Research in Transportation Economics 43 (2013) 50–61

Contents lists available at SciVerse ScienceDirect

Research in Transportation Economics

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

Valuing casualty risk reductions from estimated baseline risk

Knut Veisten [a], Stefan Flügel [a,b], Luis I. Rizzi [c,*], Juan de Dios Ortúzar [c], Rune Elvik [a]

[a] *Institute of Transport Economics (TOI), Gaustadalleen 21, NO-0349 Oslo, Norway*
[b] *Department of Economics and Resource Management, Norwegian University of Life Sciences (UMB), P.O. Box 5003, NO-1432 Ås, Norway*
[c] *Department of Transport Engineering and Logistics, Pontificia Universidad Católica de Chile, Casilla 306, Cod. 105, Correo 22, Santiago, Chile*

A R T I C L E I N F O

Article history:
Available online 5 January 2013

JEL classification:
C25
C83
C93
R41

Keywords:
Fatalities
Injuries
Mixed logit
Stated choice
Value of statistical life
Willingness to pay

A B S T R A C T

Stated choice studies have been applied regularly to the valuation of time savings and other attributes of travelling as perceived by individuals. In such experiments, respondents often provide reference levels for the attributes and the hypothetical choices presented to them are pivoted around actual behaviour. However, most individuals are not able to provide reference levels for the number of casualties on the road they travel. Thus, if valuation of this important element is attempted, it is the researcher who must provide casualty risk reference levels to the respondents. Some studies have applied route choice experiments including a safety attribute but the majority has been limited to only one particular road section with a common baseline risk for all respondents.

This study discusses the setting up and results of a more generalized route choice experiment including a safety attribute. Respondents provided, at an initial stage, their travel times and costs related to a recent trip by car. Then, expected numbers of casualties for different trip lengths were calculated based on travel distances and traffic densities. So, the calculated number of severe injuries and fatalities (casualties) per year, on the road section the respondent had travelled, entered as a third attribute in the choices, together with the reported travel times and costs. Route choice was analysed using multinomial logit and mixed logit models. From the latter models we obtained point estimates for the value of the statistical life ranging from € 7.3 million to € 19.1 million.

1. Introduction

The worst possible outcomes of a road accident are dying or becoming severely injured. Casualty risks are, to some extent, influenced by road users' own protective behaviour, but are also determined, to a large extent, by road design and the quality of enforcement of traffic rules (Elvik, Høye, Vaa, & Sørensen, 2009). Public road administrators seek valuations of casualty risk changes for the assessment of road safety impacts in cost–benefit analyses, together with time-use changes and other project impacts (see for example Gaudry, Jara-Diaz, & Ortúzar, 1989; Hensher, 1994; McFadden, 1974; Sillano & Ortúzar, 2005; Small & Verhoef, 2007). Casualty risk changes have been valued using various methodologies based on revealed preferences (RP) from market data or on stated preferences from specially designed surveys. Among stated preference techniques, the contingent valuation method dominated in the last century (De Blaeij, Florax, Rietveld, & Verhoef, 2003), but stated choice (SC) has emerged as the preferred alternative during the last decade (Hensher, Rose, Ortúzar, & Rizzi, 2009; Hojman, Ortúzar & Rizzi, 2005; Rizzi & Ortúzar, 2003, 2006a).

Most SC studies have been cast as route choices, that is, hypothetical choices between two routes with different travel times, costs, number of fatalities and number of severely injured victims. If the hypothetical choices are pivoted on actual travel behaviour, this provides a realistic context for the trade-off between casualties and other trip attributes (Hojman et al., 2005). In preliminary RP surveys, individuals can provide reference levels for attributes like travel times and costs, thus helping the analyst to pivoting the choice experiment on actual behaviour (Bradley & Daly, 1994; Caussade, Ortúzar, Rizzi, & Hensher, 2005; Hensher, 2004; Louviere, 2006). Although road safety is also perceived by individuals, as revealed for example by speed adaptations to different traffic conditions and by the level of care in private transport (car driving, cycling, and walking), respondents are usually not able to provide reference levels for casualties (fatalities/injuries) on the roads they travel. For this reason, if this important element is to be valued, the survey designer must provide reference levels to the respondents.

In the still relatively small number of route choice experiments for valuing risk reported in the literature, pivoting from actual behaviour has been enabled mostly by limiting the study to one

---

* Corresponding author. Tel.: +56 2 354 4819; fax: +56 2 553 0281.
E-mail address: lir@ing.puc.cl (L.I. Rizzi).

0739-8859/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.retrec.2012.12.009

particular road section. For example, Rizzi and Ortúzar (2003) and Hojman et al. (2005) sampled groups of drivers that travelled regularly between two specified cities, and the hypothetical travel times, costs (tolls), and casualty numbers varied around the real figures for that particular intercity route. Studies who have presented more generalized settings for the hypothetical choices have not pivoted the experiment to an actually driven section by the respondents (De Blaeij, Rietveld, Verhoef, & Nijkamp, 2002; De Brabander, 2006; Hensher et al., 2009; Iragüen & Ortúzar, 2004).

