WORKING PAPER SERIES

WORKING PAPER NO 4, 2005

ESI

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by

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* Research assistance by Jill Billborn and Agneta Grummas, and helpful comments from Henrik Andersson, Tobias Heldt, Krister Hjalte, Lena Hiselius, Olof Johansson-Stenman, Lena Nerhagen, Jan-Eric Nilsson and Ulf Persson are acknowledged. The usual disclaimer applies.

ISSN 1403-0586

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Present version: 2005-03-09

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Abstract:

We report the results of a contingent valuation study of the value of a serious statistical accident (VSSA) in an urban road safety context in Sweden. To account for scale bias of responses (i.e., the insensitivity of the willingness-to-pay value to the size of the risk reduction being valued) we derive a lower-bound estimate. This is computed from the willingness to pay for a private-good device or a public safety program that completely eliminates the risk of fatal and serious injury road accidents. We search for values from respondents with self-reported high confidence in their answers. Our conservative estimates result in average benefits of public road-safety measures targeting serious accidents that are greater than previous studies have indicated.

Keywords: Value of statistical life, vision zero, contingent valuation, scale bias, scope bias

JEL Codes: H43, I18, Q51

1. Introduction

The value of statistical life (VSL) is of major importance to cost-benefit assessment of road infrastructure investments, road maintenance planning, and to traffic control decisions, such as limitation of speed. It seems however to be of a ghostly nature that escapes precise empirical measurement. A major problem blurring the image catched by various preference-revelation instruments is the so-called scale bias[1], i.e. that measures of willingness-to-pay (WTP) for road safety are unreasonably insensitive to the size of the risk reduction. When the WTP for a larger risk reduction is almost the same as for a smaller risk reduction, the VSL will be inversely proportional to the size of the risk reduction. Therefore the WTP per unit of risk reduction, which is the VSL, can be more or less arbitrarily set to any number within a wide range, i.e., it will be high for a small risk reduction and low for a large reduction. While similar problems have been encountered for other benefits as well, they seem to be more difficult to overcome for safety improvements that result in small size probability reductions (Carson et al. 2001). A related problem is the collinearity of risks of accidents with severe and less severe consequences, respectively. This makes it difficult to estimate separate values per risk unit of fatalities and non-fatal injuries both from revealed and stated preference data (Viscusi 2003).

Several other problems add to the obscurity of VSL estimates. The bulk of studies are based on stated-preference methods that generally are plagued by hypothetical bias, leading to exaggeration of WTP, as responses reflect attitude or intention ("yes, maybe"), rather than real commitment ("yes, sure"). Another source of upward bias is that enhanced safety often is framed as a private good (like a safety cushion), although the VSL

[1] In the literature often called scope bias.

estimates will be used to evaluate actions performed by the public sector (like road improvements).

There still is hope that better preference-elicitation methods will develop, although some researchers have suggested that the core problem is in cognitive constraints that cannot be circumvented by improved instruments.[2] In this paper, we report the results of a contingent valuation study in Sweden. Instead of targeting a central-value estimate of VSL, we attempt to find a lower-bound estimate of what we call the value of a serious statistical accident, VSSA. This is based on a conservative assessment of the WTP for a risk reduction eliminating fatal and serious-injury accidents[3]. In this way, we derive values within both private and public good contexts that are not vulnerable to scale bias. We use WTP values from respondents reporting high confidence in their answers, and divide these with the whole baseline risk of fatal and serious-injury accidents to get the lower-bound VSSA estimates. Based on the results corresponding to a public safety program, we conclude that an upward revision of the combined unit value of fatalities and serious injuries used in Swedish infrastructure planning is warranted.

2. Previous research

2.1 Road safety VSL

In a recent survey of studies of the value of statistical life in road safety, de Blaeij et al. (2003) perform a meta-analysis of 85 reported point estimates from studies published from 1973 to 2001. They find significant effects on the point estimates of the choice of preference revelation method, private vs. public good framing, payment vehicle, risk elicitation method,

[2] "It is naive to expect broad psychological laws to be overcome by minor methodological adjustments" (Kahneman 1999, p. 217).

and type of safety enhancing measure. For the purposes of the present paper, it can be observed that VSL values are, other things equal, on average 60 per cent higher in stated-preference (SP) compared to revealed-preference (RP) studies (74 estimates were based on SP studies, 11 on RP data), suggesting a hypothetical bias of the SP methods. Private-good VSL estimates are on average 85 percent higher than public-good estimates. For a subset of 54 estimates from studies in which the initial risk level is specificed, the authors find a significant negative relation between VSL and the risk reduction, which is conform to economic theory. This review does not, however, address the scope and scale bias problems.

As a background for the present study we will next discuss some results in the previous literature related to the problems of scope and scale bias, hypothetical bias, and the disparity between WTP for private and public goods. We will also briefly present results from recent Swedish studies that can be used as reference for the results held in our own work.

