WORKING PAPER

4 / 2010

THE VALUE OF A STATISTICAL LIFE FOR OUT-OF-HOSPITAL CARDIAC ARREST VICTIMS

BJÖRN SUND
ECONOMICS

ISSN 1403-0586

http://www.oru.se/esi/wps
Örebro university
Swedish Business School
701 82 Örebro
SWEDEN

The value of a statistical life for out-of-hospital cardiac arrest victims

Björn Sund[1]

Swedish Business School, Örebro University, Sweden

Abstract

Background: Economic evaluation of policies regarding out-of-hospital cardiac arrest (OHCA) is important and we estimate the value of a statistical life (VSL) for OHCA victims. *Method:* Responses to a national Swedish mail survey in 2007, based on the stated-preference technique (contingent valuation) to directly elicit individuals' hypothetical willingness to pay for a reduced risk of dying from OHCA. *Results:* VSL values are found to be higher than for comparable VSL estimates from the transport sector. A lower-bound estimate of VSL for OHCA would be around SEK 20-30 million. *Conclusions:* The results in this paper indicates that it is not an overestimation to use the 'baseline' VSL value from the transport sector (SEK 22 million) in cost-benefit analysis of OHCA policy decisions. We do not support a 'senior death discount' for this cause of death.

[1] Corresponding address:
bjorn.sund@oru.se
Örebro University, Swedish Business School, SE – 702 82 Örebro, Sweden
Tel: +46 (0) 31-786 52 49

1. Background

The value of a statistical life (VSL) is a measure of the trade-off between income and mortality risk reductions. In essence, this means that VSL is the value that society deems economically efficient to spend on avoiding one (unidentified) premature death. VSL is a controversial measure, but it is essential in optimising policy in fields where weighting the saving of human lives against other effects and costs frequently occur. Especially in transport safety, environmental and health economics, VSL is often a key input in policy evaluations when performing cost-benefit analysis (CBA).

Economic evaluations regarding out-of-hospital cardiac arrest (OHCA) interventions have almost exclusively been evaluated by performing cost-effectiveness analyses (CEA) or cost-utility analyses (CUA) [1-6]. In particular, we have not found a single study that specifically has estimated VSL in case of an OHCA. The monetary value of a prevented fatality is instead typically based on valuations from the transport sector [7]. We experience different risk scenarios and the individuals that suffer from OHCA are generally older and less healthy than those suffering from a road traffic fatality. Therefore, it is not obvious which measure of VSL should be used, and if the VSL estimates from the transport sector is appropriate to use for evaluations of OHCA interventions.

The aim of this study was to estimate VSL for OHCA based on a stated-preference technique, contingent valuation (CV). CV is a survey-based stated preference technique to directly elicit individuals' hypothetical willingness to pay (WTP) for certain non-market goods or services [8]. The method has been applied to health care since the 70s [9] and although exposed to criticism [10], it has potential to deliver measures of all costs and consequences in monetary terms.

2. Methods

2.1 Data

The target population for our CV survey was the inhabitants in Sweden and we randomly sampled 1000 individuals aged 18-75. The survey mode was a mail survey and it was sent out in June 2007 and one reminder was mailed three months later in September. Our overall response rate was 43 percent. The valuation scenario and WTP questions for the survey is attached in Appendix. The sample statistics are summarised in Table 1.

[Insert Table 1 here]

We performed a pilot study with a sample of 100 individuals in May 2007 to pre-test the questionnaire and to establish an interval for the majority of the WTP values. An open-ended (OE) elicitation format was used in the pilot survey, while we used a discrete-continuous CV format in the main study where both dichotomous choice (DC) and OE questions were asked to the same sample of respondents. A dichotomous choice (closed-ended) question reads: ‘How would you vote if… [the good] costs SEK X per year? □Yes □ No’, while an open-ended question reads: ‘How much would you at most be willing to pay annually for… [the good]? Answer: …’. When calculating VSL, the DC data was used since valuing new public goods with coercive payment implies incentive compatibility and a binary question also more resembles a real market situation. Incentive compatibility implies that ‘a truthful response to the actual question asked constitutes an optimal strategy for the agent’ [11]. However, we used the information of the OE responses when correcting for zero responses. Of 293 responses to the OE WTP question, 33 responded zero (11 percent).

