"Issues in Valuing Travel Time for Calculating the Total Social Costs of Transportation"

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It has long been recognized that people place a value on time and time savings. Typically, the value of travel time savings is the largest quantifiable benefit in transport infrastructure investments. There have been numerous studies on both the theory and practice of valuing travel time.

With the growing concern for both possible energy scarcity and greenhouse gases, there is increasing interest in measuring the total costs of transport modes, i.e., including externality costs along with the direct costs borne by users. This is a prelude to developing policies such as congestion tolls to encourage a more efficient quantity and mix of transport modes and services, taking all costs into account. Travel time is a direct non-monetary cost borne by travelers and needs to be included.

The purpose of this paper is to consider a couple of issues regarding whether or not the current estimates of the value of travel time (VOTT) are appropriate for measuring the time cost component of the total social costs of transportation. The paper argues that the standard practice of using average VOTT figures from the empirical literature may not be adequate for this purpose, and there are potential additional difficulties if one uses standard VOTT estimates to make forecasts of the response to changes in travel time and/or fees charged to modify behaviour.

The paper first comments briefly on the need for VOTT estimates for calculating the total social costs of transport modes. Part 2 provides some background on the historical practice of VOTT estimates for evaluating infrastructure investments, and how this influenced empirical approaches to estimate VOTTs. The next three sections show the implications of three properties of VOTT that could be important for measuring the total social costs of modes. Part 3 focuses on the likelihood of different VOTT for journeys of different distance (or time duration). Part 4 looks at the importance of knowing something about the distribution of VOTT values across the population. Part 5 raises a long standing issue about whether large or small times savings are valued the same per unit. Part 6 is a brief conclusion and directions for research.

1.0 Travel Time in the Total Social Costs of Transportation

Although the idea is hardly new, there is growing interest in recognizing the total social costs associated with alternate transport modes; that is, to include the external costs such as pollution, congestion and contributions to greenhouse gases (GHGs) and climate change. The monetary costs of various transport modes are well known, although there are controversies in ensuring that all input costs are measured consistently, especially capital.

Inputs of personal effort and time are relevant inputs in the production of transport services. Where time is supplied via commercial transaction, such as hiring a driver of a truck, these time inputs are monetized and included in cost estimates of commercial transport operations. But there are substantial non-monetized travel time costs, particularly for commuters and all forms of personal travel. These have opportunity costs and are a part of the total costs of those transport modes. VOTT estimates are necessary to monetize these time inputs. The question arises whether or not the standard VOTT estimates used for transport project appraisal are valid for estimating total social costs, or if the VOTT estimates require further refinement and reinterpretation.

Another issue concerning VOTT in the total social costs of modes is congestion. Congestion delays involve externalities in that individual travelers impose delay costs on others that are not considered in the individual traveler's decision. Yet the total time costs of delays are borne collectively by transport users, and not imposed on society at large, unlike pollution or GHGs. The treatment of travel time and congestion costs in the total social costs of transport modes is discussed in von Wartburg and Waters (2005) and not covered here.

This paper suggests a couple directions where VOTT estimation procedures may need to be modified for the purpose of measuring the travel time component of the total social costs of transport modes. A reason for estimating the total social costs of transport modes is preliminary to considering taxes, regulations or other public interventions to shift mode use more in keeping with the full social costs of the modes as compared to their private market costs. It will be important to be able to model the response of users to taxes and charges, and the distribution of VOTT will be an influence on this, as explored below. Related issues arise concerning people's valuation of large and small time savings (Part 5 below).

2.0 Background on Valuing Travel Time

Travel time savings are almost always the largest benefit category in benefit-cost appraisals of transport infrastructure investments. Because of its importance, there is an extensive literature on both the theory and practice of valuing travel time. This literature has been reviewed extensively, e.g., Waters 1992, MVA Consultancy 1987, von Wartburg and Waters, 2004, Intervistas Consulting 2008, to name only a few. This paper only picks up a couple of themes and issues that are of central relevance to this paper.

