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Abstract

It is still an ongoing discussion whether benefits resulting from reduced mortality risk should be valuated differently, depending on the age of the beneficiaries. Theory suggests that the influence of age on the value of statistical life (VSL), which is a monetary measure for reduced/prevented mortality risks, is ambiguous. Evidence from empirical studies leads to the same conclusion. The findings in this paper suggest that age becomes effective via age-dependent hazard rates. If a particular risk affects all individuals regardless of their age VSL is rather constant for differently aged people. These results may provide an explanation for the various outcomes in empirical studies.

Keywords: Contingent valuation, risk prevention, age effects, value of statistical life, risk exposure.

JEL classification: D81, J17, Q26.

Introduction

For saving people's lives, various protective measures are generally available; each of them differs in its effectiveness depending the number and group of protected persons. For example, reducing air pollution enables a reduction of respiratory diseases which primarily saves the youngest and oldest class of population while only working people benefit from reduced work place risks. If budget constraints are relevant, the question emerges how restricted resources should be distributed to the available life saving measures so that benefits are maximized. In order to provide a monetary measure of the benefits resulting from preventing fatalities the concept of value of statistical life (VSL) is commonly used. The VSL represents the ratio at which people are willing to exchange income for risk changes. I. e., the VSL is inferred from information about the individual willingness to pay (WTP) to prevent mortality risks. Literature which deals with the estimation of VSL is extensive. The VSL is used in various contexts, such as valuation of reduced health risks (e.g., cancer, respiratory diseases, cardiovascular diseases, ...), work place risks, traffic risks, or risks arising from natural hazards.[1]

The central issue in this paper is whether people benefit differently from reduced mortality risks, in particular, whether older people obtain different benefits from reduced mortality risks compared to younger individuals once the individual risk exposure is taken into account. Obviously, the group of people protected varies with the risk and the prevention measure realised. But do benefits still vary between younger and older individuals who face the same risk type and should such differences be reflected in age dependent VSL figures?

It is an ongoing discussion whether VSL should be adjusted to age. Government agencies pursue different approaches. For example, while the European Commission, DG Environment, recommends an adjustment to age, age-dependent VSL is not accepted in the US administration bodies (Viscusi & Aldy 2007). These different governmental

[1]For example, see Alberini, Cropper, Krupnick & Simon (2004), Alberini, Hunt & Markandya (2004), Johannesson, Johansson & Löfgren (1997), Jones-Lee, Hammerton & Philips (1985), Liu, Hammitt, Wang & Tsou (2005), Viscusi & Aldy (2007).

approaches may result from the ambiguous findings in the literature regarding the age effects on VSL.

For example, Smith, Evans, Kim & Taylor Jr (2004) estimate the VSL for older workers by observing their behavior (wage-risk trade-offs) on the labor market. Their findings show an increase of compensation requirements with increasing age which is mirrored in higher VSL figures for older employees. Also Viscusi & Aldy (2007) examine how the VSL varies with age across the working population. They find a quadratic relationship between age and income which indicates that the VSL first rises and then falls with age. A considerable decrease of VSL with age is found in Alberini, Scasny & Braun Kohlova (2005) where the authors estimate the WTP for reduced cardiovascular and respiratory risks. According to their results people in their 70s state values which are about three quarters lower than the statements of 30-year old respondents. Alberini, Cropper, Krupnick & Simon (2004) examine the influence of age and health risks on VSL using data from two contingent valuation studies conducted in Canada and the US. They analyse the individuals' WTP for a reduction of their overall mortality risk – without pointing at a specific risk – and find weak (no) evidence for decreasing VSL with increasing age in the Canadian (US) sample. Liu et al. (2005) refer to mortality risks due to SARS and do not find any influence of age on WTP to eliminate the chance of becoming infected. Johansson (2002) or Alberini, Cropper, Krupnick & Simon (2004) provide theoretical analyses of the effects of age on VSL. They determine two key components which drive the monetary valuation of reduced risks: (i) the individual hazard rate (probability of dying) and (ii) the utility of income. Depending on the age sensitivity of these two components the VSL can either remain age independent, increase, or decrease with increasing age.

Referring to the arguments of Johansson (2002) and Alberini, Cropper, Krupnick & Simon (2004) the present paper investigates how the respondents' age influences the stated benefits from reduced mortality risks. The empirical output suggests that the individual probability of dying associated with a particular risk apparently plays a crucial role.[2]

[2] In the context of natural hazards the probability of dying is sometimes split into (1) probability of occurrence of a natural event (2) probability that people are present at that time and (3) the level of vulnerability which may depend on chosen protective measures (e. g., Wilhelm (1997)). Henceforth, as

For instance, while workplace risks or cardiovascular risks are age-dependent and apply to a particular group of individuals (job risks: working population; cardiovascular risks: elderly people), all adults over all ages are potentially endangered to become infected with the SARS virus. Considering the empirical findings it is assumed that the individual level of risk exposure is an important factor in the valuation process.

This paper uses data from a CV survey conducted in Tyrol, a federal state of Austria. In face to face interviews approximately 2,000 Tyrolean residents were asked about their WTP to prevent a specified mortality risk. Risk is described as annual probability of dying in an avalanche. Due to the topographical characteristics of residential areas in Tyrol[3] respondents can be assigned to two groups which differ in their exposure to avalanches. While actually all residents face a baseline risk of dying in an avalanche, skiers are more endangered to get killed by an avalanche. Thus, it is reasonable to assume that the risk of the former group is age-independent as avalanches are relevant to all people who live in Alpine regions. By contrast, the risk skiers face may depend on age as the ability to ski is age-dependent. The relevance of age is considered by calculating the WTP, VSL and value of statistical life year (VSLY) for particular age classes. The following sections deal with two research questions: (1) Does the WTP for protective measures against natural hazard systematically vary between age classes and (2) is the individual level of risk exposure an important determinant for the outcome in this study and, generally, for the age variations found in empirical literature? The results indicate that age effects do occur for skiers but are not observable for non-skiers. This is taken as evidence that age variations become effective via age-dependent hazard rates.

The paper is organized as follows: Section 1 describes the survey design, Section 2 explains the econometric model and estimation procedure and discusses the included explanatory variables. Section 3 presents results. Finally, Section 4 concludes.

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the arguments in this paper refer to the second statement, the term "risk exposure" will be used instead of "probability of dying".

[3]Tyrol is situated in the middle of the Alps. One third of its 12,600 km^2 area is not habitable (glaciers, rocks, mountain pastures). Residential areas are often located in rather steep terrain or are at least surrounded by mountains.

1 Survey design

1.1 Socio-economic characteristics

This paper analyses responses from a CVM study conducted in September/October 2004 and February 2005 in Tyrol (Austria). A randomized quota sample of 1,997 individuals was drawn from the Tyrolean population aged over 15 years. The quota applied to the subjects' district of residence and size of domicile. Within the quota, random sampling was used. At their permanent residences, the respondents were asked about their WTP to prevent an increase in the risk of dying in an avalanche. In order to give an insight into how the sample represents the population Table 1 compares socio-demographic characteristics of the survey's participants and the population of Tyrol.

