Proportionality of Willingness to Pay to Small Risk Changes – The Impact of Attitudinal Factors in Scope Tests

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Summary

Sensitivity (proportionality) of willingness to pay to (small) risk changes is often used as a criterion to test for valid measures of economic preferences. In a contingent valuation (CV) study conducted in Austria in February 2005 1,005 respondents were asked their willingness to pay (WTP) for preventing an increase in risk by 1/42,500 and 3/42,500, respectively. WTP for the higher risk variation is significantly higher than WTP for the lower risk change. We find evidence that those respondents who have personal experience with avalanches combine the information about future risk increase, provided in the survey, with the observed number of mortal avalanche accidents in the past. The proportionality of WTP holds if such prior experiences are taken into account and the influence of attitudinal factors in scope tests are controlled for.

Keywords: Contingent Valuation, Willingness to Pay, Scope Test, Sensitivity of WTP

JEL Classification: D81, J17, Q54

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1 Introduction

CV estimates are based on individual valuations of hypothetically provided goods. One possible instrument to collect information about individual preferences is the maximum amount of money a consumer is willing to give up in favor of obtaining the good in question. As the real choice and behavior cannot be observed, the validity of CV estimates is often challenged. There are two main interpretations of CV values. According to the psychological point of view, WTP and the corresponding monetary values represent another scale to articulate one's attitude toward a specific good. (Kahneman, Ritov, Jacowitz & Grant 1993) allude to a "contribution" model with individual responses to CV questions to be interpreted as willingness to support goods which are seen as eligible. In contrast economists act on the assumption of a "purchase" model with WTP as an expression of how much a good or service is worth to the individual. It is hypothesized that respondents report a money value such that they are indifferent between two situations: either they pay a certain amount and obtain the good or they forgo consumption in the absence of any financial contribution.

Within the economic framework an important criterion of (economic) preferences necessitates the sensitivity of WTP to important factors (e. g. the quantity or quality of the good in question). For the valuation of mortality risks it therefore follows that WTP has to be larger for larger risk reductions. The crucial question is: how much should WTP increase when mortality risks decrease? The standard model of WTP assumes that individuals substitute income y for risk reduction Δp such that they maximize their expected state dependent utility

$$EU(p, y) = (1 - p)u_a(y) + pu_d(y) \tag{1}$$

where p is the probability of dying during a given period, and u_a (u_d) represents the utility conditional on surviving (dying) in that period. The value of statistical life (VSL) is derived by taking the total differential of (1)

$$VSL = \frac{dy}{dp} = \frac{u_a(y) - u_d(y)}{(1 - p)u'_a(y) + pu'_d(y)} \tag{2}$$

The VSL describes the rate at which individuals are willing to forgo money for an infinitesimal reduction in risk. Two factors influence the VSL: The effect of risk (p) and the income (y) effect. The former is reflected by the difference in the marginal utilities of income in the two states (life and death). Information about the effect of income on VSL is provided by income elasticities (see (Hammitt 2000) for a detailed discussion).

(Jones-Lee 1974) show that the marginal value of a decrease in risk increases with initial risk and initial wealth/income. (Hammitt 2000) conclude that although the VSL is not constant but depends on income and baseline risk – i. e. when individuals buy a large amount of reduction income as well as risk decline and their VSL will fall – under the standard models of decision making described in (1) and (2) both effects should be small. This is the case, if the money spend on buying an infinitesimal risk reduction represents a small fraction of income (or if the income elasticity is low) and if the corresponding risk change is only modest in comparison to the individual's total survival probability.

Nearly constant VSL figures are associated with near proportionality of WTP to (marginal) variations of mortality risks. However, (Hammitt & Graham 1999) provide some reasons for the insensitivity of WTP to scope: (1) the expected utility theory may not represent the proper model for the individual valuation process, (2) respondents do not understand (small) probabilities of hazardous events, (3) individual estimates are not only based on the information provided in the survey but also on prior experiences/beliefs. The latter argument refers to situations where respondents act as Bayesian decision makers and update their prior beliefs by additionally available sources of information.[1]

(Kahneman, Ritov & Schkade 1999) provide comprehensive comments on dollar responses in conjunction with valuation of public goods. They discuss different problems such as context dependence, inadequate sensitivity of WTP to scope, framing or anchor effects. By comparing dollar responses to other measures of attitude the authors find that informa-

[1]For a discussion of Bayesian learning models in the context of risk perception see (Hakes & Viscusi 1997), (Lundborg & Lindgren 2004), (Viscusi & Evans 1998).

tion in the dollar responses could be also obtained by using other expressions of attitudes. Thus, they conclude that dollar statements should be rather interpreted as expressions of attitudes than economic preferences. Also (Hammar & Johansson-Stenman 2004), (Hammitt & Graham 1999), (Kahneman et al. 1993), (Kahneman & Knetsch 1992), (Olsen, Donaldson & Pereira 2004) doubt that WTP represents an appropriate measure to value economic preferences as they find that WTP is insignificant to the dimension of proposed risk reductions. (Carson & Mitchel 1993) and (Carson & Mitchel 1995) provide contrary evidence by describing survey designs and findings from empirical studies which reveal sensitive WTP estimates. They hold survey design problems, such as missing information about the nature of the good in question, about the manner of provision, or about the payment obligations responsible for spurious insensitivity of WTP to scope. (Hammitt & Graham 1999) examine CV studies about the reduction of health risk and show that many WTP estimates are inadequately sensitive to the underlying risk variation. Also these authors hold poorly designed studies responsible for the lack of sensitivity to probabilities and recommend the improvement of CV methods in communicating small risk changes. (Corso, Hammitt & Graham 2001) take up this recommendation and examine the effects of visual aids in communicating risks. They find that WTP figures are sensitive to the dimension of mortality risk reduction when visual aids are used. For example, the authors show that WTP varies even proportional to the underlying risk change if respondents are visually presented a logarithmic risk scale. Thus, they conclude that the use of appropriate methods to communicate risk variations will lead to valid estimates of WTP.