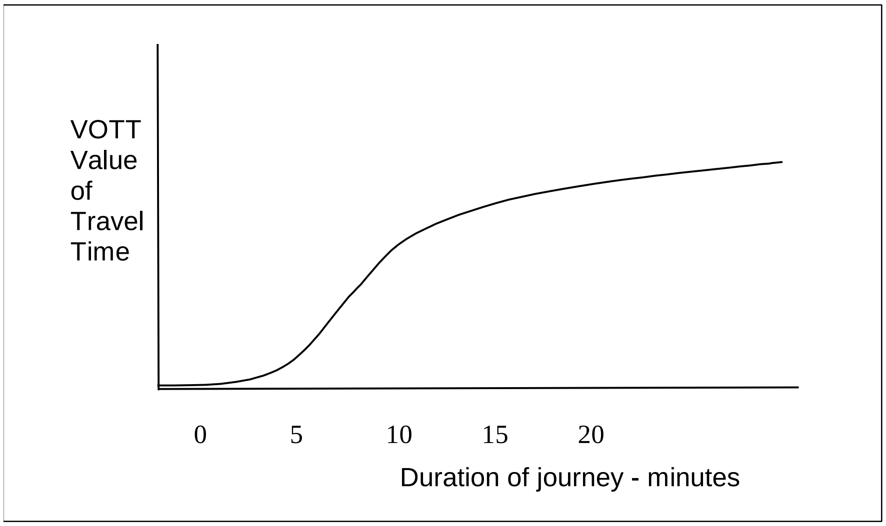
The primary use of VOTT estimates has been for the evaluation of transport infrastructure improvements, e.g., the benefit of upgraded roads or networks. The purpose of the VOTT estimates has influenced how the estimates were developed and interpreted. For upgrades of infrastructure, the relevant concept of VOTT is the valuation that existing users place on time savings (or losses). So estimation procedures, whether revealed preference (RP) or stated preference (SP) studies, focus on a representative VOTT for incremental savings or losses of travel time. The context has two implications. First, although it is possible – or even likely – that VOTT will vary among individuals, because all users share in the benefits of transport improvements, the variation of VOTT are not very important. An average VOTT is adequate to estimate the total time savings benefits to all transport users.

The second implication is that standard VOTT estimates are for incremental time savings. The valuation at the margin is not necessarily an indicator of the total time value of a trip. It is plausible that the VOTT may vary with the length (or duration) of a journey, e.g., having a fairly low value for the first few minutes of a journey, and rising as the journey length increases.

3.0 Variation in the Value of Travel Time with Journey Length

As noted above, the traditional estimates of VOTT measure the valuation of incremental changes in trip times and not necessarily the total value of all time spent traveling. Figure 1 is a conjecture of how the VOTT might vary with the length of journeys, e.g., length of a commute. Figure 1 postulates a very low or zero VOTT for the first few minutes of a journey. It has been argued that most people accept some limited travel time such as a transition time between home and work in the case of commuting. Thomas and Thompson (1970) postulated an S-shaped curve with near-zero values for less than five minutes, increasing at an increasing rate up to 15 minutes, and then increasing at a decreasing rate after that. This was in the highway cost benefit guidelines from the American Association of State Highway and Transportation Officials AASHTO (Chui and McFarland, 1990). Heggie (1976) also found that time savings of less than five minutes appeared to be valued less than larger time savings.

Figure 1: Conjectural Shape of Individual Value of Travel Time Function



A number of studies have investigated the link between the VOTT and journey length. These generally found that there was a positive relationship with distance: the VOTT increased as journey distance increased. A 1999 report by Accent Market & Research and Hague Consulting Group for the UK government estimated the distance elasticity to be 0.37, that is, each 1% increase in distance increases the VOTT by 0.37%. Similar analysis by Mackie et al. (2003) covering journeys between 10 minutes and 3-4 hours, estimated a distance elasticity of 0.26. Algers, et al. (1995) also finds that values of travel time are higher for trips of farther distances. Based on a review of the available evidence, von Wartburg and Waters (2005) suggest a distance elasticity of 0.3. This was adopted in the recent review by Intervistas Consulting (2008).