According to Table 1 53 % of the respondents are female (*female*) and 39 % are single (*alone*). The average respondent is 37 years old (*age*) and lives in a household with 2.8 members (*housemember*). 89 % were born in Austria (*birthaut*), 51 % are smokers (*smoking*). The personal take home income per month (*income*) is 1,079 Euro on average.[4] The (self-reported) health status, educational achievement, and employment status are measured using 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 attributes shows a good approximation to the population characteristics in gender, birth place, and income while the divergence in age, children per capita, and smoking behavior is considerable. The reported health in the sample conforms quite well with the census average. The differences between the sample and census with respect to education and employment may result from the younger age of individuals in the sample.

[4]Unfortunately 43,5 % did not answer the question relating to their income, which complicates the estimation of the income effect. In order to avoid losing these observations, a single imputation method (Davey, Shanahan & Schafer (2001), Little & Rubin (1987), Whitehead (1994)) is applied and missing income is replaced by the mean value. In addition, a dummy variable is generated which equals one in cases where a replacement has been made to control for potential influences of the imputation.

Table 1: Sample and population characteristics

Variable	**Sample**		**Census**
	Obs[a]	**Mean**	**Mean**
female	1996	0.53	0.52[c]
age	1954	37.08	43.79[c]
alone	1958	0.39	0.35[c]
housemember	1982	2.82	2.56[d*]
children/capita	1997	0.42	0.23[c]
birthaut	1997	0.89	0.88[c*]
smoking	1988	0.51	0.30[4]
income per month	1128	1.08	1.11[f]
healthy	1937	0.76	0.80[e]
moderate illness	1937	0.20	0.16[e]
bad illness/bad disability	1937	0.04	0.04[e]
elementary/junior high school	1967	0.22	0.37[c]
apprenticeship	1967	0.33	0.33[c]
vocational school	1967	0.16	0.13[c]
secondary school/post sec. courses[b]	1967	0.20	0.10[c]
college/university	1967	0.09	0.07[c]
employed fulltime	1967	0.53	0.48[c]
employed parttime	1961	0.10	0.07[c]
employed shorttime	1967	0.02	0.03[c]
retired	1961	0.12	0.22[c]
homemaker	1961	0.03	0.10[c]
student	1961	0.11	0.06[c]
unemployed	1961	0.02	0.03[c]
others	1961	0.06	0.02[c]

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

[b] The Austrian educational system provides a 2-year-program (post secondary courses) designed for students who did not get vocational education in their secondary school.

[c] Population in 2001. Source: Statistics Austria. Statistical Yearbook 2005, Table 2.14.

[d] Source: Tyrolean Provincial Government 2004. Tyrolean Population - Results of the Census 2001, Table 25.

[e] Population in 1999 > 15. Source: Tyrolean Provincial Government 2003. Gesundheitsbericht 2002, Table 3.4.1.

[f] Monthly take home income (= annual income/14; in 1,000 Euro) of employees in 2003. Source: Statistics Austria, Statistical Yearbook 2005, Table 9.07.

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 (* denotes where the exclusion of children was not possible).

1.2 Survey setting and wording of risk

In order to control for the sensitivity of WTP to the dimension of risk variation (= "scope effects") two different risk changes were incorporated in the questionnaire: participants in the winter survey were asked about their WTP to prevent a doubling (quadruplication) of the baseline risk.[5] The initial risk level was inferred from official statistics. Risk prevention was supposed to come from constructions against avalanches, i.e., deathly avalanche accidents could be reduced by means of construction. In the underlying study it was assumed that an increase in risk is avoidable by the maintenance of already existing protective measures. The good in question was described as follows (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 on average by avalanches. Assume that all public funds for maintaining protective measures will be cut, and so servicing costs henceforth have to be paid exclusively out of private funds. If aggregate private contributions are too small, maintenance is not carried out, 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€ to maintain the effect of previous protective measures to save human lives?

Respondents were randomly assigned to one of three versions which differ in the bid vector. The initial bids of version 1, 2 and 3 are 2.5, 5, and 10, respectively. Depending on the response to the first question participants were asked whether they would also pay 5 (version 1)/10 (version 2)/20 (version 3) Euros in case of a "yes" answer to the initial question, or 1.3 (version 1)/2.5 (version 2)/5 (version 3) Euros if the reply to the first question was "no".[6] If the interviewees' answers were "no-no" or "do not know-no"

[5] 992 respondents in fall and 672 in winter were asked to valuate the prevention of an increase from 1/42,500 to 2/42,500 (= group 1). 333 individuals (= group 2) in the winter sample base their decisions on a supposed prevention of a three times higher increase from 1/42,500 to 4/42,500 (= quadruplication of baseline risk).

[6] To define the range of the bid vector information from a previous pre-test sample was used.

