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Re-estimating UK appraisal values for non-work travel time savings using random coefficient logit model

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Abstract

The official appraisal values of travel time savings (VTTS) for non-work trips in UK were estimated by basic discrete choice model on stated choice data collected over 20 years ago. This choice model developed by Bates and Whalen (2001) was specified to address some long-standing issues in the field of VTTS valuation including the sign and size of VTTS while allowing continuous interactions between VTTS and journey covariates. With respect to the size issue, it was found that a "tapering" function, whereby time changes are increasingly discounted, could best explain the lower unit utility observed for small time savings (STS). While this set of non-work VTTS is still being used for transport appraisal in UK, the field of discrete choice modelling has evolved significantly brought by a leap of computing power and improved simulation techniques. Notably, advanced model such as mixed multinomial logit (MMNL) has been widely used to facilitate more realistic travel behavioural modelling by explaining random taste heterogeneity across respondents, which cannot be achieved in a deterministic manner. Also, techniques in specifying such model for VTTS valuation are well established by researchers nowadays. The key objective of this research was then to apply the MMNL model and re-estimate the current UK VTTS within a random coefficient logit framework. Alongside the theoretical discussions, this paper presents a synthesis of empirical evidence to support an updated appraisal value for non-work travel time savings in UK. Some key findings from this paper include a much higher mean value for the VTTS and the significantly reduced "perception effect" for the STS. In particular, this research found that MMNL model substantially reduces the "tapering" parameter of the discounting function for STS such that the "perception effect" of the VTTS becomes minimal. This finding suggests that travel benefits due to STS should be included for transport appraisal and it challenges some appraisal frameworks for countries like Germany where VTTS are discounted or even completely ignored for STS.

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Keywords: value of travel time savings, small time savings, random taste heterogeneity, mixtures of distributions

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1. Introduction

For many years, high computing costs have created significant obstacles to estimate discrete choice models with flexible specifications such as multinomial probit and mixed multinomial logit (MMNL) models. Amongst these two advanced models, MMNL model is gaining more attention in particular and has become the current state-of-the-art approach (Hess, 2005; Hess et al., 2005), largely facilitated by advances in computing power and simulation techniques in the past decade. Its advantage also lies in the capability to replicate correlation structure of any type of GEV model (McFadden and Train, 2000).

In the field of VTTS valuation, MMNL has already been applied to capture random taste heterogeneity (i.e., variation of VTTS) across respondents. These MMNL models typically assume a mixing distribution to represent the VTTS distribution as a ratio between marginal utilities of travel time and cost in preference space (Algers et al., 1998; Hess et al., 2005; Hess et al., 2008). This research was motivated by these preceding applications and it aims to compare VTTS estimates produced by the basic and advanced choice models.

Two non-work trip purposes, namely commuting trips and other trips, were modelled in the last UK VTTS study by AHCG (1999) and Mackie et al. (2003). For this research, only commuting trips were modelled to narrow the focus such that different MMNL modelling techniques can be exploited to investigate the differences in VTTS due to advanced choice modelling. It should be noted that this research primarily focuses on the comparison of choice modelling methods and is independent of the official VTTS updates being undertaken by the UK Department for Transport at the time of writing.

The remainder of this paper is organised as follows. Section 2 first presents an overview of the mixed logit model concepts. Section 3 summarizes the MNL model specification and findings from the 2001 UK VTTS study. Section 4 provides a summary of MMNL model results and discusses issues involved throughout the modelling process. Section 5 concludes.

2. Theoretical Underpinnings

2.1. MMNL model

The main motivation of the probability mixture model is to mix up different standard and restrictive functions to generate more flexible functions (Walker and Ben-Akiva, 2011). For mixed logit, probability distribution takes integrals of logit probabilities over a density imposed by researcher. It is expressed as:

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta \tag{1}$$

Where $L_{ni}(\beta)$ is the logit probability for decision maker *n* who chooses alternative *i* amongst *j* alternatives. This logit probability is evaluated at parameter β and $f(\beta)$ is a mixing density distribution. Assuming the systematic part of utility takes into a linear form of $V_{ni}(\beta) = \beta' x_{ni}$, the MMNL probability thus becomes:

$$P_{ni} = \int \left(\frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \right) f(\beta) d\beta \tag{2}$$

The MMNL logit probability is effectively a weighted average of the logit formula weighted by the mixing density $f(\beta)$ (Train, 2009). There are two types of MMNL model specifications, namely, random coefficient logit (RCL) and error component logit (ECL) models. They are mathematically equivalent in modelling terms but differ in their functional forms. RCL model is a more commonly used structure which is more suitable for this research to capture random taste variation by assuming the parameter vector β randomly distributed according to a mixing distribution. On the other hand, ECL model is mostly specified to model appropriate substitution pattern by allowing inter-alternative correlation.

The mixing function $f(\beta)$ could be a continuous or discrete distribution. Continuous distribution is commonly used for discrete choice analysis using MMNL but the integrals in choice probability are not in closed-form. As such,