(Heberlein, Wilson, Bishop & Schaeffer 2005) provide another explanation for the insensitivity of WTP. They criticize conventional scope tests which compare (mean/median) values from separate samples without looking beyond economic scope (e.g. influence of quantity of the good on WTP), thereby often neglecting affective and cognitive (attitudinal) as well as behavioral scope.[2] To overcome this deficiency the authors apply

[2]In their paper economic, affective, and cognitive scope refer to the amount of the good, feeling/satisfaction with the good, and knowledge/thinking of the resource in question, respectively.

theories from social psychology in their CV survey and testing procedure to allow a more detailed analysis of scope effects. Comparing the results of parts and wholes for four different goods they show that psychological factors such as affective and cognitive attributes of the commodity in question provide reasonable explanations why WTP seems to be inadequately sensitive to the variation in quantity. The authors mention that attitudinal influences may explain even negative scope effects but do not invalidate CV estimates. For example, if people know more about the part, are more content with the part, have more experience with the part they are expected to show higher WTP for the part than the whole. Thus, (Heberlein et al. 2005) conclude that even if in some cases poorly designed studies may lead to scope failures they can also occur for other reasons. Moreover, a failure to pass conventional scope tests would not necessarily invalidate CV results.

(Heberlein et al. 2005) estimate the joint effects of affective and cognitive scope on economic scope by running a multinomial logistic regression with the economic scope variable (three-way categorical) as dependent variable. Different from their approach we examine the scope effect by including a dummy for the higher risk variation in our WTP regression. To analyse the effects of attitudinal factors on scope sensitivity we additionally use interaction terms with the scope dummy variable and specific characteristics. This procedure allows us not only to identify whether and, if yes, which attitudinal factors influence scope sensitivity but also to determine the dimension of variation.

Our research questions refer to (Kahneman et al. 1993) who demand that *"The proponents of contingent valuation should bear the burden of demonstrating that measured WTP is not simply another measure of attitude on an arbitrary scale."* Hence, we want to examine (1) whether our WTP estimates to prevent mortal avalanche accidents are sensitive to scope and if so, whether they are proportional to the dimension of risk change, (2) whether psychological factors influence sensitivity of WTP, and (3) deductive, whether our results rather support the psychological (WTP as a measure of attitude) or the economic (WTP as a measure of economic preferences) framework. Our findings allow a determination of

important factors in scope tests and a judgement of the appropriateness of the proportionality assumptions.

The paper is organized as follows: Section 2 describes the survey design and estimation procedure. Section 3 discusses the scope test. Section 4 provides the structure of the underlying data. Section 5 presents results, and Section 6 concludes.

2 Survey design and estimation procedure

Our analysis of scope effects is based on data collected in February 2005. 1,005 residents in the Austrian province of Tyrol were asked in face-to-face interviews about their WTP to prevent an increase in the risk of dying in an avalanche. Individuals were randomly assigned into two groups and evaluate a risk change of either 1/42,500 (a doubling of the baseline risk) or 3/42,500 (a quadruplication of the status quo risk level).

2.1 Payment question

The survey respondents were presented the following information (divergence in wording for the larger risk variation in brackets):

Protective measures against avalanches on roads and in residential areas have been implemented in Tyrol. At present, 2.35 people out of 100,000 inhabitants are killed by avalanches on average. Assume that all public funds to maintain protective measures will be cut and henceforth servicing costs have to be paid exclusively by private funds. If aggregate private contributions are too small, maintenance remains undone, and the probability of a fatal avalanche doubles [quadruples]. Then on average 4.7 [9.4] people out of 100,000 inhabitants die in the snow bulk (see Figure 1). Would you be willing to pay - given your income constraint - a monthly insurance premium of 2.5/5/10 Euro to maintain the effect of previous protective measures to save human lives?

Depending on their answers to the first question the respondents were asked whether they would also pay 5/10/20 Euro if they accepted the ini-