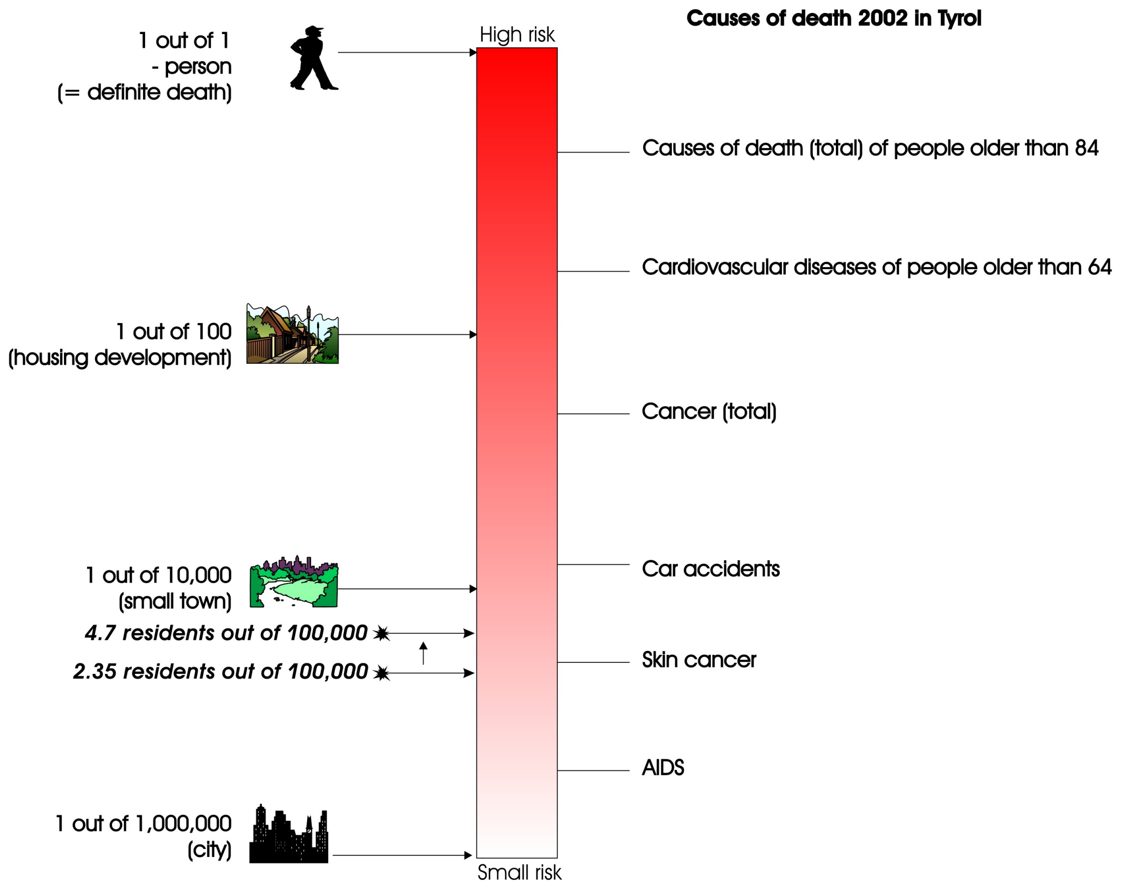

Figure 1: Causes of death in Tyrol in the year 2002

they were asked whether they would pay anything at all and why they refused payment.[7] Individual responses were classified as protest answers if the interviewees stated that they generally refuse payments for protection against natural hazards or if it was argued that the protection of citizens was the responsibility of the government. Protesters (N = 329) were excluded from further analyses.

In order to reduce the difficulties to interpret small risk variations (Kunreuther, Novemsky & Kahneman 2001, Shanteau & Ngui 1989) and the consequential erroneous results, the recommendation of Corso, Hammitt & Graham (2001) was considered and the risk change in question was visualized. In the Tyrolean study a logarithmic scale was implemented to picture the risk variation (see Figure 1; graph shown for the smaller change). The bottom and top indicate low and high risk, respectively. Along this line

[7]Though only yes/no answer possibilities were offered a "do not know" response was accepted. To ensure conservative estimates, the "do not know" responses are interpreted as negative responses and are included in the analysis. See Carson, Hanemann, Kopp, Krosnick, Mitchell, Presser, Ruud, Smith, Conaway & Martin (1998) for a related discussion.

other mortality risks, such as cancer, AIDS, or car accidents were plotted in to enable a comparison and relative estimate. Additionally, the magnitude of the risks was also stated as number of affected persons in differently sized populations (e. g., small town, city).

2 Estimation Procedure

2.1 Model specification

The valuation of reduced mortality risks refers to a state dependent utility framework. It is assumed that individuals substitute income y for a risk change δp so that they maximise their expected utility. Johansson (2001) looks at this maximization problem using a life-cycle VSL approach and explicitly considering the influence of age on the VSL. In this paper it is assumed that individuals maximise their expected remaining present value utility (ERPVU) subject to a dynamic budget constraint. Solving the maximisation problem results in the maximal ERPVU at age τ, denoted by $V_\tau(\tau)$, conditional on having survived to age τ (see Johansson (2001) for details):

$$V_\tau(\tau) = \int_\tau^\infty u\,[c^*(t)]e^{-\theta(t-\tau)}\mu(t;\tau)dt \tag{1}$$

$u\,[c^*(t)]$ denotes the utility derived from the optimal consumption level at age t, $c^*(t)$, with $t \geq \tau$, θ represents the marginal rate of time preference and is assumed to be a constant, and $\mu(t,\tau) = \frac{\mu(t)}{\mu(\tau)}$ stands for the survival function conditional on attaining the age τ with $u(t) = e^{\int_0^t \gamma(s)ds}$ ($\gamma(s)$=hazard function). Consider a decrease in the hazard rate and the associated change in the ERPVU:

$$dV_\tau(\tau) = \int_{\tau+T}^\infty u\,[c^*(t)]e^{-\theta(t-\tau)}d\mu(t;\tau) \tag{2}$$

with $\tau + T$ referring to the point in time when the risk reduction starts and $d\mu(t;\tau)$ representing the time change in the survival function resulting from the change in the hazard rate. In the VSL context, this change in the hazard rate is outweighed by a payment CV so that the ERPVU remains unchanged:

$$\int_{\tau+T}^{\infty} u\left[c^*(t)\right]e^{-\theta(t-\tau)}d\mu(t;\tau) - \lambda^*(\tau)dCV(\tau) = 0 \tag{3}$$

$\lambda^*(\tau)$ represents the dynamic Lagrange multiplier that results from differentiating the Hamiltonian function (Johannesson et al. 1997). As Johansson (2001) states, this term can be interpreted as the expected present value of marginal utility of income at age τ. dCV describes the amount of money an individual at age τ is willing to pay today to achieve a decrease in the hazard rate. Assuming for simplicity, that consumption does not change over time, equation (3) can be written as

$$\frac{u\left[c^*(t)\right]}{\lambda^*(\tau)} = \frac{dCV(\tau)}{\int_{\tau+T}^{\infty} e^{-\theta(t-\tau)}d\mu(t;\tau)} \tag{4}$$

which can be again converted to

$$\frac{V_\tau(\tau)}{\lambda^*(\tau)} = dCV(\tau)\frac{\int_{\tau}^{\infty} e^{-\theta(t-\tau)}\mu(t;\tau)dt}{\int_{\tau+T}^{\infty} e^{-\theta(t-\tau)}d\mu(t;\tau)} \tag{5}$$

The left hand side of equation (5) denotes the ERPVU that is transformed to monetary units by dividing by the marginal utility of income $\lambda^*(\tau)$. The numerator on the right hand side summarizes the expected remaining discounted life years and the denominator indicates the expected increase in discounted life years due to risk reducing programmes. Equation (5) defines the VSL, i. e. the trade-off between income and reduced mortality risk (gain in life-expectancy).

