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A comparison of bus passengers' and car drivers' valuation of casualty risk reductions in their routes

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

[a] Institute of Transport Economics (TØI), Gaustadalleen 21, NO-0349, Oslo, Norway
[b] School of Economics and Business, Norwegian University of Life Sciences (NMBU), P.O. Box 5003, NO-1432, Ås, Norway
[c] Department of Transport Engineering and Logistics, Centre for Sustainable Urban Development (CEDEUS), Institute in Complex Engineering Systems, Pontificia Universidad Católica de Chile, Casilla 306, Cod. 105, Correo 22, Santiago, Chile

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ABSTRACT

Introduction: The economic value of safety represents an important guide to transport policy, and more studies on individuals' valuation of road safety are called for. This paper presents a stated preference study of the value of preventing fatal and serious injuries involving bus passengers and car drivers in road accidents.
Objectives: Former valuation studies based on travel behaviour and route choice have involved primarily car drivers. Our study also included bus passengers, thus providing a comparison of two types of transport mode users. Moreover, the comparison was based on two different valuation methods.
Methodology: About 600 bus passengers and nearly 2300 car users from different areas of Norway reported a recent trip, described by its distance and travel cost. Then they answered stated choice tasks that took a reference in the reported trip and involved trade-offs among travel time, fatal and seriously injured victims and travel costs. Afterwards, they faced a simple trade-off between travel costs, and fatal and seriously injured victims.
Findings: Pooling the data from the two stated preference formats, we derived values of a statistical life and of a statistical seriously injured victim. Regarding the value of statistical life, our point estimates were NOK 45.5 million and NOK 58.3 million for bus users and car users respectively.
Discussion: The point estimates for bus passengers and car users were not statistically different given their confidence intervals. Thus, we recommend the use of a single value, identical for both modes of transport, for the prevention of a statistical fatality as well as for a statistical injury

1. Introduction

Estimates of the economic value of safety, primarily based on individuals' valuation of casualty risk reduction, can guide policy (Wijnen and Stipdonk, 2016). Approximately 15 years ago, the hypothetical route choice approach to the valuation of statistical lives and limbs was introduced (Ortúzar and Rizzi, 2001; Rizzi et al., 2003). Since then, discrete choice experiments (DCE) for car drivers, involving travel alternatives differing in time, cost and other travel attributes, have been carried out in Chile (Iragüen et al., 2004; Hojman et al., 2005; Rizzi et al., 2006), the Netherlands (De Blaeij et al., 2002), Belgium (de Brabander, 2006), Australia (Hensher et al., 2009), Norway (Tofte, 2006; Veisten et al., 2013) and Spain (González et al., 2016). Flügel et al. (2015) reported an application of DCE to cycling; and Hensher et al. (2011) to walking. Wijnen and Stipdonk (2016) call for more studies on individuals' valuation of road safety.

This paper extends the above-referred research, by including bus passengers' valuation of statistical lives and limbs. We compare bus passengers' valuation against car drivers' in a common stated preference (SP). To our knowledge this has not been reported in the literature. Samples of bus passengers and car drivers described a recent trip (i.e. trip length, travel time and cost) which was used as reference in the experimental design. Then, the trip lengths together with traffic volumes on the reported roads, were used to establish reference levels for the casualty risk (presented as the annual number of killed and seriously injured bus passengers, or car drivers, in the given route length). After responding to a series of choice situations (DCE) involving the above attributes, both bus passengers and car drivers faced a contingent valuation question about their willingness to pay (WTP) a set of money amounts for specific casualty reductions; a so-called multiple bounded (MB). Thus, we were able to obtain value estimates from two different SP methods.

* Corresponding author.
E-mail address: sfl@toi.no (S. Flügel).

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The remainder of the paper is arranged as follows: The next section provides the theoretical and methodological basis for the valuation of statistical lives (VSL) and serious injuries (VSSI), for the two SP methodologies used; this also includes hypotheses about value estimates from bus passengers compared to car drivers. In the third section the internet-based survey material used is described. The fourth section provides model results with attribute estimates and the implicit VSL and VSSI. Finally, our main findings are discussed in the concluding section.

2. Theoretical and methodological approaches

2.1. Theoretical and empirical expectations related to valuation of statistical lives and injuries, for bus passengers vs. Car drivers

At least in Europe, there are two casualty risk differences between travelling by bus and by car:

- The risk of fatality or serious injury is lower for bus transport than for car transport in countries within the Organization for Economic Cooperation and Development – OECD (Elvik et al., 2009).
- The risk of fatality or serious injury is (perceived) as less controllable in bus transport compared to car transport (Slovic et al., 1979; Carlsson et al., 2004).

The standard model of mortality risk valuation formulates expected utility as a weighted average of utilities associated with wealth given survival or death, with weights expressed by the survival and death probabilities; as it can be assumed *a priori* that increased safety (reduced risk) is a desired economic good, individuals' WTP for a risk reduction should be non-negative (Drèze, 1962; Schelling, 1968; Mishan, 1971; Jones-Lee, 1974; Pratt and Zeckhauser, 1996). One implication of this model is that VSL should increase with baseline risk (Jones-Lee, 1974; Weinstein et al., 1980). However, even if fatality risks for car drivers are higher than for bus passengers, transport risk constitutes one out of several risks; and for most individuals, these other risks determine the overall risk of death or health impairment (Elvik et al., 2009). Given the fact that background risks are at least an order of magnitude larger than transport risks in OECD countries, the effect of the comparatively small difference in risk between bus passengers and car drivers on WTP and VSL might be very limited – or negligible (Hammitt and Graham, 1999; Eeckhoudt and Hammitt, 2001). The effect of initial risk on VSSI is expected to be similar for VSL, transport injury risks contribute relatively more to overall injury risks than to overall fatality risks (Elvik et al., 2009). Viscusi and Evans (1990) found a positive effect of baseline risk on WTP to reduce injury risk.