2.2 Scope and scale bias

Kahneman and Knetsch (1992) observed a general problem with contingent valuations studies which they called embedding effects; i.e., "the tendency of many CV respondents to report much the same willingness to pay for a comprehensive bundle of safety or environmental 'goods' as for a proper subset of that bundle". Subsequent research has made a distinction between "embedding" and "scope", where the former term refers to changes to two or more arguments within a multivariate utility function while the latter term denotes a change in just one argument (see Bateman et al. 2002, p. 321). Recently Carson et al. (2001) have reexamined the evidence concerning the alleged insensitivity to scope. They conclude that "poorly executed survey design and administration procedures appear to be a primary cause of problems in studies not exhibiting sensitivity to scope". There is an exception though: "one

[3] The Swedish statistics use the UN/ECE definitions of killings and severe injuries in road traffic accidents. Deaths suspected to be caused by illness or suicide is excluded.

key area of concern with respect to scope sensitivity and the use of CV and that is in valuing changes in small probabilities of health risk". "The inherent problem here is that people are known to have substantial difficulties understanding and dealing with low-level risks. As such, the risk communication problem must be solved first before the CV exercise can have a chance of working".

Scope bias is sometimes called scale bias, while some researchers distinguish between these two concepts. In the present paper we define scale bias in relation to road traffic accidents as insensivity of the WTP for a risk reduction with respect to the the magnitude of the change (eg. whether a $2 \cdot 10^{-5}$ probability of a fatal accident is reduced by 25 or 75 percent); and scope bias as insensitivity to the consequences of the accidents that the risk reduction relates to.[4] According to economic theory the WTP for a safety-enhancing measure that results in a small reduction of fatal accidents should be close to proportional to the size of the risk reduction (Hammit and Graham 1999). Several CV studies that included explicit tests for scale bias in stated-preference VSL studies indicate that the results are suffering from extensive and persistent insensivity to the size of safety improvements (for example Beattie et al. (1998), Hammit and Graham (1999), and Norinder et al. (2001)).

There are some lights of hope, though. Corso et al. (2001) found that different kinds of visual aids for the communication of risks indeed can be used to reduce scale bias. However, as these authors observe, similar techniques (like marked dots or squares to visualize small probabilities) have been used in several of the previous studies reporting severe scale bias (for instance, Beattie et al. (2001) and Norinder et al. (2001)), but maybe this is a case where the devil is in the detail.

More evidence that scale bias can be mastered is provided by Alberini et al. (2004) studying VSL for mortality risk reductions in a public-health policy context with two contingent valuation surveys in the U.S. and Canada. In these surveys, respondents were trained in trading income for reduced risk by acquainting them to risk-reduction and cost assessment of a range of medical tests and products. Also, several types of visual aids were used to present the size of the risk reductions the respondents were asked to consider. The researchers then compared responses from two samples with different risk-change magnitudes; i.e., mortality-risk reductions of 1 in 1000 and 5 in 1000. Both groups were asked about both the large and small risk reductions. The first group was however first asked about the large reduction while the other group was first asked about the small reduction. The comparison concerns the between-sample difference in the answers to the questions posed first. The researchers found that for respondents that express high confidence in their own answers, the median WTP value does indeed increase in proportion to the size of the risk reduction. The authors warn though that the confidence intervals are large around the point estimates of the ratio between the WTP values for the two different risk reductions.[5]

2.3 Hypothetical bias

The hypothetical bias of stated preference studies has been investigated in numerous studies. Both field studies and laboratorial experiments have demonstrated that hypothetical WTP values often substantially exceed the actual WTP values. This tendency can arise for several reasons. First, the respondents in a hypothetical situation may not fully consider their budget

[4] These definitions are congruent to the use of the terms “scale” and “scope in production theory, for instance in “economies of scope and scale”. Norinder et al. (2001) make a similar distinction.

[5] Also, it should be observed that the risk-reduction changes are much larger than the magnitudes used in traffic-safety studies in highly developed countries. For instance, the baseline risk of a fatal traffic accident in Sweden is substantially less than 1 in 10 000. If the underlying problem is the cognitive limits of the human brain in understanding differences in very small probabilities, the challenges to valuation posed in the traffic accident

constraints. Second, the respondents can be uncertain about their true valuation. Results reported by List and Gallet (2001) indicate that when the good to be valued is more "familiar" to the consumer, which should imply better knowledge of the true preferences, the hypothetical bias is reduced. Li et al. (1996) found that when the preference uncertainty was taken into account in the econometric model, much of the discrepancy between the actual and hypothetical willingness to accept (WTA) could be eliminated. Likewise, Champ et al. (1997, 2001) and Poe et al. (2002) concluded that the level of real donations to public goods can be predicted from responses to CV studies with a self-reported high degree of confidence. Similar certainty correction approaches have been used with data from economic experiments (see for example Johannesson et al. 1999, Liljas and Blumenschein 2000, Nape et al. 2003).