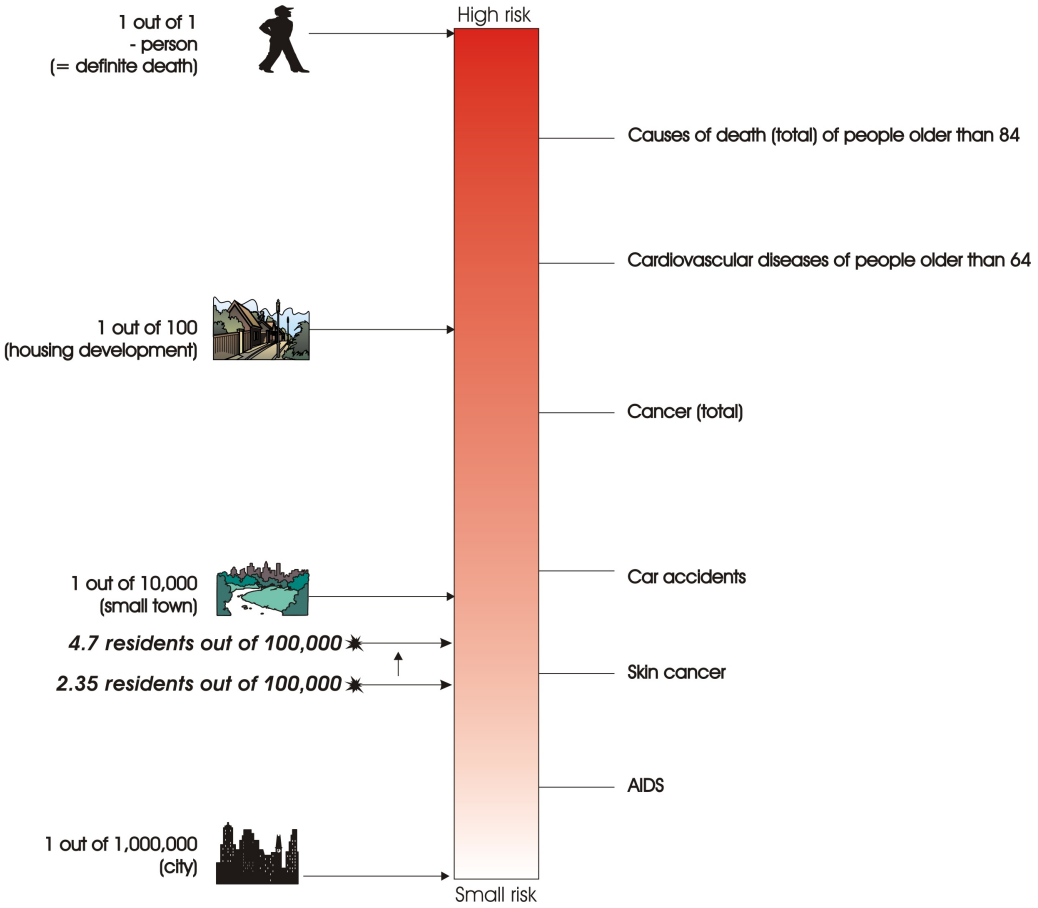

Figure 1: Causes of deaths in Tyrol in the year 2002 (small risk change)

tial bid, or 1.3/2.5/5 Euro if they did not adopt the initial amount.[3] If the interviewees' answers were "no - no" or "do not know - no" respondents were asked whether they would be prepared to pay any positive amount or why they refused a payment. Individual responses were classified as protest answers if the interviewees stated that they generally refused payments for protection against natural hazards or if it was argued that the protection of citizens was the responsibility of the government.

Based on (Corso et al. 2001) we visualized the risk variation using a logarithmic scale for a better understanding of the relevant risk change. The graph sows the baseline risk, the new risk level, and other mortality risks (e. g. cancer, car accidents, AIDS) for the Tyrolean population on

[3]In order to define the range of the bid vector information from a pre-test sample was used.

the right hand as well as the dimension of probably involved persons on the left (see Figure 1).

2.2 Explanatory variables

Information about socio-economic characteristics and risk specific attributes was collected to test for internal validity of WTP. Findings in psychological studies (e. g. (Kahneman et al. 1993), (Slovic 1987), (Slovic, Fischhoff & Lichtenstein 2000), (Sunstein 1997)) show how important risk characteristics, such as voluntariness, controllability and origin of risks are in individual risk valuation. As (Heberlein et al. 2005) argue, attitudinal factors also play a major role for the sensitivity of WTP to the dimension of risk change and therefore have to be considered in scope tests. Running two separate regressions for each sub sample we find that the influence of some factors referring to avalanche risks differ between the groups. Accordingly, we use the following risk related attributes and their interactions with the scope dummy as inputs for the sensitivity analyses[4]:

- *Risk perception (riskpercept)*: We measure individual risk perception by presenting the participants the same graph as shown in Figure 1. However, the respondents were not given information about the baseline and the new risk level. They were rather asked to draw in a line where they thought the average risk of dying in an avalanche was located. The distance in millimeters from the bottom of the graph (= small risk) to the self-plotted line has been taken as indication for risk perception. This data was gathered before we collect information about the individual WTP.

- *Subjective avalanche risk (lowrisk)*: Respondents were asked whether they thought that their subjective risk of dying in an avalanche was above/equal/below the average risk. The variable is equal to one for a risk below average and zero otherwise.

[4]For a detailed discussion of the influence of risk related factors on WTP, see (Leiter & Pruckner 2005).

- *Preferences for alternative protective measures (impalter)*: Participants were confronted with six alternative protective measures which prevent deaths due to (1) car accidents, (2) food poisoning, (3) floods, (4) rockfalls/landslides, (5) air pollution, and (6) radiation. Subsequently the respondents were asked to rate the importance of these alternatives in comparison with a prevention of avalanche accidents keeping in mind that each measure would safe the same number of lives.

- *Personal experience with avalanches (famexp)*: The fact that respondents or their family members/friends were struck by an avalanche in the past, may influence risk valuation.

- *Origin of deathly avalanches (anthropogen)*: Individuals responded to a question about the origin of avalanche risks. They stated whether they thought that avalanches were always/mostly/seldom/ never caused by humans/nature/fate. We include a dummy variable in the regressions, indicating whether avalanches are always seen as an anthropogenic event.

Additionally, we include an indicator variable for the higher risk variation *largereduct*. This dummy variable is the main regressor in the analysis of scope effects. It controls for the larger risk variation (3/42,500). Its coefficient is expected to show a significantly positive sign indicating a higher WTP for the larger change as compared to the smaller risk variation (1/42,500). Moreover, the estimated coefficient of this variable shows whether the proportionality of WTP holds.