In order to demonstrate how this VSL is measured in the present study, the numerical illustration in Johansson (2001) is used as an example. There, the survival function $\mu(t;\tau)$ is given by $e^{-\gamma t} * e^{\kappa t}$. As before, θ represents the age independent marginal rate of time preference, γ stands for the initial and constant hazard rate. κ describes the change in the hazard rate and is assumed to be positive. For a newly born individual at age $\tau = 0$

and with $\kappa = 0$ and $T = 0$ equation (5) then simplifies to

$$\frac{V_\tau(\tau)}{\lambda^*(\tau)} = dCV(\tau)\frac{1/(\theta+\delta)}{1/(\theta+\delta)^2} \tag{5a}$$

Here, $\frac{1}{(\theta+\delta)}$ stands for the discounted remaining life years (DLY) and $\frac{1}{(\theta+\delta)^2}$ represents the expected increase in discounted life years $DLY * \Delta p$ due to changes in the hazard rate. Using this notation equation (5a) can be written as

$$\frac{V_\tau(\tau)}{\lambda^*(\tau)} = VSL = \frac{dCV(\tau)}{\Delta p} \tag{5b}$$

In the present contingent valuation survey respondents were directly asked about their maximum WTP for a given reduction in avalanche risks (Δp). In other words, respondents were expected to compare two situations with different mortality risks (p_0 vs. p_1) and state the amount of money (WTP) which keeps their utility $V(\tau)$ constant:

$$V(\tau)(y(\tau) - WTP(\tau), p_1; \mathbf{X}(\tau)) = V(\tau)(y(\tau), p_0; \mathbf{X}(\tau)), \tag{6}$$

with τ indicating the individuals' age.[8] Individuals' WTP statements are summarized in 6 age classes. In this case the VSL in a particular age group j is approximated by $WTP_j/\Delta p$.

The payment question has a double bounded dichotomous choice (DBDC) format. From this follows that the "true" WTP cannot be observed but has to be estimated from yes/no answers of the respondents. What can be inferred is, whether WTP is above (below) a specific amount if the respondent answers "yes" ("no") to the payment matter. Let us assume that WTP can be described by:

$$WTP_i^* = \mathbf{X}_i\beta + \epsilon_i \tag{7}$$

where $\mathbf{X}_i$ is a 1 x k matrix of variables representing characteristics of individual i as well as risk relating attitudes, β is a k x 1 vector of coefficients which has to be estimated and

[8] This procedure is analogous to the dynamic setting described in equation (3).

ϵ stands for the error term. WTP_i^* represents the latent variable. What is observable is the probability of an affirmative response to the payment question. The sequence of the yes (y) and no (n) answers is pictured by the following dummy variables:

$$\begin{aligned} d_i^{yy} &= 1 \text{ if } WTP_i^* \geq B_i^H; \\ d_i^{yn} &= 1 \text{ if } B_i^I \leq WTP_i^* < B_i^H; \\ d_i^{ny} &= 1 \text{ if } B_i^L \leq WTP_i^* < B_i^I; \\ d_i^{nn} &= 1 \text{ if } WTP_i^* < B_i^L; \end{aligned} \tag{8}$$

where B^H, B^I, and B^L represents the higher, initial, and lower bid, respectively. The equations are estimated using a maximum likelihood procedure. In the likelihood function each response is represented with its probability:

$$\begin{aligned} &Pr(\mathbf{X}_i\beta + \epsilon_i \geq B_i^H)^{d_i^{yy}} * Pr(B_i^I \leq \mathbf{X}_i\beta + \epsilon_i < B_i^H)^{d_i^{yn}} * \\ &Pr(B_i^L \leq \mathbf{X}_i\beta + \epsilon_i < B_i^I)^{d_i^{ny}} * Pr(\mathbf{X}_i\beta + \epsilon_i < B_i^L)^{d_i^{nn}} \end{aligned} \tag{9}$$

In the underlying valuation process it is assumed that an increase in risk can be avoided by the maintenance of already existing protective measures. Thus, negative aspects of new constructions (e. g., interference with the environment, natural scenery) which may cause negative WTP values should not occur. Furthermore, if one supposes that individuals are risk averse they should perceive a prevention of risks as improvement so that their welfare increases when risks decrease. Hence, they are expected to have at least non negative WTP values so that a distribution which allows only zero or positive values is appropriate. A naturally positive distribution is therefore used to estimate WTP.

The estimates in this paper are based on a Weibull distribution assumption of the error term.[9] The cdf for a Weibull distribution is

$$F(WTP_i^*) = 1 - \exp(-(B_i^\bullet/\lambda_i)^\rho) \tag{10}$$

[9]Previous sensitivity analyses have shown that models assuming a Weibull or log-normal distribution of the error term leads to similar findings concerning the sensitive factors on WTP. Additionally, also a logistic and normal distribution was used, simultaneously allowing for a positive probability of zero responses (analogous to Tobit models). The results in these models also correspond quite well with the findings for the Weibull and log-normal distribution. However, looking at the log likelihood values the Weibull model is superior to the other distribution assumptions.

with $B_i^\bullet$ denoting the bid level, shape parameter ρ and scale parameters λ_i.[10] Thus, using (8), (9) and (10), the log-likelihood function for the Weibull can be written as

$$LogL_{weib} = \sum_{i=1}^{N} \left\{ \begin{array}{l} d_i^{nn} \ln[1 - \exp(-(\frac{B_i^L}{\lambda_i})^\rho)] + \\ d_i^{yy} \ln[\exp(-(\frac{B_i^H}{\lambda_i})^\rho)] + \\ d_i^{yn} \ln[\exp(-(\frac{B_i^I}{\lambda_i})^\rho) - \exp(-(\frac{B_i^H}{\lambda_i})^\rho)] + \\ d_i^{ny} \ln[\exp(-(\frac{B_i^L}{\lambda_i})^\rho) - \exp(-(\frac{B_i^I}{\lambda_i})^\rho)] \end{array} \right\} \quad (11)$$

The maximum likelihood estimates resulting from equation (11) are used to calculate the mean WTP. According to Carson (2000) this welfare measure is the appropriate one as the purpose of the present study is collecting information regarding individual WTP which can be included in cost benefit analysis (CBA) for protective measures against avalanches.[11] In case of a Weibull distribution mean is calculated by

$$mean_{weib} = \lambda_i \Gamma(\frac{1}{\rho} + 1) \quad (12)$$

where $\Gamma(\bullet)$ represents the gamma function (see Cameron & Trivedi (2005), p. 584).

2.2 Value of statistical life and value of statistical life years

The VSL describes the rate at which individuals are willing to forgo money for a (small) risk reduction. It is calculated by dividing the annual WTP by the given risk change. The individual level of risk exposure is taken into account and VSL figures are calculated for six different age classes to examine the variation of VSL over age.

A further possibility to demonstrate the relevance of age of respondents in the valuation process is to estimate VSLY figures. This approach takes into account individual WTP and life expectancy as well as a particular discount rate. To derive the VSLY from the age-specific VSLs the average life expectancy L_j appropriate for each age class j and

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

[11] CBA are associated with pareto improvements. A change is favored if nobody is getting worse but at least one individual can improve his/her status or, respectively, if the winner of an action could compensate the loser. The mean takes into account such considerations.

gender is used.[12] VSLY figures are calculated using two different discount rates – 2 % and 4 % – which have been recommended by the European Comission.[13] The VSLY is computed analogous to Aldy & Viscusi (2003) by:

$$VSLY_j = \frac{r * VSL_j}{1 - (1 + r)^{-L_j}} \tag{13}$$

A constant VSLY implies that the total benefits of lower risks decrease with increasing age due to a declining life expectancy. A constant or decreasing VSLY would be in line with a decreasing VSL as also the discounting period (remaining life expectancy) decreases with age.

