Thresholds in choice behaviour and small travel time savings

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Short Abstract

One of the most important benefits of transport infrastructure projects are travel time savings. Their valuation is a decisive factor in the economic assessment. In general there is consensus on the evaluation of travel time savings. However, when it comes to small travel time savings it is still not clear how to handle them: Do people value small travel time savings at a different rate then larger ones? A possible approach to this question is to test for thresholds in individual choice behaviour. This can be done by means of discrete choice modelling. I shall discuss conceptual issues and present preliminary results.

Keywords: discrete choice modelling, choice behaviour, thresholds, value of time, value of travel time savings

Long Abstract

One of the most important benefits of improvements in transport infrastructure are travel time savings. Their valuation is a decisive factor in the economic assessment of transport projects. In general there is consensus on the treatment and empirical evaluation of travel time savings. However, when it comes to small travel time savings it is still not clear how to handle them: Do people value small travel time savings at a different rate then larger ones? A possible approach to this question is to test for thresholds in individual choice behaviour. This can be done by means of discrete choice modelling. Conceptual issues on the modelling of thresholds will be discussed and preliminary estimation results based on synthetic data and a route choice experiment will be presented. Basically, I will consider two modelling approaches:

A first possibility of modelling thresholds is to transform the attribute changes (Δx_i) in the utility difference (ΔU) function into subjective (perceived) attribute changes (Δz_i) by an a priori assumed transformation function f_i:

$$\Delta U(\Delta z_1, \Delta z_2, \dots, \Delta z_k) \qquad (1)$$

$$\Delta z_i = f_i(\Delta x_i, \boldsymbol{\pi_i}) \qquad (2)$$

The threshold parameters $\boldsymbol{\pi_i}$ (e.g. threshold width and sensitivity) of the transformation function f_i have to be estimated along with all remaining coefficients of the model. Such type of model is called attribute threshold model.

Depending on the functional form different sensitivities within the threshold area can be analysed. In extreme cases a transformation function can impose a sensitivity of zero. Such kind of transformation has been used for example by LI & HULTKRANTZ (2004) and CANTILLO ET AL. (2006). The functional form is as follows:

$$\Delta z = f(\Delta x, \pi) = \begin{cases} \text{sign}(\Delta x) * (\text{abs}(\Delta x) - \pi) & \text{abs}(\Delta x) \geq \pi \\ 0 & \text{abs}(\Delta x) < \pi \end{cases} \qquad (3)$$

The parameter π – the threshold width – is part of the domain of the function. This might hinder the use of standard estimation software since π is not a priory known. In fact, π has to be determined in the estimation process.

In the strict sense of the word threshold one might think solely of a sensitivity of zero within the threshold area as in function (3). However, the case of a threshold with a reduced sensitivity is conceivable as well. Such a transformation function could also be implemented as an approximation to the piecewise-defined function (3). That way estimation can be realized with standard software. Furthermore, an increased sensitivity within the threshold area could be considered (negative threshold). At first glance, this might sound counterintuitive. Insights of prospect theory show, however, that an increased sensitivity around reference values is not unusual. Using Norwegian survey data Hjorth & Fosgerau (2012) have shown in this respect that sensitivity decreases with the size of time and cost changes. I will show transformation functions with some desired properties, which allow for reduced and increased sensitivity and which can also approximate function (3). To my best knowledge these functions have not been tested yet.

The figure below shows some exemplary plots of transformation functions.

