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Testing sensitivity of willingness to pay for mortality risk reduction

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Abstract

Contingent valuation method was used in this study to elicit willingness to pay for risk reduction of dying because of cardiovascular or respiratory diseases. The survey was conducted on a sample of 408 citizens of Warsaw between 50 and 80 years of age. Obtained results did not pass external scope test, even in its weak form. The magnitude of risk reduction did not have statistical influence on the probability of accepting the bid.

Keywords:
value of a statistical life, contingent valuation, scope test, robustness

JEL:
H41, H51, I18, I31, J17

1. Introduction

The value of a statistical life (VSL) plays an important role in the cost benefit analysis of regulations in the field of environmental protection, safety regulations and many others. In recent years, the contingent valuation method (CVM) has been widely applied to value mortality risk reduction (Alberini et al. 2007, Bhattacharya *et al.* 2007). In these CV applications individuals are asked to value a hypothetical reduction in the risk of dying in a given time period. The value of a statistical life (VSL) is defined as the marginal rate of substitution or trade-off between money and a small risk change.

An alternative method to estimate the VSL is the hedonic wage approach, where salaries are regressed against different characteristics, including the risk level associated to the job. Hedonic applications based on the labor market take only occupational risks into account. Additionally, the hedonic wage approach often assumes that workers' perceived risk is equal to their objective risk. Comparatively, the CV method tends to be more flexible. In a CV questionnaire people can be informed about their baseline risk and about the exact scale of risk reduction. Moreover, the survey sample can be created to include persons of all ages, environmental exposures, and health status, whereas in labor market studies the population being studied is often restricted to working males in their prime (Alberini, 2004a).

Although CV methods have some advantages over the hedonic approach they have their weaknesses well. Since a CV survey is designed to elicit people's WTP for a risk reduction, respondents typically have to cope with probabilities, or some other abstract or difficult concept for most people. Moreover, a significant body of psychological research suggests that individuals tend to have a poor perception of numerical differences in magnitude (Kahneman and Tversky, 1973). These restrictions may explain why most CV studies present no significant WTP sensitivity to risk reductions, the empirical findings being at odds with economic theory. The standard economic theory predicts that the WTP for small reductions in the probabilities of adverse health effects should be increasing approximately proportionally to the magnitude of the risk reduction (Hammitt and Graham, 1999). Sensitivity to scope is a key factor for the validation of CV results in VSL estimations. If a study does not pass this test, it suggests that the VSL depends on an arbitrarily taken risk reduction level.

The main aim of this article is to test the WTP sensitivity to the magnitude of the risk change in an empirical application. For this purpose, the respondents were divided into three groups and were asked to value three different annual risk reduction levels: 1, 5 and 10 in 10 000. Because 5 and 10 in 10 000 are relatively large changes, the sample of interest was limited only to people of the age of 50-80. In such age group the reduction of 10 in 10 000 is reliable due to a relatively high baseline risk level. People over 80 years old were not included because of possible cognitive problems. According to author's knowledge this is the first study that tested the sensitivity of WTP for mortality risk reduction using such a broad range of risk reduction levels.

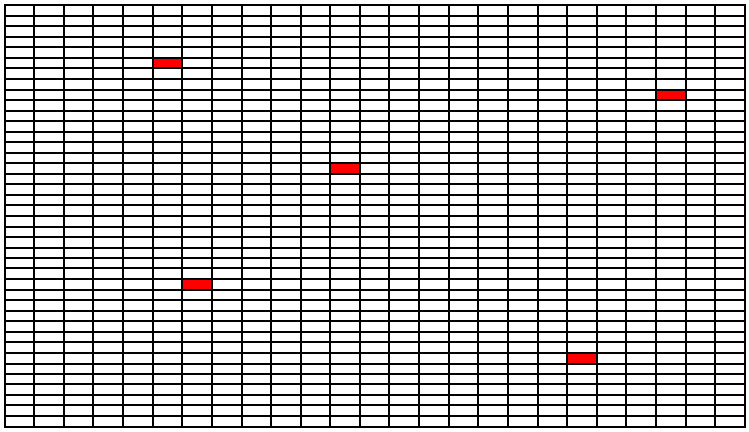
2. Survey Design

The questionnaire used in this study is based on an Italian version of the one used by Alberini (2006) in the CcashH project. It shares the structure and uses the same methods of presenting risk to respondents. While the original survey from Alberini was a self-administrated computer questionnaire this one interviewed individuals face-to-face at home. A professional survey company administered the questionnaire among citizens of Warsaw in May 2005. The ages of interest were from 50 to 80 years. The overall sample size was 408 respondents.

