VALUING STATISTICAL LIVES OR LIFE YEARS? A CHOICE EXPERIMENTAL STUDY

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ABSTRACT

Although the value of reducing mortality risks and that of reducing life year losses are closely related to each other, the valuation literature seems to treat them rather separately resulting in conflicting value estimates. While the former is more concerned with saved statistical lives from accidents, the latter is more directed to the lost life years due to air pollution etc. In this paper, we attempt to conduct an integrated valuation study for both types of values in the same choice experimental design.

We formulate an econometric model which simultaneously takes into account both mortality risk reduction and life year loss. The results indicates that conditional on given remaining life years upon survival, the marginal willingness to pay is constant for each statistical life saved, which indicates strong scope effect. The marginal value per extra life year, however, is a diminishing function of the number of life years. We have also examined the effect of other covariates such as the respondents' characteristics (e.g. gender and age), their self-confidence in making choices, and possible categorical behavior on the final value estimates.

***Keys-words**: value of statistical life, value of life years, stated preference, choice experiment*

INTRODUCTION

The economic value of reducing mortality risks is an important input for policy evaluation in many areas. Currently, most analysis is based on the value of a statistical life (VSL) which is derived from willingness to pay to reduce mortality due to accidents in contexts where many years of life lost can be prevented on average. However, the question has been raised if it is correct to use such VSL estimates also in other contexts where only few years of life are lost. In this paper we report the results of a choice experiment (CE) where we in a public good

context have evaluated the influence of years of life lost (or rather saved)[1] on choice behavior. We included this information in addition to the change in mortality risks and the cost of the policy measure.

One policy area where this question is relevant is transportation analysis. To evaluate the policy effect in economic terms, the size of the benefit needs to be determined. So far much focus has been on the value of saving lives from traffic accidents since this is one of the main disbenefits of the transport system. However, more recently the health impact of air pollution from transport has come in focus. While the value of a statistical life (VSL) has been used to evaluate the external cost of traffic accidents, it has been questioned if this is a relevant measure to be used for premature deaths due to air pollution. Since the latter mainly have an impact on the elderly, using VSL may result in estimates of costs that are upward biased. This issue has been discussed at length in various contexts but no affirmative conclusion has been reached (AEA Technology, 2005; Evans and Smith, 2006; Dolan et al., 2008)[2].

How to place a value on changes in risk and the probability of death is a research issue that has a long history. Jones-Lee (1974) provided the theoretical foundation for the use of willingness to pay to assess the value of a statistical life. Still, there are many issues unresolved on how to empirically determine this value and factors that will influence its size (Andersson and Treich, 2008). Among these issues is the influence of years of life lost (YOLL) on willingness to pay. The influence of age cannot be determined theoretically and therefore various attempts have been made to find empirical evidence (Johansson, 2002; Alberini et al, 2004; Evans and Smith, 2006). In one approach used by Johannesson and Johansson (1996) the respondents were asked for their willingness to pay to increase life by one year conditional on having survived to some pre-determined age. Alberini et al (2006) on the other hand derived the value of a life year saved by dividing the stated willingness to pay for a period of ten years by the calculated life expectancy. The results from these methods differ greatly with the former much smaller than the latter. One reason for the difference could be that these studies deal with VSL and value of a life year (VOLY) separately during the survey and the data analysis stage.

In this paper, we attempt to integrate risk reduction and the life expectancy per saved life in the same choice experiment design. The choice experiment method (cf. Admanowicz et al., 2007) is often used in transportation research to elicit people's preferences for saving time but is less common in the valuation of risk literature (Boxall et al., 1996; Foster and Murato, 2003; Goldberg and Roosen, 2007)[3]. The advantage with this method is that the good is described as a bundle of characteristics or attributes which allows for the researcher to

[1] The concept years of life lost (YOLL) is often used in the literature and we will use this concept also in this paper. What we are actually interested in valuing however is the years of lives saved. We see these concepts as interchangeable and will use both in the paper.

[2] There is also an ongoing general discussion in the risk valuation literature on the possibility to transfer values from one context to another (Brouver, 2000; Ready et al., 2004).

