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Valuing of attributes influencing the attractiveness of suburban train service in Mumbai city: A stated preference approach

Debasis Basu [a,*], John Douglas Hunt [b,1]

[a] Urban Land-use and Transportation Center of The Institute of Transportation Studies, Dept. of Environmental Science and Policy, University of California at Davis, 1 Shield Avenue, Davis, CA 95616, United States
[b] Dept. of Civil Engineering, University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada T2N 1N4

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ABSTRACT

The paper presents valuing of qualitative and quantitative travel attributes influencing the attractiveness of suburban train service in Mumbai city, India. A stated preference experiment is designed to capture the data of sub-urban train mode choice behavior. The behavioral data are analyzed using different modeling techniques such as multinomial logit (MNL) and mixed logit (ML). In ML model, the random parameters are assumed to follow constrained triangular distribution, where mean equals its spread. The decomposition of preference heterogeneity around the mean estimate of random parameter is also investigated using ML model. The study shows the influence of headway time and train ride time associated with a particular crowding level (expressed in density of standing passengers/m^2) in choosing the sub-urban train mode by calculating their willingness-to-pay (WTP) values and highlights the importance of WTP for addressing policy issues in the reduction of in-vehicle crowding level. The present study documents new findings of the effect of crowding level on train ride time in the context of a developing country and suggests some important directions for future suburban train transport crowding valuation research.

1. Introduction

Public transport in Mumbai city, India involves the transport of millions of its daily commuters by train, road and water. Over 88% of the daily commuters in Mumbai city use public transport. The Mumbai suburban train system is a part of the public transport system, which carries more than 6.6 million commuters on a daily basis. It has one of the highest passenger densities of any urban railway system in the world. Under this circumstance, estimation of user benefit becomes an essential prerequisite for evaluating the attractiveness of suburban train service and for addressing policy issues for improvement of train transport service. In order to estimate user benefit, valuing of train travel attributes becomes an essential part.

There is a wide range of attributes influencing perception of the quality of train service. A review of these attributes such as train fare, ride time, headway, wait time, walking distance, and number of transfers, were documented by Litman (2008) and Taylor and Fink (undated). Availability of seat and crowding level were also identified as other important attributes. It was sometimes discussed as comfort or quality of service (Transfund New Zealand, 1998; Syed and Khan, 2000; Litman, 2008). But among all these attributes, level of crowding is identified as an important attribute for the quality of service of

* Corresponding author. Present address: School of Infrastructure, Indian Institute of Technology Bhubaneswar, Samantapuri, Bhubaneswar 751 013, India. Tel.: +91 6742306361.
E-mail addresses: basudebasis2k@gmail.com, dbasu@iitbbs.ac.in (D. Basu), jdhunt@ucalgary.ca (J.D. Hunt).
[1] Tel.: +1 403 220 8793; fax: +1 403 282 7026.

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public transportation system (Lam et al., 1999). A reduction in crowding level is acknowledged as an improvement in the service quality of public transportation (Whelan and Crockett, 2009; Li and Hensher, 2011a). Level of crowding in train service has not received much attention, even though it is often identified as most influential attribute for the improvement of its service quality. It is also considered as a dominant component in the design of new rail system (Hensher et al., 2011). The opinion survey of transit users in Calgary revealed that overcrowding was the most frequently given reason for discontinuing train service (Calgary Transit, 2006). Repeated similar surveys in New South Wales in Australia found that in-vehicle crowding was consistently the main source of disappointment in train services (ITSRR, 2005a, 2005b, 2006, 2007). In reality, the level of crowding covers a range of condition, from the low end, where the issue is use of available seats to the high end, where the issue is of standing passenger in dense condition. Train travel in a crowded condition is understood to incur additional travel disutility relative to the same amount of trip time in an un-crowded condition (Li and Hensher, 2011a). Therefore, train ride time in association with a particular crowding level is believed to affect the attractiveness of service quality of train travel. Sometimes the average ride time of a traveler becomes critical factor for evaluating the attractiveness of a train service, where train carries almost "super dense crush" loads with passenger densities reportedly as high as 14 or more persons/m^2. Therefore, in the present study an attempt has been made to measure the values of travel attributes, specifically the effect of crowding level on train ride time. Valuing in-vehicle crowding level is one of the key research focuses in this study, where crowding is considered as a high agenda for policy issues for improvement (i.e. reducing in-vehicle crowding level) of sub-urban train service in Mumbai. Valuing of train travel attributes may vary depending on the utility model specification and modeling technique adopted. Besides it may also be influenced by one or more socioeconomic characteristics of train travelers.

Several works have been reported in the literature on valuation of travel attributes either using revealed preference (RP) or using stated preference (SP) data (Adamowicz et al., 1994; Hensher, 1994; Jose Holguin-Veras, 2002). However, for in-vehicle crowding valuation studies, SP data (Polydoropoulou and Ben-Akiva, 2001; Douglas and Karpouzis, 2006; Lu et al., 2008; Whelan and Crockett, 2009) are found to be the dominant data paradigm, where logit models (primarily multinomial logit-MNL) were employed. In the present work, SP data are used for valuation of train travel attributes. The SP data may be collected either in the form of rating, ranking or choice. In the present study, ranking based method is adopted for collecting the SP data. The best ranked alternative is actually considered to be chosen by a respondent, which can be considered as a fair assumption in this study. Initially the behavioral data are analyzed using multinomial logit (MNL) model. The MNL model is unable to represent the variation in the perception of travel attributes across travelers. Besides travelers' perception on level of crowding also changes, when the person is standing comfortably or standing in dense situation. This unobserved taste heterogeneity at individual level also becomes important in representing appropriate willingness-to-pay (WTP) values for improvement of train service quality. Li and Hensher (2011a) indicated that none of the studies addressed this issue in detail. Therefore, mixed logit (ML) model is also used to reveal both the observed and unobserved preference heterogeneity in the perception of travel attributes including the effect of a crowding level across travelers. In this study, the results contribute to both theory and practice regarding the representation and design of train service both in Mumbai city and more in general.

2. Methodology

Discrete choice models have been used repeatedly for valuation of travel attributes (Hensher, 2001a, b, c; Cherchi and Ortuzar, 2003; Jara-Diaz and Guevara, 2003; Cirillo and Axhausen, 2004; Sillano and Ortuzar, 2005). A brief background of two types of discrete choice models attempted in the present study is given below.

2.1. Theoretical basis

In econometric models based on random utility theory (McFadden, 1974), the utility of each element consists of an observed (deterministic) component denoted by V and a random (disturbance) component denoted by ε.

If the random error terms are assumed to follow extreme value type I (*Gumbel*) distribution, and be independently and identically distributed (IID) across alternatives, individuals and (also even choice situations or cases), then the probability of choosing alternative '*i*' by an individual '*n*' can be obtained by multinomial (or conditional) logit (MNL) model (McFadden, 1974; Ben-Akiva and Lerman, 1985; Train, 2003).

$$P_{in} = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{in}}} \quad (1)$$

The above model is estimated by maximum likelihood technique. The model is restrictive in nature as there are limitations like the assumption of random disturbances is independent across alternatives, individuals (and also even choice situations), and the coefficients of all attributes are assumed to be the same for all respondents in a choice experiment. In reality, the coefficients of attributes vary across individuals, which can be estimated using less restrictive random parameter logit model.

Revisiting the basic utility function it can be said that, the utility associated with each alternative '*i*', as evaluated by each individual '*n*' is represented in discrete choice model by a utility expression as