As previously noted, Alberini et al. (2004) could not falsify the conjecture that WTP is proportional to the risk reduction when only the answers from respondents reporting a strong confidence in their answers were used. Hammit and Graham (1999) got similar results, while Corso et al. (2001) did not find any difference in sensitivity to magnitude of this group of respondents compared with the full samples. This evidence is therefore not clear, but it suggests that hypothetical bias and scale bias can have similar causes.

2.5 Public or private good framing

Several CV studies of safety or health risk measures have reported that the WTP is higher when the change is framed as a private good instead of a public good (Johannesson 1996, Lindberg 2003). A possible explanation is free riding related to public funding. There is a lot of evidence from economic experiments that average contributions in public-good games start below a full cooperation outcome, and then deteriorates over time when the game is repeated (Fehr and Fischbacher 2003). To tackle this problem, some authors have used a provision

context are much greater than those that sometimes arise in medical cases (cf. the risk of dying of a planned heart surgery).

point mechanism (PPM), i.e., "a minimum level of aggregated contribution under which the public good is not provided". Recent studies (Champ and Bishop 2001, Poe et al. 2002) indicate that a PPM design significantly reduces the problem of free riding.

The PPM resembles a Vickrey-Clarke-Groove truth revelation mechanism (Milgrom 2004), i.e. a respondent may feel that it is likely that the provision of the public good depends on her own contribution and therefore has an incentive to state her full WTP. However, another possibility is that the positive effects on average WTP-levels of a PPM reflect conditional-cooperation behaviour, i.e., that the individual WTP depends on the average contribution from other individuals (Fischbacker et al. 2001) . Moreover, there may be other reasons for the different WTP responses to the public and private good framings of safety improvements than free riding. For instance, respondents may perceive a publicly funded measure as an "impure public good" providing benefits that are more valuable to other citizens than to themselves; or they may be suspicious to the quality of services provided by public agencies.

Fischbacher et al. (2001) report that most individuals in a series of economic experiments testing conditional cooperation increased their contribution to a public good in response to an increase in the average contribution level of others. However, there were two minority groups; one consistently free riding, and another exhibiting a "hump-shaped" profile, first increasing and later decreasing contributions as the average level rose. Heldt (2005) provides field-experimental evidence for conditional cooperation in a public good context. He finds an inverted-U relationship for fixed-amount contributions to the public good with respect to beliefs about the share of other people that contribute, i.e. some people tend to free-ride if they believe that few others or most others will contribute, but less so for beliefs in between.

2.6 Reference studies

The research reported here was triggered by issues that emerged in a revision of the parameters of the CBA models used for appraisal of infrastructure investments in Sweden (SIKA 2002), based on a series of contingent valuations studies for assessing the values of enhanced road safety (Persson et al. 2001, Norinder et al. 2001, Persson 2004).

Table 1 collects some results from these studies. The last column shows the unit values of fatality, serious non-fatality, and slight non-fatality risks that were actually adopted by the Swedish authorities. They can be compared to the numbers in the column showing the unit values of risk reductions of fatal and non-fatal injuries suggested by the group of researchers (Persson 2004).

In a survey (Persson et al. 2001) assessing the VSL for fatal injuries, respondents were asked to consider the purchase of a private-good device giving risk reductions of four different magnitudes: 10, 30, 50 and 99 percent. To help respondents in understanding the size of the base risk and the proposed changes, a squared net was used. Also, the respondents were asked to report their own subjective risk perception.

Despite these efforts problems of scale bias remained (see Norinder et al. 2001). The WTP in a sub-sample of respondents asked about a 30 percent risk reduction of dying from any cause to be higher than corresponding values for subsamples considering 10 and 50 percent reductions, respectively. The estimated VSL increased remarkably when the group that valued the lowest risk reduction was excluded from sample. Alberini (2004) recently has extended the analysis of data from this study. She finds that the WTP values vary significantly with the relative size of the risk reduction, although less than proportionally, but not with the respondents own assessment of the baseline risk. The WTP elasticity with respect to the relative risk reduction is estimated to approximately 0.5.

Other studies made by this research team estimated the WTP for risk reductions corresponding to non-fatal casualities. The first three columns of Table 1 show within-sample and between-sample WTP values from three different surveys. The first and second columns show results from studies made in 1993 (Persson et al. 1995), surveying two groups of respondents that were asked different sets of open-ended WTP questions on risk reductions for different kind of injuries. The third column show estimates from surveys performed during 1998. The 1998 WTP values are independent-sample estimates for 30 percent risk reductions, while the 1993 values are dependent sample estimates for 50 percent risk reductions from specified base risk levels. These three studies consistently find larger WTP values for measures that reduce permanently disabling injuries than for measures that reduce fatalities, while WTP values are lower for reductions of the risk of a slight or serious temporary injury. Based on these and other results, Norinder et al. (2001) conclude that respondents confronted with two different risk reduction questions seem to be able to differentiate the valuation according to scope.[6]

[6] In estimates within the same sample, the WTP values of a 30 percent reduction of the risk of traffic death and the risk of death from all causes were found to be SEK 1549 and SEK 1747, respectively. The own perceived baseline risk of the former (the part) was estimated to 30 procent of the latter (the whole).