[3] This approach belongs to a group of methods called stated preference where questions are used to elicit people's preferences. Another approach is revealed preference methods where values are derived form actual observed behavior. The latter method is difficult to use for the question that we are interested in since there are few real life situations where there is a trade-off between saving lives and saving years.

determine separate values for each attribute as well as to examine trade-offs between individual attributes. We expect that what the individuals' value are not only the lives per se but also the quality of the saved lives in terms of the number of expected life years upon survival. Hence, the used approach enable us to test the "quantity" (i.e. the number of lives saved) and the "quality" (i.e. life years saved life) trade-offs. In addition, we will also be able to reconcile the approaches for eliciting VSL and VOLY in a more consistent manner. For example, a "saved" life with a zero life expectancy would be valued zero as life is virtually not saved. (there is no pure "love of life" effect). Conditional on other things equal, the VSL is higher the longer the life expectancy is.

We also test for weak and strong scope effect that has been discussed in the literature. Scope bias is when the respondents are insensitive to variations in risk magnitude. This scope bias[4] puts the results from these types of studies into question, since economic theory suggests that WTP should increase with the magnitude of the risk reduction (Anderson and Treich, 2008). Alberini et al., (2004) and Goldberg and Roosen (2007) use two test to for scope sensitivity. Weak scope sensitivity is fulfilled if willingness to pay for a reduction in health risk increases in the amount of risk reduction. Strong scope sensitivity is fulfilled if willingness to pay is almost proportional in health risk reductions for small changes in risk. The former test is derived from expected utility theory while the second is not since concavity or convexity of WTP is health risk reductions cannot be predicted from theory. In most applications, it is assumed that it is possible to approximate WTP for health risk reductions by a linear function for sufficiently small changes in health risks (Goldberg and Roosen, 2007)[5].

One explanation given for the presence of scope bias is that respondents have a difficulty to understand probabilities. One way to avoid this problem in contingent valuation studies have been to test individuals understanding and exclude respondents that do not behave as expected (Alberini et al., 2004; Itako et al., 2006; Viscusi et al., 2008). However Boxall et al. (1996) and others argue that this could be a consequence of the elicitation format and that the use of a CE design may avoid the problem since the way information is presented in a CE design give respondents decision support. Support for this suggestion is found in Foster and Murato (2003) and Goldberg and Roosen (2007) who have evaluated the difference between the elicitations format used in CE and CVM. According to their results choice experiments perform better regarding sensitivity to scope. They also found that the values elicited differ between the two methods where the CE estimates for the inclusive good is

[4] Carson et al. (2001) definition of a scope test is that it looks at whether respondents are willing to pay more for a good that is larger in scope, either in a quality of quantity sense. A scope test can be implemented either internally (within-sample tests) or externally (between sample tests). With the CE methodology it is possible to undertake within sample tests, hence to see if respondents are internally consistent.

[5] If this is not true this will have implications when using WTP to calculate the value of a statistical life. Alberini et al. (2004) and Hammitt and Zhou (2006) finds that WTP is not proportional to the size of the risk change and hence that the VSL estimates are larger when calculated using WTP for a smaller risk change. When the CE method is used it is common to rely on the linearity assumption and calculate the VSL for a unit change in risk (Adamowicz et al., 2007, Itaokoa et al., 2006) but this may not be a correct approach. The influence of the absolute size of the risk reduction that is used in a valuation study has also been discussed since it is important for the size of the estimates VSL (Itaoka et al.,2006; Hammit and Zhou, 2006).

higher. Adamowicz (2007) on the other hand found that the estimates were in the same range.

In addition to studying the trade-offs between the number of saved lives and the life years per saved life including the scope test, we also examine the effect of several other variables such as gender, age, and a few survey related variables. The outline of the paper is as follows. In the next section we describe the survey administration, the experimental design and the descriptive statistics of the data material. After that, we formulate the econometric models, perform scope and correlation tests, and derive the valuation functions. The last section sums up the paper.

SURVEY ADMINISTRATION AND THE CHOICE EXPERIMENTAL DESIGN

Every survey trying to elicit the willingness to pay for intangible goods need to describe the good to be valued and the context in which the transaction will take place. This survey is related to previous research undertaken in Sweden and hence is influenced by the information given and the statistics used in these studies. These studies have investigated the willingness to pay to reduce traffic accidents (Hultkrantz et al., 2006) as well as deaths due to sudden heart failure (Sund, 2008). Both surveys investigated the willingness to pay for a public good provided by the authorities. The changes in risk that have been estimated ranges from 1/100 000 to 7/100 000 while the bid levels have ranged from 200 SEK to 2000 SEK per year.

