Dying in an Avalanche: Current Risks and Valuation

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Abstract

This paper examines the influence of implicit information associated with the occurrence of avalanches on willingness to pay (WTP) values for a risk prevention of dying in an avalanche. We present results of a contingent valuation (CV) study carried out in Austria in two different periods (fall 2004 and winter 2005). The comparison of WTP results between the two waves allows the identification whether the immediate occurrence of avalanches and their attendant deathly accidents affect individual risk evaluations. Surprisingly, individuals state a lower WTP in winter although avalanche accidents are predominant at that time. Personal responsibility of risk exposure and its associated voluntariness are main reasons for the decrease in WTP over time. Preferences for alternative protective measures (e.g. against car accidents or food poisoning) also lead to a decrease of WTP while a higher risk perception and personal experience with avalanches show a positive influence. We conclude that the change in WTP across seasons is not arbitrary but can be explained by specific risk characteristics. It follows that WTP is more robust as previously assumed and therefore represents a proper measure for the elicitation of individual risk reduction preferences.

Keywords: Contingent valuation, willingness to pay, risk prevention, risk perception.

JEL classification: D81, J17, Q51, Q54.

1 Introduction

Different disciplines examine the influence of information on individual assessment, consumer decision and behavior and illustrate its importance for decision making. Sources of information are multi-purpose, and the individual process of gathering and processing information is complex. This paper examines the influence of information about risk exposure on the individual valuation of protective measures to prevent deathly avalanche accidents. The underlying Contingent Valuation (CV) data were collected in Austria in two different periods (September/October 2004 and February 2005) which differ in their magnitude of avalanche risks. While avalanches do not occur in fall they are common in winter. The second wave of data collection started after a period of heavy snowfalls (February 2005) which has led to an accumulation of deathly avalanche accidents. Five individuals died in an avalanche in the Austrian province of Tyrol in the first week of February 2005 which is equivalent to one fifth of all deathly avalanche accidents between December 2004 and March 2005.[1] Local and national media report such fatalities for informative and/or preventive reasons. This raises the question whether individual responses to avalanche-related issues and risk valuation change between the periods.

Risk is expressed as the probability of deathly avalanche accidents. Apart from information provided by the CV survey individuals are supposed to derive implicit information from the current occurrence of avalanches and the connected media coverage. It seems reasonable that the up-to-dateness of risks matters in individual valuation; an assumption that is supported by different studies. For example, [Liu et al. 2005] estimate values of statistical life (VSL) based on the risk reduction of dying from SARS and find - in comparison to earlier studies - higher values. They conclude that the up-to-dateness may be an explanation for their results. Signalling effects of events and their media coverage provide information on various levels which different people understand

[1] ASI-Tirol 2005. Lawinentote Tirol 2004/2005.

differently. Psychological studies find that lay people differ in their risk assessment from experts' judgement and include hazard characteristics such as dread, catastrophic potential, familiarity, or controllability too ([Slovic 1987], [Slovic et al. 2000]), i.e., the potential of observed differences in risk assessment is extensive.

In general, there are two dimensions how the presence of avalanche risks may influence WTP for risk prevention. First, the occurrence of risks can influence WTP directly and thereby indicate a change of WTP over time. Second, current avalanche risks might induce a change in risk perception and attitudes which in turn can cause a shift in WTP. If the former explanation is true the observed rise or decrease of WTP has to be traced back to the salience of avalanche danger. This raises the question whether WTP is the proper measure to elicit individual preferences as it probably represents an overreaction to external influences such as media coverage. If the latter assumption holds and the shift in WTP can be explained by risk relating factors the use of WTP as a measure of individual preferences gets strengthened. Obviously, the empirical evidence may represent a combination of both effects.

This paper focuses on three research questions. First, we examine whether the perceived risk influences the valuation process. Previous studies find that risk perception plays a decisive role in regulation requirements and that it represents a complex process which is sensitive to cultural, social, and economic influences ([Huang 1993], [Slovic et al. 2000]). Although respondents receive identical information about the current baseline risk their perceived risk might influence their WTP for a prevention of deathly avalanches.

Second, [Slovic et al. 2000] find that risk characteristics like voluntariness, controllability or fairness determine the individual risk assessment. Thus, we analyze whether such attributes also determine WTP for a prevention of deathly avalanche accidents.

Third, salience of avalanche dangers and the update of prior risk assessment due to new (implicit) information about risks might cause differences in individual risk relating characteristics between the periods. By comparing the responses in the two samples we test whether the new survey circumstances and the associated signals have an impact on risk perception, risk attitude, and WTP.

The paper is organized as follows: Section 2 describes the experimental design and presents the payment question. Section 3 explains the econometric models for risk perception and the estimation of WTP for risk prevention. Section 4 presents the underlying data, and Section 5 discusses the results. Finally, Section 6 concludes.

2 Experimental design

The underlying study was carried out in the Austrian province of Tyrol. In face-to-face interviews Tyrolean residents were asked about their WTP to prevent an increase in risk of dying in an avalanche. The data were collected in two waves, the first in September/October 2004, and the second in February 2005. Almost 2000 observations (992 in fall and 1,005 in winter) are used to examine the influence of current avalanche occurrence on WTP for protective measures against avalanches. The winter sample is further divided into two groups with the first one evaluating a risk variation of 1/42,500 and the second one of 3/42,500.[2]

2.1 Willingness to pay for the prevention of increasing avalanche risks

The survey focuses on the WTP for the prevention of an increase in the risk of dying in an avalanche. After the respondents received a detailed description of the good in question they were asked about their individual valuation. The wording of the CV question was as follows:

[2]Although both sub samples are included in the regressions the analysis of scope effects is not a purpose of this paper.