The valuation scenario was a public programme to increase survival rate after out-of-hospital cardiac arrests, by increasing the density of defibrillators in the municipality. Defibrillation was explained to be initiated by firemen, policemen, security guards or nurses, and public access defibrillators may be located in hotels, shopping malls, sports centres or theatres. The willingness to pay for an increased survival rate was elicited as an annual individual fee for 10 years and the key phrase was: “*The programme will reduce your own and others’ risk* [of dying from cardiac arrest] *and the survival rate will be increased from 5 to 10 percent on average*”. A provision condition of at least 50 percent of the inhabitants of the municipality in favour of the programme (i.e. a referendum format) was included, according to the recommendations by the National Oceanic and Atmospheric Administration (NOAA) panel [12].

2.2 Method

Estimating VSL means that we are examining the rate at which people are prepared to trade off income for a reduction in the risk of dying. In a standard theoretical model of one individual’s baseline mortality risk (p) [$0 \leq p \leq 1$], where $u_a(y)$ and $u_d(y)$ are the individual’s utility as a function of income (*y*) conditional on staying alive (*a*) and dying (*d*), the expected utility is equal to [13-14]:

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

The model is simplified to only consider a marginal change in the probability of one individual’s own death and also within a specified time period. Assuming that utility of income is zero when the individual is dead (u_d=0), simplifies the expression to (1-p)u_a(y). Then the trade off between income and risk will be [11-12]:

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

In practice, VSL is not estimated by using the derivative, but instead by estimating WTP for a specified risk reduction (Δp). Then, VSL is estimated as:

$$VSL = \frac{WTP}{\Delta p} \tag{3}$$

Through our CV survey we measure WTP for a hypothetical risk reduction of dying from OHCA and arrive at a VSL measure that is specific for this diagnosis and the scenario in the survey. As far as we know, this is the first estimate of VSL for OHCA ever attempted. The analysis of our CV data follows the recommendations from Bateman et al. [8] regarding the objective to estimate mean and median WTP.

3. Results

First, we examined the proportions of yes-responses by bid amount (Figure 1) and found that they decline from 85 percent at the SEK 200 bid level to 16 percent at the SEK 5000 bid level (€1=SEK 10.53, $1=SEK 7.07: 2009-11-13). The bid levels were determined to capture the interval of WTP responses from the pilot study and the sample size of each bid level was 200 questionnaires. As we can see from the figure, the survival function was monotonically decreasing.

[Insert Figure 1 here]

Since we have chosen to use the data from dichotomous choice questions, we have to make assumptions about the distribution of the underlying WTP to calculate mean and median WTP. Following Bateman et al. [8], we start by estimating a non-parametric model to derive lower bound estimates of mean and median WTP. Both the more conservative Kaplan-Meier-Turnbull (KMT) estimator and the Spearman-Karber (SK) estimator are calculated. As lower and upper intervals we use SEK 0 and SEK 5000. Table 2 shows that mean VSL for the conservative KMT model is SEK 49 million and median VSL is SEK 30 million. The marginal risk reduction (Δp) in our CV survey was 3.35/100 000.

[Insert Table 2 here]

Further, we have estimated a variety of constant only bid function parametric models. A constant only bid function model includes the parameter estimate for the constant alone, i.e. for logit and probit distributions the WTP function for individual k is: $WTP_k = \beta_{constant} + \varepsilon_k$ (see Appendix). The confidence intervals from all parametric estimation of mean and median WTP are numerically estimated by employing bootstrapping with 10 000 replications. The variation of VSL values is large, but none of the values are smaller than the non-parametric KMT estimates. The 'best' parametric model, i.e. the model having the highest value for the likelihood function [8], is the lognormal distribution. However, we notice that the differences are small. The lognormal distribution restricts WTP to be non-negative. Negative WTP is plausible since we value a public good, but we regard it to be unlikely that a respondent would reject the programme if it was offered for free. The lognormal model rules out the possibility of zero WTP, but we also introduce a mixed spike and lognormal model that account for this possibility.