However, since we wanted to explore aspects that have not been accounted for in previous work this study differs from the others on two major points. First of all we wanted to obtain information on whether or not the number of years saved would influence the response behavior in addition to the influence of the size of the risk reduction (i.e. number of lives saved). Therefore we chose to use the choice experiment design discussed by Adamowicz et al. (2007). Moreover, we wanted to provide more information on the public good context and investigate if this would influence the response behavior. We therefore framed the choice situation as a public referendum on the provision of public goods that would reduce accident risks in society. Since a public referendum is often undertaken after a period of distribution of information, we provided our respondents with information on baseline risks for some common fatalities in Sweden. We also gave information on the work undertaken by the authorities to reduce these risks and the related cost. This was presented in a separate information sheet[6].

[6] The question of information provision has been extensively discussed in the literature and as stated by Heberlein et al. (2005) for example there is a risk that providing information will create preferences. Carson et al. (2001) on the other hand argues that it is common also in the market place to inform consumers about new products. We believe since the context we use is a referendum, not providing information would be counterintuitive. A recent example in Sweden where a referendum was preceded by a massive information campaign was the congestion charges. Hence, as in Halvorsen (2000) we have chosen to provide a summary of data on why society is engaged in activities to save lives, the baselines in risk, available policy measures as well as what such measures cost to society.

We also wanted to send the survey to a sample of the Swedish population, something that was also done in the study by Sund (2008) concerning heart failure. Hence, the description of the good and the policy measure had to be general. But this was also a necessity due to the chosen design of questions. Since we asked the respondents to answer several questions, where the attributes varied in size and we wanted them to be able to vary orthogonally, it was difficult to describe policy measures that would correspond to the described alternatives. However, in the information sheet we gave examples of policy measures that would mainly reduce the mortality risk for certain age groups such as defibrillators that help elderly or separate bike lanes to schools which prevent accidents among young people.

One specific problem with changes in risks is that the good is presented as a change in a probability that is often very small in magnitude. Since people in general are unaccustomed to discuss events as changes in probability, phrasing questions in this way put people in an unusual choice situation. Different aids to risk communication, where the information is presented both numerically as well as graphically have been developed (Sund, 2008). One commonly used aid is to give an illustration using a rectangle with small squares representing the number of people in a population. The actual risk (or baseline risk) and the change in risk is depicted as squares with different colors. In Adamowicz et al. (2007) they use this type of device together with numerical information. In our study we adopted a similar approach.

We used debriefing questions to try to separate “true” responses from protest bids or warms glow. As discussed by Harrison (2006) hypothetical bias may rather manifest itself in the “buy something” versus the “buy nothing” stage in decision making. The problem this poses is how to treat those choosing the status quo alternative (in our case current situation). This issue could be particularly relevant for Sweden where we by international standards live in a safe and secure environment and where much of the welfare is provided by the authorities. Therefore it can be expected that some individuals may either think that more should be left for the individuals themselves to care for but also that it will difficult for the authorities to make improvements regarding safety. That the underlying welfare system can drive answers to these types of questions has for example been found in a study undertaken by Alberini et al (2006) for the NewExt project (Bickel and Friedrich, 2005).

We chose to use mail instead of internet for the distribution of the questionnaire to achieve a representative sample but also because this is still the most common method used for surveys in Sweden. The survey was distributed in April 2008 with a follow-up in the end of May. In the introduction of the questionnaire questions were asked about the respondent and his/hers previous experience of serious accidents. After that a description was given of the risk reduction that the respondent was asked to evaluate and the choice context. A thorough description was also given of the choice task where each respondent could either choose status quo (current situation) or an alternative program where they would contribute by a small increase in their tax payment to the provision of a policy measure that would save a certain number of lives and a certain number of years during the coming 10 years. An example of a choice question is presented in Figure 1.

We included three attributes in the questions. Number of lives saved varied from 1 to 7 in a population of 10 000 people over ten years (implying a change in risk of 1-7 per 100 000 annually) while the number of years saved varied from 20 to 80 over the ten year period. The final attribute was a tax increase that varied from 200 SEK to 2000 SEK per year (or 2000 to 20 000 SEK for the ten year period). The three attributes were defined to have four values each that were varied according to a fractional factorial experimental design procedure (Louviere et al., 2000). We identified 16 combinations and divided these into four blocks of four questions each. In order to avoid respondent fatigue, each respondent was only asked to four questions and hence four versions of the questionnaire were distributed randomly among the respondents.