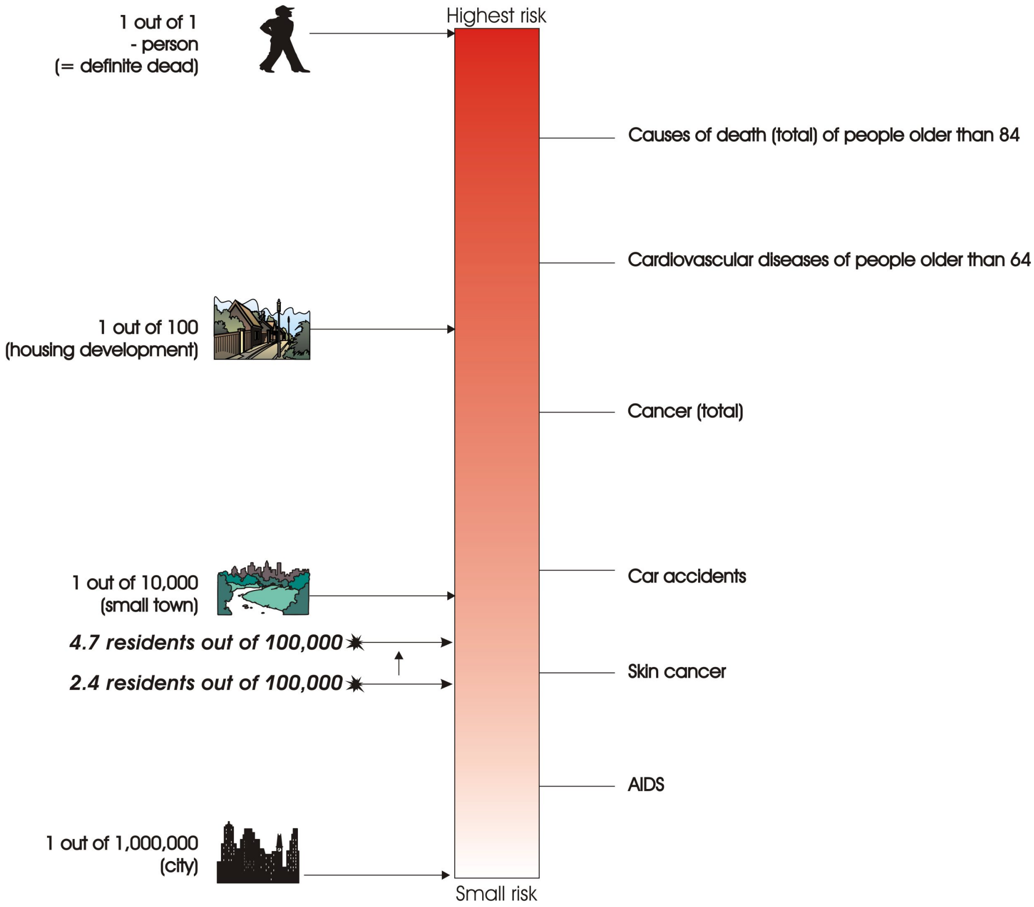

Figure 1: Causes of deaths in Tyrol in the year 2002

Protective measures against avalanches on roads and in residential areas have been realized in Tyrol. At present, 2.4 people out of 100,000 inhabitants are killed by avalanches on average. Assume that all public funds to maintain protective measures will be omitted and henceforth servicing costs have to be exclusively paid by private funds. If aggregate private contributions are too small the maintenance remains undone, and the probability of a fatal avalanche doubles. Then on average 4.7 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 the answer to this initial question the respondent was asked whether she would also pay 5/10/20 Euro to avoid the risk increase if the first bid was accepted or 1.3/2.5/5 Euro if the first bid was rejected.[3] If the interviewee answered "no-no" or "do not know - no" she was asked whether she would be prepared to pay any positive amount and also why she refused a contribution.[4] Protest answers were those who stated that they generally refused payments for protection against natural hazards or who argued that it was the government's responsibility to care about the protection of citizens.

2.2 Risk characteristics and individual attitudes in risk valuation

We collect information about socio-economic characteristics and risk relating attitudes and behavior in the questionnaire to test for internal validity of WTP. Furthermore, the implementation of two waves allows the analysis of changes over time. We investigate whether the occurrence of avalanches in winter may influence stated WTP and test such influences by including a time dummy and interaction terms with specific risk characteristics (e.g. voluntariness, subjective risk estimates). The collected risk relating factors are:

- *Risk perception*: People were presented the scale served as devise to visualize risk variation (see Figure 1). The bottom and top of this graph indicate the lowest and highest risk (= death), respectively. Different mortality risks such as cancer, AIDS or car accidents are plotted along this scale to show the relative magnitudes of different risks. Moreover, the dimensions of risks are indicated by the number of probably involved persons out of different populations. Before they were presented the current avalanche risk respondents were asked to draw in a bar where they think the average risk of dying in an avalanche would be. The corresponding variable *riskpercept* ranges between 0 (= lowest risk) to 131 (= death) and denotes the distance from the bottom to the self-plotted

[3] Answers from an open-ended pretest were used to define the range of the bid vector.

[4] A "do not know" category was accepted as a response.

line, measured in millimeters on the scale.[5] The variable represents the individual risk assessment of avalanches in relation to other mortality risks.[6] Although the respondents receive identical information about the current baseline risk and the future risk change the subjective baseline risk assessment might influence individual WTP. We expected an increase in WTP with a higher assessment of the average avalanche risk.

- *Subjective avalanche risk*: In addition, respondents were asked how they estimate their subjective risk of dying in an avalanche as compared to the average risk. When respondents state a personal risk below average *lowrisk* we expect a lower WTP as this group considers a lower benefit from the prevention of avalanche risks.

- *Skiing*: Skiers *skiing* are expected to show a higher WTP as they especially benefit from avalanche protection.

