Road Safety and Willingness to Pay

Henrik Andersson

Toulouse School of Economics

March 8, 2018

Outline

- Background
- Valuation of safety
- The value of a statistical life (VSL)
- Elicitation of VSL (and VSI)
- The value of a statistical injury (VSI)
- VSL and VSI in transport policies
- Discussion

Background

- W/o market failures no need for intervention - individuals' decision would maximize social welfare
  - Obvious market failure for transportation health risks:
    - Non-informed individuals
    - Safety a "public good"
    - Externalitities
- Benefit cost analysis (BCA) a strong tool to guide resource allocation (legislation, investments, etc.)
- Common metric for benefits and costs ? monetary values
  - Monetary values should reflect individual preferences!
  - Many benefits and costs do not have easily available prices $\Rightarrow$ non-market evaluation techniques?
- Time savings and reducing health risks usually the dominating benefits of transport policies/projects, two goods without any easily observable market prices

Valuation of safety

- No easily available market prices for safety $\Rightarrow$ non-market evaluation techniques need to be used to estimate benefit measures
  - Stated preferences: Hypothetical market is created in which respondents are asked to state their preferences
    - Contingent valuation, Discrete choice experiments, etc.
    - Flexible
    - Framing effects, strategic and hypothetical bias, etc.
  - Revealed preferences: Observed market decisions are used to elicit individual preferences
    - Hedonic pricing, Travel cost method, etc.
    - Actual decisions
    - Assumes that analyst is informed about individuals' decision alternatives

Valuation of safety – Empirical findings

- Rich literature using both RP and SP studies to elicit the marginal willingness to pay (WTP) to reduce health risks
  - Mortality risk: Value of a statistical life (VSL)
  - Morbidity risk: Value of a statistical illness (VSI)

- Evidence suggests that respondents have difficulties understanding small probabilities $\Rightarrow$ risk valuation difficult
  - Scope insensitivity a common problem in SP studies
  - Near-proportionality of the WTP usually rejected

- Most empirical estimates of the VSL fall within the range USD 2 to 14 million (2013 price level; Robinson and Hammitt, RA, 2015)
  - VSL for road risk in Sweden: USD 1 to 11 million (2010 price level; Hultkrantz and Svensson, HP, 2012)

Brief introduction to Value of a statistical life (VSL)