This will happen in your community in the coming 10 years	**Current situation**	**New policy**
Deaths per 10 000 people	110	107 (3 persons are saved)
Total amount of years lost	1100	1000 (33,3 saved years per saved life)
Your total cost for 10 years	Current taxation	+2000 (+200 SEK per year)

I choose (put a cross in a square):

☐ Current situation ☒ New policy

Comments to the example: *In the example the person has chosen the New policy since this square is marked with a cross. This new policy will reduce the number of people who die a sudden death in the coming 10 years by 3 (from 110 to 107). The reduction in number of years lost due to the new policy will be 100 (about 33 years saved per death). The cost for the person is 200 SEK per year in addition to the current taxation, 2000 SEK in total during 10 years. The reduction in number of deaths and years saved in this example is similar to the effect that would be achieved if the risk of dying in traffic was reduced by half.*

Figure 1 The information given regarding the choice question

The survey ended with follow-up questions where the respondent was asked to state how certain he/she was about the responses but also the reason for the choices they made. In

particular we wanted to know what the reason would be for having chosen status quo (current situation) but also the reason for having chosen the alternative program.

The questionnaire was distributed to 2000 random individuals in the age of 18-74 in Sweden. After one reminder 441 complete answers were returned. This resulted in 1764 answers that were used in the final analysis. This is a low response rate compared to willingness to pay studies undertaken in other areas in Sweden where a response rate of 50% or more is common. However, studies on the valuation of risk often receive fewer responses which probably have to do with the good being valued. Halvorsen (2000) reports that 20% of the respondents found the questions difficult to answer. An additional explanation could be that the CE design is more cognitively demanding than the CVM questions commonly used. A similar Swedish CE-study by Carlsson et al. (2008) had a response rate of 40% after two reminders[7].

Some descriptive statistics for the respondents and their household are presented in Table 1. In the table we have also included the same information for the Swedish population for comparison. According to these figures we have a higher share of households with children and individuals with higher education in our sample than in the population on average. One reason for this could be that a larger share of young people do not live at the stated address due to studies or travel and hence were not reached by this mail survey. For income we have only found national statistics about disposable income at the household level which is 27 000 SEK. At a tax rate of 35% a disposable income of 27 000 SEK implies a total household income of about 41 000 SEK. Some of the respondents chose not to answer the questions about personal circumstances and hence our statistical analysis that includes covariates is based on observations from 438 persons.

Table 1 Descriptive statistics for sample in basic analysis (n=441)

	Sample statistics	**n**	**National statistics**
Sex (age group 18-74)	53% men	438	51% men
Age (age group 18-74)	46,35 years	438	44,8 years
Households with children	44%	395	27%
Individuals with higher education	46%	432	31%
Households with total income above 40 000 SEK per month	51%	429	Disposable income about 27 000 SEK per household
Experience of accident (1=yes)	19%		-
Certainty (scale 1-10)	6.67		-

[7] That this risk reduction was a difficult question to have an opinion on was a commentary made by many respondents. Some respondents also stated that the lack of a description of the policy measure made the question "too" hypothetical. However, in a small follow-up among non-respondents we also found that an additional reason for not having responded was that younger persons in particular spend time abroad or away studying and hence the questionnaire does not reach them. The comments made to the questionnaire also revealed that this is an issue that affects people. One person did not respond due to having lost a relative recently in an accident while a young person staying abroad cared enough to send a reply all the way from Australia.

In table 2 we have compiled some statistics for the samples that received different versions. We see that the basic characteristics (age and sex) are similar and that the responses are evenly distributed among the different versions of the questionnaire. What is more interesting however is the response behavior. Contrary to what might be expected according to economic theory, quite a large share of the respondents is categorical in their responses choosing either only the current situation in all choice situations or only the policy program. The reason for only choosing the program alternative could be warm glow as discussed in Adamowizc et al. (2007) while the current situation (status quo) option could be chosen due to the context of public provision. The implication this has for the willingness to pay estimates will be investigated in the empirical section.

Table 2 Descriptive statistics and response behaviour for subsamples

	Age	**Men**	**Total number of respondents**	**Respondents choosing only Current situation**	**Respondents choosing only Programme**	**Respondents choosing Both options**
E1	47	55%	109	30 (28%)	36 (33%)	43 (39%)
E2	47	53%	112	18 (16%)	28 (25%)	66 (59%)
E3	47	50%	115	26 (23%)	35 (31%)	54 (46%)
E4	45	53%	104	16 (15%)	31 (30%)	57 (55%)
Total			440	90 (20%)	130 (30%)	220 (50%)

In table 3 we present the responses for individuals who gave a ranking of nine or ten in the certainty question, about 25% of the total sample. Here an even larger share of the respondents were categorical and only 25% of these respondents actually did state both alternatives in their choices. This is unexpected since the underlying assumption behind certainty calibration is that those who state that they are certain of their responses are the ones who have considered and evaluated the attributes. The pattern in these responses instead indicates that those who state they are certain are those who base their responses on other convictions about what is right and wrong. This is in line with the proposition made by Harrison (2006) that in a stated choice setting as the one we have used here, the important thing to consider is if individual choose to choose or not and how to treat those who choose not to choose. Unfortunately our questions were not comprehensive enough to investigate this issue further but we believe this is an important issue to address in future research.