The significance of this in calculating total social costs is that one would need to know the variations in journey lengths across society, and value the total trip time in accordance with some function as suggested in Figure 1. This would produce a different total time cost estimate than would be obtained by simply using an average VOTT as used for transport project appraisal. However, note the difficulty of estimating Figure 1, not to mention there would probably be a distribution of functions as in Figure 1 differing for each traveler, as well as sundry other influences on VOTT including income levels. In brief, there is a need for some research into variations in VOTT across individuals and the implications for developing estimates of total time costs in the context of total social costs.

4.0 The Distribution of Values of Travel Time

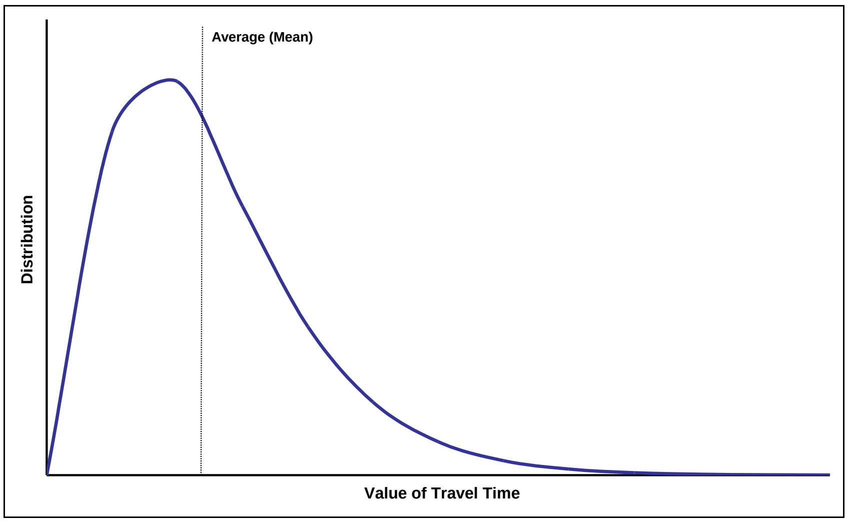
The previous section focused on how VOTT might vary for an individual depending on journey distance or duration. This section considers how VOTT might vary across the population. It is easiest to focus on this by ignoring Figure 1 and now suppose each individual has a constant (or linear) VOTT, but this differs across individuals. It will differ systematically due to differences in income and possible other variables, but of interest here are the random variations in VOTT across society.

Of particular interest is the likelihood that the distribution of VOTT is left-skewed as illustrated in Figure 2. This could be for two reasons. One is that the distribution of income is skewed left, i.e., more low-income people that high-income, and individual VOTT are related to income (although not in proportion, see von Wartburg and Waters 2005 or Intervistas consulting 2008 for a discussion of the relationship of VOTT with income). But setting income aside, even for a group of people with the same income, it is plausible that there will be a distribution of VOTT, and many people might have relatively low VOTT balanced by fewer people with higher VOTT. Figure 2 is still a plausible representation of the variation in VOTT across a population of people with similar income levels.

In evaluating an infrastructure improvement that benefits all users, note that it is not necessary to be aware of the exact shape of the

VOTT distribution. The average VOTT can be applied to the time savings to estimate the total time saving benefits to users. And also in this case, use of an average VOTT could still be used to estimate a total time cost associated with existing travelers (this is ignoring the discussion in the previous section that pointed out the VOTT may vary with travel distance and average values could be misleading).

Figure 2: Illustration of a Left-Skewed Distribution



Source: Intervistas Consulting (2008), p.17.