Table 1. Willingness to pay (annual payment per person in SEK) and the value of statistical life/unit value of risk reduction (million SEK per casuality) in the 1993 and 1998 studies (Persson et al. 1995 and Norinder et al. 2001). All results in SEK at the time of each study.

(Risk reduction)	*WTP 1993A* (-50%)	*WTP 1993B* (-50%)	*WTP 1998* (-30%)	*Unit value 1998* (-30%)	*Adopted CBA values (2001 price level)*
Death	1268	1448	2054	21.8	16.3
Serious, perm. disabling	1459	1821	2080	8.8	3.1
Serious, temp. disabling	962	1764	1388*	2.9	3.1
Slight injury		907		0.4	0.2

* One-year disabled

The two final columns of Table 1 show the unit values computed by the research team and those actually adopted by the traffic authorities for use in the CBA models. The VSL for fatal accidents was estimated to 21.8 MSEK. Unlike the ordering of WTP values, the unit values are descending with the degree of severity of injuries. The value per unit of risk reduction of a serious disabling injury is around 40 percent of the corresponding value of a fatal casuality, and so on. The values of the CBA models have a similar pattern, but calibrated at a lower level.[7]

However, the unit values are constructs distorted by scale bias. The WTP values taken at face suggest that respondents' attitudes do not make any strong distinction between serious injuries and fatalities. The reason for the low unit values of non-fatal accidents relative to fatalities is thus that the base-line risks are larger than for fatalities. However, according to Alberini (2004) the respondents to this study have not taken the baseline risk into account. Given this observation, there seems to be no clear evidence that the per unit value of a reduction of serious injuries (a mixture of temporary and permanent disabling injuries) should

[7] The final decision was to use a nominally deflated update of the previously used VSL for fatalities, and unit values for serious (average type) and slight injuries in the same proportions as the estimated unit values.

be substanitally differentiated from the unit value of fatalities. Notice that in the 1993B sample where respondents could evaluate all four categories of injuries, reductions of both permanently and temporarily disabling serious injuries were valued higher than reductions of accidents with fatal outcomes.

Lindberg (2003) used a different approach to valuation of road safety in a contingent-valuation study. He links the valuation to the so-called "Vision Zero", which is a long-term road-safety objective adopted by the Swedish Parliament in 1997. The idea of this concept is that roads and vehicles should be designed so as to prevent accidents from happening and, when they do happen, protect the road users from fatalities and serious injuries. Examples of road and vehicle systems that accord to this vision by forgiving mistakes by the human beings using the roads are crash cushions, cable-guard rails, intersection roundabouts (instead of traffic lights), and speed limits. The Swedish government issued an 11-point programme by in 1999 and numerous local and regional programmes have followed.

The "Vision Zero" makes a crucial distinction between accidents that inflict major and minor force on victims, giving priority to the reduction of the former type. Stepwise national targets are set by the Parliament for the reductions of the number of fatalities and serious injuries, but not for other casualities.

Lindberg´s study follows this distinction, valuing a local "Vision Zero" program in a medium-size city (Örebro). The valuation questions are thus related to reductions of the total number of fatalities and serious injuries in the city. Although the focus of this study is on non-selfish preferences for road traffic safety, comparable results were held for pure selfish preferences. Five different safety products were used as valuation vehicles; providing private safety, children's safety, household safety, safety for relatives and friends, and public safety. All of the safety measures were described as totally reducing the risk of fatal and severe non-fatal road traffic accidents. The first four safety products were unspecified safety devices while the public safety measure had the nature of a public program in accordance with the "Vision Zero" program. The unit value estimates (treating fatal and serious non-fatal injuries equal, price level of 1998) were 36.6 MSEK for children's safety, 14.4 MSEK for household safety, 26.2 MSEK for private safety, 15.1 MSEK for the safety of relatives and friends and finally 13.0 MSEK for the public good.

The private safety values held with these different approaches coincide at 26 MSEK (Lindberg 2003) and 21.8 MSEK (Persson 2004). However, besides that both values are obscured by scale bias, the difference in scope is important as the number of serious fatalities in road traffic in Sweden is about seven times as large as the number of persons killed. Also to be noted is that Lindberg finds a considerably lower VSL for public safety measures. In neither of these studies were respondents asked to report their own confidence in the answers used for estimating the WTP.