So far, we have implicitly assumed that the responders (43 percent) are representative for the non-responders as well. A conservative assumption would be to treat the non-responses as 'no'-answers [12]. For the non-parametric models this would imply mean/median VSL of MSEK 15/0 (KMT) and MSEK 22/4 (SK). Probit and logit parametric estimates would be negative, but mean/median VSL would be MSEK 23 (logit positive), MSEK 130/2 (lognormal) and MSEK 34/1 (mixed spike and lognormal). All VSL estimates decreases significantly, except for the lognormal distribution.

Mean VSL is larger than median VSL for the lognormal models and for the non-parametric models. This indicates a positively skewed distribution. Median VSL can be said to be a more robust measure than mean VSL, since it is not so greatly influenced by a few high VSL values or by the chosen distributional assumption. However, the choice of mean or median VSL is also a choice between an efficiency criteria and a majority voting rule as well as an ethical decision [8, 15-16]. If the mean VSL is higher than the cost per head, then the project should proceed, since the losers can be compensated by the gainers (Hicks-Kaldor criteria). On the other hand, if median VSL is higher than the cost per head, then we know that a majority of the respondents would vote in favour of the project.

4. Discussion

In this paper, we have attempted the first estimation, known to us, of the value of a statistical life for out-of-hospital cardiac arrest. The estimate is sensitive to assumptions of the distribution, but this is not an unusual feature of stated preference surveys [14]. However, we find that the estimates are consistently higher than the official VSL for road traffic safety in Sweden, which is estimated to be SEK 22 million [17]. This value is established from a number of CV surveys and is the ‘baseline’ VSL in Sweden, since it is the most used and explored. The distributional assumptions made for estimating the road-traffic VSL is usually a probit, logit or probit positive. VSL values for road traffic casualties are roughly the same in similar European countries [18].

Our hypothesis was that VSL for OHCA would be lower than SEK 22 million, since statistical lives are both longer and 'healthier' for road traffic victims. It has been shown that heterogeneity of VSL regarding various ages are substantial and international practices have often been to decline VSL with age, i.e. a 'senior death discount' [19-21]. On the other hand, this policy has also been argued not to be supported by neither theoretical nor empirical findings [21-22]. Our results do not support the practice of declining VSL with age for victims of cardiac arrest.

A speculation about why this unexpected difference exists could be that differences between questionnaire designs and contexts have an effect. A second possibility is that the cause of death is important. We might measure some kind of preference for 'individual freedom', compared to further road traffic safety measures that are perceived as limiting freedom of action (e.g. speed cameras, seat belts, helmets). An increased density of defibrillators does not affect individuals in this way. Also, we may capture solidarity with older and helpless individuals suffering from an OHCA ('dread'), while road-users are perceived to have more controllable risks to manage. The qualitative characteristics of a risk has been shown to affect WTP and WTP is usually reduced if the target group of the intervention is perceived as being blameworthy of the risk [19, 23].

It is fair to say that the stated preference technique, in this case represented by the contingent valuation method, suffer from a number of potential biases. Using surveys to ask about hypothetical payments may result in e.g. hypothetical bias, where individuals WTP from the hypothetical scenario deviate from WTP in a real market situation, or in scope/scale bias, where individuals are insensitive to the amount of a good (scope) or the size of a good (scale). In the face of these uncertainties, we regard the method as one possibility to achieve an indication of the value of non-market goods.

From only one small sample survey, we do not intend to draw too far-reaching conclusions. Data suggests that a lower-bound of VSL for OHCA would be around SEK 20-30 million, but it might be significantly higher. We recommend that a conservative approach would be taken when applying our estimates for cost-benefit purposes. At the same time, the results indicates that there probably is no reason why the baseline VSL value used in the transport sector (SEK 22 million) should be an overestimation to use in OHCA interventions at the moment.