- *Risk aversion*: Seven different categories are included in the questionnaire to reflect individual behavior in risky situations. Respondents where asked whether they (1) wear seat belts when they go by car, (2) use sun screen, (3) wear biking helmets, (4) gamble, (5) would rather prefer a risky lottery over a safer one, (6) would defend an unpopular opinion, and (7) would pass a friend's/team mate's work or idea off as theirs'. The respective answers (e.g. always, mostly, sometimes, never) which reflect the frequency of such behavior are subsequently transformed into values from 0 to 3 for each category with 0 representing a risky and 3 a risk averse behavior. Hence, the variable *riskaversion* ranges between 0 (risk lover) and 21 (averse).

  [Eeckhoudt and Hammmit 2004] examine the influence of financial risk aversion on WTP for a reduction of mortality risks. They find that the relationship between risk aversion and the VSL is ambiguous in many cases and depends on the characteristics of

[5]The layout of Figure 1 is based on the results of [Corso et al. 2001].

[6]The current average risk of dying in an avalanche is 2.4 persons out of 100,000 inhabitants (equivalent to 30 millimeters).

the utility function which are held constant (when risk aversion changes) as well as on the assumptions about marginal utility for wealth conditional on death. Among others, the authors show the ambiguity of the aversion effect particularly in the case of a partial reduction of mortality risks, i.e., depending on the local concavity of the utility function risk aversion may either lead to an increase or decrease of WTP. We examine the influence of risk aversion on a specific prevention of avalanche risk (1/42,500).

- *Preferences for alternative protective measures*: This indicator variable *impalter* provides insights into the respondents' assessment of protection. It reflects whether the respondents valuate the reduction of mortal car accidents and food poisoning as more important than protective measures against avalanches, even if all measures save the same number of people. In this case a lower WTP is anticipated as the respondents prefer alternative protection measures.

- *Personal experience with avalanches*: We asked respondents whether they or their dependents were struck by avalanches in the past as we assume a stronger concern and therefore higher WTP to prevent avalanche risks among these individuals.

- *Origin of deathly avalanches*: The questionnaire further provides information who or what is being seen responsible for avalanche accidents. We create two dummies *anthropogen* and *natural* which indicate whether the respondents regard avalanches as being caused by humans or by nature. The dummy is one if the respondents state that avalanches are always caused by humans (nature), and zero for the answer categories mostly/seldom/never. According to [Sunstein 1997] who mentioned that the voluntariness of risk exposure can be connected with who is seen responsible for deathly avalanches, the variables *anthropogen* and *natural* are interpreted as indicators of voluntary and manageable risks. Those who state that people themselves are responsible for mortal avalanche accidents probably assume that individuals can choose their level of exposure to that risk. Thus, they are expected to show a lower probability of affirmative answers. The opposite is expected for those who consider avalanches as a natural phenomenon. If they assume that risk exposure is not voluntary and/or not manageable protective measures against avalanches should become more valuable inducing a positive influence on the probability of a yes-answer.

[Cookson 2000], [Slovic et al. 2000], and [Sunstein 1997] have examined these hypotheses. [Lesser et al. 1997] argue that the possibility of a choice between different risk levels considerably influences the individual risk valuation. If no option is available and risk averse people face a given and uniform level, they state a higher WTP for a risk reduction in comparison to situations where they can choose the extent of risk exposure.

In contrast, a higher (lower) WTP for anthropogenic (natural) events is anticipated when effectiveness considerations are involved. Respondents might consider protective measures against forces of nature as ineffective whereas in cases of human failure and/or human misbehavior risk prevention seems to be feasible and reasonable.

- *Variation over time*: Differences in valuation over time are accounted for by including a *winter* dummy for the February 2005 sub sample and interaction terms of risk-specific characteristics with the saisonal dummy. Hence, the variables *riskpercept*, *riskaversion*, *lowrisk*, *anthropogen*, *natural*, *impalter* and *skiing* are combined with the *winter* dummy. The impact of time is expected to be positive as people might be more aware of the risks when avalanche accidents occur and their media coverage accumulates. Furthermore, it is assumed that the occurrence of avalanches and the associated information might cause changes in the influence of explanatory variables.

3 WTP for risk prevention

The aim of this study is the calculation of individual WTP for a risk variation to be used in cost benefit analysis (CBA). In the underlying valuation process the risk increase is avoided by the maintenance of existing protective measures. Therefore, negative aspects of new constructions (e.g. interference with the aesthetics of natural scenery) and their decreasing effect on WTP seems to be irrelevant. Furthermore, risk averse individuals perceive a prevention of increasing risks as an improvement such that their welfare increases when risks decrease. Thus, their WTP to obtain the less risky status should be at least nonnegative. A WTP distribution which only allows zero or positive values seems therefore appropriate. The Weibull and the log-normal are common distribution functions for positive WTP values ([Alberini 2004], [Haab and McConnell 1997]). Concerning the appropriate welfare statistics (median/mean) [Carson 2000] argues that mean WTP is the proper measure when the estimates are intended to enter in CBA where the potential Pareto criterion (winners could compensate losers) is important. Median WTP is relevant for public choice problems when the approval of a majority turns the balance. Our empirical analysis is based on a double-bounded dichotomous choice format (DBDC). The underlying specification reads as:

$$WTP_i^* = \mathbf{X_i}\beta + \epsilon_i \tag{1}$$

with WTP_i^* the latent variable of an individual's WTP for the prevention of an increase in risk and $\mathbf{X_i}$ the vector of variables representing individual characteristics and risk-related attributes. β is the vector of coefficients to be estimated, and ϵ_i represents the error term. In a DBDC format we use the following dummy variables to capture the sequence of "yes(y)" and "no(n)" answers for individual i:

$$\begin{aligned} d_i^{yy} &= 1 \text{ if } WTP_i^* \geq B_i^H; \\ d_i^{yn} &= 1 \text{ if } B_i^I \leq WTP_i^* \leq B_i^H; \\ d_i^{ny} &= 1 \text{ if } B_i^L \leq WTP_i^* \leq B_i^I; \\ d_i^{nn} &= 1 \text{ if } WTP_i^* \leq B_i^L; \end{aligned} \tag{2}$$

where B_i^H, B_i^I, B_i^L represent the higher, the initial, and the lower bid an individual gets confronted with. A maximum likelihood procedure is used to estimate the coefficients in the WTP function. Each response is represented with its probability

$$\begin{aligned} &Pr(\mathbf{X_i}\beta + \epsilon_i \geq B_i^H) + Pr(B_i^I \leq \mathbf{X_i}\beta + \epsilon_i \leq B_i^H) + \\ &Pr(B_i^L \leq \mathbf{X_i}\beta + \epsilon_i \leq B_i^I) + Pr(\mathbf{X_i}\beta + \epsilon_i \leq B_i^L) \end{aligned} \tag{3}$$

which is equivalent to

$$\begin{aligned} &1 - F(B_i^H;\tau) + [F(B_i^H;\tau) - F(B_i^I;\tau)] \\ &+[F(B_i^I;\tau) - F(B_i^L;\tau)] + F(B_i^L;\tau) \end{aligned} \tag{4}$$

where $F(\bullet)$ denotes the cumulative distribution function (cdf) and τ the parameter vector to be estimated. Following [Cameron and James 1987] let $\alpha_i = \mathbf{X_i}\beta/\sigma$ and $\gamma = -(1/\sigma)$.[7] Substituting the corresponding cdf of the log-normal distribution for $F(\bullet)$ in (4) leads to the following log likelihood function:

$$LogL_{logn} = \sum_{i=1}^{N} \left\{ \begin{array}{l} d_i^{nn} \ln[\Phi(\alpha_i + \gamma \; lnB_i^L)] + \\ d_i^{yy} \ln[1 - \Phi(\alpha_i + \gamma \; lnB_i^H)] + \\ d_i^{yn} \ln[\Phi(\alpha_i + \gamma \; lnB_i^H) - \Phi(\alpha_i + \gamma \; lnB_i^I)] + \\ d_i^{ny} \ln[\Phi(\alpha_i + \gamma \; lnB_i^I) - \Phi(\alpha_i + \gamma \; lnB_i^L)] \end{array} \right\} \tag{5}$$

where $\Phi(\bullet)$ denotes the WTP cumulative density function for the log-normal. Under the assumption of a Weibull distribution $F(WTP_i^*) = 1 - \exp(-(B_i^\bullet/\lambda_i)^\rho)$ with shape parameter ρ and scale parameters λ_i the

[7] μ and σ represent the mean and the standard deviation of the log-normal, respectively.

log likelihood function can be written as:[8]

$$LogL_{weib} = \sum_{i=1}^{N} \left\{ \begin{array}{l} d_i^{nn} \ln[1 - \exp(-(\frac{B_i^L}{\lambda_i})^\rho)] + \\ d_i^{yy} \ln[\exp(-(\frac{B_i^H}{\lambda_i})^\rho)] + \\ d_i^{yn} \ln[\exp(-(\frac{B_i^I}{\lambda_i})^\rho) - \exp(-(\frac{B_i^H}{\lambda_i})^\rho)] + \\ d_i^{ny} \ln[\exp(-(\frac{B_i^L}{\lambda_i})^\rho) - \exp(-(\frac{B_i^I}{\lambda_i})^\rho)] \end{array} \right\} \quad (6)$$

Depending on the chosen distribution function mean and median WTP is calculated as (Model 1):

$$\begin{array}{l} mean_{logn} = \exp[-(\frac{\alpha_i}{\gamma}) + 0.5\ (\frac{1}{\gamma})^2] \\ median_{logn} = \exp[-(\frac{\alpha_i}{\gamma})] \end{array} \quad (7)$$

$$\begin{array}{l} mean_{weib} = \lambda_i \Gamma(\frac{1}{\rho+1}) \\ median_{weib} = \lambda_i [-ln(0.5)]^{\frac{1}{\rho}} \end{array} \quad (8)$$

with $\Gamma(\bullet)$ representing the Gamma function. Those respondents who did neither accept the initial nor the lower bid were subsequently asked whether they would be willing to pay any positive amount. This allows the distinction between two sub groups: respondents whose WTP is definitely zero and individuals with a positive WTP below the lower bid. In utilizing this information we estimate a second model (Model 2) with mean and median WTP being calculated as the weighted sum of means and medians for sub group 1 with zero WTP and sub group 2 with some positive WTP again following the log-normal and the Weibull distribution. This "Spike model" represents a more appropriate approximation of the true WTP distribution as it accounts for the significant number of zero responses.[9] The use of a difference-in-difference model with a dummy for the time period and several interaction terms enables to account for variations in risk attitudes over time. However, due to the complexity of the risk perception process the problem of omitted variables might be relevant.

[8]The error term in the Weibull follows the type I extreme value distribution. Therefore, the scale parameter varies across individuals: $\lambda_i = exp(\mathbf{X_i}\beta)$

[9]Descriptive results from the surveys can be directly used as weights for the two sub groups. 50.9 percent (50.6 percent) state a zero WTP in the fall (winter) sample.

Based on ([Blundell and Powell 2004], [Guevara 2005]) we use the control function approach and test for endogeneity. Two steps are necessary. First, risk perception is regressed as a function of exogenous instruments. Second, the residuals from this equation are then included as an additional explanatory variable in the log-normal WTP regression. The existence of endogeneity is tested by (1) a t-test on the statistical significance of the error coefficient, and (2) by comparison of two different models with one including and the other one excluding the error term (likelihood ratio test). We find that the hypothesis of an endogenous perception variable has to be rejected.

