Transportation Research Part A 59 (2014) 144–158

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

# Experiences from the Swedish Value of Time study

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ARTICLE INFO

*Article history:*
Received 10 March 2012
Received in revised form 18 October 2013
Accepted 21 October 2013

*Keywords:*
Value of time
Appraisal
Cost-benefit analysis
Travel behavior

ABSTRACT

We provide a synthesis of results and insights from the Swedish Value of Time study, with focus on what is relevant for transport appraisal and understanding travel behavior. We summarize recent econometric advances, and show how these enable a better understanding and identification of the value of time distribution. The influence of the sign and size of changes is estimated and discussed, including the problems of loss aversion and the value of small time savings. Further, we show how the value of time depends on trip and traveler characteristics, discuss in what dimensions the value of time should be differentiated in appraisal, and provide recommended values for use in applied transport appraisal.


## 1. Introduction

The value of travel time savings (VTTS) is central in transport economics and transport policy. Still, it is a remarkably elusive concept, since the VTTS varies across situations and individuals. The VTTS varies both with socioeconomic characteristics, such as income, family situation and employment status, and with trip-related characteristics such as time of day, trip purpose and comfort aspects. Even after controlling for such observable factors, there is a considerable "unexplained" or "idiosyncratic" variation in the VTTS.

The advances in nonparametric and semi-parametric estimation of choice models have been enormous in the last two decades. Applied to VTTS estimation, they have made it possible to gain a deeper understanding of the variation in the VTTS, both the part related to observable characteristics and the idiosyncratic part (Fosgerau, 2006, 2007; Greene and Hensher, 2003; Rouwendal et al., 2010). The VTTS is often estimated on data from hypothetical experiments such as stated choice surveys. The recent methodological advances have also resulted in a better understanding of how VTTS estimates are affected by the design of the choice experiment and by its short-term nature, and also how these phenomena can be removed to reveal a reference-free VTTS that is usually the relevant entity for use in transport appraisal (see Section 4).

The purpose of this paper is to present results and experiences from the Swedish Value of Time study, carried out in Sweden during 2008, comprising trips with car, bus or train of all lengths and purposes except employer's business. This study is the first where the methodological advances proposed by Fosgerau (2006, 2007) have been used to successfully estimate the mean of the VTTS distribution. Previous attempts, using data from the Danish value of time study, highlighted the demands put on the data by the presence of heterogeneity in the valuations. In particular, the data needs to support identification of a sufficient range of the valuation distribution. The Swedish study was explicitly designed to meet these data requirements, giving unprecedented opportunities to understand VTTS variation. The subsequent Norwegian value of time study (Ramjerdi et al., 2010) also used the same design and estimation technique as the Danish study and a similar bid range as the Swedish

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0965-8564/$ - see front matter 
http://dx.doi.org/10.1016/j.tra.2013.10.022

study. The VTTS study in the Netherlands (Significance, VU University Amsterdam, & John Bates Services, 2013) did not use the same estimation technique, since they had more than two variables in the experimental design.

The purpose of this paper is not to present the details of the econometric methodology – there are companion papers that do that (Börjesson, 2013; Börjesson et al., 2012a, 2012b). Instead, the focus of this paper is to summarize and discuss the results and insights from the Swedish value of time study and to give a synthesis relevant for applied transport appraisal. We also briefly compare this with experiences from the Danish and Norwegian value of time studies, which also used the Fosgerau methodology. Moreover, this paper is the first to present the VTTS results for all travel modes from the Swedish study, which are now included in the official Swedish CBA guidelines. This paper also add to previous papers by describing in more detail how the size and sign effects affect the estimated VTT, and how these are dealt with to achieve a VTTS to be used in applied appraisal.

Section 2 summarizes the econometric models relevant for VTTS estimation, and specifically those that are applied in the subsequent analyses. Non-parametric methods provide insights concerning the identification of the VTTS distribution and the appropriate parametric model specification (Börjesson et al., 2012a; Fosgerau, 2006; Rouwendal et al., 2010). Parametric methods make it easier to include covariates that capture effects of socioeconomics variables and reference dependence.