Competing interests

None

Acknowledgements

I would like to thank Peter Frykblom, Catharina Hjortsberg, Jacob Hollenberg, Lars Hultkrantz, Henrik Jaldell, Leif Svensson and Mikael Svensson for helpful comments and Mikael Gustafsson, Lars Hallander, Åke Karlsson, Johan Lahti, Britt Stålhandske and Sandra Wallberg for research assistance. Financial support from the Swedish Civil Contingencies Agency is gratefully acknowledged.

References

1. Forrer C S, Swor R A, Jackson R E, Pascual R G, Compton S, McEachin C: **Estimated cost effectiveness of a police automated external defibrillator program in a suburban community: 7 years experience**. Resuscitation, **52** (2002): 23-29.

2. Nichol G, Valenzuela T, Roe D, Clark L, Huszti E, Wells G A: **Cost effectiveness of defibrillation by targeted responders in public settings**. Circulation, 2003;**108**:697-703.

3. Walker A, Sirel J M, Marsden A K, Cobbe S M, Pell J P: **Cost effectiveness and cost utility model of public place defibrillators in improving survival after prehospital cardiopulmonary arrest**. BMJ, **327**, 6 December 2003.

4. van Alem A P, Dijkgraaf M G W, Tijssen J G P, Koster R W: **Health system costs of out-of-hospital cardiac arrest in relation to time to chock**. Circulation, 2004;**110**;1967-1973.

5. Næss A, Steen P A: **Long term survival and costs per life year gained after out-of-hospital cardiac arrest**. Resuscitation, **60** (2004), 57-64.

6. Groeneveld P W, Owens D K: **Cost-effectiveness of training unselected laypersons in cardiopulmonary resuscitation and defibrillation**. The American Journal of Medicine (2005) **118**, 58-67.

7. Caro J J, Ward A, Deniz H B, O'Brien J A, Ehreth J L: **Cost-benefit analysis of preventing sudden cardiac deaths with an implantable cardioverter defibrillator versus amiodarone**. Value in Health, **10**, 1, 2007.

8. Bateman, I J, Carson, R T, Day B, et al: *Economic valuation with stated preference techniques. A manual*. Department for Transport. Edward Elgar, 2002.

9. Klose, T: **The contingent valuation method in health care**. Health Policy, **47** (1999), 97-123.

10. Carson, R.T., Flores, N.E., Meade, N.F: **Contingent valuation: controversies and evidence**. Environmental and Resource Economics, **19**:173-210, 2001.

11. Carson, R.T. Groves, T: **Incentive and informational properties of preference questions**. Environmental and Resource Economics (2007) **37**:181-210.

12. Arrow, K., Solow, R., Portney, R., Leamer, E.E., Radner, R., Schuman, H: **Report of the NOAA panel on contingent valuation**. Federal Register, January 15, **58**, 10, 4601-4614.

13. Jones-Lee M: **The value of changes in the probability of death and injury**. Journal of Political Economy, 1974, **82**(4), 835-849.

14. Alberini A: **What is a life worth? Robustness of VSL values from contingent valuation surveys**. Risk Analysis, 2005, **25**, 4, 783-800.

15. Johansson P-O, Kriström B, Mäler K G: **Welfare evaluations in contingent valuation experiments with discrete response data: Comment**. American Journal of Agricultural Economics, November 1989, **71**, 4, 1054-1056.

16. Hanemann W M: **Welfare evaluations in contingent valuation experiments with discrete response data: Reply**. American Journal of Agricultural Economics, November 1989, **71**, 4, 1057-1061.

17. SIKA (Swedish Institute for Transport and Communications Analysis): **Samhällsekonomiska principer och kalkylvärden för transportsektorn: ASEK 4. SIKA PM 2008:3. (In Swedish)**. (Accessed 7 November 2008, at http://www.sika-institute.se/Doclib/2008/PM/pm_2008_3.pdf).