4 The data

Before we discuss the results of the econometric analysis we provide descriptive statistics of the underlying data and discuss the observed differences in risk relating attributes across periods.

4.1 Socio-economic characteristics

Table 1 presents socio-economic characteristics of the respondents and compares them with the attributes of the Tyrolean population. It can be seen that 53 percent of the respondents are female and 39 percent are single. The average respondent is 37 years old and lives in a household with 2.8 members. 84 percent of interviewees were born in Austria and 51 percent smoke. The personal take home income per month is €1,090 Euro on average.[10] The (self-reported) health status, educational achievement, and status of employment are measured by categories ranging from "healthy" to "badly disabled", "elementary/junior high school" to "university", and "fulltime employment" to "others", respectively. A comparison of the sample characteristics with the Census shows a good sample representation for population characteristics in sex, nationality, family status, household members, health status, and income while the divergence in age, children per capita, and smoking behavior is significant. On average

[10] 48.1 percent did not answer the income question.

the respondents in the sample have finished a higher level of education which might also explain the observed deviations in employment.

Table 1: Sample and population characteristics

Variable	Sample		Census
	Obs[I]	Mean	Mean
female	1996	0.53	0.52[a]
age	1954	37.08	43.79[a]
alone	1958	0.39	0.35[a]
housemember	1982	2.82	2.56[b*]
children/capita	1296	0.64	0.23[a]
birthaut	1997	0.84	0.88[a*]
smoking	1988	0.51	0.30[c]
inceuro/month	1128	1.08	1.11[d]
healthy	1937	0.76	0.80[c]
moderate illness	1937	0.20	0.16[c]
bad illness/bad disability	1937	0.04	0.04[c]
elementary/junior high school	1967	0.22	0.37[a]
apprenticeship	1967	0.33	0.33[a]
vocational school	1967	0.16	0.13[a]
secondary school/course lectures[II]	1967	0.20	0.10[a]
college/university	1967	0.09	0.07[a]
employed fulltime	1967	0.53	0.48[a]
employed parttime	1961	0.10	0.07[a]
employed shorttime	1967	0.02	0.03[a]
retired	1961	0.12	0.22[a]
homemaker	1961	0.03	0.10[a]
student	1961	0.11	0.06[a]
unemployed	1961	0.02	0.03[a]
others	1961	0.06	0.02[a]

[I] Differences in numbers of observations due to missings.
[II] The Austrian educational system provides a 2-years-program ("course lectures") designed for students who did not get vocational education in their secondary school.
[a] Population in 2001. Source: Statistics Austria. Statistical Yearbook 2005, Table 2.14.
[b] Source: Tyrolean Provincial Government 2004. Tyrolean Population - Results of the Census 2001, Table 25.
[c] Population in 1999 > 15. Source: Tyrolean Provincial Government 2003. Gesundheitsbericht 2002, Table 3.4.1.
[d] Monthly take home income (= annual income/14) of employees in 2003. Source: Statistics Austria, Statistical Yearbook 2005, Table 9.07.
* The exclusion of children was not possible.
The survey sample refers to Tyroleans ≥ 15 interviewed in September/October 2004 and February 2005. The Census represents the whole population of Tyrol (= 673,504)

in 2001 (exceptions are mentioned). Where feasible, children < 15 (= 123,855) are excluded for comparison reasons.

4.2 Risk perception

Table 2 shows the individual assessment of the average risk to be killed in an avalanche in Tyrol. As can be seen the winter sample evaluates this risk significantly higher than the respondents in the fall sample. Even though the mean of winter respondents (26.22) is higher, it still underestimates the true risk of deathly avalanche accidents (30). Several studies ([Hanley et al. 1997], [Viscusi 1990]) find that people overestimate small risks. Although the risk level for deathly avalanches is comparably small (1/42,500) the overestimation hypothesis cannot be supported by our data. An important characteristic of avalanches may explain the underestimation. In the Alps avalanches are known and imaginable. Every year people are being confronted with the occurrence of avalanche accidents and their consequences. Therefore, the risks might be seen as common, controllable and less likely than they are in reality.

Table 2: Relative risk evaluation

	Fall		**Winter**	
	Observations	***estprob***	**Observations**	***estprob***
median	992	20.00	1005	22.00
mean	992	23.65	1005	26.22

4.3 The subjective avalanche risk

Table 3 summarizes the responses on the assessment of the personal risk of dying in an avalanche. [Shanteau and Ngui 1989] allude that people tend to believe in their inviolableness and therefore underestimate their vulnerability to specific risks. While the proportion of those who estimate their personal risk higher (equal) than the average is smaller (higher) in the winter sample, the percentages for the categories "less endangered" are almost the same in both waves. As [Slovic et al. 1982] mention, reports about avalanche accidents may induce an indirect confirmation of lower personal risk: if those who regarded themselves as highly endangered incipiently were not struck by the reported events they may infer higher confidence and reduce their risk estimates.

Table 3: Subjective avalanche risk

	Fall		Winter	
Subjective risk	**Frequency**	**Percent**	**Frequency**	**Percent**
higher	79	7.96	59	5.87
same	185	18.65	221	21.99
lower	688	69.35	699	69.55
missing	40	4.03	26	2.59
Total	992	100.00	1005	100.00

4.4 Origin of deathly avalanches

In winter 2004/2005 each of the 25 deathly avalanche accidents occurred in the terrain, i.e. neither on traffic routes nor in living areas. This fact may explain the results in Table 4. 37 percent of the respondents in the winter sample think that humans always cause deathly avalanches whereas this proportion is significantly lower (33 percent) in fall.