2.3 WTP for risk prevention

The payment question is designed as a double-bounded dichotomous choice format (DBDC) under which the "true" WTP cannot be directly observed. Depending on whether individual WTP is above (below) a predetermined amount the respondent answers yes (no) to the payment question. Formally, the specification of WTP (dependent variable) is:

$$WTP_i^* = \mathbf{X_i}\beta + \epsilon_i \tag{3}$$

where WTP_i^* represents the latent individual WTP for the prevention of an increase in risk, $\mathbf{X_i}$ is a vector including individual socio-economic and risk related attributes, β is a vector of coefficients to be estimated, and ϵ_i denotes the error term. The following dummy variables are used to infer the sequence of "yes(y)" and "no(n)" responses for individual i to the payment questions (see 2.1):

$$\begin{aligned} d_i^{yy} &= 1 \text{ if } WTP_i^* \geq B_i^H; \\ d_i^{yn} &= 1 \text{ if } B_i^I \leq WTP_i^* \leq B_i^H; \\ d_i^{ny} &= 1 \text{ if } B_i^L \leq WTP_i^* \leq B_i^I; \\ d_i^{nn} &= 1 \text{ if } WTP_i^* \leq B_i^L; \end{aligned} \tag{4}$$

with the first (second) letter in the superscript representing the answer to the initial (following) payment question (y = yes; n = no). B^H, B^I, B^L are the higher, initial, and lower bid, respectively. Assuming a Weibull and log-normal distribution of the error term, mean and median WTP are estimated by a maximum likelihood procedure. Each response is included with its probability in the likelihood function. Formally, this probability can be written as

$$\begin{aligned} &1 - F(B_i^H; \tau) + [F(B_i^H; \tau) - F(B_i^I; \tau)] \\ &+[F(B_i^I; \tau) - F(B_i^L; \tau)] + F(B_i^L; \tau) \end{aligned} \tag{5}$$

where $F(\bullet)$ represents the cumulative distribution function (cdf), and τ denotes the parameter vector which indexes the distribution and has to be estimated.

3 Scope test – Sensitivity of WTP to probability changes

3.1 Testing sensitivity of WTP

In accordance with the approach by (Hammitt & Graham 1999) we conduct an external scope test to examine the sensitivity of WTP to the dimension of risk variation. For this purpose we include in the regressions

both an indicator variable for the higher risk variation and interaction terms with this scope dummy and particular risk related factors (for a discussion see 2.2). As mentioned, we use naturally non-negative distribution assumptions to estimate WTP, namely the Weibull and log-normal distribution. For the Weibull, mean and median WTP are estimated by

$$\begin{aligned} mean_{weib} &= \lambda_i \Gamma(\tfrac{1}{\rho} + 1) \\ median_{weib} &= \lambda_i [-ln(0.5)]^{\frac{1}{\rho}} \end{aligned} \tag{6}$$

with the scale parameter $\lambda_i = exp(\mathbf{X_i}\beta)$, shape parameter ρ, and $\Gamma(\bullet)$ representing the Gamma function. Assuming a log-normal distribution of the error term mean and median are calculated by

$$\begin{aligned} mean_{logn} &= \exp\left[(\mathbf{X_i}\beta) + 0.5\sigma^2\right] \\ median_{logn} &= \exp(\mathbf{X_i}\beta) \end{aligned} \tag{7}$$

with σ representing the scale parameter of the log-normal.

The core factor is the coefficient of the indicator variable for the larger risk prevention *largereduct*. In case of a Weibull or log-normal distribution this term represents the logarithm of the ratio of WTP for the large risk change (3/42,500) to the WTP for the smaller one (1/42,500).[5] Thus, as the ratio of the larger to the smaller variation is 3 and provided that the proportionality assumption holds, WTP for the former should also be thrice as large as for the latter.

To give a first impression about the dimension of WTP in the two samples we run two separate simple regressions including the bid interval and a constant. WTP figures are calculated with a Weibull and log-normal distribution, respectively. Table 1 depicts the corresponding results.

As can be seen, the welfare measures for Group 1 are explicitly higher as compared to Group 2. However, WTP for the latter is definitely not the triple from the estimates in sub sample 1. What are the implications of this observation?

[5] Formally displayed (exemplified for a Weibull):

$$\frac{WTP_{large}}{WTP_{small}} = \frac{\lambda_{large}}{\lambda_{small}} = \frac{exp(1*\beta_1)}{exp(0*\beta_1)} \Rightarrow ln(\frac{WTP_{large}}{WTP_{small}}) = \beta_1.$$

Table 1: Mean and median WTP in € per month (bid and constant)

	Weibull		Log-normal	
	Group 1	**Group 2**	**Group 1**	**Group 2**
Observations	672	333	672	333
Mean	4.39	6.12	5.89	8.46
	(0.36)	(0.58)	(0.76)	(1.35)
Median	1.53	3.02	1.56	2.84
	(0.16)	(0.31)	(0.14)	(0.27)

Notes:
Standard errors (delta method) in parentheses.
Group 1: Risk variation of 1/42,500; Group 2: Risk variation of 3/42,500.

Based on the expected utility theory we focus on the arguments referring to insensitivity of WTP mentioned in (Hammitt & Graham 1999) and (Heberlein et al. 2005) and discuss their appropriateness for our data set. According to (Hammitt & Graham 1999) problems in understanding probabilities and the importance of various information sources may influence the individual valuation process. As avalanches and deathly avalanche accidents occur every year in Tyrol residents are familiar with the corresponding risk and should be able to understand even relatively small probabilities. To improve comprehension we visualize the risk change to be evaluated by a graph. Beside the provided information in the questionnaire, media reports and official statistics are another source of information which may influence understanding. Respondents may keep in mind avalanche accidents in previous years and update their prior beliefs.

As mentioned, Group 2 received information that the current risk of dying in an avalanche of 2.35 inhabitants out of 100,000 quadrupled (to 9.4 out of 100,000) if maintenance work on existing protective measures were cut. This quadruplication corresponds with an annual death toll of 64. Facing these figures, respondents may believe in a substantial increase of deathly avalanches but may think that the presented quadruplication is too excessive. Indeed, respondents might gain this impression from previous avalanche accidents. The death toll of the recent winter period

(December 2004 - April 2005) ran up to 25 fatalities ((ASI-Tirol, Alpine Safety & Information Center 2005)) which is above the ten-year average of 16 deaths ((Amt der Tiroler Landesregierung, Lawinenwarndienst Tirol 2003)). This tendency has already become apparent in February 2005 when the survey took place and avalanche accidents frequently occurred.[6] A peak of 45 casualties (nearly the triple of the ten-year average) was observed in the winter of 1998/1999. This relatively high figure was mainly caused by one single avalanche in a small village where 31 people died. This disaster was documented by a broad local and international media coverage which makes individual recollection of information even years later plausible.