3. The Örebro 2004 study

3.1 General

To resolve some of the issues raised by the results of the studies reviewed in the previous section, we conducted a study that to a considerable extent resembles the study by Lindberg (2003). In the spring of 2004, we inquired residents of the urban area in the city of Örebro, 200 kilometers west of Stockholm. The population of the urban areas of Örebro is approx. 97 000 and the average income is 95 percent of the national average (Statistics Sweden). The frequency of urban road traffic accidents that result in death or severe injuries in Örebro is approximately 80 percent of the national average.[8]

[8] The average annual frequency of such accidents per 100 000 inhabitants from 1994 – 1998 was 22.4 and 18.1, respectively, in Sweden and Örebro. Most of this difference falls on car users, while unprotected road users in Örebro were exposed to a risk very close to the national average

By this choice, we can, as in Lindberg´s study, use the “community analogy” (or frequencies of occurence) approach of communicating risk reductions, i.e., by communicating the risk as the number of mortal and serious morbidity accidents per year within a given area (Calman and Royson 1997). Also, the survey questions relate to the “Vision Zero”, which is well known to the Swedish public. In Örebro, there has been a “Vision Zero” traffic area since 1997 to demonstrate some basic ideas of the vision. There is a local “Vision Zero” program and various activities connected to this are often presented in the local newspapers.

In our survey, we informed the respondents that four persons were killed and twelve persons were severely injured from road traffic accidents in the urban areas of Örebro in 2002. As the baseline risk we will use this number divided by the urban population of Örebro. Hence, we do not estimate separate values for fatalities and serious injuries. In consistency with the observations we made above, casualities in these two categories are given equal weights. The corresponding unit value is called a value of severe statistical accidents, VSSA, to distinguish it from VSL values valid for fatalaties only.

In contrast to both Persson et al. (2001) and Lindberg (2003), we use a follow-up question after the closed ended WTP question, where the respondent is asked to grade on a scale from one to ten how confident she is in her response. We estimate the WTP for both private and public safety measures. Also, we investigate if a provision condition, designed as a “conditional cooperation mechanism”[9] increases the WTP for the public good. By using self-reported confident responses to a public safety program implying a total risk reduction (in the sense defined by the “Vision Zero”), we are able to estimate lower bound estimates of the compound unit value of fatalitites and serious injuries risk reductions.

[9] As the provision condition is defined as a minimum share of contributors and not as a minimum monetary amount we use the term “conditional cooperation” instead of “provision point”.

3.2 Details of the survey

We used a postal questionnaire survey design. The first letters were sent out in March 2004 to 1435 persons aged 18-75[10] in the urban parts of Örebro municipality[11]. These persons were randomly drawn from an address register. The mail contained an Örebro University and Swedish National Road and Transport Research Institute headed introduction letter. The letter included a presentation of the study and information about the number of people killed and severely injured in traffic in the urban area of Örebro. The full sample was split in five sub-samples, introduced to a private safety product and a public safety program, respectively, as shown in Table 2.

The private safety product was presented in the following way:

"Assume that a traffic safety device is developed which can reduce serious accidents. It can totally prevent fatal and severe injury risk for the users of this equipment within an urban area, e.g. Örebro. The device would be possible to use both by pedestrians, bicyclists and car users. It reduces the risk to zero within the urban area only for the person using it; it can not be used by others, not even within the same household."

The public safety program was presented as:

"Assume that a road traffic safety program to reduce the number of serious accidents is considered to be implemented in Örebro. It would reduce the number of fatal and severe injuries within the urban area of Örebro with an average of 16 persons per year within the urban area of Örebro. The reduction applies to both by pedestrians, bicyclists and car users."

To test for scale bias, in some questionnaires the size of the risk reduction was 8 fewer per year.

A part of the public safety sub-sample was presented a provision condition (PC). This criterion was described as follows:

[10] Individuals born 1929-01-01 to 1986-04-01.

"A requirement for the program to be provided is that 70% of the inhabitants in Örebro contribute with a fee to a special road traffic fond used and administrated by the Örebro municipal. If not sufficiently many inhabitants contribute, the road traffic program will not be implemented and your money will be repaid"

A closed ended yes/no format for the willingness to pay for a predetermined bid was used. The bid levels were SEK 200, 1000, 2000, 5000, 10 000 and 20 000, respectively.[12]

Table 2. Sub-samples of the survey.

	Good	*Risk reduction*	*Bid level*	*Number of questionnaires*
1	Private	Total safety	all	390 (65 per bid)
2	Public	16 fewer per year (total safety)	all	390 (65 per bid)
3	Public with PC	16 fewer per year (total safety)	all	390 (65 per bid)
4	Public with PC	16 fewer per year (total safety)	1000	100
5	Public with PC	8 fewer per year (half of total safety)	1000	165

In all questionnaires the respondents were asked to carefully consider that the household budget must cover a lot of expenses such as housing, food, clothes, journeys, pleasures, etc. They were reminded that a new item of expenditure can call for a reduction of other consumption. In order to get the respondents to consider the value of safety per se, the safety program was described as not affecting the possibility to choose means of transportation, travel quality, mean speed or the urban environment in Örebro.