Section 3 discusses the influence of size and sign effects in stated choice experiments that are due to the short-run nature of the experimental setting. Size effects include the problem of valuing small time savings, while sign effects include phenomena such as loss aversion. Recent methodological advances have made it possible to uncover how the VTTS is affected by size and sign effects, and also how to remove them to some extent, to capture the long-run, reference-free VTTS that is relevant for most policy purposes. Failure to control for these phenomena may cause severe bias of estimation results: results will depend critically on the stated choice design, in a way that is impossible to detect without looking for it.

Section 4 presents estimation results, showing how the VTTS varies with the characteristics of the trip and the traveler. In Section 5, we discuss in which dimensions the VTTS can and should be differentiated in applied appraisal, and present our recommended values for use in appraisal. In particular, we discuss how income effects on the VTTS should be treated, and show how the VTTS changes if income effects are removed. Section 6 concludes.

## 2. The econometrics of VTTS estimation

### 2.1. Recent methodological advances in VTTS estimation

The multinomial logit model has been the standard method used for VTTS estimations for decades. Econometric advances together with an increased appreciation of the heterogeneity in VTTS among travelers have made the mixed logit model increasingly popular (Abrantes and Wardman, 2011). Usually, distributions of the marginal utilities of travel time and travel cost are estimated, i.e. the estimation is carried out in "marginal utility (MU) space" (see Eq. (2) below) (see e.g. Hess et al. (2005), Cirillo and Axhausen (2006), Brownstone and Small (2005) and Hensher (2006)). The VTTS is then computed as the ratio between the two marginal utilities. A problem with this approach is that the resulting VTTS distribution may not have a finite mean. This is the case if the cost parameter belongs to one of several commonly used distributions (Daly et al., 2012). Another major problem when applying the mixed logit model is that a parametric distribution of the parameters has to be assumed, and this assumption could strongly affect the final result, in particular in cases where the tail of the VTTS distribution cannot be identified due to a significant share of non-traders (Fosgerau, 2006).

To avoid having to assume parameter distributions, semi- and non-parametric estimation techniques have been applied in VTTS estimation. For example, Fosgerau (2007) applies a non-parametric estimation technique to estimate the VTTS distribution directly, i.e. the estimation is carried out in "marginal rate of substitution (MRS) space" (see eq. (4) below). With this approach, the VTTS distribution is estimated directly, rather than as the ratio between two distributions. However, this non-parametric technique does not account for a panel structure of the data (which is typical for stated choice data where each respondent makes a sequence of choices), since it treats each response as independent, implying that it is not possible to separate response errors from intra-individual variation. Using a parametric specification, the panel effect can be taken into account, but it comes at the cost of having to make several assumptions, which may bias the result.

The non-parametric model is not a substitute for the parametric model (as discussed in Section 2.3); rather, the main virtue of the non-parametric model is that it allows the analyst to explore over which range the VTTS distribution can be identified, and to support the choice of parametric model. In the present paper, both parametric and non-parametric methods are used, with the Fosgerau specification and estimation techniques. In the parametric case, the assumed mixing distribution is tested by the Fosgerau and Bierlaire (2007) method.

The Fosgerau specification cannot be applied in cases where there are more than two variables defining each choice, and the test proposed by Fosgerau and Bierlaire (2007) can only be applied to one distribution in each model. In other cases, an option is to use latent class modeling (Greene and Hensher, 2003), which also frees the analysis from having to make strong assumptions about the VTTS distribution. The basic assumption of this model is that the travelers can be divided into different classes, each with its own VTTS. The share of respondents belonging to each class is estimated. The Panel Latent Class model estimates the probability that an individual belongs to each class based on the series of choices made by this individual, rather than treating each observation as independent. This method has been used in the Dutch valuation study (Significance et al., 2013). The results from that study show that the Panel Latent Class model fits data better than the applied