However, we have no explicit information to what extent individuals actually consider such (media) reports. A source of information we can control for by including a dummy variable *famexp* is prior experience with avalanches. Respondents who state that they or their relatives/friend were struck by an avalanche in the past are expected to take into account these experiences. Furthermore, it is reasonable that they show higher concern to reports and statements referring to avalanche risks and accidents. Therefore, we assume that the respondents who valuated the higher risk variation and had personal experience with avalanches have a risk change in mind which is below the proposed quadruplication and will state a lower WTP for risk prevention. This hypothesis is tested by including an interaction term with *largereduct* and *famexp*.

(Heberlein et al. 2005) argue that controlling for attitudinal characteristics may strengthen the arguments of proportionality. We test the importance of cognitive and affective factors for scope effects by using variables representing individual risk perception *riskpercept*, self-assessment of subjective avalanche risk below average *lowrisk*, preferences for alternative protective measures *impalter*, avalanches assessed as anthropogenic events *anthropogen*, and their interactions with the scope dummy *largereduct*.[7]

[6] Transferred to the Tyrolean population 16 people killed is equivalent to our baseline risk of 1/42,500.

[7] See 2.2 for an explanation of these variables.

4 The data

Before we start discussing the results on the sensitivity of WTP to the dimension of risk variation we shortly present descriptive statistics of our data. This description provides information whether the two samples (Group 1 and Group 2) differ in their characteristics and answers to the payment questions.

4.1 Socio-demographic attributes

Table 2 represents socio-economic characteristics of the two groups. Group 1 (confronted with a risk variation of 1/42,500) includes 672 individuals and Group 2 (risk variation = 3/42,500) contains 333 respondents. A two-sample t-test reveals significant differences (5 % level) between the groups in gender only: the proportion of women in sub sample 1 is considerably lower than in Group 2 (47 % vs. 55 %).[8] In the remaining attributes the samples correspond well.

The average respondent is 35 years old and lives in a household with approximately 3 members. 40 % of the participants live alone. More than one fourth has at least a university entrance diploma. The average personal take home income per month ranges between 1,040 and 1,140 Euro. Less than 50 % of the respondents are non-smokers, more than half are skiers, 66 % and 65 %, respectively, are of normal weight (measured by the BMI), and 56 % and 50 %, respectively, go in for sports at least once a week.

4.2 WTP – Response structure

Table 3 summarizes the responses to the payment questions for both sub samples. The requirements that the positive (negative) answers should decrease (increase) when bids rise are fulfilled. Furthermore, as expected, the proportion of yes (no) answers is higher (lower) for individuals in Group 2 who evaluate the higher risk change. Looking at the frequency

[8] To control for this difference we include in the regressions an interaction term of *female* and the scope dummy *largereduct* as explanatory variable.

Table 2: Sample characteristics

Variable	Group 1		Group 2	
	Obs[a]	Mean	Obs[a]	Mean
female	671	0.47	333	0.55
age	655	35.05	324	34.56
alevel	672	0.28	333	0.26
alone	672	0.39	333	0.43
housemember	666	3.00	330	2.73
inceuro/month[b]	451	1.14	265	1.04
non-smoker	672	0.45	333	0.48
skiing	672	0.53	333	0.57
normal weight	672	0.66	333	0.65
weekly sport	672	0.56	333	0.50

[a] Differences in numbers of observations due to missings.

[b] Monthly take home income in 1,000 Euro (data collected by income classes).

of protest answers we do not find any significant difference between the sub samples.[9]

Table 3: Response sequence to payment questions

initial	Group 1					Group 2				
bid	yy	yn	ny	nn	Tot	yy	yn	ny	nn	Tot
2.5	50	57	22	151	280	33	30	8	52	123
	17.9	20.4	7.9	53.9	100.0	26.8	24.4	6.5	42.3	100.0
5.0	18	28	33	116	195	19	27	11	44	101
	9.2	14.4	16.9	59.5	100.0	18.8	26.7	10.9	43.6	100.0
10.0	9	39	21	128	197	7	20	25	57	109
	4.6	19.8	10.7	65.0	100.0	6.4	18.4	22.9	52.3	100.0
Total	77	124	76	395	672	59	77	44	153	333
	11.5	18.5	11.3	58.8	100.0	17.7	23.1	13.2	46.0	100.0

[9] We include protest answers to allow for conservative estimates.

5 Results

5.1 Regression analysis

Whereas the predetermined risk variation for Group 1 is 1/42,500 (prevention of a risk increase from 1/42,500 to 2/42,500) the presented risk change to be evaluated by group 2 goes up to 3/42,500 (prevention of an increase from 1/42,500 to 4/42,500). The plausibility of the proposed risk variation to be evaluated is based on the assumption that respondents exclusively use direct information provided in the questionnaire. This means, that other sources of information would not have an influence on the credibility of the dimension of risk changes. However, if participants combine current and prior (personal) experience they may be assumed to base their assessment on a differing risk variation. While the coefficient of the dummy variable for the larger risk prevention allows testing whether proportionality of WTP holds interaction terms enable to examine the importance of prior experiences and beliefs in the individual valuation process.

As was mentioned above, the scope coefficient *largereduct* represents the logarithm of the ratio of WTP for the larger to WTP for the smaller risk change. If respondents take the described risk variation in the survey at face value individuals in Group 2 value a threefold risk reduction as compared to Group 1. If proportionality holds, the expected value of the dummy coefficient is $ln(3) = 1.099$. However, apart from standard economic and for psychological reasons for non-proportionality (for a discussion see Section 1) the provided information in the questionnaire may not correspond with prior experience/knowledge about avalanche risks, and individuals may attach higher importance on other sources of information. This argument may be the case particularly for Group 2 members who had personal experience with avalanches in the past. As discussed in Section 3.1 there is good reason to assume that the valuation of these respondents is biased by prior knowledge. Therefore, these interviewees can be expected to state a WTP for a smaller – and to their understanding a more realistic – risk change. Hence, respondents in Group 2 who have personal prior experience with avalanche accidents

may express a lower WTP than expected, represented by a coefficient of the scope variable below 1.099.