All the respondents were asked to grade on a scale from one to ten how confident they were in their response. The questionnaires also contained questions about accident experience, the perceived risk, gender, age, family structure and monthly income.

[11] Swedish postal codes 70210-70235, 70340-70378.
[12] These bid levels were used in the study by Lindberg (2003).

3.3 Statistical methods

The acceptance probability, i.e. the probability of a yes response, p, is estimated with the logistic model:

$$p = \frac{1}{1 + e^{-\Delta v}},$$

where ? v is the change in the utility level. The explanatory variables are:

Bid. The predetermined bid level; SEK 200, 1000, 2000, 5000, 10 000 or 20 000.

Arrival. Unit dummy variable if the answer arrived before April 21, 2004 when the survey was presented in a local radio program, zero otherwise.

Acc exp. Accident experience, unit dummy variable if the respondent or anyone close to him/her have experienced a severe road traffic accident, zero otherwise.

Sex. Unit dummy variable if the respondent is a woman, zero otherwise.

Age. The age of the respondent.

High risk. Unit dummy variable if the own perceived risk is higher than average, zero otherwise.

Low risk. Unit dummy variable for lower than average own perceived risk, zero otherwise.

Disp inc. The disposable income per consumption unit given by the total disposable income[13] for the household divided by the number of persons in the household weighed by the following weights: 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.

Confidence. The respondent´s own confidence in the reply to the valuation question on a Likert scale from one to ten.

The mean WTP ($\overline{w}$)is defined as the area under the survivor function for positive WTP values (*w*):

[13] The respondents were asked to mark an interval with a range of SEK 4999; the disposable income was then approximated by the mid value of the interval.

$$\overline{w} = \int_0^\infty 1/\left[1+e^{-\Delta v}\right] dw = -\frac{1}{b}\left[\ln(1+e^{bx})\right],$$

where bx is the constant term in the changed utility $?v$. This measure rules out negative values.

Both bivariate (bid function) and multivariate (structural) models will be used. In the bivariate model the mean WTP is estimated as:

$(-1/ß_{bid})(log(1+exp(ß_{constant})))$.

The multivariate model is estimated as:

$(-1/ß_{bid})(log(1+exp(ß_{constant}+ß_1*\overline{x_1} + ß_2*\overline{x_2} \ldots))),$

where x_i are the covariates presented above.

All calculations are made in the statistical software LIMDEP version 8.0.

3.4 Response rates

After one reminder the final sample contained 873 observations[14], which gives a response rate of 61%. This can be compared to the overall response rates of Persson et al. (2001) at 51% and Lindberg (2003) at 55%. In the study by Persson et al. (2001) a drop-out questionnaire was mailed to persons that had not answered the main survey. This revealed that individuals who answered the main questionnaire had on average a higher income, higher education and drove or rode more often in cars than both the individuals who answered the dropout questionnare and the Swedish population. For this reason the researchers adjusted the estimated WTP values upwards by 7 percent. In our survey, these differences are likely to be smaller because of the higher response rate and the 5 percent lower average income in Örebro, compared to Sweden as a whole. We will therefore not make any such adjustment.

[14] Observations with obvious errors were eliminated from the sample.

Table 3. Mean and standard deviation of the variables in the different sub-samples.

	Private	*Public*	*Public, 50% risk reduction*
Number of returned questionnaires	225	548	100
Yes responses	0.33	0.18	0.29
	(0.47)	(0.39)	(0.45)
Bid	6950	5844	1000
	(7390)	(6775)	(0)
Arrival	0.49	0.52	0.42
	(0.50)	(0.50)	(0.50)
Acc exp	0.25	0.26	0.27
	(0.44)	(0.44)	(0.45)
Sex	0.55	0.50	0.62
	(0.50)	(0.50)	(0.49)
Age	45.5	44.1	46.9
	(15.4)	(16.0)	(15.2)
High risk	0.10	0.06	0.08
	(0.30)	(0.24)	(0.27)
Low risk	0.23	0.22	0.20
	(0.42)	(0.42)	(0.40)
Disp inc	11400	10671	10778
	(6380)	(6186)	(5808)
Confidence	7.60	7.91	7.19
	(2.40)	(2.41)	(2.56)

There are no substantial sub-sample differences in the socioeconomic variables sex, age and disposable income. Also, the average confidence level is similar in all groups. The fraction of respondents who perceived a lower own risk than average was remarkably larger than those who perceived a higher own risk than average.

3.5 Results

The frequencies of yes-responses at the various bid levels are shown in Figure 1. The survivor function is falling in bid levels as expected. The yes-frequencies are higher at all bid levels for the private good compared to the public safety program. The effect of the provision condition on responses to the public safety program is not unambiguous; positive for low and medium bid levels, but negative for high levels. The change of scale (from 16 to 8 annual casualitites) does not seem to have any effect.

