Value of time variation and socioeconomic attributes in car route choice models

Niken Prameswari, Carlo Giacomo Prato & Otto Anker Nielsen *

Department of Transport,

Technical University of Denmark, Kgs. Lyngby, DK-Denmark

***** Email: {nikp, cgp, oan }@transport.dtu.dk

1 Introduction

Policies that include road user charging are drawing increasing interest. Hence, the accuracy of willingness to pay forecasts and the role of value of time (VoT) in the route choice context are becoming increasingly important to model. In particular, this is essential for route choice models in congested road networks where charging is introduced. In the Danish context, charging policies include toll rings, GPS-based road user charges, specific tolled sections of motorways, and new fixed links projects replacing ferries or bridges with capacity problems.

However, large-scale route choice models seldom consider explicitly VoT distributions among car drivers, whilst there is a rich literature on the behavioural importance of this (see, e.g., [1, 2, 3]). Multi-class route choice models may consider differences between average VoT across different trip purposes, and a few route choice models may account for VoT distributions within a given trip purpose, but typically applied large-scale route choice models do not include a full relationship between socioeconomic variables and VoT distributions.

This paper analyses VoT distributions in the route choice context. The work relies on several GPS-data sources, thus allowing the estimation of VoT distributions of car road users, detailing how VoT relates to socioeconomic variables and trip purposes. The estimated models are implemented and tested on cases in the Danish National Transport Model (NTM), and differences between the model outcome with and without VoT distributions are discussed.

2 Background

Mixed discrete choice models with random distributed VoT for road users have been used for more than two decades (see, e.g., [4]). Early work has also considered random distributed VoT in route choice models [5], and is an example of a large-scale multi-class stochastic user equilibrium model (SUE) including VoT distribution has been presented for the Copenhagen region [6]. This model built upon Stated Preference (SP) data.

The AKTA experiment in Copenhagen contained a rich data of behavioural responses to road pricing [1, 7]. 500 car drivers were followed over 2 periods of 12-16 weeks with and without road pricing. A total of about 300,000 trips was recorded. A sample of participants also carried out a SP-experiment prior to the RP-experiment.

Interestingly, the analysis of the data showed the wide variety of the VoT among participants. Nielsen [1] revealed that this contained both an unexplained distribution of travel time including an extra annoyance for delays (modelled as correlated logarithmic normal distributions), as well as an explainable part due to socioeconomic attributes – especially income. Also, the analysis showed a significantly large difference between VoT from the initial SP-experiment and the actual behavioural changes in the main RP-experiment [8].

Taste variation has been accounted for in the NTM, and income dependency has been considered in the European Trans-Tools model. Trans-Tools v2 also moved from a traditional matrix-based traffic assignment model for a tour-based, where VoT depends upon the zone where trips generated. This general model formulation allows implementing a more rigid relationship between socioeconomic variables and VoT distributions within the assignment model.

3 Data and approach

The aim of this paper is to build upon the data and empirical evidence from the AKTA experiment, in order to analyse VoT variability issues. Improved estimation techniques and choice set generation methods were used in order to explain as much as possible of the variation by socioeconomic data, still including a component for stochastic (random) taste variation.

The paper first describes the processing and cleaning of the GPS-data, then the doubly stochastic method for route choice set generation [9] where it was secured that observed routes were included, and finally the error component logit [see, e.g., 6] with a path size term [10] accounting for similarities across alternatives for model estimation.

Data and networks from the NTM are used for model estimation and as "test laboratory". The LTM is a large-scale model consisting of 51,172 links and 890 zones. Although the NTM has as many as 19 trip purposes, VoT distributions were only considered for the four passenger car purposes that are relevant within the Copenhagen region (long-distance, vans and truck utility functions remain unaltered, because unsupported by the AKTA data). The tour-based approach from TransTools was adapted to this model in order to analyse the relationship between socioeconomic variables and VoT variation.

4 Results

This paper presents model estimation results, including how VoT relates to income and other socioeconomic variables, trip purposes, and how congestion is perceived when compared to free flow conditions. Not surprisingly, VoT increases with income. Probably more surprisingly, VoT depends on the trip purpose. This means that the same traveller may have different VoT depending on trip purpose (e.g., a higher VoT when going to work, a lower VoT when going for a leisure trip in the evening).

Then, this paper compares results from the NTM with VoT distributions and income dependency with results from an NTM version with fixed mean values. The full model is a multi-class SUE model, with random distributed correlated VoT, and where the mean VoT depends on the zone of origin of the travellers (home zone for both outgoing and homebound trips). The conclusion of the comparison is that the model is improved considerably by explaining VoT distributions endogenous and, especially, that forecasts of pricing scenarios varies significantly.

The final part of this paper discusses how socioeconomic evaluations of charging schemes would change – typically increasing benefits – if the specific route choice VoTs are adapted in the appraisal methods. This is an expected result, since the users with high VoT will choose to pay and will get the time benefits, which are evaluated higher than the average population. At the same time, users with low VoT and low willingness to pay will change route, but their time loss will be evaluated less than on average due to their lower VoT. This result indicates that introducing road user charging may prove to have a higher socioeconomic benefit than what is calculated by models using mean VoT only.

References

[1] Nielsen, O.A., “Behavioural responses to pricing schemes: Description of the Danish AKTA experiment”, *Journal of Intelligent Transportation Systems* 8(4), 233-251, 2004.

[2] Brownstone, D., and K.A. Small, “Valuing time and reliability: Assessing the evidence from road pricing demonstrations”, *AEA meetings*, Washington, D.C., January 2003.

[3] Hensher, D.A., “The valuation of commuter travel time savings for car drivers: Evaluating alternative model specifications”, *Transportation* 28(2), 101-118, 2001.

[4] Ben Akiva, M.E., Bolduc, D., and M. Bradley, “Estimation of travel choice models with randomly distributed value of times”, *Transportation Research Record* 1413, 88-97, 1993.

[5] Nielsen, O.A., “Do stochastic traffic assignment models consider differences in road users utility functions?”, *24th European Transport Forum* (PTRC Annual Meeting), Seminar M, Vol II, Uxbridge, U.K., 1996.

[6] Nielsen, O.A., Daly, A. and R.D. Frederiksen, “A stochastic route choice model for car travellers in the Copenhagen region”, *Networks and spatial economics* 2(4), 327-346, 2002.

[7] Schönfelder, S., Rich, J. Nielsen, O.A., and C. Würtz, “Road pricing and its consequences for individual travel patterns”, *Mobilities* 2 (1), 75-98, 2007.

[8] Nielsen, O.A., and G. Vuk, “Car users' trade off between trip time, length, cost and road pricing in behavioural models”, in: Jensen-Butler, C., Sloth, B., Larsen, M.M., Madsen, B. and O.A. Nielsen (eds.), *Roadpricing, the Economy and the Environment*, Springer, pp. 351-374, 2008.

[9] Nielsen, O. A., “A stochastic transit assignment model considering differences in passengers utility functions”, *Transportation Research Part B* 34(5), 377-402, 2000.

[10] Ben-Akiva, M.E., and M. Bierlaire, ”Discrete choice methods and their applications to short term travel decisions”, in: Hall, R.W. (ed.), *Handbook of Transportation Science*, Kluwer, pp. 5-34.1999.