18. HEATCO: **Proposal for harmonised guidelines. HEATCO Deliverable 5, Second revision, February 2006, IER, Germany**. (Accessed 7 November 2008, at http://heatco.ier.uni-stuttgart.de/).

19. Viscusi W.K: **The heterogeneity of the value of statistical life: Introduction and overview**. Journal of Risk and Uncertainty (2010) **40**:1-13.

20. Aldy J.E., Viscusi, W.K: **Age differences in the value of statistical life: revealed preference evidence**. Review of Environmental Economics and Policy, 2007, **1**(2), 241-260.

21. Krupnick A: **Mortality-risk valuation and age: stated preference evidence**. Review of Environmental Economics and Policy, 2007, **1**(2), 261-282.

22. Evans M.F., Smith V.K: **Do we really understand the age-VSL relationship**? Resource and Energy Economics, 2006, **28**, 242-261.

23. Slovic P: **The perception of risk**. Science, **236**, No. 4799: 280-285.

24. Johannesson M, Johansson P-O, Löfgren K-G: **On the value of changes in life expectancy: blips versus parametric changes**. Journal of Risk and Uncertainty, 1997, **15**, 221-239.

Tables

Table 1. Sample statistics

Variable	*Definition*	*Mean (std.dev.)*	*Min*	*Max*	*N*
Female	Gender=female	0.50 (0.50)	0	1	333
Age	Age of the respondent	48.3 (15.3)	17	75	333
High education	Education level is at least one term at a university	0.44 (0.50)	0	1	331
Low education	Education level is at most nine-year compulsory school	0.18 (0.39)	0	1	331
High risk	Own perceived risk of cardiac arrest is higher than average	0.16 (0.36)	0	1	333
Low risk	Own perceived risk of cardiac arrest is lower than average; zero otherwise	0.41 (0.49)	0	1	333
Income	The income (SEK) per consumption unit given by the total household income* divided by the number of household members weighted as follows: adult person # 1 = 1.16, adult person # 2 = 0.76, children 0-3 years old = 0.56, children 4-10 years old = 0.66, children 11-17 years old = 0.76	19 223 (10 992)	1220	68966	327
Population	Number of inhabitants (self assessed by respondents) in the municipality	147 676 (227 607)	3000	1000000	314
Heart	The respondent has suffered from heart disease	0.11 (0.31)	0	1	333

** The respondents were asked to mark an interval with a range of SEK 4999.The income was then approximated by using the mid value of the interval.*

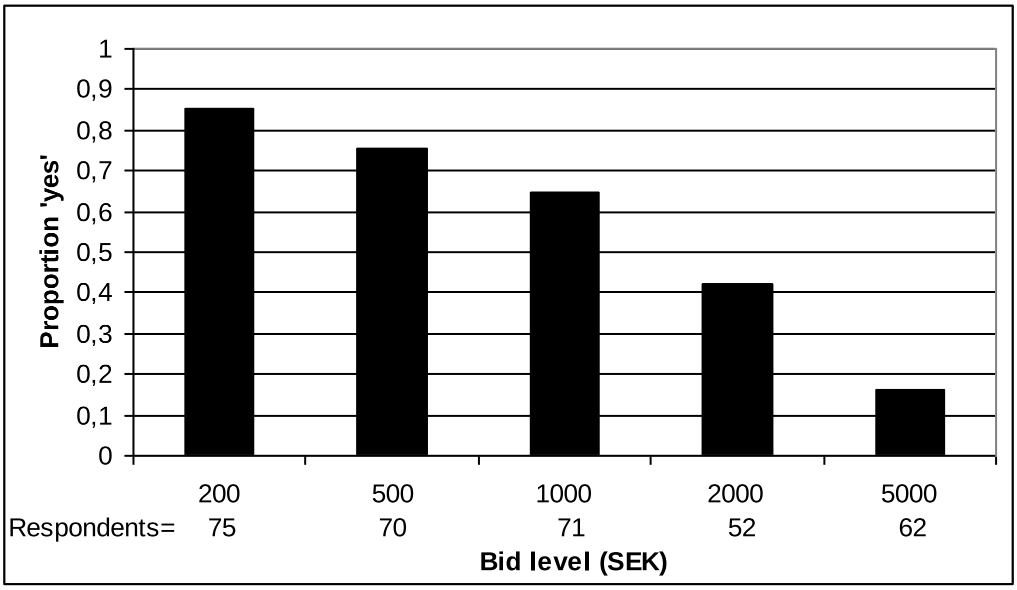
Table 2. Mean and median VSL (million SEK) for various distributional assumptions.