Table 3 Response of respondents who stated nine or ten in the certainty questions

	Total number of respondents	**Respondents choosing only Current situation**	**Respondents choosing only Programme**	**Respondents choosing Both options**
E1	22	7 (32%)	12 (54%)	3 (14%)
E2	28	11 (39%)	8 (29%)	9 (32%)
E3	29	8 (27,5%)	13 (45%)	8 (27,5%)
E4	22	5 (23%)	12 (54%)	5 (23%)
Total	101	31 (31%)	45 (44%)	25 (25%)

As discussed regarding the methodological issues, one reason for using CE is that we expect that the format will help individuals to notice and account for the trade-offs involved in the choice situation. In the table 4 we provide an illustration of the response pattern to the questionnaire. Since we are interested in the willingness to save lives and how it is modified by years saved per life, we have the calculated values for these two estimates and present them in the column and row head. The numbers used to calculate them are presented in the end of the columns and rows. The numbers stated within the table is the share of respondents accepting to pay for the policy measure. Given the chosen design we have a wide range of values that has been evaluated (although not by all respondents).

We have divided the table into four sections, marked by different shades of gray, to provide information on the size of the risk reduction that the respondent was asked to evaluate. For each section we expect the share accepting to pay to increase with years per life saved but decrease with an increase in SEK per life. This is also the pattern we see in the three first sections. One problem with the chosen design however is that we only have information where many years are saved for the alternative one life saved. Hence, in the last section of the table we only have observations on the high end of the bid range. Here the pattern is a decrease in the share accepting the bid but the decrease is modified due to the increase in years per life saved.

Table 4 Share (%) of yes answers for different choice alternatives

	SEK/life per year															
Years/life	**29**	**40**	**67**	**114**	**160**	**200**	**267**	**280**	**286**	**400**	**467**	**800**	**1400**	**2000**	year	life
2,9									33,4						20	7
5,7						42,3									*40*	*7*
8,6				63,3											60	7
11,4	77,9														80	7
4								33,7							*20*	*5*
8										38,5					40	5
12		78,4													60	5
16					62,6										80	5
6,7							49,5								20	3
13,3			67,8												40	3
20			74												60	3
26,7											51,4				*80*	*3*
20						56,9									20	1
40												46			40	1
60													45,2		*60*	*1*
80														28,8	80	1
SEK/year	200	200	200	800	800	*1400*	800	*1400*	2000	2000	*1400*	800	*1400*	2000		
Life	7	5	3	7	5	*7*	3	*5*	7	5	*3*	1	*1*	1		

One issue of interest is how the acceptance for a bid is related to the total number of lives saved and the number of years saved per life. For illustration purposes we have marked the responses where were the bid the respondents were to evaluate was 800 SEK per year. These are the white squares in the table. The acceptance rate to this bid varies from 46% to

63%. The alternatives where many years and lives were saved reached similar acceptance rates, about 60%, hence 7 lives and 60 years or 5 lives and 80 years seem to be equally valued while less people are willing to pay the same total amount when fewer lives and years are saved. Still, quite a large share, 46%, stated that they are willing to pay 800 SEK per year for a risk reduction of 1/100 000 prevented deaths when 40 years are saved per death.

Looking at the last three rows in the fourth section we can also see that acceptance rate for 1 life and 40 years saved is about the same as the same risk reduction when 60 years are saved (46% and 45.2%). That it is not higher for the latter is reasonable since the bid was higher, 1400 SEK per year. Still, the acceptance rate is rather high and this is so even for the highest bid where 28.8 % state they are willing to pay 2000 SEK per year for a risk reduction of 1/100 000 where 80 years are saved. Hence, we seem to lack information on the tail of the willingness to pay distribution.

THE BASIC ECONOMETRIC MODEL AND RESULTS

We are interested in the trade-offs between cost and the quantity-quality changes in saving lives and life years. In the basic econometric model here, we include the three key attributes i.e. the proposed cost ΔC, the expected reduction in mortality risk ΔR and the expected increase in life years per saved life ΔY. The expected saving in the number of life years per individual can thus be expressed by ΔRΔY. Suppose that ΔR=5/100,000, and ΔY=20 years, then ΔRΔY=(5/(100000))∗20= 0.001. This implies that for a population of 100,000 individuals, the expected number of saved lives is 5 and the corresponding number of life years saved becomes 100000∗0.001= 100 life years.