Public transport involves other risks than going by car; for example, the security risks related to sharing a mode with other individuals. The statistical risk of attacks/violence on public transport or at station/bus stop is small in Norway (Backer-Grøndahl et al., 2009). Notwithstanding, subjective risk has an emotional component, in addition to the cognitive element (Sjöberg, 1998, 1999); and the emotional discomfort might be different, and possibly more important, for personal security risk compared to accident risk (Teigen et al., 1988; Brun, 1992; Moen and Rundmo, 2006). In a survey of Norwegians, Backer-Grøndahl et al. (2009) found that security risk was considered more important than accident risk for the attractiveness of a transport mode. Another survey of Norwegians, indicated that the cognitive component of risk (accident probability) was more pronounced for private transport modes, while the emotional component of risk (accident fear or fear of other unpleasant/dangerous incidents) was more pronounced for public transport modes (Moen and Rundmo, 2006; Rundmo et al., 2011).

Emotional dread might still be important for accident risk in public transport; although small, when accidents happen they will normally imply several casualties. Moreover, accident risk when riding a bus will be perceived as less controllable than accident risk when sitting behind the wheel of one's automobile; and this relative lack of control may affect the emotional component of risk (Slovic et al., 1979). In fact, Chilton et al. (2006) found a large dread effect in the valuation of rail accident death risk relative to automobile accident death risk. Thus, there are potentially opposite effects on the WTP for accident risk reductions in public transport compared to the WTP for accident risk reductions in car travel.

2.2. An operational model for the valuation of safety in discrete choice experiments (DCE)

Assume the utility of each available alternative *j* for person *i* is given by:

$$V_{ij} = \alpha \cdot \mathrm{CAS}_{ij} + \beta \cdot c_{ij} + \gamma \cdot t_{ij} \tag{1}$$

where CAS refers to casualties, *c* to costs, and *t* to time use. This is a simplified specification where all attributes enter utility additively. V_{ij} represents the deterministic part of a random utility function, U_{ij}, also including an error term ε_{ij} reflecting non-observability of part of what drives the choices (McFadden, 1974). We also include another error term to account for the correlation among choices/responses, *l*, from the same individual, τ_{ij}, yielding a mixed logit (ML) model (Train, 2009):

$$U_{ijl} = V_{ijl} + \tau_{ij} + \varepsilon_{ijl} \tag{2}$$

It is assumed that each alternative has a probability of being chosen given by the probability that U_{ijl} is the highest random utility for each individual *i*. The monetised marginal utility of an attribute in an alternative is given by the marginal rate of substitution between that attribute and the cost attribute; and with a simple linear specification of V_{ijl} this equals the ratio of the casualty coefficient and the cost coefficient:

$$\mathrm{WTP}_{\mathrm{CAS}} = \frac{\partial V_i / \partial \mathrm{CAS}}{\partial V_i / \partial c_{|V=\bar{V}}} = \frac{\alpha}{\beta} \tag{3}$$

This expression for the WTP of a marginal reduction of casualties can be termed the "subjective value of a casualty reduction" (Hojman et al., 2005; Veisten et al., 2013). The casualties will contain a share of fatalities (Δ_f) and a share of serious injuries (Δ_{si}). Similarly, γ/β yields a subjective value of travel time savings (Gaudry et al., 1989; Hensher et al., 2005; Sillano et al., 2005).

We will assume that τ is an iid Normal error term and ε is the traditional iid Gumbel error term (i.e. Extreme Value Type I) of logit models. The likelihood of the observed sequence of choices for individual *i* (suppressing this subscript for notational convenience), is given as:

$$\int \prod_{l} \prod_{j} \left(\frac{\exp(\alpha \cdot \mathrm{CAS}_{jl} + \beta \cdot c_{jl} + \gamma \cdot t_{jl} + \tau_j)}{\sum_j \exp(\alpha \cdot \mathrm{CAS}_{jl} + \beta \cdot c_{jl} + \gamma \cdot t_{jl} + \tau_j)} \right)^{g_j} \prod_{j} f(\tau_j) d(\tau_j) \tag{4}$$

where $f(\tau_j)$ is the Normal density function with zero mean and variance (σ) to be estimated, and g_{jl} is a dummy variable that takes the value of one if alternative *j* is chosen in choice scenario *l* and zero otherwise. If τ_j is zero in Eq. (4) the ML model collapses to the simple multinomial logit model (Ortúzar et al., 2011).

In the choice situations presented to respondents, both the left-hand and right-hand alternatives could have the lower number of casualties (and/or travel time and cost). We can thus apply a generic choice model. However, another way of modelling the choices is to re-arrange the alternatives in the data such that Alternative 1 (the re-arranged left-hand alternative) can be labelled the "safer route", always having the lower casualty number. Then the alternative-specific constant (ASC) can be interpreted as a preference for safety *per se* when travelling. For the ML model (4), there are then four or five coefficients to be estimated: the coefficients for casualties, time, and cost, a coefficient for the value of the standard deviation of the iid Normal error added to