In this study we build further on the Internet approach introduced by Iragüen and Ortúzar (2004) and also used by Hojman et al. (2005), by designing a choice experiment for the valuation of risk reductions that can be pivoted to the actual travel behaviour of a Norwegian sample of car drivers, encompassing both urban and inter-urban settings. We combine fatalities and injuries, as done by Hojman et al. (2005), but our study takes a step further in generalization, compared to Hensher et al. (2009), by customizing/pivoting to any type of reference trip of more than 10 min duration.

Respondents provided, at an initial stage, their travel times and costs related to a recent trip by car yielding reference levels for these attributes. A combined annual number of fatalities and serious injuries on the reported road section was calculated by estimating the distance travelled using average speeds and adjusting by the annual average daily traffic estimates for the corresponding road section. The SC experiment was carried out as a self-administered Internet survey among a fairly large sample of Norwegian drivers. To our knowledge, this is the first study for a countrywide sample of car drivers that pivots hypothetical choices involving risk reductions from actual travel behaviour.

The remainder of the paper is organised as follows. The next section describes the theory and methodologies underlying choice experiments and the associated modelling issues in road safety. The third section describes the Internet-based survey and the applied choice experiment design. The fourth section provides the resulting model estimates that are discussed in the last section.

2. The value of fatal and serious injury risks reductions

In this section we describe the microeconomic foundations of risk reduction valuations in a road safety context and show how this theory may be operationalized using discrete choice models. We also show how to deal with risks when they are tiny, as in our context of road safety in Norway. Instead of valuing separately fatal risk reductions and serious injury risk reductions, we value reductions in casualty risks (that encompasses both fatalities and serious injuries) and from this value we derive the values of fatal risk and serious injury risk reductions. We then proceed to briefly describe alternative questionnaire methods designed to elicit people's valuation of risk reductions, giving special emphasis to stated choice experiments.

2.1. Modelling the valuation of risk reduction

Assume that a trip, on a given route, provides traveller j a level of dissatisfaction given by a deterministic indirect utility function $V_j = V(r, c, t)$, where r stands for the risk of becoming a fatal (or seriously injured) victim, c is the cost of travelling and t is the travel time on the route (there could be more attributes, of course). Jones-Lee (1974) formally defined the value of a statistical life (VSL) as the value of avoiding one expected death per unit of time. This corresponds to the population (or sample) average of the marginal rate of substitution between income and risk of death for j (MRS_j), plus a covariance term that accounts for possible correlation between the MRS_j and the reduced risk (δr_j):

$$\mathrm{MRS}_j = \frac{\partial V_j/\partial r}{\partial V_j/\partial c} \quad (1)$$

$$\mathrm{VSL} = \frac{1}{N}\sum_{j=1}^{N}\mathrm{MRS}_j + N\,\mathrm{cov}\left(\mathrm{MRS}_j, |\delta r_j|\right) \quad (2)$$

The value of a statistical serious injury (VSSI) may be defined analogously. In empirical work it is typically assumed that the second term in equation (2) is zero; this assumption would be correct if, for example, δr were the same for every individual. Then, equation (2) would simplify to equation (3), and to estimate the VSL it would be sufficient to have a good estimate of the MRS (equation (1)).

$$\mathrm{VSL} = \frac{1}{N}\sum_{j=1}^{N}\mathrm{MRS}_j \quad (3)$$

The MRS can be interpreted as an implicit value for the own life, and we can see from equation (3) that averaging it over all individuals travelling on the route yields the VSL. The MRS clearly depends on personal risk perceptions according to the functional form of V_j. The same analysis can be carried out in terms of fatalities f (or serious injuries) instead of risk r (where $r = f/N$). However, in this case the VSL should be derived differently (but obviously yielding the same value):

$$\mathrm{VSL} = \sum_{j=1}^{N}\frac{\partial V_j/\partial f}{\partial V_j/\partial c_{|V=\overline{V}}} = \sum_{j=1}^{N}\mathrm{SVF}_j \quad (4)$$

where SVF stands for the subjective value of fatalities (or serious injury) reductions and can be interpreted as a Lindahl price or Lindahl tax (Varian, 1992, chap. 23).

Equation (4) embodies the definition of community willingness-to-pay (WTP) for a public good (i.e. road safety in this case), as the sum of individual marginal rates of substitution between income and number of fatalities (or serious injuries) and we avoid making any assumption about δr. If we think in terms of a hypothetical tolled route the operators of which were able to extract the full consumer's (compensatory) surplus, the SVF_j would be the maximum amount of money that can be extracted from person j following the safety improvement, such that s/he is as well-off as before the improvement.

2.2. Making the model operational

The above model can be made operational within a discrete choice framework where the indirect deterministic utility of each available alternative i for person j is given by:

$$V_{ij} = \alpha \cdot f_{ij} + \eta \cdot \mathrm{SI}_{ij} + \beta \cdot c_{ij} + \gamma \cdot t_{ij}$$

where the letter f, stands for number of fatal crashes and SI for serious injuries; as can be seen, all attributes enter utility in an additive way. As the modeller does not possess (or is incapable of observing) all the relevant information, he must assume randomness in the utility function. Random utility, U_{ij}, is simply expressed as the sum of two terms: the deterministic utility, V_{ij}, and a random component, ε_{ij}:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

and it is assumed that each alternative has a probability of being chosen given by the probability that U_{ij} is the highest random utility