Assume that an individual's true willingness to pay for a policy program (ΔR, ΔY) is ΔW according to the following model

$$\Delta W = A(\Delta R)^{\alpha}(\Delta Y)^{\beta}\gamma \qquad (1)$$

where A>0 is a scale parameter and (α,β)>0 denote the elasticity of WTP with respect to (ΔR, ΔY), respectively, and γ is a log-normally distributed stochastic term with unity mean. With such a multiplicative model, any “saved” life with zero life year is valued zero as the life is virtually not saved. Similarly, without saving the life, the number of “life” years experienced by an individual is also meaningless. To fix ideas, let us pretend that α=β=1, then the median value of the project becomes ΔW=A(ΔRΔY) meaning that the individual's WTP is proportional to the expected life years saved. In this case, it does not matter whether to save 2 lives with 50 life years each or a single life with 100 life years. With other parameter values, however, such an interpretation cannot be made. In case that α >β, people would tend to value life saving per se relatively more than the life years.

Conditional on a certain number of life years, this model also allows us to make the strong and weak scope tests, namely whether the revealed WTP is proportional to the mortality risk reduction or alternatively the number of lives saved. If yes, then there is a strong scope effect i.e. α=1. Otherwise, if the value increases less proportionally with respect to risk reduction

with 0<α<1, the case of weak scope effect occurs. If the value is completely insensitive to the change in risk level, where α=0, the there is no scope effect.

Taking a log-transformation, we obtain

$$\ln(\Delta W) = a + \alpha \ln(\Delta R) + \beta \ln(\Delta Y) + \varepsilon \quad (2)$$

where $\varepsilon = \ln \gamma$ is assumed to be normally distributed with a zero mean and constant variance, i.e. N(0,σ²), and $a = \ln A$. Suppose that the cost associated with the policy program is ΔC (200 to 2000 per year proposed in the survey), then the individual would accept the policy program if ln(ΔW)>ln(ΔC), i.e. ln(ΔW)-ln(ΔC)>0, i.e.

$$-\varepsilon < \ln(A) + \alpha \ln(\Delta R) + \beta \ln(\Delta Y) - \ln(\Delta C) \quad (3)$$

where (-ε) is also normally distributed by symmetry. For a policy program (ΔR, ΔY) associated with a cost ΔC, the probability for an individual to accept the program is given by

$$P = \Phi\left(a' + \alpha' \ln(\Delta R) + \beta' \ln(\Delta Y) + b \ln(\Delta C)\right) \quad (4)$$

where $a' = \ln A / \sigma$, $\alpha' = a / \sigma$, $\beta' = \beta / \sigma$ and $b = -1/\sigma$ are parameters. In the dataset, we have 1764 observations collected from 441 respondents who each answered 4 choice questions. With the Stata package, we have estimated the model by random-effects probit regression as in Table 5.

Table 5 The basic econometric model estimates using random effects probit

Variable	Parameter	Std. Err	T-value	P-value
Ln(ΔC)	-0.8718	0.0646	-13.49	0.0000
Ln(ΔR)	0.8719	0.1136	7.67	0.0000
Ln(ΔY)	0.5794	0.09116	6.36	0.0000
Constant	5.5089	0.63253	8.71	0.0000
Rho	0 .7997	0.0241	$\chi^2 = 538.06$	0.0000

Note that all the parameters have the expected algebraic signs, and they are statistically significant at the 99% level. Both life saving per se and life years contribute positively to the individuals' decision to accept the program whereas the cost variable has a negative effect. The Rho value is estimated to be 0.7997, which indicates strong positive correlation between the 4 choices made by the same individual.

To test for scope effect, we calculate the original parameters α and β and make inference on whether they are significantly different from 0 (no scope effect) and from 1.0 (strong scope effect). Note that $\alpha = -\alpha'/b$ and $\beta = -\beta'/b$ so we have to make certain parameter

conversions. The test results are reported in Table 6. The results from the first two rows indicate that both life saving and life years are statistically significant determinants of the individual willingness to pay at any conventional level, and thus the no scope effect is safely rejected. Results on the third row indicate that there exists strong scope effect on the life saving variable i.e. people's willingness to pay increases almost by the same proportion as the increase in mortality risk reduction or life saving. This is in contrast to Bosworth, Cameron and DeShazo's (2009) result with diminishing marginal willingness to pay (MWTP) for avoided deaths and illnesses but constant MWTP for a given percentage increase in the number of avoided deaths or illnesses. For the life years saved, the last row indicates a rejection of any strong scope effect. Conditional on life saving, an increase in life years brings less than proportional change in people's WTP. Together with the no scope test results, we conclude that there exists some weak scope effect for the life year variable. A 1% increase in life years leads only to about 0.6% more willingness to pay.