The average WTP values for the full sample for the privat good and public safety program, computed from estimates of the bid function, are SEK 4685 and 1794, respectively. These values are somewhat lower than the corresponding WTP estimates at SEK 5231 and 2594, respectively, found in the similar study performed in the same city six years earlier by Lindberg (2003). The reasons for this discrepance are left for further research.

The results of the logit models estimated separately for the private and public good frameworks are presented in Tables A1 and A2 in the appendix. Significant effects on the acceptance probability were held for bid values and, in the public goods setup for the confidence variable. Below we investigate more thouroghly the effects of confidence, scale and strategic bias, before we present the lower-bound unit value estimates from our study.

3.5.1 Confidence

Table 4 presents the mean WTP values for samples that are ex-post divided into different sub-groups with respect to the self-reported confidence level. Level i represents a sample where all the respondents circled a confidence level higher or equal to i, where i= 5,6,7,9 or 10.

Table 4. Mean WTP in groups with different levels of confidence, estimated in a bivariate logit model.

Confidence level	*Private safety*	*Public safety*
Full sample	4685 (-6.085) n=210	1794 (-6.334) n=492
Level ≥5	4704 (-5.879) n=182	1872[ab] (-6.217) n=444
Level ≥6	4069[ab] (-5.683) n=167	1719[ab] (-5.657) n=390
Level ≥7	4169[a] (-5.464) n=151	1630[ab] (-5.081) n=367
Level ≥8	4487[ab] (-5.182) n=151	1229[ab] (-4.69) n=321
Level ≥9	4432[a] (-4.062) n=92	1250[a] (-3.726) n=255
Level 10	3232[ab] (-3.638) n=64	1283[a] (-3.785) n=204

a = significantly different from the mean WTP for the full sample for a = 0.1[15]
b = significantly different from the mean WTP for the previous certainty level for a = 0.1
t-values in parentheses, n = number of observations.

The results indicate that the more confident the respondents are in their responses, the lower is the estimated mean WTP. For the private safety alternative, the mean WTP among the most confident respondents, i.e. confidence level 10, is considerably lower than among the rest of the respondents. For the public safety there seems to be a break point at level 8, over which the mean WTP is remarkably lower. For calculating the VSSA estimates, we therefore use the WTP values among fully confident respondents for the private good (SEK 3232) and the 8 through 10 confidence levels WTP values for the public good (SEK 1283).

3.5.2 Scale bias

Table 5 summarizes the proportion of yes responses for the public safety program (with the provision condition) preventing on average 16 road traffic accidents and the program preventing on average 8 accidents. The predetermined bid level in both cases is SEK 1000.[16] The table reports both the results from the full sample and for fractions of respondents in an increasing confidence scale. It shows that for the full sample and for low-confident responses the share of yes-responses to a program offering just half the effect of the vision-zero program is even higher than that of the full program. However, respondents expressing confidence at level 8 and higher are on average less likely to accept the program that gives a smaller reduction. In fact, as shown in Table 6, in a structural model based on a sub-sample of respondents expressing confidence at level 8 and above, the coefficient of the scale parameter implies a close to proportional 53 percent reduction of the mean WTP-values to a 50 percent reduction of scale. However, the precision of these estimates is low and the scale parameter is not significant. Therefore, although we notice this weak indication of sensitivity to scale among confident respondents as a suggestion for further research, our overall conclusion is that the responses to this survey are, as expected, suffering from scale bias. This means that we can get only lower bound VSSA estimates.

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[16] The scale test was performed for this bid level only. This level was chosen because it was expected to be close to the median WTP of a public good.

[18] Bateman et al. (2002, pp. 323-324) report that Jones-Lee and Loomes, in an unpublished study for the British Department of Transport in 1999, got a similar result in an experimental survey using this risk-communication technique.

Table 5. Proportion of yes-responses, Public PC, bid = 1000 SEK. Standard deviations within parentheses.

	16 fewer accidents		*8 fewer accidents*	
Full sample	0.247	(0.433)	0.291	(0.457)
Confidence level ≥5	0.231	(0.424)	0.263	(0.443)
Confidence level ≥6	0.235	(0.427)	0.281	(0.453)
Confidence level ≥7	0.206	(0.408)	0.246	(0.434)
Confidence level ≥8	0.184	(0.391)	0.167	(0.376)
Confidence level ≥9	0.143	(0.355)	0.097	(0.296)
Confidence level ≥10	0.200	(0.408)	0.115	(0.325)

Table 6. Mean WTP (SEK/year), from the estimated structural models reported in Table A3 evaluated at the means of the variables and scale = 16 or 8 fewer accidents per year.

