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Catching the tail: Empirical identification of the distribution of the value of travel time

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A B S T R A C T

Recent methodological advances in discrete choice analysis in combination with certain stated choice experiments have allowed researchers to check empirically the identification of the distribution of latent variables such as the value of travel time (VTT). Lack of identification is likely to be common and the consequences are severe. E.g., the Danish value of time study found the 15% right tail of the VTT distribution to be unidentified, making it impossible to estimate the mean VTT without resorting to strong assumptions with equally strong impact on the resulting estimate. This paper analyses data generated from a similar choice experiment undertaken in Sweden during 2007–2008 in which the range of trade-off values between time and money was significantly increased relative to the Danish experiment. The results show that this change allowed empirical identification of effectively the entire VTT distribution. In addition to informing the design of future choice experiments, the results are also of interest as a validity test of the stated choice methodology. Failure in identifying the right tail of the VTT would have made it difficult to maintain that respondents' behaviour is consistent with utility maximisation in the sense intended by the experimenter.

1. Introduction

Numerous stated choice studies have found a significant proportion of apparent non-traders. We demonstrate empirically that in our case, a value of time study, non-trading can be virtually eliminated by providing a sufficient range of trade-offs in the stated choice design. This finding is of vital practical importance as the effect on the estimated willingness to pay distribution, and hence on the estimated mean value, often depend strongly on the assumptions regarding apparent non-traders.

More specifically, we consider the empirical identification of the distribution of the value of travel time (VTT) from discrete choice data. Essentially, the required data consist of observations of individual choices between alternatives differing in the time and cost dimensions. With binary choices, one trip is faster but more expensive than the other, such that a price of travel time is implicit in each choice. The implicit price of time is the trade-off value or the offered 'bid'. Rational respondents with a VTT that is lower than the bid will choose the cheaper and slower alternative; otherwise they will choose the other alternative. So in making their choice, respondents reveal whether their VTT is larger or smaller than the bid. Observation of many respondents for the same bid then reveals the share of respondents with VTT less than the bid. But this is just the value of the cumulative distribution of the VTT evaluated at the bid. Data for a range of bids then allow the analyst to trace out the VTT distribution.

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From this perspective, it is clear that the data do not reveal the VTT distribution outside the range of bids. Estimates of, e.g., the mean VTT hence have to rely on additional identifying assumptions if the range of bids is not sufficiently large. Such assumptions are hard to verify and the impact on the results can be extreme. This is shown in Fosgerau (2006), who analysed discrete choice data with a maximum bid of 25 EUR/h. About 13% of respondents accepted this bid, indicating that their VTT was larger than 25 EUR/h. In other words, these respondents were non-traders with this experimental design (we include seemingly lexicographic behaviour in the term non-traders). Fosgerau (2006) shows that fitting distributions to these data leads to estimates of the mean VTT that can be arbitrarily high.

The need to apply a stated choice experiment design covering the range of preferences when eliciting VTT distributions has been recognised since many years. Fowkes and Wardman (1988) explicitly suggest inclusion of some choices implying "implausible high or low boundary values of time" in order not to erroneously omit respondents using lexicographic decision rules. This advice is supported by explicit studies of lexicographic behaviour. Killi et al. (2007) find that seeming lexicographic behaviour is due primarily to steep indifference curves in combination with insufficient attribute scale extension. Similar evidence on seeming lexicographic behaviour can be found in other application areas. Cairns and van der Pol (2004) use an adaptive design in a health related experiment to show that non-trading behaviour can be virtually eliminated by adjusting trade-offs presented to respondents in the light of their previous answer. While this procedure introduces endogeneity which must be handled in order not to bias results, their evidence does indicate that non-trading is, also in their case, a genuine expression of preferences. Ryan et al. (2009) find (also in a health related experiment) that individuals who appear to adopt non-compensatory decision making strategies do so because they rate particular attributes very highly and not because they try to simplify the task.