Table 6 Scope test results from the basic model

Test	Hypotheses	Estimate	Std Error	T-value	P-value
No Scope	$H_0: \alpha = 0\ H_1: \alpha \neq 0$	1.0002	0.1357	7.3700	0.0000
	$H_0: \beta = 0\ H_1: \beta \neq 0$	0.6646	0.1082	6.1400	0.0000
Strong Scope	$H_0: \alpha = 1;\ H_1: \alpha \neq 1$	0.0001	0.1357	0.0011	0.9999
	$H_0: \beta = 1; H_1: \beta \neq 1$	-0.3353	0.1082	-3.0988	0.0020

By imposing a restriction with $\alpha = 1$, we have re-estimated the model and obtained the value of a Statistical life expression as:

$$VSL = \Delta W / \Delta C = 6.318(\Delta Y)^{0.6645} \qquad (5)$$

which is depicted in Figure 2 (with a million as measurement unit). The value of a statistical life depends on the expected life years of the saved statistical life. For the average life years saved according to the survey design, the value of a statistical life is about SEK 40 million, about 6 million USD.

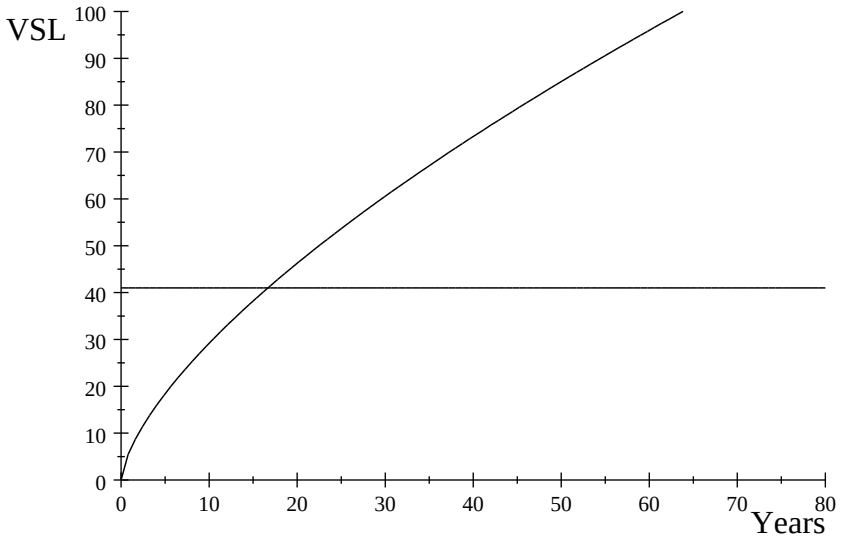

Figure 2 VSL as a function of life years

What is the value per life year? It is straightforward to show that

$$VOLY = 4.1938\Delta Y^{-0.3355} \quad (6)$$

as shown in Figure 3. Upon survival, a life year is much valued at the beginning but an extra life year upon a certain number of life years already becomes smaller and smaller. Around the average life years per saved life, VOLY is about 1.5 million SEK, about 200 thousand USD.

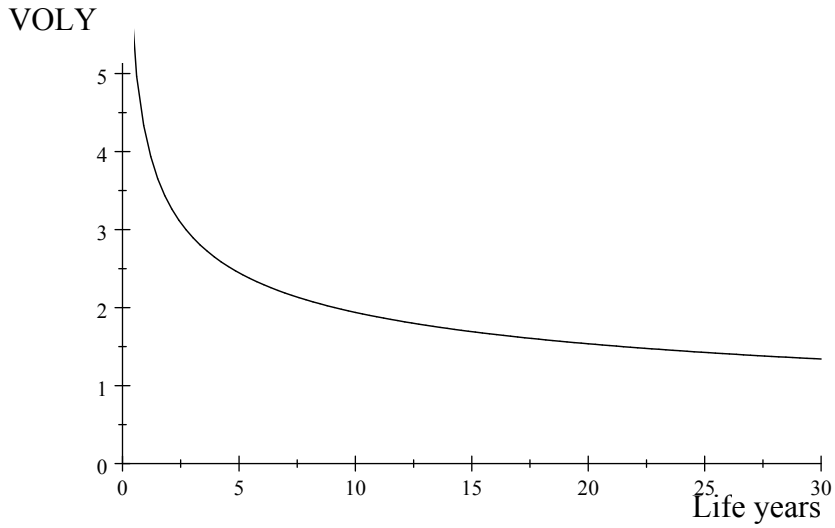

Figure 3 Value of a life year (VOLY)