Let V denote state-dependent expected utility,

$$V \equiv pu(w) + (1-p)v(w)$$

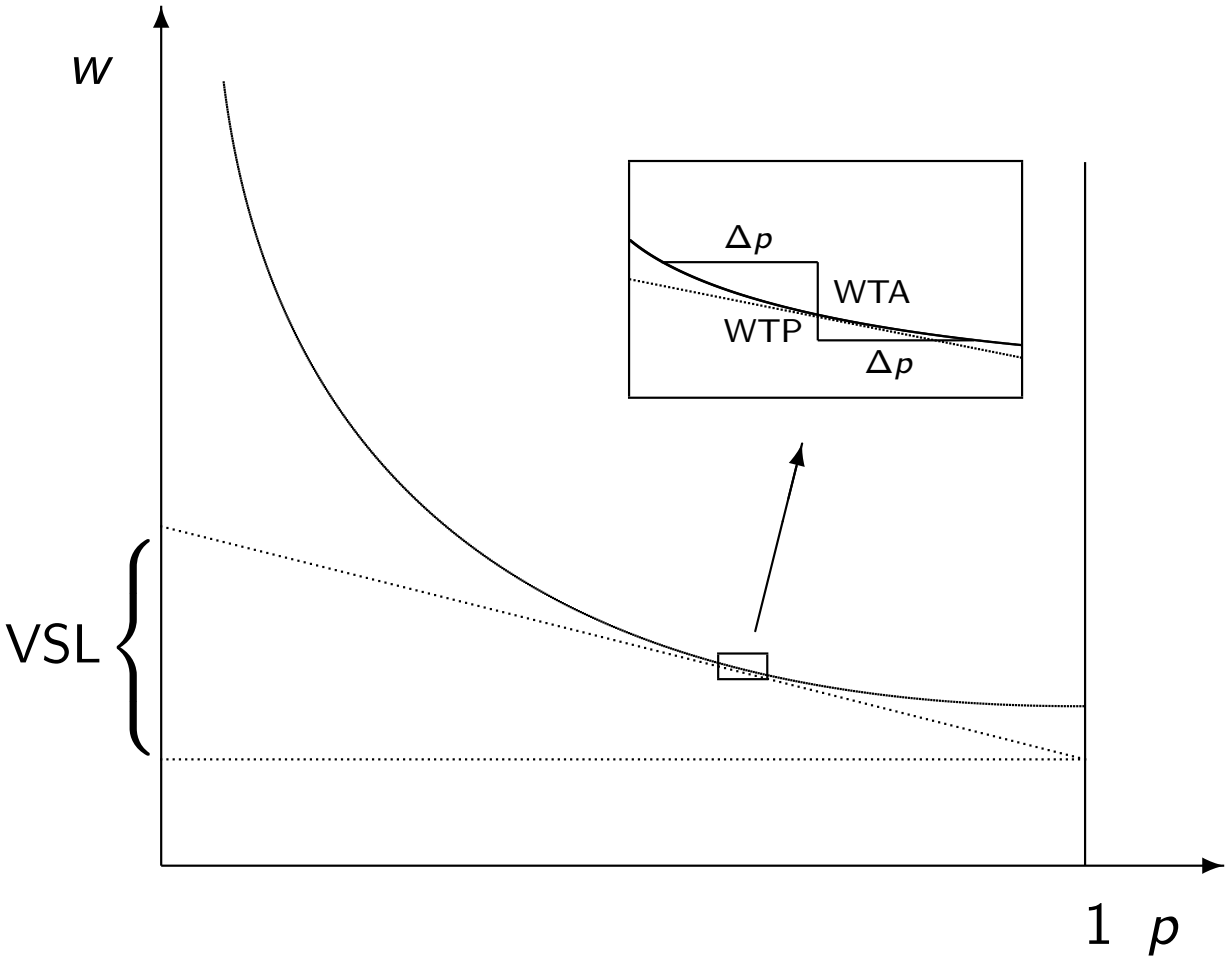
where p is the probability of survival, $u(w)$ and $v(w)$ is the utility of wealth if he survives and dies, respectively. u and v are twice differentiable with standard assumptions

$$u > v,\ u' > v' \geq 0,\ u'' \leq 0 \text{ and } v'' \leq 0.$$

The MRS(w, p) is given by differentiating V keeping utility constant,

$$\text{VSL} \equiv \frac{-dw}{dp} = \frac{u(w) - v(w)}{pu'(w) + (1-p)v'(w)}$$

Brief introduction to Value of a statistical life (VSL)



Intuitive description of the value of a statistical life (VSL)

"To understand the VSL concept, it may be useful to take an example. Suppose that in a city composed of 100,000 identical individuals, there is an investment project that will make the city's roads safer. It is known that on average five individuals die every year on these roads, and the project is expected to reduce from five to two the number of expected fatalities per year. Suppose now that each member of the city is willing to pay \$150 annually to benefit from this reduction in mortality risk induced by the project. Then the corresponding VSL would be $\$150 \times 100,000/3 =$ *\$5 million. Indeed, \$15 million could be collected in this city to save three statistical lives, and so the value of a statistical life could be established at \$5 million." (Andersson and Treich, 2011)*

Monetized preferences to reduce mortality risk

Table 1: Empirical estimates of the value of a statistical life in road traffic, in US$ 2005 ($\times$1000)