	Mean VSL	*95 percent CI*	*Median VSL*	*95 percent CI*	*Log-likelihood*
Non-parametric models					
Kaplan-Meier-Turnbull	49	39-58	30	0-149	-
Spearman-Karber	65	61-70	49	2-149	-
Parametric models					
Probit	65	53-78	65	53-78	-181.67
Logit	63	51-78	63	51-78	-181.58
Logit positive	73	58-89	73	58-89	-181.58
Lognormal	144	84-354	41	33-53	-180.58
Mixed spike and lognormal	126	74-321	36	29-48	-180.58

Notes: *Specifications of the distributions are included in the Appendix*

Figures

Figure 1. Proportions of yes-responses by bid amount



Appendix

A1. The valuation scenario and WTP questions for the contingent valuation survey

A number of individuals suffer from cardiac arrests each year in your municipality. Imagine that there exists a possibility to **reduce mortality risks** for cardiac arrests. We will ask you about your willingness to pay for such measures. Remember that the money you are willing to pay for security improvements reduces your possibilities for other consumption.

To reduce the mortality risk a public programme to increase the density of defibrillators is considered. One possibility is to equip and educate employees within certain professions in the municipality which may respond faster than the ambulance. These professions might be firemen, policemen, security guards or nurses. Public access defibrillators may also be located in hotels, shopping malls, sports centres or theatres.

A prerequisite for the programme to be implemented is that at least 50 % of the individuals in your municipality are positive to the introduction of the programme. The cost is paid as an annual fee. If the individuals will not contribute enough with the fee, the programme will not be imposed.

What is the effect of the programme?

The programme will result in **your own risk as well as the risk of all other individuals** in your municipality being reduced, and **the survival rate will increase from 5 % to 10 % on average**. In the table the effect of the programme for various municipality sizes are presented.

Observe that the table represents effects over 10 years!

Inhabitants	*Number of out-of-hospital cardiac arrests over 10 years*	*Number of survivors over 10 years (before), 5 %*	*Number of survivors over 10 years (after), 10 %*	*Difference*
10 000	*70*	*3*	*7*	***+4***
20 000	*130*	*6*	*13*	***+7***
30 000	*200*	*10*	*20*	***+10***
50 000	*330*	*16*	*33*	***+17***
75 000	*500*	*25*	*50*	***+25***
100 000	*670*	*33*	*67*	***+34***
150 000	*1000*	*50*	*100*	***+50***
250 000	*1670*	*83*	*167*	***+84***
500 000	*3350*	*167*	*335*	***+168***
750 000	*5020*	*251*	*502*	***+251***

Example from the table: In a municipality of 10 000 individuals, 70 persons will suffer from out-of-hospital cardiac arrest during a 10 year period on average. Now 3 persons will survive and after the programme 7 persons will survive, which implies an increase of 4 persons over 10 years.

Question 10. How would you vote if your personal fee was SEK 200 **per year** (i.e total SEK 2000 for 10 years), for this programme to be implemented in your municipality?

I would vote: □ Yes □ No

Question 12. Provided that the programme is carried out, how much would you at most be willing to pay **annually** for the implementation of the programme, that reduces your own risk as well as the risk of all other individuals in your municipality for a cardiac arrest mortality?

Answer: ……………SEK per year

Note: The survey was divided into two sub-samples that use two different aids to communicate the risk reduction. We present the valuation scenario of the 'flexible community analogy', but also used an array of dots. There was no difference in WTP between the samples.