AN EXTENDED ECONOMETRIC MODEL WITH MORE COVARIATES

In this section, we extend the basic model by a few other covariates such as the respondents' gender, age, their confidence on the choice made as well as whether they made any trade-offs in their choices. This implies that the intercept term α in equation (2) is a function of these variables instead of being a constant. From the model estimates as shown in Table 7, it can be seen that the essential parameters for Ln(ΔC), Ln(ΔR) and Ln(ΔY) still have the same algebraic signs as earlier and all are statistically significant at any conventional level. Moreover, scope tests give the same conclusion as drawn earlier based on the basic model, namely there is a strong scope effect for the number of lives saved, and a weak effect on the life year variable.

The variable *Choosing* is a dummy with value 1.0 if the person's choice is sensitive to the bids given and 0 if the person always favors or rejects the same program irrespective of the cost. Since the sign of the associated parameter for this variable is negative, those who took active choices seem to have somewhat lower valuation than those who seem to have lexicographic preferences. The *Gender* has a value 1.0 if the person is a male and 0 for a female. It is seen that the male population value lives and life years lower than the females (who love lives more). The *age* variable has a non-linear effect on the individual's willingness to pay. The WTP increases in age initially but after about 42 years old, their valuation of life saving and an extra life year begin to decline as compared to the earlier phase in life. The *Certainty* variable measures how certain an individual is about his or her choice. It is seen that the more certain respondents place large values to life saving and life years. The Rho value is of almost the same size as in the basic model indicating strong within-unit correlation.

Table 7 The extended model estimates with covariates

Variable	Parameter	**Std. Err**	**T-value**	**P-value**
Ln(ΔC)	-0.8971	0.0668	-13.42	0.0000
Ln(ΔR)	0.9415	0.1170	8.05	0.0000
Ln(ΔY)	0.6315	0.0944	6.69	0.0000
Choosing	-0.4623	0.2198	-2.10	0.0350
Gender	-0.9453	0.2186	-4.32	0.0000
age	0.0729	0.0439	1.66	0.0970
age2	-0.0009	0.0004	-1.82	0.0690
certainty	0.1516	0.0455	3.33	0.0010
Constant	3.9479	1.1654	3.39	0.0010
rho	0.7875	0.0258	$\chi^2 = 477.67$	0.0000

CONCLUSION AND DISCUSSION

To the best of our knowledge, this is the first study that has included life years saved in addition to number of lives saved in the same stated choice context. This is in line with the earlier attempts by Adamowicz et al. (2007) and Bosworth et al. (2009) who have included and explored the impact of morbidity endpoints in addition to mortality risk. Using the data collected from a random sample of respondents in Sweden, we have estimated our econometric model with both life saving and life year loss attributes taken into account. The results indicate that conditional on a certain number of life years upon survival, each statistical life is valued the same. This is termed a "strong scope" effect in the valuation literature. This finding is in strong contrast with earlier results where people's marginal willingness to pay diminishes as the number of lives saved increase.

Another issue concerns the treatment of categorical respondents. These are respondents who accept or reject all bids irrespective of the size of the attributes. Often they are left out of the analysis. In this study, we have explored the implication of such responses, and found that people that made categorical choices tend to have larger VSL and VOLY estimates. For the personal characteristics variables, we found that the Swedish females on average value both statistical lives and life years more than the male population. Concerning the individual's age, our result indicates that this variable has an "inverted U" shape, meaning that the VSL and VOLY increases in age up to about 42 years old and after that the values begin to decline. As expected, the certainty variable, i.e. the respondents' self confidence on their choices have a positive effect of the final value estimates.

It is worth mentioning that our study was a rather small mail survey aimed at the general population in Sweden. We did not have the possibility to train the respondents in a way that is common in the US studies. However, since the results are promising, and the issues raised are important, we believe that further research into how to design these kinds of studies is needed.

Since these can be complicated choice tasks we think more research is needed on how the questions are understood and interpreted by the respondents. Especially regarding questions like those in this study, which concern matters of life and death that are related to ethical considerations. Special care may for example be needed in a Swedish context since people in general are not used to explicitly paying for public provision of risk reducing measures, for example through private insurances.

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