Authors	Country	Year of data, Study type	No. of estimates[b]	Range of VSL estimates		
				Single	Lowest	Highest
Andersson (2005a)	Sweden	1998, RP	1	1,425		
Andersson (2007)	Sweden	1998, SP	8		3,017	15,297
Atkinson and Halvorsen (1990)	US	1986, RP	1	5,521		
Beattie et al. (1998)	UK	1996, SP	4		1,510	17,060
Bhattacharya et al. (2007)	India	2005, SP	1	150		
Blomquist (1979)	US	1972, RP	1	1,832		
Blomquist et al. (1996)	US	1991, RP	4		1,434	7,170
Carthy et al. (1999)	UK	1997, SP	4		4,528	5,893
Corso et al. (2001)	US	1999, SP	2		3,517	4,690
Desaigues and Rabl (1995)	France	1994, SP	6		1,031	23,984
Dreyfus and Viscusi (1995)	US	1987, RP	1	4,935		
Ghosh et al. (1975)	UK	1973, RP	1	1,901		
Hakes and Viscusi (2007)	US	1998, SP	5		2,396	6,404
	US	1998, RP	6		2,288	10,016
Hojman et al. (2005)	Chile	2005[c], SP	1	541		
Hultkrantz et al. (2006)	Sweden	2004, SP	2		2,192	5,781
Iragüen and Ortúzar (2004)	Chile	2002, SP	1	261		
Jara-Diaz et al. (2000)	Chile	1999, SP	1	4,555		
Jenkins et al. (2001)	US	1997, RP	9		1,350	4,867
Johannesson et al. (1996)	Sweden	1995, SP	4		5,798	6,981
Jones-Lee et al. (1985)	UK	1982, SP	1	4,981		
Kidholm (1995)	Denmark	1993, SP	3		898	1,338
Lanoie et al. (1995)	Canada	1986, SP	2		1,989	3,558
Maier et al. (1989)	Australia	1989[c], SP	6		1,853	5,114
McDaniels (1992)	US	1986, SP	3		10,131	36,418
Melinek (1974)	UK	1974[c], RP	1	881		
Persson et al. (2001)	Sweden	1998, SP	1	2,551		
Rizzi and Ortúzar (2003)	Chile	2000, SP	1	486		
Schwab Christe (1995)	Switzerland	1993, SP	1	1,094		
Vassanad. and Matsuoka (2005)	Thailand	2003, SP	2		3,208	5,458
Viscusi et al. (1990)	US	1991[c], SP	1	11,091		
Winston and Mannering (1984)	US	1980, RP	1	2,315		

Source: Andersson and Treich (2011)

Example elicitation of VSL – Hedonic pricing

- Andersson (JRU, 2005)
- Data: Swedish car market (RP)
- Objective: Derive price premium of safer cars $\Rightarrow$ monetary value of safety, e.g. VSL
- Method: Multivariate regression analysis:

$$P = P(S, \mathbf{A})$$

- Let S be fatality risk,

$$VSL = \frac{\partial P}{\partial S}$$

- Semi-log function, $\ln P = \alpha + \beta S + \sum_k \gamma_k a_k + \varepsilon \Rightarrow$

$$VSL = \beta \bar{P}$$

Example elicitation of VSL – Hedonic pricing

Table 6. Atemporal model: Dependent variable, natural logarithm of user costs.

	Equation A1		Equation A2	
Variable	Coeff.	(Std. err.)	Coeff.	(Std. err.)
Fatal	−252.150**	(96.433)	−255.768**	(95.388)
Non-fatal	−1.410	(4.412)	–	–
Acceleration	4.039**	(0.337)	4.045**	(0.335)
Compartment	1.506**	(0.210)	1.505**	(0.210)
Cargo	0.045	(0.051)	0.047	(0.050)
Styling	1.791‡	(0.124)	1.797‡	(0.122)
Reliability	0.034**	(0.012)	0.034**	(0.012)
Station wagon	0.069**	(0.015)	0.069**	(0.015)
Germany	0.043‡	(0.012)	0.043‡	(0.012)
France	0.197‡	(0.020)	0.197‡	(0.020)
US	0.092‡	(0.012)	0.091‡	(0.012)
Year88	0.103**	(0.023)	0.103**	(0.023)