4.5 Preferences for alternative protective measures

Respondents were asked to compare protection against mortal avalanche accidents with alternative protective measures against the risk of deaths caused by traffic accidents (streets), air pollution (air), food poisoning (food), floods, rockfalls, and radiation. Additional information was given that each alternative protective measure saves the same number of lives. Table 5 depicts the proportion of respondents who think that alternative protective measures are more urgent than measures against avalanches. For each risk category the percentages of those who prefer alternative measures are higher in the fall sample as compared to the winter respondents. Apparently, interviewees seem to be more concerned avalanche protection in winter; a fact to be attributed to the frequent occurrence of avalanches in this period.

Table 4: Origin of deathly avalanche accidents

	Nature		Humans		Fate	
	Freq.	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Fall						
always	336	33.87	324	32.66	146	14.72
mostly	382	38.51	545	54.94	194	19.56
seldom	222	22.38	104	10.48	372	37.50
never	34	3.43	5	0.50	253	25.50
missing	18	1.81	14	1.41	27	2.72
Total	992	100.00	992	100.00	992	100.00
Winter						
always	336	33.43	371	36.92	168	16.72
mostly	379	37.71	556	55.32	180	17.91
seldom	236	23.48	56	5.57	382	38.01
never	36	3.58	6	0.60	258	25.67
missing	18	1.79	16	1.59	17	1.69
Total	1005	100.00	1005	100.00	1005	100.00

Table 5: Preferences over alternative measures

	Street	**Air**	**Food**	**Rockfall**	**Flood**	**Radiation**
	%	%	%	%	%	%
Fall						
more	64.0	35.5	24.5	26.1	22.2	16.6
equal	31.1	47.9	40.4	62.6	57.2	40.8
less	3.1	13.5	31.3	8.4	16.7	38.8
missing	1.8	3.1	3.8	2.9	3.9	3.7
Total	100.0	100.0	100.0	100.0	100.0	100.0
Winter						
more	52.2	35.3	19.0	20.9	15.8	11.8
equal	41.6	49.1	43.1	62.2	58.3	39.6
less	4.2	13.9	35.0	12.3	21.5	43.9
missing	2.0	1.7	2.9	4.6	4.4	4.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

4.6 WTP to prevent an increase in risk

The following Table 6 illustrates the sequence of answers to the WTP questions.[11] As we analyze the changes in response behavior over time we only include answers based on the smaller risk variation (1/42,500). As expected, both samples show a decrease (increase) in the number of positive (negative) responses for increasing bids. However, the proportion of "yes-yes" statements in the winter sample is always slightly lower than in the first wave. The comparison of the total results in the last row of Table 6 shows that the observed differences between the two sub samples are modest.

Table 6: Response sequence to payment questions

initial	**Fall**					**Winter**				
bid	**yy**	**yn**	**ny**	**nn**	**Tot**	**yy**	**yn**	**ny**	**nn**	**Tot**
2.5	59	75	38	152	324	50	57	22	151	280
	18.2	23.2	11.7	46.9	100.0	17.9	20.4	7.9	53.9	100.0
5.0	38	57	41	207	343	18	28	33	116	195
	11.1	16.6	11.9	60.4	100.0	9.2	14.4	16.9	59.5	100.0
10.0	21	56	34	214	325	9	39	21	128	197
	6.5	17.2	10.5	65.8	100.0	4.6	19.8	10.6	65.0	100.0
Total	118	188	113	573	992	77	124	76	395	672
	11.9	18.9	11.4	57.8	100.0	11.5	18.4	11.3	58.8	100.0

5 Results

The previous chapter has provided a short description of the risk related factors and their variation over time. The following section focuses on the econometric analysis and reports the results of WTP estimates.

[11] The first (second) letter indicates the response to the initial (following) question (yn means a positive "yes" answer to be followed by a negative "no" reply).

5.1 Risk characteristics and time dependence

Table 7 depicts the regression results for the Weibull and log-normal WTP distribution, and a short description of all included variables is provided. The focus of the empirical analyses is on the role of socio-economic characteristics and on the influence of avalanche risk-relating attributes and their change over time.

It can be seen that the influence of the variables is robust for the different distribution assumptions. The coefficients for age *age*, the education level *alevel*, the assessment of avalanches as a natural event *natural*, the preference for other protective measures *impalter*, and whether a person is of normal weight *normalweight* show significantly negative signs. The negative coefficient of *impalter* meets expectations as it indicates a lower WTP for those who prefer other protective measures over protection against avalanches. A reasonable explanation for the negative impact of education is that highly educated people may believe that they could reduce their individual risk at low cost by avoiding dangerous areas.[12] The significantly negative coefficient of *natural* supports the validity of the aforementioned effectiveness hypothesis. Individuals may suppose that an effective reduction of avalanche risks is not possible in case of natural events. This assumption is strengthened by the positive and significant impact of *anthropogen*. Respondents seem to be willing to support the prevention of man-made risks.

As expected, the variables *female*, *lnincome*, *famexp*, *riskpercept*, and *skiing* show a significantly positive influence. Women state a higher WTP. The same is true for skiers and people who have already had personal experience with avalanches. Moreover, the affirmation of payment increases with an increase in income and with a higher risk perception. The impact of risk aversion *riskaversion* is positive, however, the coefficient is only significant for a log-normal distribution. Other positive and significant variables are: whether a person volunteers *volunteer*[13],

[12] See, [Alberini et al. 2004]

[13] The interaction term *lowriskvol* is significantly negative.

whether a person faces risks at work *jobrisk*, whether a respondent gets regular exercise *weeklysport*, and - as expected - whether the person was asked to evaluate the prevention of the higher risk *largereduct*. The positive sign of *lowrisk* is unexpected. It shows that people are willing to support protection measures even if they assess their personal risk of dying in an avalanche below average. Altruistic arguments may serve as an explanation of such behavior, however, the detailed examination of altruistic motives is a matter of future research.