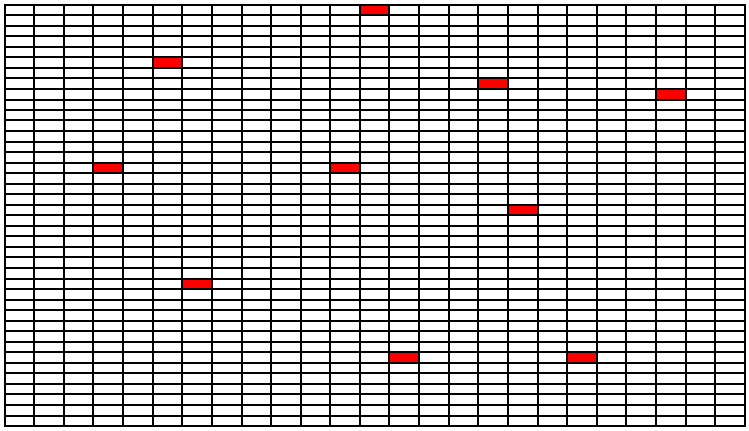
The first part of the questionnaire explored respondents' health and the health of their families. In the second part, the idea of probability was introduced and explained with the use of coins and roulette wheels. Next, the questionnaire focused on the risk of death. Two 1000-square grids showing the risk of death level corresponding to two hypothetical individuals were presented to each respondent (figure 1), following Krupnick *et al.* (2002) and Alberini (2006). Some authors argue that respondents find larger number of grids e.g. 10^4or 10^5 confusing and for that reason it is better when respondents value risks of range 10^{-3} over a period of 10 years than 10^{-4} on an annual basis (Krupnick *et al.*, 2002). When the risk is in the 10^{-3} range it can be presented using 1000 squares. In order to test the risk comprehension, respondents were asked to assess which of two presented grids showed a higher risk of dying, as reflected in figure 1. If a respondent failed to choose the correct chart then he or she was trained again on probability and had to take the test once more, with the same format but different numbers. Respondents who failed twice were excluded from further analyses.

Fig. 1. **Probability chart**

Suppose there are two people:



Person 1: **probability of dying = 5 in 1000 in the next 10 years.**



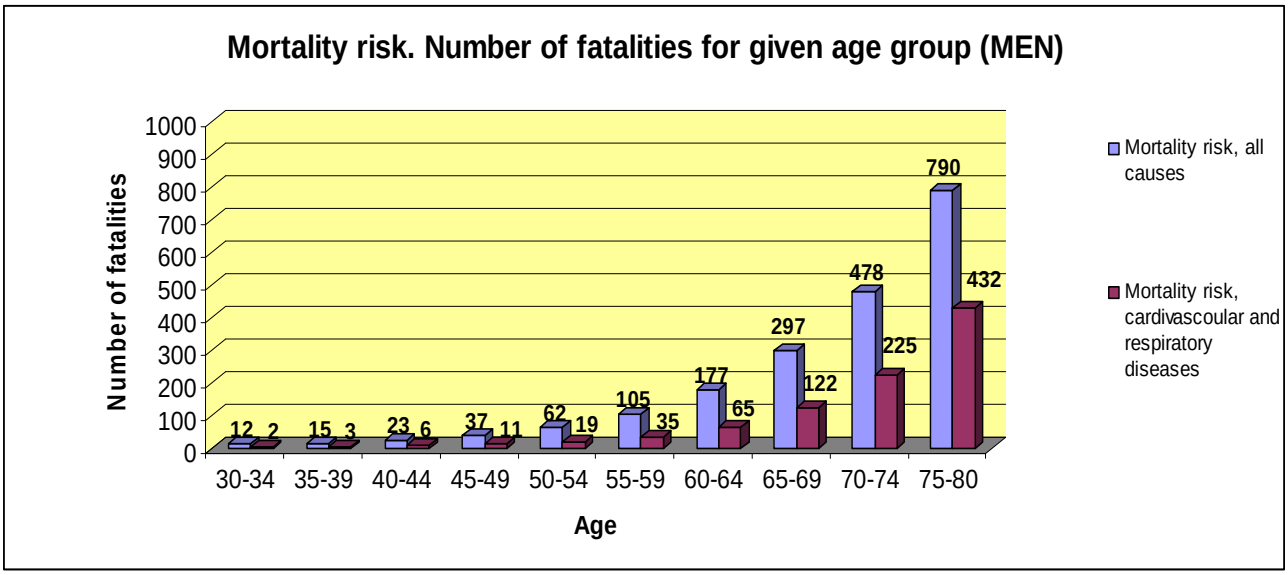
Person 1: **probability of dying = 10 in 1000 in the next 10 years.**

Which of the two person is the most likely to die in the next 10 years?

Source: Design based on Alberini (2006).

In the third part of the questionnaire individuals were informed about their baseline risk according to their age and gender. The risk was presented both in a numerical and graphical way. Figure 2 shows the version for male respondents.

Figure 2. Baseline risk card



Source: Design based on Alberini (2006).

Part four of the questionnaire introduced the main causes of death for people in different age groups and frequent ways of risk reducing behavior. Table 4 contains an example of the card showed to respondents.

Table 4. Card example with alternative ways of risk reduction

Person	Risk of dying because of cardiovascular or respiratory diseases	Activities taken in each year in the period of the nearest10 years.	Reduction of the risk of dying in the period of the nearest10 years.	Percentage reduction of risk in relation to the initial level
Average women age 50 years.	7 in 1000	Regular taking medicines, in case of diagnosed hypertension.	4 in 1 000	57%
Average men age 40 years.	6 in 1000	Regular taking medicines, in case of diagnosed hypertension.	2 in 1 000	33%
Average men age 70 years.	225 in 1000	Regular taking aspirin or other anti-coagulants which reduces the risk of thrombosis.	39 in 1 000	17%

Source: Design based on Alberini (2006)

In part five, individuals were asked to report their willingness to pay for a product that when used and paid for would reduce their baseline risk by 1 (WTP1), 5 (WTP5) or 10 (WTP10) in 1000 over the period of the next ten years. The sample was divided into three groups and in each of them, respondents were asked to value only one different risk reduction level. Following the studies from Krupnick et al. (2002) and Alberini (2006), the elicitation format

was a dichotomous choice with an open-ended follow-up question. Table 5 presents the bid structure used in the study.

Table 5 Bid structure (in zł)

	Initial bid (t)	Higher bid (t_H)	Lower bid (t_L)
1	100	200	50
2	200	500	100
3	500	1000	200
4	1000	2000	500

Notes: Exchange rate 1zł = 3.30 USD (Janury of 2006)

3. Statistical Model

Following Hanemann (1998), the probability of the responses is given by

$$\Pr\{\text{Yes/Yes}\} \equiv \mathrm{P}^{\mathrm{yy}} = 1 - F_c(t_H)$$
$$\Pr\{\text{No/No}\} \equiv \mathrm{P}^{\mathrm{nn}} = F_c(t_L)$$
$$\Pr\{\text{Yes/No}\} \equiv \mathrm{P}^{\mathrm{yn}} = F_c(t_H) - F_c(t_L)$$
$$\Pr\{\text{No/Yes}\} \equiv \mathrm{P}^{\mathrm{ny}} = F_c(t) - F_c(t_L),$$

where F_c is any underlying WTP distribution, t is the initial bid, t_L is the lower bid in the follow-up question, and t_H is higher bid in the follow-up question. Given these probabilities, the log-likelihood function for the double-bounded dichotomous choice model is

$$\ln L = \sum_{i=1}^{n} \left[I_{yy} \ln P_i^{yy} + I_{yn} \ln P_i^{yn} + I_{ny} \ln P_i^{ny} + I_{nn} \ln P_i^{nn} \right]$$

with I^{xy} being a function indicator that equals one when the two responses are *xy*, and zero otherwise.