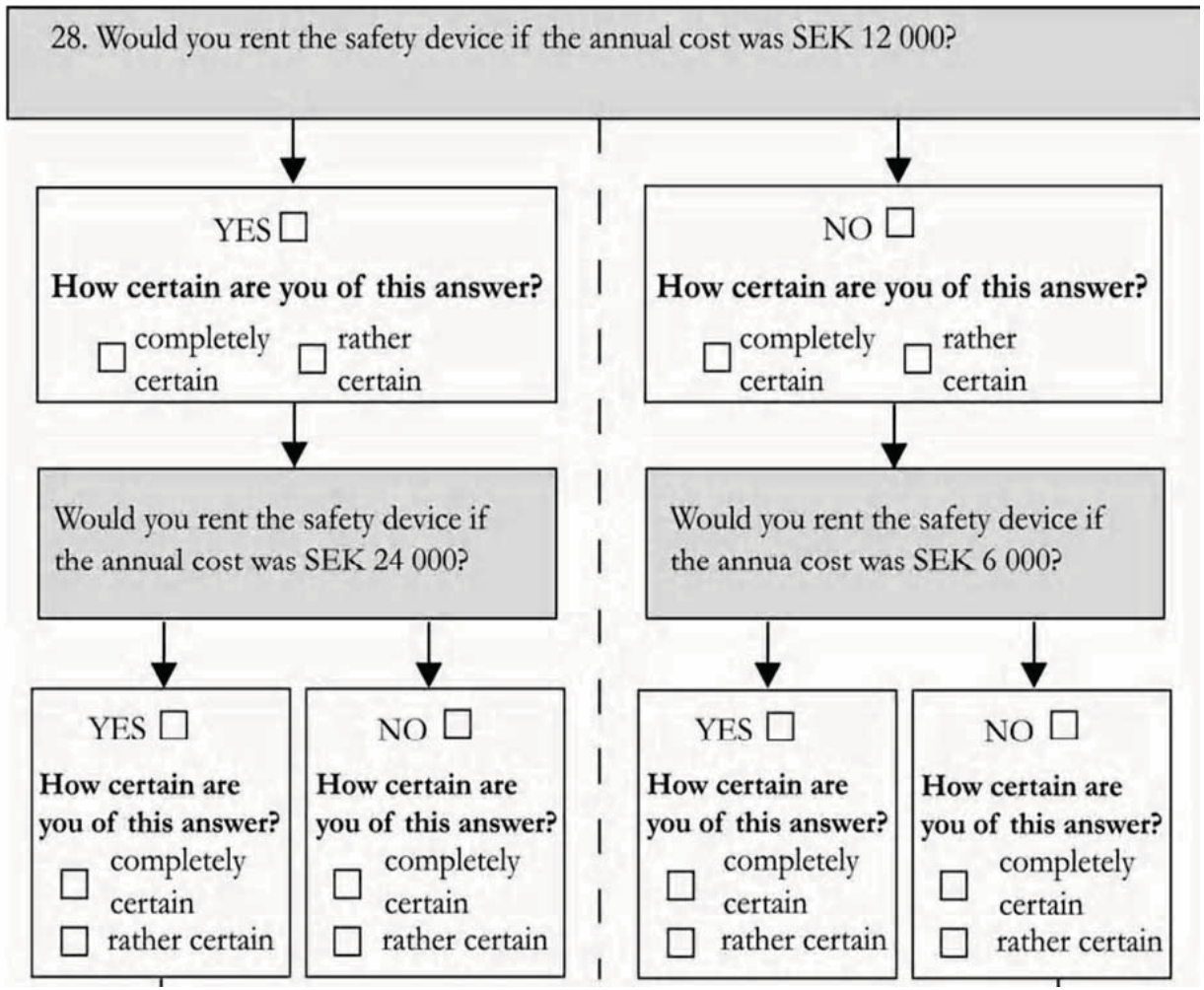
Example elicitation of VSL – CVM

- Andersson et al. (ERE, 2013)
- Data: Survey data (SP)
- Objective: Elicit WTP for road safety in a CVM study
  - Research questions – "time framing"
- In a CVM respondents are asked a "simple" direct question:
  - "What is your maximum WTP?"
  - "Would you be willing to pay EUR x for...?"
- In our study we used the second type of question, which is the preferred one in the literature.
  - Produces interval data $\Rightarrow$ probabilistic models used to analyze data (e.g. logit and probit)
- Since answers hypothetical, validity tests very important

CVM: Binary choices

Single bound →

Double bound →



Example elicitation of VSL – DCE

- DCE can be seen as an extension of the CVM approach
- Multi-attribute setting
  - CVM: Money + one attribute
- Repeated questions $\rightarrow$ more observations
- DCE extracts more information from the same number of respondents
- More realistic but also more demanding?
- New Swedish project with the aim to (among other things) elicit WTP for safety for different transport modes
  - Transport mode will be included as one attribute in the DCE to examine if preferences vary between road, rail, air and sea traffic (everything else equal)

Example elicitation of VSL – DCE

Everything else equal, would you choose travel alternative A or travel alternative B?

