



A framework for capturing heterogeneity, heteroskedasticity, non-linearity, reference dependence and design artefacts in value of time research



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ARTICLE INFO

Article history:

Received 10 June 2016

Revised 2 November 2016

Accepted 3 November 2016

Available online 10 December 2016

Keywords:

Value of time

National studies

Discrete choice

Random heterogeneity

ABSTRACT

In early 2014, the UK Department for Transport (DfT) commissioned the first national value of travel time (VTT) study since the mid-1990s. This paper presents the methodological work undertaken for this study, with important innovations along a number of dimensions, both in terms of survey design and modelling methodology. Our findings show a rich pattern of heterogeneity across the travelling public, in terms of an impact on the VTT by both person and trip characteristics, as well as a major role for a number of characteristics that relate to the specific choices faced in a hypothetical stated choice setting, including reference dependence and non-linearities in sensitivities. We also discuss how these behavioural values were translated into values for use in appraisal, and the challenges faced when doing this on the basis of results obtained with advanced models.

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1. Introduction

Many countries conduct national value of travel time (VTT) studies to produce official values for use in appraisal (see the review by [Daly et al. \(2014\)](#)). There have been three previous waves of such studies in Britain. First, a series of research projects during the 1960s and 1970s, the results of which were adopted and synthesised by the Department for Transport (DfT). Second, the MVA/ITS Leeds/TSU Oxford study of the 1980s leading to revised values of travel time in 1987. Third, the AHCG study of using 1994 data ([AHCG, 1996](#)) which was further analysed by ITS Leeds ([Mackie et al., 2003](#)).

Whilst routinely updated for changes in income and travel patterns, the evidence base for the values used in UK appraisal is now more than twenty years old. Along with changes in incomes, prices, demography and the mix of travel by purpose and trip length, the world has changed in other ways – the internet revolution, the quality and comfort of vehicles, working practices and, perhaps most fundamentally, the way in which people perceive time spent travelling. These substantive developments challenge the credibility of simply updating values based on old behavioural data.

Furthermore, whilst the existing set of behavioural values were obtained with methods that represented the state of the art in 1994/2003, the fields of stated choice data collection and discrete choice modelling have also seen substantial developments in the subsequent years, making the toolkit from the previous study very outdated. These developments include the growing popularity of more statistically efficient stated choice design techniques (see e.g. [Rose and Bliemer \(2014a\)](#), for an overview) and the availability of ever more flexible discrete choice structures (see e.g. [Train \(2009\)](#), for an overview).

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Along with these developments in choice modelling more broadly, there have been substantial improvements to the statistical techniques used in national value of time studies, most notably starting with the work of Fosgerau et al. (2007a).

Against this background, a new study was conducted in 2014/2015¹ to meet DfT's requirement 'to provide recommended, up-to-date national average VTT measures using modern, innovative methods'. The work conducted in the course of this study did not simply apply the best currently available methods, but made further methodological improvements. This paper presents an overview of the data collection work conducted and then focusses primarily on the modelling work undertaken, presenting our approaches to capturing reference dependence, non-linearities in preferences, and deterministic and random heterogeneity across travellers. Finally, we discuss the way in which these behavioural values were translated into values for use in appraisal, and highlight the challenges that can be faced in that context when working with advanced model structures.

The remainder of this paper is organised as follows. Section 2 gives an overview of the survey work conducted, Section 3 presents the modelling work, Section 4 outlines the results and Section 5 discusses the application of the modelling results to derive values for scheme appraisal. Finally, Section 6 presents our conclusions.

2. Survey work

Stated Preference (SP) data was collected for the three key purposes required for the appraisal framework (commute, travellers in the course of business and other non-work) and for four modes (car, rail, bus, other public transport (PT)²). The aim of the survey work was to provide valuations not just for travel time, but also travel time reliability and the quality of the travel experience (e.g. crowding). While work for example in Australia routinely values all these components in a single SP game, this study was required to adhere to the UK and European tradition of using a number of separate games, each looking at a subset of the journey components. Unlike previous studies, we ensured a greater representation for the more complex games, and also used joint estimation across the games.

For each purpose-mode combination, multiple SP experiments were developed, involving different unlabelled trade-offs between two alternatives described by: time/money (SP1), time/money/reliability (SP2), and time/money/quality (SP3). It should be noted that the ways in which some journey attributes, particularly reliability, are valued in the models relate to the specific appraisal framework used in the UK. Respondents received all three games, with 5 choices per game.³ Whilst the two-game format used in previous European studies (presenting SP1 plus either SP2 or SP3) would arguably moderate cognitive burden (although those studies have consistently presented 8 choices per game), the decision to present three games was influenced by three main considerations.

Firstly, there was a desire for comparability, with values for all components being obtained from data collected from all respondents, avoiding a situation where differences in valuations across components might be due to differences in the groups of respondents supplying those valuations. Second, in order to estimate meaningful and robust values, it was judged that it would be advantageous to maximise the volume of data from games with more than two design variables (i.e. SP2 and SP3), in contrast with a two-game format that would deliver a dataset comprising around 50% SP1 observations, and 25% each of SP2 and SP3 observations. Third, we had an a priori expectation (subsequently confirmed in the results) that respondent behaviour in SP1, which is the most simplistic (and hence possibly least realistic), would be most affected by design effects, potentially reducing quality.

Where possible, with a view to enhancing realism, we 'pivoted' attribute levels around travellers' current trips, though we made some exceptions to this approach, such as for headway and crowding. The design used balance between gains and losses across the sample, as well as in terms of size of changes. The design treated time in the different levels of congestion separately, but again with symmetric pivots, ensuring that the gain-loss relationship in terms of changes in congestion was also symmetric.

2.1. SP1

SP1 used a generic format across all modes, presenting respondents with a choice between two options described only on the basis of travel time and travel cost, where one option was cheaper, but the other option was faster.

While this represents the established approach in a number of European countries (e.g. Mackie et al., 2003; Fosgerau et al., 2007a; Ramjerdi et al., 2010, Significance and Bates., 2013 and Bořjesson and Eliasson, 2014), it is very different from the more complex approaches used in other countries (e.g. Austroad, 2006; ATC, 2006). Other than simplicity, a potential shortcoming is that the context in which time is spent is not explicitly described, and that some respondents might consider the proposition of a faster but cheaper car journey to be unrealistic, especially in a short term context in the explicit absence of tolls. Whilst we sought to contextualise the SP through the preamble instructions, it is impossible to know a priori how respondents interpret travel time in an SP1-style experiment, i.e. whether they regard it as free flow time, congested time,

¹ The project was managed by ARUP, with ITS Leeds (in conjunction with John Bates) being responsible for the survey design, modelling work, and translation of modelled values into appraisal values. Data collection was carried out by Accent. Further information on the study as a whole can be found in the final report (Arup/ITS/Accent, 2015).

² Other public transport encompassed tram, light rail and underground.

³ In order to mitigate order effects, SP1 (the easiest game) was presented initially, whilst the order of SP2 and SP3 was randomised.

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