However, if one wanted to use VOTT calculations to estimate how users would respond to a change in prices or tolls or taxes, then the distribution of VOTT becomes important. By way of illustration, suppose a road improvement benefited all existing users. The average VOTT in Figure 2 could be used for that calculation. But now suppose a toll is to be imposed to capture those time benefits into government revenue (via the toll authority). The toll is set equal to the average VOTT times average time saved. It is still true that the sum total of all users collectively value of time saved and would be willing to pay for it (in practice, one would have to charge something less than the total value of time saved, but assume that a breakeven price would still induce travelers to use the facility). But in Figure 2, note that none of the users whose VOTT was below (to the left) of the mean VOTT would use the facility. Only those with VOTT above the mean would be willing to pay the toll. This is true for a normal distribution, but even more serious for left-skewed distribution such as Figure 2. In this case, less than half of the travelers would use the improved facility. The road improvement was economically justified, but imposing a price loses a substantial portion of the benefits because the low-value users are displaced. This is an illustration of a common experience with toll roads, that the revenues projected based on average VOTT are proving to be serious overestimates.

Empirical studies of the distribution of VOTT are starting to appear, e.g., Hensher and Goodwin (2004) present evidence from a toll road study in Australia that illustrates the implication of a left-skewed distribution of VOTTs as in Figure 2. Similarly, Yang, Kong and Meng (2001) examine the impact of assuming different VOTT distributions on forecasted passenger volumes and revenues for a bus company in Hong Kong. Fosgerau (2005) examines the distribution of VOTTs using SP data from Denmark. See also Small, Winston and Yan (2005) and Wardman (1987).

5.0 The Valuation of Large and Small Time Savings

Another potential complication in VOTT valuation concerns whether or not users value large or small time savings equally per unit. In a great many transport infrastructure projects, much of the time saving benefits are small, but multiplied by a large number of users, the estimated monetary value of time savings is substantial. It is plausible that small time savings are not as useful to people as larger time savings. And there is some empirical evidence to support this characterization. Nonetheless, it has been the practice to value large and small time savings as the same per unit (a linear VOTT). There are arguments to support this practice. For example, infrastructure improvements have long term impacts, and often a sequence of modest investments can accumulate to substantial time savings per user. In these circumstances, and the need for consistency in evaluation procedures across transport investments, the practice of using constant VOTT per unit of time is understandable. Note however, the concept of VOTT appropriate for long term investment appraisal might not be accurate for short term predictions of behaviour, where individual perceptions of the size and usefulness of time savings could be important. This is a property of VOTT that has not been important in transport project evaluation, but it may be important for making forecasts of behavioural responses to changes in travel time and/or user fees imposed associated with such time savings.

This is a longstanding issue in VOTT literature, overlapping with studies of the influence of journey length on VOTT (Part 3 above). The standard practice of using constant or linear VOTT has been criticized (Tipping, 1968, Welch and Williams, 1997, and more recently by Hultkrantz and Mortazavi, 2001. As noted, there are compelling arguments for treating small and large time savings consistently for transport project evaluation (further discussion in von Wartburg and Waters, 2004 and Intervistas Consulting, 2008).

6.0 Conclusions and Directions for Research

The empirical literature on VOTT and its use was primarily for valuing the benefits of time savings in infrastructure investments. Fairly simple averaged VOTT values were adequate for this purpose. These are the estimated values for marginal changes in traffic volumes and travel speeds. Measuring total time costs requires a more detailed understanding of travel time costs than what is adequate for incremental infrastructure investments.

First, if VOTT varies with journey length, this implies that a single VOTT be replaced by a function, along with data on actual trip times. Data on the latter can be compiled via surveys in cities, but there is very little consensus or evidence on the shape of a VOTT function as in Figure 1.

There are some additional complications regarding VOTT in estimating the total social costs of transport modes. A purpose of these calculations is to provide a foundation for recommending taxes, subsidies, regulations or other measures to modify the use of the various modes. This requires an ability to predict the behavioural response of transport users. This is a more difficult task than estimating overall average VOTTs that are adequate for investment appraisal. VOTT varies across the population and we will need some understanding of the distribution of individual VOTTs. Also, the long-standing issue of valuing large versus small time savings becomes important if it can be shown that people's behavioural response rate differs depending on the size of time savings. This is a vexing issue that can be overlooked for infrastructure appraisal, but it could be important in forecasting responses to measures intended to alter usage rates and shifts among transport modes.

The implications for research are that subsequent investigations of VOTT should concentrate more on understanding variations in values and response rates across the population, rather than simply updating traditional measures of the average VOTT.

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