In a recent paper, Hess et al. (2010) discuss the incidence of non-trading and lexicographic behaviour and arrive at the recommendation that such observations should be discarded. This advice is followed by Potoglou et al. (2010) and also Ahern and Tapley (2008) discard non-traders in analysis of stated choice experiments. Abrantes and Wardman (2011) note in a meta-study of 226 VTT studies that discarding non-traders is a common approach in VTT practice. Wardman and Ibáñez (2011) find a considerable amount of non-trading in a UK VTT stated choice data set and note that the model fit improves when these are discarded. They suggest that the lower level of non-trading found in a similar US data could be due to the fact that this data collection was computer assisted and not relying on pen and paper.

The results of our paper contradict the recommendation of Hess et al. and much of the above refereed practice. This study indicates that in the Danish data, also analysed by Hess et al., the lexicographic behaviour is a genuine expression of preferences and it would hence be a mistake to discard such observations. Lancsar and Louviere (2006) comment on the deletion of seemingly non-trading observations by saying "it seems somewhat paradoxical, if not paternal, to design and implement discrete choice experiments because one is interested in consumer preferences, but if the results do not conform to researchers' a priori expectations of how preferences 'should' behave, to then impose one's own preferences on the data by deleting such responses".

With alternatives described in terms of travel time and cost, the maintained theory holds that respondents make utility maximising choices governed at the margin by the marginal rate of substitution between time and money, i.e. the VTT. Non-trading occurs simply when the maximum bid is not sufficiently high and the share of non-traders decreases as the maximum bid is increased. This observation provides an opportunity for testing the validity of choice experiments. If the share of non-traders did not decrease as the maximum bid was increased then it would be hard to maintain that choices are governed solely by the VTT.[1] The present paper analyses new data from an experiment carried out in Sweden during 2008, comprising the car mode as well as long and short distance bus and train modes. The experiment design was essentially the same as that used in Denmark but with the bid range extended up to 50 EUR/h, about twice the maximum in Fosgerau (2006). The results show first that most of the VTT distribution is now identified. By the above discussion, this also indicates that the methodology passes the validity test implicit in the extension of the bid range. Moreover, we observe about 90% of the VTT distribution below 25 EUR/h, in approximate coherence with the Danish findings. Hence, the non-trading found in the Danish data seem to be a genuine expression of VTT values which mostly lie in the interval 25–50 EUR/h.[2]

Many VTT studies have estimated the VTT using standard logit models, although we now know that the VTT is very heterogeneous in the population. After simulation techniques made the mixed logit model easier to estimate, attempts to capture the heterogeneity of VTT have become frequent. Mixed models have normally been estimated in preference space (examples are Hess et al. (2005), Cirillo and Axhausen (2006), Brownstone and Small (2005) and Hensher (2006)), estimating marginal utilities of travel time and travel cost. The mean value of time is then computed as the mean of the ratio between the marginal utilities of travel time and travel cost. Still, it is unclear how this ratio relates to the VTT distribution. When using a randomly distributed cost parameter a mean value of time is often not even defined. The model specifications are rarely tested. In particular, they do not report any check of range in their data.

Inspired by Beesley (1965) and Cameron and James (1987), Fosgerau (2006) proposed an empirical model that estimates the VTT directly in log(*bid*) space. By estimation in log(*bid*) space, in contrast to the more traditional models estimated in the preference space, the problem of computing the ratio between two distributions is avoided. Fosgerau (2007) uses

[1] But not impossible. In principle, it may be that there is an empty interval with seeming non-traders all having VTT above this interval. Such gaps in the distribution of VTT are however quite implausible.

[2] The findings of the Norwegian value of time study are consistent with the Swedish and the Danish findings (Ramjerdi et al., 2010). They used bid ranges similar to those in the Swedish study and found the same, low, frequency of non-trading as found in the Swedish study.