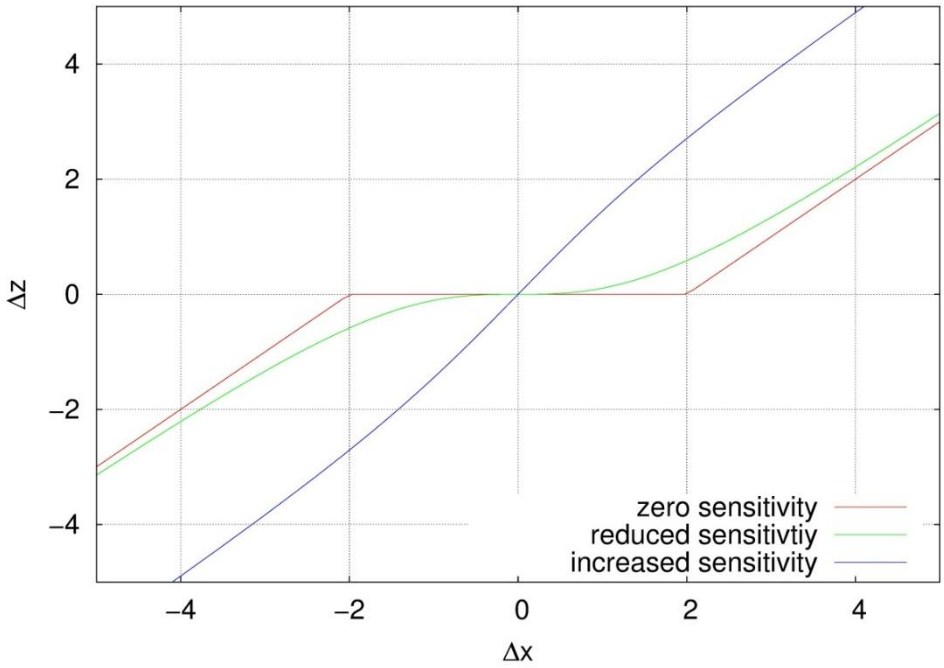

Figure 1: Plot of attribute transformation functions

A second possibility is to model thresholds on the utility level. In this case the threshold does not apply to attribute level differences but to utility differences. Indifference thresholds have been discussed in the literature for decades but are employed rarely in empirical studies on transportation issues. CANTILLO ET AL. (2010) proposed a model which requires data from choice experiments where people can explicitly report indifference between two alternatives. In such a model Alternative A_1 is preferred to A_2 if and only if the utility difference from A_1 to A_2 exceeds a positive threshold δ. An absolute value of the utility difference below δ however, causes indifference between A_1 and A_2. Assuming Gumbel distributed stochastic utility components, it can easily be shown that the standard logit probabilities have to be replaced by the following:

$$P(A_i) = \frac{e^{V_i}}{e^{V_i} + e^{V_j + \delta}} \tag{4}$$

Apart from the probabilities for A_1 and A_2 the probability of choosing the indifference option, equal to $1 - P(A_1) - P(A_2)$, has to be taken into account as well. The somewhat strange looking fact that there are two utilities, one for A_1 and one for A_2, but three probabilities might impede the use of standard estimation software.

The subsequent calculation of the value of travel time savings, when thresholds are in effect, is not a trivial task. It depends not only on the modelling approach and transformation function but also on the underlying definition of the value of travel time savings. If, for example, thresholds were considered as a mere artefact of the stated preference experiment but not as a real part of individual behaviour one would proceed calculating the value of time savings as marginal rate of substitution between time and money disregarding the threshold parameters. If, however, thresholds are considered as part of real individual behaviour one could argue for regarding the threshold parameters as well. In doing so further difficulties may arise as shown exemplarily for the indifference threshold model with a deterministic linear utility function ($V = \alpha T + \beta C$) in in the figure below. Here the value of travel time savings has been defined as the monetary compensation for a discrete change of travel time leaving the person indifferent. However, as can be seen from the figure, there exists not a precise value but a band of compensation for a given time change.

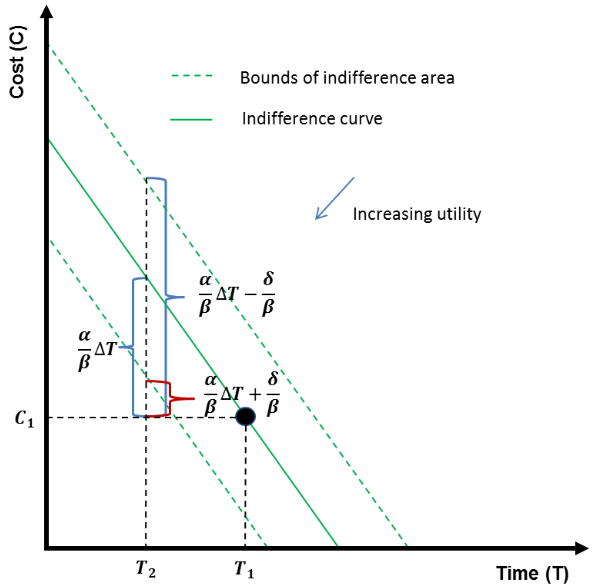

Figure 2: Compensation for a discrete time change - Indifference threshold model (OBERMEYER ET AL., 2013)

It has to be emphasized that the explanations presented so far are on an individual level and for single projects. However, it should be acknowledged the presence of arguments against the consideration of thresholds in a social cost-benefit analysis even if they take effect on the individual level. One of these arguments states that people might have an individual “time savings account”. Thus, they can add up time savings across projects and different periods of time. Consequently, the aggregate time saving might exceed the threshold. Since the time savings account will be filled differently from person to person, an additional time saving by a specific project will push some people over the boundary and some not. FOWKES (1999) has demonstrated that the total effect of this is equivalent to valuing small and large time savings at the same rate. Nevertheless, this does not mean that thresholds, if they are present, should be ignored in the estimation process. Rather, they should be included in order to derive unbiased time and cost estimates. In the calculation of the value of time savings the threshold parameters could be neglected, depending on the acceptance of the arguments mentioned above. Apart from this, the inclusion of thresholds might generally contribute to a more accurate prediction of individual reactions on attribute changes.

Contributions of this paper in brief

- Summary of modelling approaches for thresholds in discrete choice models
- Extended interpretation of the term thresholds: including reduced and even increased sensitivity inside the threshold area
- Presentation of some new attribute transformation functions with desired properties
- Showing estimation results for discrete choice threshold models
- Discussing value of time estimation with regard to thresholds

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