2.3 Age effects and risk exposure

In order to examine the influence of age on WTP for the two groups of risk exposure, indicator variables for age classes – which are defined analogous to Viscusi & Aldy (2007) – are included as explanatory variables in the regressions.[14] The observations of respondents aged 18 and older are used and are classified into 6 age classes: 18-24, 25-34, 35-44, 45-54, 55-62, and 62+.

The theoretical arguments given in Johansson (2002) or Alberini, Cropper, Krupnick & Simon (2004) as well as previous empirical analyses show that the impact of age on the VSL is ambiguous. Johansson (2002) and Alberini, Cropper, Krupnick & Simon (2004) point at two key determinants of the VSL which may change with increasing age: the individual hazard rate/probability of dying and the level of optimal consumption. The authors argue that theory does not support a general decline of VSL with age. An overall adjustment for age would therefore not be justified.

In this paper it is assumed that the effect of forgone income on optimal consumption is small as the money spent on buying an infinitesimal risk reduction represents only a

[12]Information about the age-specific years of life expectancy is obtained from official statistics (Statistik Austria 2005, Table 2.3).

[13] Alternatively, the discount rate could be estimated from the statements of the respondents. For example, Alberini, Cropper, Krupnick & Simon (2006) examine the effect of latency on WTP and calculate implicit discount rates which range from 1.3 % to 8.6 %.

[14]Conducting separate regressions for each age class would postulate an adequate sample size for each group which is not given by the Tyrolean data set.

small fraction of income.[15] It is therefore supposed that optimal consumption is age-independent. On this condition, the theoretical analysis put forward above indicate two possibilities how age influences the VSL:

- if the hazard rate is age independent also VSL should be constant over age;
- if the hazard rate increases with age the VSL is expected to decrease with age.

The empirical examples also suggest that the level of individual risk exposure may be a crucial argument. Thus, the further analysis will particularly examine the relevance of the hazard rate in individual valuations. If it is true that the type of risk exposure (age-dependent vs. age-independent) influences individual utility differently, this pattern should also be considered in the valuation of corresponding protection measures.

The present survey about WTP for reducing avalanche risks allows for distinguishing between two groups of risk exposure: non-skiers and active skiers. While the former face a baseline avalanche risk which – due to the specific landscape in Tyrol – is relevant for most residents (independent of their age), the group of skiers are confronted with additional avalanche risks by exercising their hobby. From the official statistics of avalanche fatalities in winter 2004/2005 it can be inferred that all the deaths occurred among the group of skiers and that the probability of dying due to an avalanche is indeed age dependent. Furthermore, also the probability of being a skier or not varies with age. Table 2 presents the proportion of active skiers and non skiers per age class and combines the fatality rates due to avalanches in the survey period 2004/2005 with the share of skiers in the sample. This probability - conditional to being an active skier - shows that the probability of dying in an avalanche is lowest for the youngest age group (18-24 years old) and peaks for the oldest (63+).

Thus, by splitting the sample into skiers and non-skiers it is possible to examine age effects on the VSL considering the different levels of individual risk exposure. Assuming an age independent consumption path (as the bid values represent only a small fraction of income) it is expected that the VSL among the group of skiers is lower for older individuals

[15] See Hammitt (2000) for a detailed discussion of the income effect on VSL.

Table 2: Skiing behavior and avalanche fatalities per age class

Age class	Non-Skiing		Skiing		Deaths 04/05[a]	
	N	Share	N	Share	N	Cond. Prob.[b]
age 18-24	152	0.10	261	0.17	1	0.003
age 25-34	147	0.10	232	0.15	6	0.026
age 35-44	119	0.08	162	0.10	7	0.043
age 45-54	106	0.07	90	0.06	5	0.056
age 55-62	76	0.05	43	0.03	2	0.046
age 63+	123	0.08	34	0.02	4	0.118

[a] Source: Alpine Safety & Information Center, Austria

[b] Number of deaths due to avalanches divided by number of skiers (e. g. 1/261)

(increasing risk exposure with increasing age) while the VSL should be constant among non-skiers (age independent hazard rate).

2.4 Further explanatory variables

Beside the socio-demographic characteristics (age, gender, income, . . .) of the participants the Tyrolean data provides information about risk related attributes, such as individual behavior in risky situations (e. g. using sunscreen, wearing safety belts), preferences for alternative protective measures (others than protection against avalanches), and risk perception[16]. These variables are included in the regression to control for internal validity of WTP estimates. Table 2.4 provides a brief description for these explanatory factors.

[16] As risk perception is a complex measure that might be influenced by factors which cannot be controlled for, this variable might be correlated with the error term. However, when risk perception is regressed on a set of variables and the error term is included as additional explanatory variable in the original equation, the error coefficient does not reveal a significant influence on WTP. This approach is analogous to Smith & Blundell (1986) and Rivers & Vuong (1988) who discussed the exogeneity test in a Tobit and probit framework.

Variable	Description
age18-24	
age25-34	
age35-44	Dummies. 1 if respondent is 18-24, 25-34, 35-44, 45-54, 55-62, and above 62 years old, respectively.
age45-54	
age54-62	
age63+	
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.
healthy	Dummy. 1 if respondent states that he/she is in good health; 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.
missaversion	Dummy. 1 if missing observations of risk aversion are replaced by zero; 0 otherwise.
missincome	Dummy. 1 if missing observations of income are replaced by mean income; 0 otherwise.
natural	Dummy. 1 if respondent always regards avalanches as a natural event; 0 otherwise.
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.
winter	Dummy. 1 if the survey took place in February 2005; 0 otherwise.

3 Results

3.1 Maximum likelihood estimates

The intensive discussion how age influences WTP for protective measures encourages a detailed analysis of age effects. First, an econometric model is estimated using all observations and subsequently regressions for each sub sample (skiers and non-skiers) are conducted. This procedure allows for determining whether the influence of age on respondents' WTP differs between the two levels of risk exposure. Table 3 presents the estimated coefficients.

The estimates using the information in the total sample are discussed first. The coefficient of the scope dummy (*largereduct*) indicates that the results pass the sensitivity test. Respondents, who valuate the higher risk prevention, reveal a significantly higher WTP than those, whose statements are based on the smaller variation.[17] As expected, WTP increases with increasing income (*lnincome*) and increasing perception of avalanche risks (*riskpercept*). WTP is significantly higher for respondents who had personal experience with avalanches in the past (*famexp*), who volunteer their time for welfare service (*volunteer*), who are skiers (*skiing*), and who face workplace risks (*jobrisk*).[18] Negative impacts on WTP show higher education (*alevel*) and existing preferences for alternative protective measures (*impalter*). Surprisingly, respondents in the winter sample state a significantly lower financial contribution although avalanche events frequently occur in this period. From the findings in Leiter & Pruckner (2007) it can be inferred that interviewees in winter who consider avalanches as anthropogenic events state a significantly lower WTP and that the "outrage effect" as discussed in Kahneman, Ritov, Jacowitz & Grant (1993) or more recently in Bulte, Gerking, List & de Zeeuw (2005) is weaker than the "responsibility effect" (Walker, Morera, Vining & Orland 1999).

