Paying for Safety: A Discrete Choice Experiment to Estimate the Willingness-to-pay for Risk Reductions on Alpine Roads

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INTRODUCTION

The use of Discrete Choice Experiments (DCE) for valuing public goods has been tremendously increasing over the last 15 years. Recently, DCE have been used to elicit preferences for risk reductions in public health programs (DeShazo and Cameron 2005; Tsuge et al. 2005) and environmental hazards (Alberini et al. 2007; Itaoka et al. 2006). These DCE applications aim at valuing reductions in mortality risks by estimating the marginal rate at which individuals would trade off their money against small changes in their likelihood to die within a specified time period. This marginal rate of substitution between individual risk and money is commonly termed the value of statistical life (VSL). It is used as policy guideline in environmental regulations and other life-saving programs (Boardman et al. 2005; Hammitt 2000), helping to quantify the benefits from risk reduction. So far, DCE have not been used to determine the estimate willingness-to-pay (WTP) for safety against natural hazards. In this study, we describe a DCE to estimate the WTP for safety against snow avalanches, rock falls and—as reference risk—ordinary car accidents on local Alpine roads and to deduce the VSL in the domain of natural hazards.

MATERIAL & METHODS

For this purpose, we conducted a survey-based DCE with respondents from two regions of Switzerland. Respondents were asked to consider the hypothetical “privatization” of financing protection measures against these road hazards. By choosing among different risk reduction policies, they reveal their preferences for safety and their willingness to make a personal contribution to finance protection measures. Based on the aggregated choices, we can estimate the VSL, which expresses the collective marginal utility of protection against two common natural hazards in Switzerland.

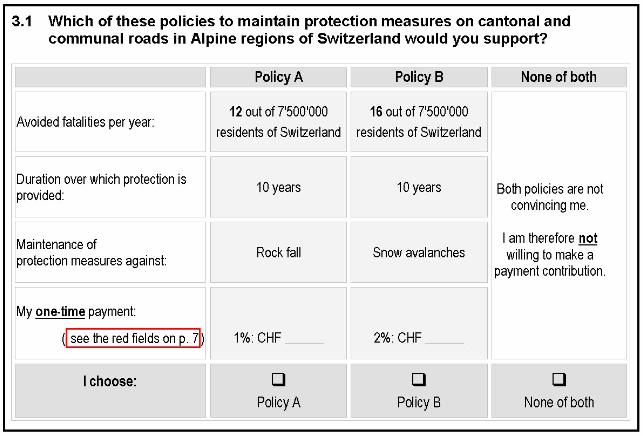
Choice experimental task

In the choice experimental task, respondents had to imagine a national poll on different road safety policies. They were told that every household would have to make a onetime payment to finance such a safety policy. The specifics of the policies are described by four attributes: the number of avoided fatalities per year, the duration over which the specified policy would reduce the risk, the type of road hazard the measures are aimed to protect against, and the cost of the policy to the respondent, which would be incurred as a one-time payment relative to their last income tax. A summary of these attributes is given in Table 1.

Table 1: Description of the attributes and their respective levels

Attribute	Levels of the attribute
(1) Number of avoided fatalities per year	10, 12, 14, 16
(2) Duration of protection in years	10, 20, 30
(3) Type of hazard	Snow avalanche, rock fall, ordinary road accident
(4) Relative costs as percentage of income tax	1%, 2%, 3%

Each respondent was presented with six pairs of hypothetical policies and had to indicate which of the options they prefer in each situation: policy A, B, or none of both. Fig. 1 exemplifies one possible discrete choice question.



3.1 **Which of these policies to maintain protection measures on cantonal and communal roads in Alpine regions of Switzerland would you support?**

	Policy A	Policy B	None of both
Avoided fatalities per year:	**12** out of 7'500'000 residents of Switzerland	**16** out of 7'500'000 residents of Switzerland	Both policies are not convincing me. I am therefore **not** willing to make a payment contribution.
Duration over which protection is provided:	10 years	10 years	
Maintenance of protection measures against:	Rock fall	Snow avalanches	
My **one-time** payment: (see the red fields on p. 7)	1%: CHF ______	2%: CHF ______	
I choose:	❑ Policy A	❑ Policy B	❑ None of both

Fig. 1. Example of a discrete choice question (translated from German).

Participants

The questionnaire was sent to 900 individuals who previously agreed during a phone recruitment to participate in the study. This recruitment allowed contacting 450 respondents each from the Alpine region around Davos (mountain group) and the city of Zurich (urban group). The samples were well balanced with respect to gender and age. We required respondents to be at least 18 years old—the minimum age for voting and for obtaining a driver's license in Switzerland. The rate of valid responses was at 49% (n = 445). For the analysis, we discarded individuals who made less than two choices, assuming that they were not able or willing to respond to the choice questions. Further, we excluded the answers from three individuals who only chose policy A and from one individual who only chose policy B, though this meant to be inconsistent with their earlier choices. The data cleaning left us with 2,652 choices. Descriptive statistics for both sample groups are given in Table 2.