A2. Specification of the estimation method

Kaplan-Meier-Turnbull

$$Mean\ WTP = E_{KMT}(WTP) = \sum_{k=1}^{K} t_k\left(P_k - P_{k+1}\right),$$

where K is the number of bids, t_k is the bid level, P_k is the observed share of yes-responses at bid level t_k and

$$Var\left(E_{KMT}\right) = \sum_{k=1}^{K} \frac{P_k\left(1-P_k\right)}{N_k}\left(t_k - t_{k-1}\right)^2 .$$

N_k is the sample size at bid level t_k, t_0=0, P_0=1 and P_{k+1}=0.

Spearman-Karber

$$Mean\ WTP = E_{SK}(WTP) = \sum_{k=0}^{K} \frac{\left(t_k + t_{k+1}\right)\left(P_k - P_{k+1}\right)}{2},$$

where t_{k+1} is the upper interval (=SEK 5000 in our case) and

$$Var\left(E_{KMT}\right) = \sum_{k=2}^{K-1} \frac{P_k\left(1-P_k\right)}{4\left(N_k - 1\right)}\left(t_k - t_{k-1}\right)^2 .$$

Probit and Logit

For both probit and logistic distributions the linear constant only WTP function for individual k is:

$$WTP_k = \beta_{constant} + \varepsilon_k$$

where:

$\varepsilon_k \sim N(0, \sigma^2)$ probit

$\varepsilon_k \sim N(0, \pi^3 \tau^2 / 3)$ logit

The probability of accepting a certain bid (t_k) for normal and logistic distributions is then:

$$P[Yes] = 1 - \Phi\left(\frac{t_k - \beta_{constant}}{\sigma}\right) = 1 - \Phi(\lambda t_k - \beta^*) \qquad \lambda = 1/\sigma,\ \beta^* = \beta_{constant}/\sigma\ ,$$

and:

$$P[Yes] = 1 - \Lambda\left(\frac{t_k - \beta_{constant}}{\tau}\right) = 1 - \Lambda(\lambda t_k - \beta^*) \qquad \lambda = 1/\tau,\ \beta^* = \beta_{constant}/\tau\ ,$$

where Φ and Λ are the standard normal and standard logistic cdf respectively. Both distributions are symmetric and therefore mean WTP is equal to median WTP. For a constant only bid function:

$$Mean\ WTP_1 = Median\ WTP_1 = -\frac{\beta_{constant}}{\beta_{bid}}$$

Logit positive

The second calculation method for logistic distribution allows for negative values as well, but when calculating mean WTP the WTP is set equal to zero for the proportion of the distribution with predicted negative WTP [24]:

$$Mean\ WTP_2 = Median\ WTP_2 = -\frac{1}{\beta_{bid}} \ln[1 + \exp(\beta_{constant})].$$

Lognormal

The lognormal model restricts WTP to be non-negative by using an exponential constant only WTP function:

$$WTP_k = \exp(\beta_{constant} + \varepsilon_k) \qquad \varepsilon \sim N(0, \sigma^2)\ ,$$

The probability of accepting a certain bid (t_k) is then:

$$P[Yes] = 1 - \Phi\left(\frac{\ln t_k - \beta_{constant}}{\sigma}\right) = 1 - \Phi(\lambda \ln t_k - \beta^*) \qquad \lambda = 1/\sigma,\ \beta^* = \beta/\sigma$$

and:

$$Mean\ \ WTP = \exp\left(0.5 \times \left(\frac{1}{\beta_{\log bid}}\right)^2 - \frac{\beta_{constant}}{\beta_{\log bid}}\right)$$

$$Median\ WTP\ = \exp\left(-\frac{\beta_{constant}}{\beta_{\log bid}}\right).$$

Mixed spike and lognormal

Correction for the lognormal models exclusion of zero WTP can easily be done by multiplying mean and median WTP by the probability (1-ρ) that the individuals will have a positive WTP. In our case ρ is equal to 0.11 (Section 2.1).