[17] A detailed analysis of the scope effects is given in Leiter & Pruckner (2006).

[18] The variables *healthy* and *jobrisk* are introduced to test for the "background risk hypothesis" (Eeckhoudt & Hammitt 2001). The authors find that if the marginal utility of bequest is positive and high competitive risks (background risks) occur, WTP for reducing a specific mortality risk is smaller due to lower benefits from risk reduction when respondents still face a high remaining risk level. The Austrian results do not support their hypothesis.

Table 3: WTP – Regressions

Variable	Total	Skier	Non-Skier
largereduct	0.508***	0.697***	0.291
winter	−0.162*	−0.337***	0.036
age 25-34	−0.126	−0.228*	0.069
age 35-44	−0.234*	−0.331 * *	−0.071
age 45-54	−0.173	−0.245	−0.006
age 55-62	−0.149	0.014	−0.152
age 63+	−0.310*	−0.516*	−0.143
female	−0.030	−0.045	−0.027
lnincome	0.200 * *	0.115	0.306 * *
missincome	−0.091	−0.087	−0.125
alevel	−0.252***	−0.433***	−0.005
housemember	0.030	0.034	0.021
volunteer	0.412 * *	0.514***	0.111
famexp	0.319***	0.332***	0.311
riskpercept	0.011***	0.012***	0.007 * *
skiing	0.171*		
lowrisk	0.093	0.202*	−0.090
lowriskvol	−0.279	−0.667***	0.306
anthropogen	0.065	0.104	0.029
natural	−0.042	−0.003	−0.087
riskaversion	0.020	0.034*	0.015
missaversion	0.063	0.325	−0.103
impalter	−0.393***	−0.114	−0.666***
healthy	0.000	0.022	−0.030
jobrisk	0.202 * *	0.229 * *	0.197
constant	−0.564	0.000	−1.170
Observation	1494	806	688
Log-L	-1826	-1011	-793

Legend: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Dependent variable = WTP intervals, protest answers (N = 329) and respondents younger 18 (N = 87) excluded.

Once the sample is split into two groups an interesting pattern concerning these significant variables can be observed. Skiers are in general much more sensitive towards the mentioned characteristics than non-skiers – with two exceptions. (1) While the coefficient on income (*lnincome*) is positive in both groups it is significant for non-skiers only. (2) If non-skiers think that other protective measures to save human lives are more important than protection against avalanches they state a significantly lower WTP (*impalter*). For skiers this effect is not significant.

Which influences of age on WTP can be observed? Using the full sample it is found that respondents aged 35 to 44 (*age35-44*) and 63+ (*age63+*) reveal a significantly lower WTP (21 % and 27 %, respectively). When the sample is divided into "Skier" and "Non-Skier" the declining pattern of VSL with increasing age is only valid for respondents at higher risk (see column "Skier")[19]. For this group the age effects are even more pronounced while no age effects at all occur for their counterparts ("Non-skier"). Among skiers three age classes reveal a significantly lower WTP: people aged 25-34, 35-44, and 63+ state payments which are 20 %, 28 %, and 40 % lower than the WTP of the reference group of 18-24 year old individuals.

3.2 Willingness to pay for preventing fatalities, value of statistical life and value of statistical life year

Mean WTP for protective measures against avalanches is calculated by using the estimated coefficients shown in Table 3. From Table 3 it can be inferred that the relationship between WTP and age depends on the type of risk exposure (age dependent vs. age independent). The coefficients reported for "Skiers" and "Non-skiers" are combined with the characteristics of an average respondent in the particular group. Mean WTP is computed using equation (12). VSL figures can be calculated from the WTP values by dividing the annual WTP by the dimension of prevented risks. As discussed above, the VSLY is

[19] Skiers face an additional risk of dying in an avalanche which is age dependent while among non-skiers each member is equally affected – independent of his/her age.

a further possibility to take into account the age of individuals. Table 4 depicts WTP, VSL, life expectancy, and VSLY for each age class and group of risk exposure.

Table 4: WTP/month, VSL, and VSLY per age class[a]

Age class	Obs.	WTP[b]	VSL[c]	VSLY[d]	
				(r=4%)	(r=2%)
		Skiers			
Age 18-24	255	5.75 (0.984)	2.93	130,432	85,412
Age 25-34	227	4.58 (0.873)	2.34	108,294	73,791
Age 35-44	159	4.13 (0.757)	2.11	105,529	75,934
Age 45-54	89	4.51 (1.011)	2.30	129,726	99,185
Age 55-62	43	5.84 (1.570)	2.98	195,776	157,948
Age 63+	33	3.43 (1.044)	1.75	162,752	141,594
		Non-Skiers			
Age 18-24	139	5.37 (1.395)	2.74	121,860	79,935
Age 25-34	144	5.75 (1.511)	2.93	135,587	92,205
Age 35-44	111	5.00 (1.364)	2.55	128,024	92,280
Age 45-54	102	5.33 (1.422)	2.72	151,970	115,656
Age 55-62	73	4.61 (1.300)	2.35	155,054	125,184
Age 63+	119	4.65 (1.307)	2.37	234,110	205,557

[a] WTP and VSLY in Euro; VSL in million Euro.
[b] Standard errors (based on the delta method) in parentheses.
[c] Calculation of VSL: (annual WTP)/risk variation = (monthly WTP*12)/(1/42,500).
[d] Discount rate according to the recommendation of the European Comission (European Commission 2000).

While mean WTP (and therefore VSL) is quite similar for non-skiers a pronounced variation among age classes is observable for skiers. For the former group monthly WTP (VSL) ranges from 4.61 to 5.75 Euro (from 2.4 to 3.0 million Euro) while the corresponding figures for skiers range from 3.43 to 5.84 Euro (= monthly WTP) and from 1.8 to 3.0 million Euro (= VSL), respectively. The VSLY does not reveal a constant or monotonic declining pattern with increasing age for the group of skiers. Among non-skiers the VSLY rather increases as respondents become older.

According to these analyses strong evidence is found that the type of risk exposure matters. Therefore, it is of importance to distinguish between the different risk levels when one wants to evaluate the benefits resulting from reduced mortality risks. Apparently, age effects occur for individuals whose risk exposure to avalanches is age dependent while no age effects are observable for respondents whose risk level is independent of their age. In other words, age become effective via age-dependent risk exposure. These results are also in line with the arguments in Johansson (2002) and Alberini, Cropper, Krupnick & Simon (2004) who assume a decreasing VSL with increasing age in cases where the utility of consumption remains constant but the individual hazard rate/probability of dying increases with age.