In order to test proportionality of WTP we follow the approach by (Hammitt & Graham 1999) and focus on the coefficient of the indicator variable for the larger risk prevention *largereduct*. Four different models are estimated to examine the variation of the scope coefficient and to study its interrelation with socio economic and risk related characteristics. Model A and B just differ in the number of included observations: while in Model B respondents who apparently have problems in understanding probability contexts were excluded[10], Model A uses all statements. Analogously, "non-learners" are included/excluded in Model C and D, too, but the number of regressors is additionally extended by interaction terms of the scope variable and particular risk characteristics[11]. Table 4 depicts closed-ended double-bounded maximum likelihood estimates for each model assuming a Weibull distribution of the error term.[12] A brief description of the included regressors can be found in Table 5.

Model A and B in Table 4 show regression results, once including all observations (Model A) and once excluding those who seem to have problems in probability comprehension (Model B). The effect of included regressors is quite similar in both models. Risk perception (*riskpercept*) is highly significant and positively influences WTP in Model A and B, i. e. the higher individual risk perception the higher the contributions. The assessment of avalanches as an always anthropogenic event *anthropogen* and preferences for alternative protective measures *impalter* induce a lower WTP in both models. "Background risks" (Eeckhoudt &

[10]Our questionnaire starts with issues concerning probability comprehension. Respondents were confronted with two questions: First, they were asked to choose the higher chance of winning (15:10,000 vs. 20:100,000). Secondly, they were shown the annual mortality risk of two persons (5:10,000 vs. 10:10,000) and were asked to state who face the higher risk to die. Each question was followed by an explanation of the right solution. Participants who gave the wrong answer to the second matter although the right solution was argued before ("non-learners") may have problems in understanding probabilities. Excluding the statements of such respondents is analogous to procedures in other studies (e. g. (Alberini, Cropper, Krupnick & Simon 2004)) which distinguish individuals by the degree of confidence they have in their answers.

[11]For an explanation of these factors see Section 2.2.

[12]Log-normal regressions provided similar results for both the coefficient of the scope dummy and the significance of the other right hand side variables. However, the likelihood values of the Weibull distribution were superior to the log-normal estimates.

Table 4: Regression results (Weibull distribution)

Dependent variable: bid interval

	Model A		Model B[a]		Model C		Model D[a]	
Variable	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***
largereduct	0.346**	0.17	0.393**	0.19	1.069***	0.31	1.263***	0.34
age	−0.001	0.00	0.000	0.00	−0.002	0.00	−0.001	0.00
female	0.049	0.13	0.035	0.15	0.066	0.13	0.044	0.15
lnincome	0.149	0.09	0.180*	0.10	0.168*	0.09	0.202*	0.10
missincome	0.034	0.13	0.131	0.14	0.045	0.13	0.145	0.14
alevel	−0.202	0.12	−0.259*	0.14	−0.231*	0.12	−0.302**	0.14
housemember	0.006	0.03	0.002	0.03	0.008	0.03	0.006	0.03
volunteer	0.029	0.23	0.155	0.25	0.029	0.23	0.147	0.25
famexp	0.216	0.14	0.195	0.15	0.400**	0.17	0.449**	0.18
riskpercept	0.014***	0.00	0.014***	0.00	0.017***	0.00	0.017***	0.00
lowrisk	−0.144	0.14	−0.200	0.16	0.037	0.17	0.009	0.19
lowriskvol	−0.149	0.27	−0.215	0.31	−0.141	0.27	−0.189	0.30
anthropogen	−0.243**	0.11	−0.248**	0.13	−0.243*	0.13	−0.204	0.15
natural	−0.025	0.12	0.054	0.13	−0.031	0.12	0.045	0.13
skiing	0.007	0.12	0.001	0.14	−0.012	0.12	−0.022	0.13
riskaversion	0.014	0.02	0.008	0.02	0.017	0.02	0.012	0.02
missaversion	0.054	0.29	0.008	0.33	0.100	0.29	0.058	0.33
impalter	−0.446***	0.16	−0.434**	0.17	−0.416**	0.19	−0.361*	0.21
jobrisk	0.259**	0.11	0.183	0.13	0.244**	0.11	0.175	0.13
normalweight	−0.296**	0.12	−0.304**	0.13	−0.292**	0.12	−0.297**	0.13
nosmoke	−0.094	0.11	−0.038	0.13	−0.110	0.11	−0.058	0.13
weeklysport	0.289**	0.12	0.252*	0.13	0.287**	0.12	0.262**	0.13
largefemale	0.354	0.24	0.454*	0.26	0.315	0.24	0.450*	0.27
largeimpalt					−0.150	0.36	−0.222	0.38
largeexp					−0.539*	0.29	−0.778**	0.31
largelow					−0.508**	0.26	−0.585**	0.29
largepercept					−0.009	0.01	−0.008	0.01
largehuman					−0.013	0.24	−0.152	0.27
constant	−0.236	0.74	−0.388	0.83	−0.622	0.76	−0.851	0.84
Observations	956		794		956		794	
Log Likelihood	-1096		-915		-1091		-909	
Ratio[b]	1.41		1.48		2.91		3.54	
H_0 : proportionality[c]	r		r		nr		nr	

*, ** and *** indicate statistical significance at the 10-% level, 5-% level and 1-% level.