Alternative A	Alternative B	
Average travel time per trip: *15* min (approximately *130* hours per year)	Average travel time per trip: *17* min (approximately 147 hours per year)	
Cost per trip: *30* NOK (approximately *15,600* NOK per year)	Cost per trip: *34,50* NOK (approximately *17,940* NOK per year)	do not know
Seriously/severely injured and fatalities per year: *3*	Seriously/severely injured and fatalities per year: *1*	

Flügel et al., 2015, 'Asymmetric preferences for road safety: Evidence from a stated choice experiment among car drivers', Transportation Research Part F, 31, 112-123

The value of a statistical injury

- By replacing the fatality risk by injury risk and the utility conditional on survival and death by non-injured and injured, the VSL concept above can be used for the VSI concept
- Whereas there is a very rich empirical VSL literature, VSI has been less studied
  - VSL is relatively straightforward since there is only one health endpoint (death)
- In addition to the (in theory) infinite number of health endpoints for non-fatal risks
  - Difficult to find data for RP studies
  - Difficult to elicit valid and reliable estimates in SP studies

Elicitation of VSI – Monetary

- The most suitable approach to elicit VSI seems to be SP approach
  - The analyst can precisely describe the health outcomes and controls the choice alternatives
  - Since scenario is hypothetical willingness to pay (WTP) for any health endpoint can be estimated
- Among the SP methods, discrete choice experiments (DCE) seem most suited
  - In DCE respondents choose between different alternatives described by the levels of the attributes of the alternatives.
  - Several injury severity-levels can be used as attributes which enables the analyst to estimate both the marginal WTP and the relative valuation of the different attributes
  - However, demanding for respondents and concerns that they cannot process all attributes accurately at the same time (Note: When using RP data we assume that they can.)
- How many studies need to be conducted to have valid and reliable WTP estimates for a sufficient number of health outcomes?

Elicitation of VSI – Non-monetary

- A different approach is to establish the relationship the between fatality and different levels of severity and then to monetize these levels
- Often this relationship is defined by the utility based measure labeled Quality Adjusted Life Years (QALYs)
  - QALYs $= \sum_{i=1}^{M} q_i T_i$
    where M, q_i, and T_i is the periods indexed by i, measure of "health-related quality of life" (HRQL), $q \in [0, 1]$, and the duration of period i, respectively
- An advantage with the QALYs compared to the WTP approach is that there already exists many health profiles (benefit transfers)
- However, also QALYs depends on individual preferences (q above) being elicited in SP studies, and they rest on strong assumptions that have often been rejected in empirical work

WTP and altruism

- As described, eliciting WTP for "safety" has proven to be difficult (e.g. due to difficulties among the public to understand small probability changes)
- An issue of interest when eliciting preferences for road safety is altruism
- In many cases values will be used for projects/policies where safety can be considered as a *public good*
- Empirical evidence suggests that WTP_{Public} can be different from $WTP_{Private}$, hence the definition of policy relevance
- Empirical evidence suggests individuals altruism is safety/health focused
- Based on theory and the empirical evidence regarding altruism it can be shown that $WTP_{Public} \geq WTP_{Private}$ (Andersson et al, WiP, 2018)
- Empirical evidence suggest, though, the opposite – Important research question

VSL and VSI in transport policies – France

- Source: Quinet (2013) (Price level = 2010)
- VSL = €3.0 million
  - Based on result from meta-analysis
- VSI(serious injury) = €450.000 (15% of VSL)
- VSI(minor injury) = €60.000 (2% of VSL)
- VSI based on Boiteux (2001)

VSL and VSI in transport policies – Sweden

	Value (SEK 2014)
Fatality	24,000,000
Severe injury	4,000,000
Minor injury	160,000

- Source: Trafikverket, ASEK 6.0 (2016)
- Severe injury based on the Bush's index. Given the classification of a severe injury the Bush's index has been set to 16.6% of VSL.
- Minor injury based on evidence from WTP a study in the early 1990s
- To be revised next month...

VSL and VSI in transport policies – US

MAIS level	Severity	Fraction of VSL	Unit value ($2016)
MAIS 1	Minor	0.003	$28,800
MAIS 2	Moderate	0.047	$451,200
MAIS 3	Serious	0.105	$1,008,000
MAIS 4	Severe	0.266	$2,553,600
MAIS 5	Critical	0.593	$5,692,800
MAIS 6	Death	1.000	$9,600,000

- Source: US DoT (2017)
- Each type of accidental injury is rated on a scale of QALYs, in comparison with the alternative of perfect health, and grouped according to the Maximum Abbreviated Injury Scale (MAIS).

Conclusions and thoughts for discussion

- Safety valuation of high policy relevance and a vast number of studies have been conducted eliciting VSL
- Much less attention has been given to eliciting preferences for non-fatal risks
- However, "getting the values right" also for non-fatal risks of very high policy relevance, and hence, the issue deserves more attention
- Direct estimation of WTP for morbidity risks is attractive, but is it a feasible road, or is it better to rely on approaches relatively well established in the health care sector like QALYs?