To next step consists in making an assumption about the distribution of the WTP responses. The analysis of respondents' answers to debriefing questions led to the assumption that the WTP for a risk reduction was non-negative. Hence the likelihood function based on distributions which are limited to non-negative values: log-logistic, log-normal and extreme value distribution. The best fit was obtained with a log-normal model. The mean and median WTP in a log-normal model are respectively equal to $\exp(\gamma + \frac{1}{2}\sigma^2)$ and $\exp(\gamma)$ respectively, where γ and σ denote the location and scale parameters of the distribution. A maximum likelihood approach was used to estimate the values of the unknown parameters.

4. Empirical Results

Table 6 reflects some descriptive statistics of the sampled population, aged 50-80 years.

Table 6. Mean values for the three subsamples, with standard deviation in parenthesis

	1in 10 000	5in 10 000	10 in 10 000
% of men	44.8	45.5	46.2
Age	62.94	62.42	63.19

	(11.84)	(11.44)	(11.95)
Material status, self assessed, from 1 (bad) to 5 (very good)	3.22 (1.05)	2.97 (1.07)	3.05 (1.15)
Education (years of schooling)	14.03 (2.43)	13.87 (2.15)	13.55 (2.33)
Health status (dummy, 1 if some serious health problems)	32.35	31.85	32.73
Number of observation	136	136	136

Most respondents (56%) declined to answer the question concerning their income. The officer responsible for the survey reported that this was a common difficulty while questioning people. To overcome this problem Polish survey companies usually request respondents to value their material status on a 5-grade scale. This study uses the grades as a proxy for differences in income level. The education variable reflects the number of years of education. All respondents were asked to report their health condition, i.e. if they suffered from a heart disease, high blood pressure, serious respiratory diseases or cancer. People who indicated at least one of these diseases were coded with a dummy variable indicative of having health problems. In the whole sample, 32% of respondents reported suffering from at least one of these diseases.

People who failed twice to give the right answer to the probability question were removed from the sample and were not taken into account in the econometric part. Table 7 shows some information concerning risk comprehension and negative answers to the bids. Respondents stating no twice were further asked if they were willing to pay anything at all. Respondents who answered 'yes' were considered to have a positive WTP.

Table 7 Frequencies on risk comprehension and scenario rejection

	1/10 000	5/10 000	10/10 000
Initial number of observations	136	136	136
Wrong answers in both probability questions	15	16	18
Protesters	7	9	9
Number of observation, without respondents who failed probability test and protesters.	114	111	109
Answers NN	58	56	53
Answers NN but 0<WTP<t	44	38	37
Respondents who declared WTP=0	12	17	19

The 48 respondents who declared a WTP=0 were further asked about reasons for not willing to pay. 25 respondents protested against the payment vehicle (*I have worked all my life and I have paid health insurance so I am not going to pay anything for medical treatment that I should get for free* or *Since I am paying health insurance it should be provided for free, I will not pay anything extra* or *My medical insurance covers all necessary medical tests I don't need anything extra*). Identified protesters were excluded from the sample. Remaining 23 respondents were identified as genuine WTP=0, 14 of them declared not to be in the risk group and therefore not being interested in undergoing medical tests (*I am fit, I exercise regularly, I use natural medicine and I don't need any medical tests, I have a doctor in family and I don't need any medical tests*). The remaining 9 respondents gave different kind of answers that also indicated that they were true zeros (*I am too old to buy a medical test, everyone must die some day*). Respondents who were identified as true zeros were left in the sample.

