Generalised journey time in the British rail sector

GJT stemmed from the need for an index to represent the timetable related attractiveness of train services which have somewhat different journey times, departure time profiles and interchange requirements across the day (Tyler and Hassard, 1973). Ultimately this paper is concerned with whether this is a reasonable index method and if there are indices (either in terms of GJT or generalised cost) which better capture service heterogeneity.

The demand function in rail (and other) direct demand models is typically specified in constant elasticity. It takes the form:

$$V = \mu GJT^{\lambda} F^{\gamma} GVA^{\delta} \tag{1}$$

where λ is the GJT elasticity, γ is the elasticity to fare (F), δ is the elasticity to income (GVA) and μ represents all other factors that determine the number of rail trips, which in turn could comprise a set of further covariates, such as price of other modes. GJT is constituted as:

$$GJT = T + \alpha H + \beta I \tag{2}$$

T is the station-to-station journey time, including any interchange connection time. The frequency penalty (α) and interchange penalty (β) convert service headway (H) and the number of interchanges (I) into equivalent journey time.[2]

By way of background, the frequency penalty covers a mix of random arrivals at the station when service frequencies are higher, whereupon wait time is the relevant measure, and planned arrivals and hence displacement time values at lower service frequencies. So using a value of wait time that is twice in-vehicle time, as is customary, the frequency penalty is equal to one at higher service frequencies where wait time is half the service interval. A value of displacement time of either 0.2 or 0.4 is used for planned arrivals, depending upon journey purpose, along with a 'planning penalty' of 15 min. So for a 30 min headway, the frequency penalty is in the range 0.70–0.90 and for an hourly service it is in the range 0.45–0.65.

The interchange penalties used in PDFH are unlike those typically used in transport planning which tend to be of the order of a few minutes to reflect the pure inconvenience and risk related aspects of interchange independent of any connection time. In PDFH, and for historic reasons, connection time has not been separated from station-to-station time. Given that connection time is regarded to have a premium valuation, the interchange penalty used therefore proxies for the unweighted connection time. In addition, there is an allowance for distance, justified on the grounds that otherwise the effect of a fixed interchange penalty within GJT is too small for longer distance journeys. By way of illustration, and for non-season tickets, the recommended interchange penalties for 30, 100 and 200 mile journeys are respectively 19, 40 and 65 min.

[2] Note that for convenience we here represent the frequency and interchange penalties as constants when in PDFH the former are a function of the service interval and ticket type and the latter are a function of distance and ticket type.