Table 2: Descriptive statistics for the sample groups (M = Mean; SD = Standard Deviation)

Setting	Urban group	Mountain group
Number of participants	228	214
Gender:		
Males	51%	47%
Females	49%	53%
Age, M (SD)	47.9 (16.2)	48.0 (16.3)
Income tax class (1-6), M (SD)	2.88 (1.4)	2.77 (1.3)
Risk framing referred to:		
Resident population	50%	53%
Fatalities in car accidents	50%	47%

Model specifications

Applied to mortality risk reductions, random utility theory assumes that the utility of avoiding or reducing a specific risk can be split into a value-based cognitive part expressed by the indirect utility function V and a random component ε. Drawing on the conditional logit model (McFadden 1974), we assume that the random component ε_{ij} is independent across alternative policies j within the same individual i and follows a Type I extreme value distribution. By fixing the scale parameter of the random component's distribution to be unity, individual i will choose the policy k with probability:

$$\Pr(k \mid i) = \exp\,(V_{ik}) \Big/ \sum_{j \in K} \exp\,(V_{ij}), \tag{1}$$

whereby K denotes the set of policies at choice. The indirect utility V of any policy j depends on the discounted stream of risk reduction ΔR_j, on the individual cost C_{ij} for this policy and on all other attributes X_n relevant for i's choice (e.g., the type of hazard):

$$V_{ij} = \alpha \Delta R_j - \beta C_{ij} + \sum\nolimits_n \gamma_n X_n, \tag{2}$$

whereby α, β and γ_n are the coefficients to be estimated. To specify the discounted stream of risk reduction ΔR_j, we use a constant exponential discounting model:

$$\Delta R_j = \int_0^{T_j} \Delta r_j \exp(-\delta\, t)\, \mathrm{d}t = \Delta r_j [1 - \exp(-\delta\, T_j)] \delta^{-1}, \tag{3}$$

where Δr_j is the constant annual risk reduction by policy j. T_j is the duration over which policy j is providing this risk reduction and δ is the discount rate. By maximizing the log-likelihood function $L^* = \sum_i \sum_j \lambda_{ij} \ln[\Pr(j|i)]$ (whereby $\lambda_{ij} = 1$ if i chooses j and $\lambda_{ij} = 0$ else), we can estimate coefficients α and β that denote the marginal utility of risk reduction and of income, respectively. Being the marginal WTP for a marginal decrease in risk, the VSL is then simply derived as $(\hat{\alpha} / \hat{\beta}) = (\partial V / \partial \Delta R_j) / (\partial V / \partial C_j) \equiv \text{VSL}$.

Testing whether the framing of risks or the perception of the different hazard types affect the WTP requires specifying the indirect utility function given in Eq. (1). To this purpose, we specified the following three indirect utility functions:

Spec. 1: $V_{ij} = \alpha \Delta R_j - \beta C_{ij} + \gamma_1 AVAL + \gamma_2 RFALL + \gamma_3 OACC + \theta(\Delta r_j \times FRAME),$ (4.1)

Spec. 2: $V_{ij} = \Delta R_j (\alpha + \theta_1 AVAL + \theta_2 RFALL) - \beta C_{ij} + \gamma_1 AVAL + \gamma_2 RFALL + \gamma_3 OACC,$ (4.2)

Spec. 3: $V_{ij} = \alpha \Delta R_j + \gamma\,(\Delta r_j \times FRAME) - C_{ij}\,(\beta + \theta_1 EXPOSURE + \theta_2 GENDER),$ (4.3)

with α, β, γ_n, θ_m: coefficients; ΔR_j: discounted risk reduction by policy j over the duration T_j; Δr_j: annual risk reduction by policy j; C_j: individual cost for this risk reduction; *FRAME*: dummy that takes on the value 1/0 if the risk reduction is/is not referred to the overall number of fatalities in car accidents; *AVAL* / *RFALL* / *OACC*: dummies that take on the value 1/0 if the hazard type is/is not avalanche, rock fall or ordinary car accident respectively; *EXPOSURE*: dummy that takes on the value 1/0 for individuals who expose themselves more/less than once a week on Alpine roads; *GENDER*: dummy that takes on the value 1/0 for females/males.

RESULTS

From the estimated model specifications 1-3, we can calculate the VSL as ($\hat{\alpha}/\hat{\beta}$), which leaves us with values between CHF 5.65 million (specification 3) and CHF 6.86 million (specification 2). This range of VSL estimates is in line with other DCE-based VSL estimations (Alberini et al. 2007; Tsuge et al. 2005). In specification 1, all variables are statistically significant. As expected, the sign of ΔR_j is positive and the sign of C_j is negative. The coefficients of the hazard dummies are significant, suggesting that the valuation of risk reduction varies with the associated hazard type. Specification 2 additionally included the hazard type against which protection is provided. The interaction terms between risk reduction and rock fall hazards and between risk reduction and avalanche hazards are not significantly different from the baseline risk, suggesting that the respondents perceive the type of hazard differently, but that they value risk reductions of any type of hazard as equally worthy. Estimations for specification 3 show that women value mortality risk reductions somewhat higher than males. Surprisingly, respondents who stated high exposure value mortality risk reductions ceteris paribus less than respondents with lower exposure.

DISCUSSION AND CONCLUSIONS

In this study, we used an integrated framework for valuing reductions in mortality risk by three different hazard types. This approach allows to not only estimate the marginal WTP for risk reduction, but also to test the impact of specific hazard types based on respondents preferences for risk reduction policies. The results of our experiment suggest that the WTP for mortality risk reductions is about CHF 6 million per avoided fatality. Further, this WTP depends significantly on the type of hazard. Our results show that the WTP varies over the different hazard types against which measures are taken. Reduction in avalanche and road accident risk is slightly preferred over reduction in rock fall risk. The reasons for this preference may lay in factors of risk perception such as the experience with a certain hazard, the degree of voluntariness, or the possibility to shape one's own faith, e.g. by driving carefully. While we conclude that respondents really care for which hazard type their money would be spent, more research is necessary to understand this preference. In summary, our findings suggest that DCE may be a valuable tool for natural hazard management. Their use requires an appropriate description of risks in order to reflect the real good—namely safety-—that is hypothetically bought by the survey respondents.

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