To check for a pattern among respondents who declared WTP=0, the probability of rejecting the scenario was analyzed using a standard probit model. Table 8 shows the results. The only significant variable was education. People with a higher education level, *ceteris paribus*, were less prone to reject the scenario. A possible explanation would be that people with lower education may have more cognitive problems which could result in scenario rejection.

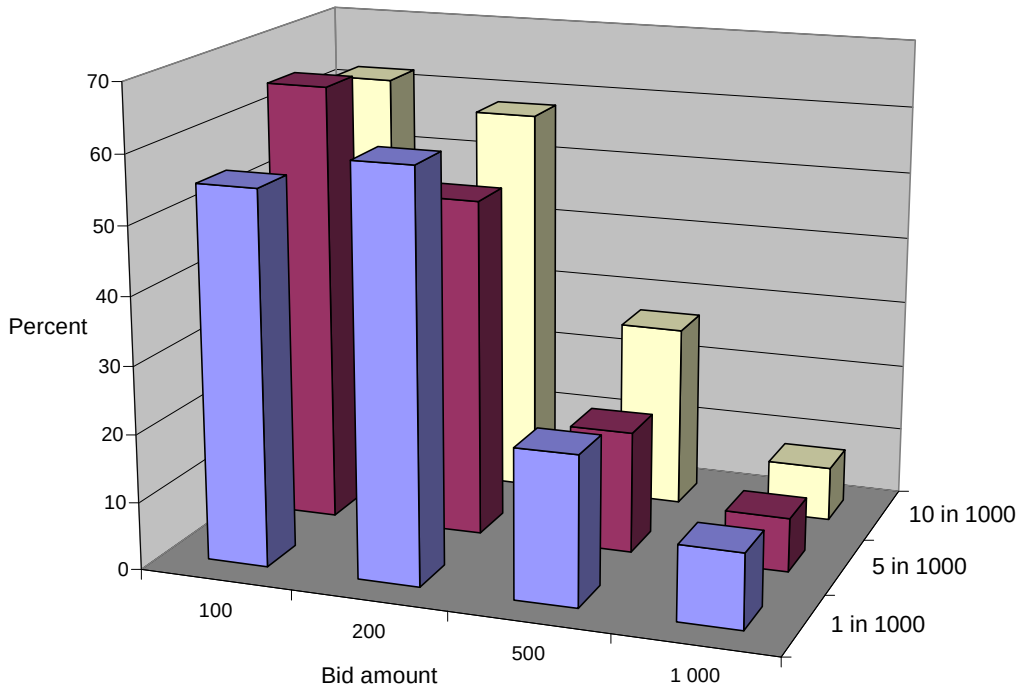
Table 8. Probability of rejecting the scenario

	Marginal effect (std errors)
Health	0.074 (0.054)
Age	-0.0012 (0.0011)
Income	-0.032 (0.049)
Education	-0.016** (0.0073)
Gender	-0.0003 (0.042)
Risk	-0.0034 (0.0057)
Bid	0.00001 (0.00006)

*Notes:*** denotes test statistic significance at the 5% level.

Figure 4 reflects the percentage of 'yes' responses to the initial payment question for a given risk reduction level. Economic theory predicts that the percentage of 'yes' responses should decline with the bid level. Results confirm this assumption. The theory also predicts that the probability of accepting the bid should increase with the scale of risk reduction (given the same bid structure), but this is not supported by the data. This important limitation will be discussed below.

Figure 4. Percentage of 'yes' responses to the initial payment question.



A log-normal version of the double-bounded model was estimated. The model was first estimated without covariates. Table 9 reports the mean and median WTP with the corresponding standard errors for a given risk reduction. The standard errors were calculated with the Wald command in Limdep 8.0. This software was used also used for the econometric estimations.