3.3 Robustness checks

The estimation procedure described in Section 2.1 assumes a Weibull distribution of the error term. Both responses (initial and follow-up) to the payment questions are used which implies that respondents show a consistent behavior and base their statements on the same WTP amount. It is often questioned whether it is appropriate to use both answers from a DBDC format. The resulting estimates are inconsistent when the responses to the follow up questions do not reveal utility-maximising behaviour or rational preferences but are influenced by various factors such as yea-saying, weariness, free-riding, . . . (see for example, Herriges & Shogren (1996), Bateman, Langford, Jones & Kerr (2001), McFadden (1994), Park (2003)). An alternative to deal with these problems would be to only consider the first response to the payment question. The disadvantage of this approach is that one forgoes an efficiency gain by not using the follow-up responses (e. g., Alberini (1995), Hanemann, Loomis & Kanninen (1991)). This means that a trade off between bias and efficiency exists.

In order to check how the results vary using the single-bounded approach the same regressions discussed for the DBDC format ignoring the responses to the second question are conducted. The estimated coefficients do not change considerably. For example, using the sample of skiers the corresponding coefficients on the age dummies *age25-34*, *age35-44*, *age45-54*, *age55-62*, and *age63+* are -0.232, -0.083, -0.201, 0.337, and -0.652. However, the age effects cannot be estimated precisely any more due to the large standard errors which are at least twice as high as in the double-bounded case.

A second approach – the Turnbull distribution-free estimator described in Haab & McConnell (2002) – that imposes as few restrictions as possible on the estimation procedure is conducted to test for the robustness of age effects.[20] The calculation of the welfare measure is quite straightforward but this is at the cost of testing for covariate effects[21], i. e. the Turnbull mean WTP is a descriptive unconditional estimate. Comparing the Turnbull WTP among age classes for the group of skiers one finds that the WTP for people aged 25-34 and 55-62 are significantly lower than the WTP for the youngest.[22] The depreciation is strongest and highly significant for the oldest: WTP of people who are 63 or older is about one fourth the WTP of the 18-24 year olds. In the group of non-skiers such a pronounced age pattern is not observable. There is only one age class (35-44) where WTP differs significantly from the reference group (18-24). As the Turnbull estimates represent a lower bound of WTP, mean WTP virtually always lies below the parametric mean values.

To summarize, strong evidence for a lower WTP for older people among the group of skiers is found using the Turnbull estimator but this clear pattern does not occur among non-skiers. Apparently, the difference in age effects between the two groups is not dependent on the chosen distribution assumption. Furthermore, as the Turnbull mean WTP is

[20] Haab & McConnell (2002) provide a detailed explanation and examples how to calculate Turnbull mean values in a CV framework.

[21] See Haab & McConnell (2002), pp. 80-83, for a discussion.

[22] Analogous to the parametric approach the youngest age class is taken as reference group.

calculated using only the first response to the bid question also the implications imposed by using the DBDC format do not change the conclusions regarding the dependence of WTP on age. As the single-bounded estimates also suggest that the dimensions of age effects do not differ significantly when only the first response is used, the double-bounded approach is favoured and the additional information from the follow-up response is used.

4 Conclusion

This paper uses a CV survey carried out in Austria in two waves (fall 2004/winter 2005) to analyse age effects in the individual valuation of mortality risks. Using an interval-data model and assuming a Weibull distribution of the error term the WTP for preventing fatal avalanche accidents is estimated by the method of maximum likelihood. For the purpose of analysing the relevance of individual risk exposure the sample is split into two groups which differ in their levels of risk exposure. Age class dummies are included in the regression model to test for age effects among the two groups.

A general adjustment of VSL to age is not supported by this analysis. Age apparently influences the VSL via age-dependent hazard rates. A declining VSL over age is only observable for respondents to whom the risk in question is more relevant (skiers). But no significant differences between age classes are observable for non-skiers who face a "baseline" risk due to the location of their residential area which is age independent. Average VSL for non-skiers ranges from 2.4 to 3.0 million Euro. For the group of skiers the VSL lies between 1.8 and 3.0 million Euro and a significant depreciation of VSL for the age classes 25-34, 35-44, and 63+ which is 20 %, 28 %, and 40 % lower than the WTP for the youngest can be observed.

Which implications can be drawn from these findings for the efficient use of public funds to finance protective measures against avalanches? These results could be interpreted as evidence that age effects coincide with the individual level of risk exposure. In the context of preventing fatal avalanche accidents the use of a decreasing VSL with increasing age, or respectively, a constant VSLY, is solely appropriate for skiers. If protection measures are at stake which aim at protecting residential areas or traffic routes and hence, at protecting all residents independent of their age (i. e., risk exposure is the same for all beneficiaries) an adjustment of the resulting benefits to age is not justified. The universality of risk exposure may be of particular relevance for risks related to environmental hazards (avalanches, floods, hurricanes, water pollution, ...) which are relevant to all individuals who live in endangered areas.

This paper points at a potentially relevant feature for monetary valuation of reduced mortality risks. It shows that the differentiation between the type of risk exposure and the people at risk is important and can explain the different findings regarding age effects in the empirical literature.

References

Alberini, A. (1995), 'Efficiency vs Bias of Willingness-to-Pay Estimates: Bivariate and Interval-Data Models', *Journal of Environmental Economics and Management* **29**, 169–180.

Alberini, A., Cropper, M., Krupnick, A. & Simon, N. B. (2004), 'Does the value of a statistical life vary with age and health status? Evidence from the US and Canada', *Journal of Environmental Economics and Management* **48**, 769–792.

Alberini, A., Cropper, M., Krupnick, A. & Simon, N. B. (2006), 'Willingness to pay for mortality risk reductions: Does latency matter?', *Journal of Risk and Uncertainty* **32**(3), 231–245.

Alberini, A., Hunt, A. & Markandya, A. (2004), Willingness to Pay to Reduce Mortality Risks: Evidence from A Three-Country Contingent Valuation Study, Nota di lavoro 111.2004, FEEM. http://www.feem.it/NR/rdonlyres/8904A715-57A3-4FDD-A7E9-52318537EEFF/1258/11104.pdf.

Alberini, A., Scasny, M. & Braun Kohlova, M. (2005), The Value of Statistical Life in the Czech Republic: Evidence from a Contingent Valuation Study, Working Paper presented at the 14th Annual Meeting of the EAERE in Bremen, Germany. http://www.webmeets.com/files/papers/EAERE/2005/24/alberini%20scasny%20EAERE%202005.pdf.

Aldy, J. E. & Viscusi, W. K. (2003), Age Variations in workers' value of statistical life, Working paper 10199, NBER. http://www.nber.org/papers/w10199.

Bateman, I. J., Langford, I. H., Jones, A. P. & Kerr, G. N. (2001), 'Bound and path effects in double and triple bounded dichotomous choice contingent valuation', *Resource and Energy Economics* **23**, 191–213.

