



## On the income elasticity of the value of travel time

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### ABSTRACT

Transport infrastructure is long-term and in appraisal it is necessary to value travel time savings for future years. This requires knowing how the value of time (VTT) will develop over time as incomes grow. This paper investigates if the cross-sectional income elasticity of the VTT is equal to inter-temporal income elasticity. The study is based on two identical stated choice experiments conducted with a 13 year interval. Results indicate that the relationship between income and the VTT in the cross-section has remained unchanged over time. As a consequence, the inter-temporal income elasticity of the VTT can be predicted based on cross-sectional income elasticity. However, the income elasticity of the VTT is not a constant but increases with income. For this reason, the average income elasticity of the VTT in the cross-sections has increased between the two survey years and can be expected to increase further over time.

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### 1. Introduction

This paper is based on two essentially identical stated choice surveys for car drivers carried out in 1994 and 2007, designed to measure the value of travel time (VTT). Analysis of these data indicates that the income elasticity of the VTT is not constant, but an increasing function of income. This function does not change significantly from 1994 to 2007, indicating that the relationship between income and the VTT is stable. An implication of these findings is that the aggregate income elasticity of the VTT can be expected to increase as average income grows.

The first survey was carried out in 1994 as a part of the Swedish value of time study (Algers et al., 1995). The survey was repeated in 2007. Care was taken to use exactly the same questionnaire and survey method as in 1994. The sampling of drivers was carried out in the same way, and at the same places. The design of the stated choice experiments was exactly the same, except for cost levels, which were increased by 40%, corresponding to real income growth and inflation since 1994.

The VTT is an important number in several ways. It is a central driver in predictions of travel demand, and time savings usually constitute the main benefit of transport infrastructure investments (Hensher, 2001; Mackie et al., 2001). Decisions concerning transport infrastructures are of a long-term nature. Prediction of demand and calculation of benefits must have a similarly long horizon. Therefore it is important to anticipate how the VTT will develop over time. The standard approach has been to use an income elasticity of the VTT, which is assumed to be constant in the future.

From the simplest model one finds that VTT equals the marginal after-tax hourly wage, which has also been the most common assumption in practice. An early and influential discrete choice application in the field is Train and McFadden (1978), who formulate a mode choice model in connection with the choice of the optimal number of working hours. Their model implies a unit income elasticity of VTT.

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In a review of a large number of (primarily British) studies, the general finding is that the income elasticity of the VTT is less than one (Wardman, 2001b). A few studies have estimated the income elasticity by applying meta-analysis to a number of studies, i.e. pooling results and applying regression analysis describing the influence of GDP (or GDP/capita) on the value of time. Using evidence from British studies conducted during 1980–1996 Wardman (2001a) obtains an estimate of 0.51 and  $t$  statistics of 1.70. The low  $t$  statistics was attributed to a clustering of studies conducted around 1988 and 1994, creating too little variation in the data. Extending the set of studies (conducted during 1963–2000) to create more variation in the data, Wardman (2001b) obtains an estimate of 0.6. Wardman (2004) obtains an estimate of 0.72 employing the same studies as Wardman (2001b) but including more details, while Shires and de Jong (2009) find an income elasticity of VTT of 0.62 for private passenger transport, using evidence from many countries and points in time, in most cases from 1990 and later. In a more recent meta-study, covering 226 studies carried out between 1960 and 2008, Abrantes and Wardman (2011) estimate the considerably higher GDP per capita elasticity on the VTT of 0.90. In the Danish value of time survey, an average cross-sectional income elasticity of 0.90 has been found, which is also considerably larger than most previous estimates and not significantly different from unity (Fosgerau, 2005). Although most studies on the income elasticity of the VTT is based on stated preference data, a clear relationship between income and VTT has also been found in revealed preference data (Brownstone and Small, 2005; Brownstone et al., 2003).

Almost all studies on income elasticity of VTT are cross-sectional. Now, there has been a discussion concerning whether cross-sectional income elasticities are equal to inter-temporal income elasticities. As discussed below, there is no strong reason why this should be the case. Combining DeSerpa (1971) and Evans (1972), Jiang and Morikawa (2004) propose a time allocation model that demonstrates that each component of the VTTs may vary differently over time. For instance, the VTT could change over time in response to income increases, changes in time allocated to consumption and work and to changes in time required for certain activities. This makes the variation of the VTT over time complicated to understand and to predict.

Three previous studies have collected stated choice data at two points in time in order to estimate the inter-temporal relationship between income and VTT. In all cases the replication used essentially the same questionnaire and survey methods. The first of these studies was conducted in the Netherlands in 1988 and 1997 (reported in Gunn et al., 1999). The second study used data collected in Britain 1985 and 1994 (reported in Wardman, 2001b) and the third study used data collected in Britain 1994 and 2006 (Tapley et al., 2007).

In the first study it was found that the VTT had decreased within each income group. The income increase was large enough to cancel out the trend decline in VTT at each real income level, such that the real value of time remained unchanged between the survey years. This appears to indicate that the income elasticity over time is zero, which is unexpected. The second and third studies both gave the puzzling result of a slight trend decline in the VTT. It was speculated that the trend decline was caused by a decreased marginal disutility of travel time (opportunity cost and disutility of the time spent travelling), which was attributed to shorter working hours and to the accessibility to mobile phones and laptops while travelling.

In spite of these findings, it seems hard to justify projecting constant or even decreasing average VTT into the future. Further study of the income elasticity of the VTT is therefore well motivated.

A constant cross-sectional income elasticity of the VTT is a linear relationship between log income ( $\log I$ ) and log VTT ( $\log w$ ). The same holds for the inter-temporal income elasticity. There is, however, no particular reason why these relationships should be linear. In general, we may expect a nonlinear relationship  $\log w = f(\log I)$  between log income and log VTT at the individual level in a cross-section. The income elasticity at income  $I$  is then the derivative  $f'(\log I)$ . Say that incomes in some cross-section vary over the interval  $A$ . The income elasticity in the cross-section will then attain values in the interval  $f'(\log A)$ . Even though the “true” relationship is nonlinear it is possible to estimate a linear relationship whereby  $\log w = \alpha \cdot \log I + \varepsilon$ . However, then the value of  $\alpha$  may attain any value in the interval  $f'(\log A)$ , depending on how incomes are distributed in  $A$ .

Say now that the average income in the cross-section increases over time and that we measure the average VTT as a function of average income. Then again, this aggregate inter-temporal income elasticity may attain any value in the interval  $f'(\log A)$ , depending on how incomes and income growth are distributed in  $A$ .

It is then clear that the cross-sectional “average” income elasticity  $\alpha$  and the aggregate inter-temporal income elasticity might be different. It is possible to take this into account using cross-sectional data by estimating a flexible relationship between income and the VTT. The results of this paper indicate that this relationship is not linear, but increasing in income.

However, this leaves open the possibility that the cross-sectional relationship  $f$  is not stable over time. We are able to address this issue using the present two identical stated choice data sets. Results indicate that  $f$  does indeed seem to be about constant over time. As the whole income distribution shifts upwards, the average VTT will hence grow at an increasing rate. The aggregate income elasticity of the VTT will therefore be increasing.

The paper is organized as follows. Section 2 introduces the data and Section 3 sets out the econometric model. Estimation results are presented in Section 4, while Section 5 concludes the paper.

## 2. Data

### 2.1. Survey method

The data originate from the Swedish value of time studies. In the present paper we consider only private trips made by car drivers. As mentioned, the data collection was undertaken in two waves, the first in 1994 and the second in 2007. The 2007

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