[a] Exclusion of respondents with lack in probability comprehension ("non-learners")

[b] Ratio of WTP for large risk prevention to WTP for small risk prevention: = $exp(largereduct)$

[c] r = H_0 of proportionality has to be rejected; nr = H_0 of proportionality cannot be rejected

Table 5: Explanatory Variables – Description

Variable	Description
age	Age of respondent in years.
alevel	Dummy = 1 if respondent holds a university entrance diploma; 0 otherwise.
anthropogen	Dummy = 1 if respondent always regards avalanches as an anthropogenic event; 0 otherwise.
famexp	Dummy = 1 if respondent or another family member has had personal experience with avalanches; 0 otherwise.
female	Dummy = 1 if respondent is female; 0 otherwise.
housemember	Number of persons in the respondent's household.
impalter	Dummy = 1 if the respondent prefers alternative protective measures; 0 otherwise.
jobrisk	Dummy = 1 if respondent states that she faces workplace risks; 0 otherwise.
largereduct	Dummy = 1 if the predetermined risk variation = 3/42,500; 0 otherwise.
largeexp *largefemale* *largehuman* *largeimpalt* *largelow* *largepercept*	Interaction terms with scope variable
lnincome	Logarithm of personal monthly take home income.
lowrisk	Dummy = 1 if respondent assesses her personal risk of dying in an avalanche below average.
lowriskvol	Interaction term: *lowrisk* and *volunteer*.
missaversion *missincome*	Dummy = 1 if missing observations of riskaversion (income) are replaced by zero (mean income); 0 otherwise.
natural	Dummy = 1 if respondent always regards avalanches as a natural event; 0 otherwise.
normalweight	Dummy = 1 if respondent is of normal weight; 0 otherwise.
nosmoke	Dummy = 1 if respondent does not smoke; 0 otherwise.
riskaversion	Respondent's behavior in risky situations. Ranges between 0 (risk loving) and 21 (risk averse).
riskpercept	Respondent's perception of deathly avalanche risks. Ranges between 0 (no risk) and 131 (death).
skiing	Dummy = 1 if respondent is a skier; 0 otherwise.
volunteer	Dummy = 1 if respondent volunteers; 0 otherwise.
weeklysport	Dummy = 1 if respondent goes in for sport at least once a week; 0 otherwise.

Hammitt 2001) also play a role in the valuation process. While the existence of workplace risks (*jobrisk*) show a significant positive impact in Model A only, supposed lower health risk due to normal weight and sportive activities are relevant for both models. People who are of normal weight (*normalweight*) state a significantly lower and those who go in for sports at least once a week (*weeklysport*) a significantly higher WTP, respectively. The impact of income (*lncinome*) and education (*alevel*) is significant in Model B only. While higher income induces higher WTP, higher education negatively influences individual contributions. The coefficient of the interaction of the scope variable and female (*largefemale*) carries a positive sign. It is just significant in Model D and implicates that women who valuated the larger risk variation state a higher WTP. This term is included to control for the significant difference in proportion of women between the two samples.

Concerning scope effects a glance at Models A and B shows that the coefficient of the scope variable is considerably lower than 1.099. Although it is higher when we just use the answers from individuals who show some confidence in dealing with probabilities, WTP for Group 2 is definitely not three times as high as for Group 1. We take this as evidence that participants in Group 2 seem to attach higher importance on prior experience about the risk of fatal avalanche accidents. Another explanation can be inferred from psychological findings as, for example, (Heberlein et al. 2005) discuss. For example, respondents may consider the larger spread as too excessive or its prevention as less urgent or even lavish.

To examine such influences we additionally include interaction terms in Model C and D. The effect of this procedure on the coefficient of the scope dummy (*largereduct*) is quite considerable. Once controlling for prior experience and attitudinal factors (such as preferences for alternative protective measures or self-assessment of subjective avalanche risk) the hypothesis of proportionality of WTP estimates to the risk change cannot be rejected anymore. While the scope coefficient is almost identical to the postulated value of 1.099 in Model C, it is higher in Model D. A Wald test on the coefficients of the scope dummy (*largereduct*) in the

two latter models reveals that they are not significantly different from 1.099.[13] The interaction terms with the scope dummy in Models C and D enables to clarify which factors cause the observed non proportional increase of WTP.

As expected, respondents who mentioned that they had personal experience with avalanches (*famexp*) state a higher WTP than those who were not personally affected by avalanches. But the WTP for the former is significantly lower when they evaluate the larger risk reduction (*largeexp*). From that we follow that people with prior experience combine the information about the prevented risk dimension provided in the survey with their personal knowledge and apparently valuate a smaller risk change. The peak of fatal avalanches per year within the last 10 years – 45 casualties – approximates the triple of the baseline risk. It seems realistic that particularly struck people are more sensitive in avalanche matters, use different sources of information, and therefore value a lower than the proposed risk variation.

A similar effect can be observed when respondents assess their personal avalanche risk below average. While the coefficient of the indicator variable for lower subjective risks (*lowrisk*) indicate a positive though insignificant impact on WTP, its interaction with the scope variable (*largelow*) reveals a negative influence on WTP. One explanation for this observation is, that people who already regard their current risk of dying in an avalanche as low may think that a fourfold higher risk than the baseline risk will less than ever apply to them. Hence, they are less willing to pay for a prevention of a quadrupling in risk.

Besides these attitudinal influences, which other significant impacts occur? Different from the regressions without scope interaction terms, the positive influence of income (*lnincome*) is now significant in both Models (C and D), WTP in regressions C as well as D is significantly lower for higher educated people (*alevel*) than WTP of those who do not hold a university entrance diploma, and the assessment that avalanches are always caused by human (*anthropogen*) shows a relevant impact just

[13] A Wald test is used to test linear hypothesis. It follows a chi-square distribution with as many degrees of freedom as restrictions to test.

for the full sample, represented by Model C. Regarding the remaining significant variables *impalter*, *jobrisk*, *normalweight*, and *weeklysport* the same impact as in Models A and B can be observed for Models C and D, too. Preferences for alternative mitigation measures negatively influence WTP. People who face job risks and those who take exercises at least once a week state a higher WTP while persons who are of normal weight reveal a lower WTP.