The most surprising result is the lower WTP in the winter sample. This was already identifiable in Table 6 and is reaffirmed by Tables 8 and 9 below. Although the winter dummy is insignificant it contains important implications. The salience of avalanche accidents in winter and the associated media coverage do not cause an exogenous shift in willingness to pay; the observed differences between the two waves can rather be explained by reasonable risk characteristics.

Our data allow a deeper insight into which variables may cause the observed decrease in WTP. Whereas the variable indicating whether avalanches are regarded as anthropogenic events *anthropogen* indicates a positive sign its interaction with the period dummy *anthropogenw* is significantly negative. In other words, the occurrence of avalanche accidents in winter causes a change in respondents' attitudes towards self responsiveness. This strengthens the psychological view that (deathly) avalanches are being implicitly interpreted as voluntary and controllable risks which leads as a consequence to a lower concern of its prevention. This interpretation seems appropriate as all deathly avalanche accidents in winter 2004/2005 happened to occur in the terrain. Hence, respondents are supposed to think that the accidents could have been easily prevented by avoiding unsecured (ski) routes, and therefore, they are less willing to spend money on avalanche protection. The same argument may be relevant even for skiers as their interaction term *skiw* in the Weibull regression indicates a significantly lower valuation for this group too.

Table 7: Estimated Coefficients for the DBDC model (Weibull and Log-normal)

	WEIBULL		***LOG-NORMAL***	
Variable	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***
largereduct	0.546***	0.12	0.562***	0.12
winter	0.266	0.23	0.198	0.24
age	−0.007**	0.00	−0.006**	0.00
female	0.181**	0.08	0.205**	0.09
lnincome	0.221***	0.07	0.208***	0.08
missincome	−0.105	0.09	−0.096	0.09
alevel	−0.216**	0.09	−0.313***	0.09
housemember	0.033	0.02	0.015	0.02
volunteer	0.425***	0.16	0.420***	0.16
famexp	0.231**	0.10	0.260***	0.10
riskpercept	0.008***	0.00	0.008***	0.00
lowrisk	0.318**	0.14	0.251*	0.14
lowriskvol	−0.452**	0.20	−0.516***	0.20
anthropogen	0.286**	0.12	0.316**	0.12
natural	−0.278**	0.12	−0.250**	0.12
skiing	0.277**	0.12	0.307**	0.13
riskaversion	0.022	0.16	0.030*	0.02
missaversion	0.123	0.22	0.107	0.24
impalter	−0.333**	0.14	−0.280*	0.15
perceptw	0.005	0.00	0.005	0.00
anthropogenw	−0.530***	0.17	−0.516***	0.17
naturalw	0.251	0.17	0.259	0.17
impaltw	−0.119	0.22	−0.050	0.23
lowriskw	−0.317*	0.17	−0.339*	0.18
skiw	−0.339**	0.16	−0.251	0.17
jobrisk	0.229***	0.08	0.246***	0.09
normalweight	−0.275***	0.08	−0.261***	0.09
nosmoke	−0.109	0.08	−0.089	0.09
weeklysport	0.370***	0.09	0.346***	0.09
constant	−1.140*	0.59	−1.659***	0.62
Observations	1896		1896	
$Wald - \chi^2$(22df)	172		198	
Log Likelihood	-2115		-2130	

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

Variable	**Description**
age	Age of respondent in years.
alevel	Dummy = 1 if respondent has 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 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.
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.
missincome	Dummy = 1 if missing observations of income are replaced by mean income; 0 otherwise.
missaversion	Dummy = 1 if missing observations of riskaversion are replaced by zero; 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.
perceptw	Interaction terms: risk characteristics and the period dummy.
anthropogenw	
naturalw	
impalterw	
lowriskw	
skiw	
riskaversion	Respondent's behavior in risky situations. Ranges between 0 (risk lover) 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.
winter	Dummy = 1 if the survey took place in February 2005; 0 otherwise.

Another explanation for the lower WTP in the second period is provided by the interaction *lowriskw*. The negative influence of this variable reveals that the positive impact of lower risk estimates *lowrisk* disappears in winter. The coefficients of the remaining variables are not significant.

5.2 WTP for risk prevention

For the estimation of mean WTP we use the reduced sample of respondents who valuates a risk variation of 1/42,500; i.e. 992 individuals in fall and 672 persons in winter. First, only the bid structure and a constant term are included as explanatory variables. The corresponding means and medians are listed in Table 8. The estimation of the full model including the above mentioned regressors provides mean and median values shown in Table 9. The estimates are referred to an average respondent in the fall, winter, and total sample, respectively.[14] As expected, the standard errors indicate a more accurate estimate for Model 2. Both Tables 8 and 9 indicate that mean WTP is significantly lower in winter than in fall. However, as was mentioned above, this result is not caused by the salience of current avalanche accidents but is associated with a changing influence of specific risk characteristics over time (see the role of the interaction terms in Table 7).

5.3 The value of statistical life (VSL)

The VSL is defined as the rate at which people are willing to exchange income for a reduction in mortality risks. It is calculated by dividing the annual mean or median WTP by the corresponding risk variation. As Tables 8 and 9 show, monthly mean WTP ranges between €3.60 and €10.16 and median WTP goes from €0 to €3.49, depending on the underlying WTP distribution and the time period. The equivalent WTP per year lies between €43 and €122 (mean values), and between €0 and €42 (median values), respectively. The underlying risk variation is 1/42,500. Hence, mean VSL is in an interval between €1.8 and €5.2 million. These figures represent a conservative estimate as protest answers have been included and treated as "no" responses. A cursory com-

[14] Mean (mode) values are used for continuous (indicator) variables.