Bulte, E., Gerking, S., List, J. & de Zeeuw, A. (2005), 'The effect of varying the causes of environmental problems on stated WTP values: evidence from a field study', *Journal of Environmental Economics and Management* **49**, 330–342.

Cameron, A. C. & Trivedi, P. K. (2005), *Microeconometrics: Methods and applications*, Cambridge University Press.

Carson, R. T. (2000), 'Contingent Valuation: A User's Guide', *Environmental Science & Technology* **34**(8), 1413–1418.

Carson, R. T., Hanemann, W. M., Kopp, R. J., Krosnick, J. A., Mitchell, R. C., Presser, S., Ruud, P. A., Smith, V. K., Conaway, M. & Martin, K. (1998), 'Referendum Design and Contingent Valuation: The NOAA Panel's No-vote Recommendation', *The Review of Economics and Statistics* **3**, 484–487.

Corso, P. S., Hammitt, J. K. & Graham, J. D. (2001), 'Valuing Mortality-Risk Reduction: Using Visual Aids to Improve the Validity of Contingent Valuation', *The Journal of Risk and Uncertainty* **23**(2), 165–184.

Davey, A., Shanahan, M. J. & Schafer, J. L. (2001), 'Correcting for Selective Nonresponse in the National Longitudinal Survey of Youth Using Multiple Imputation', *Journal of Human Resources* **36**(3), 500–519.

Eeckhoudt, L. R. & Hammitt, J. K. (2001), 'Background Risks and the Value of a Statistical Life', *The Journal of Risk and Uncertainty* **23**(3), 261–279.

European Commission (2000), 'Recommended Interim Values for the Value of Preventing a Fatality in DG Environment Cost Benefit Analysis'. http://europa.eu.int/comm/environment/enveco/others/recommended_interim_values.pdf.

Haab, T. C. & McConnell, K. E. (2002), *Valuing environmental and natural resources: the econometrics of non-market valuation*, Edward Elgar Publishing, Cheltenham.

Hammitt, J. K. (2000), 'Evaluating Contingent Valuation of Environmental Health Risks: The Proportionality Test', *AERE Newsletter* **20**(1), 14–19. http://www.aere.org/newsletter/Newsletter_May00.pdf.

Hanemann, M., Loomis, J. & Kanninen, B. (1991), 'Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation', *American Journal of Agricultural Economics* **73**(4), 1255–1263.

Herriges, J. A. & Shogren, J. F. (1996), 'Starting Point Bias in Dichotomous Choice Valuation with Follow-Up Questioning', *Journal of Environmental Economics and Management* **30**, 112–131.

Johannesson, M., Johansson, P.-O. & Löfgren, K.-G. (1997), 'On the Value of Changes in Life Expectancy: Blips Versus Parametric Changes', *Journal of Risk and Uncertainty* **15**, 221–239.

Johansson, P.-O. (2001), 'Is there a meaningful definition of the value of a statistical life?', *Journal of Health Economics* **20**, 131–139.

Johansson, P.-O. (2002), 'On the Definition and Age-Dependency of the Value of a Statistical Life', *Journal of Risk and Uncertainty* **25**(3), 251–263.

Jones-Lee, M. W., Hammerton, M. & Philips, P. R. (1985), 'The value of safety: results of a national sample survey', *The Economic Journal* **95**, 49–72.

Kahneman, D., Ritov, I., Jacowitz, K. E. & Grant, P. (1993), 'Stated Willingness to Pay for Public goods: A Psychological Perspective', *Psychological Science* **4**(5), 310–315.

Kunreuther, H., Novemsky, N. & Kahneman, D. (2001), 'Making Low Probabilities Useful', *Journal of Risk and Uncertainty* **23**(2), 103–120.

Leiter, A. M. & Pruckner, G. J. (2006), Proportionality of Willingness to Pay to Small Risk Changes – The impact of attitudinal factors in scope tests, FEEM Working Paper, Nota di Lavoro 90.2006. http://www.feem.it/NR/rdonlyres/E4CEE029-5957-4945-A449-E0E18D0E6474/2037/9006.pdf.

Leiter, A. M. & Pruckner, G. J. (2007), Dying in an Avalanche: Current Risk and Valuation, Working paper, Department of Economics, University of Linz. http://www.economics.uni-linz.ac.at/Pruckner/papers/risk.pdf.

Little, R. J. A. & Rubin, D. B. (1987), *Statistical analysis with missing data*, John Wiley & Sons, Inc., New York.

Liu, J. T., Hammitt, J. K., Wang, J. D. & Tsou, M. W. (2005), 'Valuation of the risk of SARS in Taiwan', *Health Economics* **14**(1), 83–91.

McFadden, D. (1994), 'Contingent valuation and social choice', *American Journal of Agricultural Economics* **76**(4), 689–709.

Park, J. H. (2003), 'A test of the answering mechanisms of the double-bounded contingent valuation method', *Applied Economics Letters* **10**, 975–984.

Rivers, D. & Vuong, Q. H. (1988), 'Limited information estimators and exogeneity tests for simultaneous probit models', *Journal of Econometrics* **39**, 347–366.

Shanteau, J. & Ngui, M. L. (1989), 'Decision Making Under Risk – The Psychology of Crop Insurance Decisions'. http://www.ksu.edu/psych/cws/pdf/insurance_paper90.PD.

Smith, R. J. & Blundell, R. W. (1986), 'An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply', *Econometrica* **54**(3), 679–685.

Smith, V. K., Evans, M. F., Kim, H. & Taylor Jr, D. H. (2004), 'Do the near-elderly value mortality risks differently?', *The Review of Economics and Statistics* **86**(1), 423–429.

Viscusi, W. K. & Aldy, J. E. (2007), 'Labor market estimates of the senior discount for the value of statistical life', *Journal of Environmental Economics and Management* **53**, 377–392.

Walker, M. E., Morera, O. F., Vining, J. & Orland, B. (1999), 'Disparate WTA–WTP disparities: the influence of human versus natural causes', *Journal of Behavioral Decision Making* **12**(3), 219–232.

Whitehead, J. C. (1994), 'Item Nonresponse in Contingent Valuation: Should CV Researchers Impute Values for Missing Independent Variables?', *Journal of Leisure Research* **26**(3), 296–303.

Wilhelm, C. (1997), *Wirtschaftlichkeit im Lawinenschutz*, Davos.

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Age effects in monetary valuation of mortality risks - The relevance of individual risk exposure

Abstract
It is still an ongoing discussion whether benefits resulting from reduced mortality risk should be valuated differently, depending on the age of the beneficiaries. Theory suggests that the influence of age on the value of statistical life (VSL), which is a monetary measure for reduced/prevented mortality risks, is ambiguous. Evidence from empirical studies leads to the same conclusion. The findings in this paper suggest that age becomes effective via age-dependent hazard rates. If a particular risk affects all individuals regardless of their age VSL is rather constant for differently aged people. These results may provide an explanation for the various outcomes in empirical studies.

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