Table 9. Mean and median WTP (in zl), standard errors in parenthesis

	1 in 10 000	5 in 10 000	10 in 10 000
$\frac{\alpha}{\sigma}$	4.904 (0.51)	4.525 (0.55)	4.801 (0.94)
$\left(\frac{1}{\sigma}\right)^{a}$	0.943 (0.092)	0.846 (0.099)	0.943 (0.092)
Mean	317 (46)	421 (77)	353 (65)
Median	180 (21)	209 (26)	193 (24)

Notes: all estimates significant at 1% level
[a] Coefficient for variable -log(bid)

These results confirm what was depicted in figure 4, i.e. that the mean and median WTP seem to be insensitive to the level of the risk reduction. Because the sample size was rather small (334 individuals), all observations were pooled together in order to check the effect of covariates on the probability of accepting a bid. Among the variables that could affect the probability of accepting bid, age, health status, education, gender, material status and the proposed risk reduction level were include. The estimated model took the following form,

$$\Pr(\theta < (\alpha_0 + \alpha_1 Risk + \alpha_2 Econ\_st + \alpha_3 Health\_st + \alpha_4 Gender + \alpha_5 Age + \alpha_6 Edu - \frac{\log(bid)}{\sigma}))$$

where θ is standardized stochastic error[1]. The econometric results are presented in table 10.

Table 10 Results of double-bounded log-normal model with covariates

	Parameter estimate (std. error)
Risk	0.011 (0.019)
Economic status	0.16** (0.064)
Health status	0.081 (0.19)
Gender	0.052 (0.12)
Age	-0.015** (0.007)
Education	0.076** (0.032)
Scale parameter (σ)	1.068*** (0.062)
Constant	5.03*** (0.49)
LL 369.4908	

Note: *** denotes test statistic significance at the 1% level.,
** denotes test statistic significance at the 5% level.
[a] σ is a scale parameter

This analysis indicates that a higher risk reduction does not increase the probability of accepting the bid. Instead, the probability of accepting bid increases with respondent's economic status and education level and declines with age.

5. Conclusions

The mean and median WTP were estimated in three independent samples. In each of them respondents were asked to value different risk levels of death, 1, 5 and 10 in 10,000 people on an annual basis. The estimated values did not pass an external scope test even in its weak form, i.e. mean and median WTP did not increase with the magnitude of risk reduction. The mean and median WTP_{10} was in fact lower than median WTP_5.

Because the mean and median WTP were estimated from small samples, all observations were pooled together. The results showed that the probability of accepting the bid increased with respondent's higher material status and education level and declined with age. The probability of accepting the bid did not depend on the magnitude of risk reduction that was valued.

It is difficult to compare results obtained in this study with results from other studies that used a similar approach (Krupnick *et al.*, 2002, Alberini, 2003). In those studies two levels of risk reduction were used: 1 and 5 in 10,000. Also, their surveys were run interactively with the use

[1] The log-linear WTP function has the following form. $WTP = \exp(\boldsymbol{\alpha z_j} + \eta_j)$. Probability of respondent *j* answering 'yes' is equal to $Pr(\theta_j > \beta \ln(t_j) - \boldsymbol{\alpha}^* \mathbf{z_j})$ where $\theta = \eta/\sigma$, $\beta = 1/\sigma$ and $\alpha^* = \alpha/\sigma$, and η is assumed to be distributed normally with mean zero and unknown variance σ^2 **(**Haab and McConnell, 2004).

of computers. For example, in the study by Krupnick *et al.* (2002) the mean WTP obtained for sample with 1 in 10,000 annual risk reduction was 1.6 higher than in the sample with 5 in 10,000 annual risk reduction. In the present study the ratio between WTP_1 and WTP_5 is 1.3, but the mean and median for 10 in 10,000 risk reduction are lower than for 5 in 10,000. The results may indicate that respondents answering to the valuation question mainly reveal sensitiveness to the name of good being valued – 'a product that will reduce their risk of dying' and not to the scale of the reduction that seems an abstract concept difficult to grasp for most people.

The lack of sensitivity of the WTP to the risk reduction in CV studies is a worrisome issue. Ideally WTP should increase proportionally to the scale of risk reduction (Hammitt and Graham, 1999). Since this condition is not satisfied, estimated VSL depends on an arbitrarily taken risk level and thus estimates obtained through CV might not be satisfactory.

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