Table 8: Mean and median WTP in € per month: bid and constant

	Weibull			Log-normal		
	Fall	**Winter**	**Total**	**Fall**	**Winter**	**Total**
Observations	992	672	1664	992	672	1664
Mean – Model 1	4.80	4.39	4.63	6.24	5.89	6.11
	(0.31)	(0.36)	(0.24)	(0.62)	(0.76)	(0.49)
Mean – Model 2	3.96	3.60	3.82	4.47	3.97	4.27
	(0.18)	(0.19)	(0.13)	(0.29)	(0.29)	(0.21)
Median – Model 1	1.75	1.53	1.66	1.80	1.56	1.70
	(0.14)	(0.16)	(0.11)	(0.12)	(0.14)	(0.09)
Median – Model 2	0	0	0	0	0	0

Standard errors (delta method) in parentheses.

Table 9: Mean and median WTP in € per month: complete structure

	Weibull			Log-normal		
	Fall	**Winter**	**Total**	**Fall**	**Winter**	**Total**
Observations	940	642	1582	940	642	1582
Mean – Model 1	5.97	4.10	8.05	7.74	4.96	10.16
	(0.99)	(0.65)	(1.38)	(1.37)	(0.84)	(1.87)
Mean – Model 2	4.42	4.28	5.42	5.17	4.82	5.99
	(0.55)	(0.51)	(0.71)	(0.67)	(0.62)	(0.82)
Median – Model 1	2.59	1.78	3.49	2.62	1.68	3.44
	(0.43)	(0.29)	(0.60)	(0.45)	(0.28)	(0.60)
Median – Model 2	0	0	0	0	0	0

Standard errors (delta method) in parentheses.

parison shows that these estimates lie within the range of VSLs found in other studies. For example, [Alberini et al. 2004] estimate mean VSL between \$ 0.9 million and \$ 3.7 million for a Canadian sample and figures between \$ 1.5 million and \$ 4.8 million for an American sample, respectively. [Viscusi and Aldy 2003] review about 60 studies on mortality risk premiums based on labor data and report that the VSL ranges between \$ 4.0 and \$ 9.0 million. [Liu et al. 2005] estimate a VSL between \$ 2.8 million and \$ 11.8 million. Each study is based on a different valuation design (e.g. difference in risk variation, risk category, region, valuation method) so that the attempt of a more precise comparison might cause misleading inferences. These and other related studies are summmarized in Table 10.

Table 10: The value of statistical life

Authors	Country	Method	VSL
[Alberini et al. 2005]	Czech Republic	CV	€2.86 m
[Alberini et al. 2004]	France/Italy/UK	CV	€2.26 m
[Alberini et al. 2004]	Canada	CV	$ 0.93-3.7 m
[Alberini et al. 2004]	U.S.	CV	$ 1.54-4.83 m
[EU 2000]	EU	different	€0.65-2.5 m
[Liu et al. 2005]	Taiwan	CV	$ 2.8-11.8 m
[Persson et al. 2001]	Sweden	CV	$ 2.6 m
[Viscusi and Aldy 2003]	different	Labor data	$ 4.0-9.0 m
[Weiss et al. 1986]	Austria	Labor data	$ 3.9-4.7 m

6 Conclusions

The paper discusses the influence of current risk events on WTP for a prevention of a risk increase. In a CV study conducted in the Austrian federal state of Tyrol individuals were asked in two waves (fall 2004 and winter 2005) their WTP for the prevention of an increase in the risk to die in an avalanche. The question was worded as a double-bounded dichotomous choice format. Using an interval data model and assuming a Weibull and a log-normal distribution, WTP is estimated by a maximum likelihood procedure. Depending on the underlying distribution function of WTP and on the treatment of zero responses mean VSL ranges between €1.8 and 5.2 million while median VSL goes from €0 and 1.8 million.

The occurrence of avalanches, their associated deathly accidents, and their media coverage seem to represent important factors in monetary risk valuation. We estimate the impact of new (implicit) information on WTP for a prevention of deathly avalanches by the comparison of responses in the two periods. Descriptive analysis indicates a higher risk perception among the respondents in the winter sample. Furthermore, differences between the fall and the winter responses are observed with respect to the assessment of subjective avalanche exposure, the perceived causes of deathly avalanches, and the preferences for alternative protective measures. The inclusion of socio-economic and risk-specific characteristics in the regression model allows a deeper insight into the process of individual risk valuation.

Risk perception reveals a significantly positive impact on WTP; i.e. although all respondents are provided with identical information about the baseline risk and the change in risk to be evaluated their subjective assessment of the baseline risk still has an influence on their monetary valuation. However, further risk-specific attributes exist which play a role in the valuation process. Personal experience with avalanches in the past, a lower personally sensed avalanche risk, and the individual classification of avalanches to represent anthropogenic events induce a higher WTP while the characterization of deathly avalanche accidents as natural and existing preferences for other protective measures indicate a negative influence. Women tend to have a higher affirmation to pay, and an increase in income also leads to higher WTP. The respondents' age and higher education reveal a negative impact.

The observation that WTP figures are lower in winter although avalanches accumulate at that time seems surprising. One would have expected that the occurrence of deathly avalanche events and their media coverage in winter increase WTP responses in CV surveys. We control for changes in risk valuation over time by including a time dummy and different interaction terms. The significant decrease in WTP can then be explained by the interaction of the period dummy with the variables indicating whether avalanches are being characterized as anthropogenic, whether the personal avalanche risk is sensed to be below average, and whether a person is skiing. Hence, we infer that the presumed origin of a risk matters, and that WTP tends to be lower when the risk is characterized as voluntary and controllable, i.e. when respondents suppose that people have control over their exposure to risk. The change of the influence of voluntariness and controllability of risk exposure over time are the main reasons for lower WTP in winter. These results show that WTP figures fluctuate between the time periods, however, this variation is not arbitrary. Objections that their sensitivity to uncontrollable external influences would invalidate WTP figures from CV studies as proper measures for individual preferences are weakened by our findings.

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