The main finding of our analysis is that the observed impact of attitudinal variables on the scope dummy supports the arguments of (Heberlein et al. 2005) who demand an inclusion of social and psychological attributes in scope tests. Although our survey focussed not the importance of attitudinal attributes for scope tests our results provide evidence that individual characteristics matter and therefore have to be included in future analyses.[14] The disregard of (psychological) influences may hardily call WTP into question as a valid instrument for the measurement of economic preferences.

We find evidence that the WTP for the larger risk reduction is significantly higher than the figures for the smaller prevention of risk. Moreover, we could show that the ratio of WTP for the larger to WTP for the smaller reduction depends on psychological attributes such as individual risk attitudes and risk assessments. Therefore we agree with (Heberlein et al. 2005) that future scope tests have to include attitudinal factors to prevent premature judgements on the scope insensitivity of WTP figures in risk assessments.

[14] Another potential influence on individual valuation is the effectiveness and likelihood of allocation of the good. As (Carson & Mitchel 1995) argue respondents might discount the likelihood of provision for the larger good more than they discount the likelihood for the less extensive good. (Powe & Bateman 2004) show that perceived realism regarding the good in question may be an important factor which influences scope analyses. Once considering just responses from those who felt the scheme was realistic WTP for the "whole" is significantly higher than WTP for the "part". Unfortunately, our data do not provide the necessary information to explicitly control for these influences.

5.2 Value of statistical life (VSL)

WTP figures for reduced mortality risk are often used for the calculation of VSL. As was painted out in the introduction the VSL is a monetary measure for the utility of fatality prevention. It is defined as the ratio at which individuals are willing to exchange income for risk changes and it is calculated by dividing the annual WTP by the corresponding risk variation (see Section 1).

If WTP increases less (more) than proportional, VSL based on the larger risk variation will be lower (higher) than for the smaller risk reduction. In order to examine the range of VSL depending on the risk change we use the coefficients of Model C and D (see Table 4) and multiply them by the characteristics of an average respondent in the full sample and of an average individual when "non-learners" are excluded, respectively. To show the scope effect on WTP and VSL figures we vary these calculations by just one variable: while the scope dummy for Group 1 is zero, it equals one for Group 2. Table 6 summarizes the results.

For Group 2 mean (median) WTP per year to prevent the risk increase ranges between € 129 and € 171 (€ 59 and € 77). Dividing these values by the risk variation of 3/42,500 leads to mean (median) VSL between € 1.83 million and € 2.42 million (€ 0.83 million and € 1.09 million). Analogously calculated, mean (median) VSL in Group 1 lies between € 1.89 million and € 2.06 million (€ 0.85 million and € 0.93 million). Obviously, VSL figures between the groups are quite similar which is caused by the observed sensitivity (proportionality) of WTP to the dimension of risk variation.

6 Conclusions

Scope analysis is a common instrument to test the validity of CV estimates. WTP is hypothesized to be sensitive to major characteristics, such as the quantity of the provided good. In this study WTP is expected to increase with the magnitude of risk prevention. For the purpose of testing sensitivity of WTP to the dimension of risk change 1,005 Tyroleans were organized into two groups and asked about their WTP for a preven-

Table 6: WTP/month (in €) and VSL (in mio. €)

	non-learners included		non-learners excluded	
	Group 1	**Group 2**	**Group 1**	**Group 2**
Mean WTP	3.70	10.77	4.03	14.25
	(0.75)	(3.52)	(0.86)	(5.08)
Median WTP	1.67	4.88	1.81	6.41
	(0.35)	(1.58)	(0.40)	(2.24)
Mean VSL	1.89	1.83	2.06	2.42
Median VSL	0.85	0.83	0.93	1.09

Notes:
Standard errors (delta method) in parentheses.
Group 1: Risk variation of 1/42,500; Group 2: Risk variation of 3/42,500.

tion of a risk increase of 1/42,500 (from 1/42,500 to 2/42,500) for Group 1 and 3/42,500 (from 1/42,500 to 4/42,500) for Group 2, respectively.

Provided that buying an infinitesimal risk reduction only requires a small fraction of income and that the bought risk change is modest in comparison to the individual's total survival probability, WTP for small reductions should vary proportional to the underlying risk variation. Thus, as the provided risk change for Group 2 is a triple of the variation for Group 1, we expect a threefold WTP for Group 2 as compared to Group 1 – provided that respondents take the given information in the questionnaire at face value. However, this assumption must not necessarily be true and the information content of external sources (e. g. prior risk beliefs or experiences, media coverage) may influence individual risk valuation.

A maximum likelihood estimation including a constant, a scope dummy for the larger risk change and socio economic and risk related attributes reveals that WTP is significantly higher in Group 2. However, the proportionality hypothesis of welfare measures with respect to risk variation cannot be supported since the WTP for a triplication of risk prevention increases considerably less than threefold. This result indicates that Group 2 participants combine current information and prior experiences.

Moreover, the scope sensitivity of WTP may also depend on attitudinal factors such as preferences for alternative protective measures or the perceived subjective risk exposure. Whether these assumptions actually influence scope tests is tested by including interaction terms with the scope variable and particular risk related variables.

We find strong evidence that prior experience as well as attitudinal characteristics matter. Controlling for such impacts leads to the final conclusion that WTP for preventing fatal avalanche accidents is proportional to the risk variation. These results are also mirrored in the narrow range of VSL figures across different variations in risk. Thus, our results support that WTP serves as an appropriate measure for individual economic preferences which can be further improved by taking into account the relevance of attitudinal factors.

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