	Full sample	*Confidence level ³5*	*Confidence level ³8*
Mean	1348	1319	846
Scale=8	1153	952	510
Scale=16	1417	1447	966
Ratio	0.81	0.66	0.53

3.5.3 Strategic bias

Table 6 presents the estimated full sample WTP values for the public good without and with the provision condition (PC). Contrary to our expectation, the mean WTP for the public good with PC exceeds the mean WTP for the public good without PC. This could be an indication of an inverted U-relationship of conditional cooperation. However, a closer examination of the data shows that this result is very much driven by two yes responses to the public good without PC at the bid level of SEK 20 000, while no one accepted the bid for the public good with PC. If these two observations are excluded from the sample, the mean WTP for the public good without PC is SEK 1250. It should be remembered though that “fat right-tails” are common in studies such as this. The corresponding logistic regressions are presented in Table A4 in the Appendix. They show that the effect of the provision condition is positive but not statistically significant

Table 6. The mean WTP for the public good with and without a provision conditions. Bivariate logit model estimates.

No PC	*PC*
1991 (4.048)	1550 (4.856)

t-values in parentheses.

3.5.4 Lower-bound estimates of VSSA

The lower bound VSSA unit values are calculated as a conservative estimate of WTP divided by a maximum reduction of the initial risk level. The risk change is set to 16 persons killed or severly injured divided by 97 000 the urban population of Örebro. If the average WTP values from this survey in one town is used as estimates of the average WTP values of the whole Swedish population, one might instead want to divide with the national risk level, which is 24 percent higher. This gives the following lower bound unit values of a reduction of a statistical victim to fatal or serious-injury causalities in million SEK for the private and public goods.

Table 7. Lower-bound estimates of the values of a reduction of a severe statistical accident (VSSA) for the private and public goods (MSEK).

	Private good	*Public safety program*
Örebro risk level	19.6	7.5
National risk level	15.8	6.0

The estimated lower bound VSSA for a private good is slightly below the level of private good VSL for fatalities at 21.8 MSEK estimated by Persson (2004). However, our estimates apply to serious injuries as well.

4. Discussion

We have used the Swedish “Vision Zero” policy context to frame a contingent valuation study that estimates the WTP for a complete elimination of severe road-traffic accidents within a city, i.e. accidents that lead to fatalities or serious injuries. In line with results from previous research that indicates that the WTP for reductions of serious casualities is not considerably lower than for fatalities, we do not separate these two categories (i.e., every victim of a serious accident is implicitly given equal weight). By using the responses from confident respondents we derive lower bound estimates of the value per statistical victim of such accidents (VSSA).

From this design we are able to by-pass the scale-bias problem. Based on the full sample of our study we can confirm that scale bias is prevalent as in most other studies of this kind. The use of a community-analogy representation of risk probabilities did not change the picture in this respect.[18] The study yields point estimates, though, that are consistent with the conjecture that confident respondents value risk reductions proportionally to the magnitude of the change. However, no conclusions can be drawn. The precision of these estimates is too low to rule out the presence of scale bias within this category of respondents as well.

We find that the willingness to pay is considerably lower for a public safety program than for a private-good device. Also, fully confident respondents reveal lower WTP amounts than less confident respondents.

Our lower-bound estimate of the value of a reduction of one serious statistical accident resulting from a private-good safety measure is close to the level for the value of a statistical life (VSL) suggested by previous studies. However, as infrastructure planning is made in the public-good context, we find it natural to consider a value based on a public-good context for use in CBA models that are used for assessing public infrastructure programs. Our estimate of the public-good value is 60 percent below the private-good value. On the other hand, the scope of VSSA is wider than that of VSL, as it applies also to serious injuries, not just to fatalities.

In road accidents in Sweden there are on average seven times as many seriously injured victims as the number of persons killed. The “Vision Zero” public-safety program for Örebro valued in our study is supposed to prevent four fatalities and twelve serious injuries per year. Therefore, our conservative lower-bound public-good estimates imply that the average benefits from publicly provided safety improvements targeting serious accidents are at least 16 – 27 percent greater than what is indicated by the current CBA models.[20]

Obviously, more research is needed in this field. The possibility of getting results from fully confident respondents free from scale bias is enticing. Possibly, a larger sample and other ways of communicating risk magnitudes could help. Also, it seems worthwhile to try the combined within and between sample method used by Alberini et al. (2004) in the road safety context.

Other issues for future research relate to the reasons for the large difference between the values of private and public goods. The provision condition could be varied in several ways. It is not clear from this study whether the respondents found this condition credible in this local community context. Questions about the beliefs about the share of others that would be willing to contribute may yield important clues (for an application to speeding by car drivers, see Johansson-Stenman and Martinsson 2004). Another issue is to what extent respondents believe that the public and private frameworks differ in the provision of safety enhancement with respect to efficiency, regional distribution etc.

[20] 16 percent for Örebro, 27 percent for the whole country.

Appendix

The effect of the preference uncertainty on the acceptance probability is estimated in four different models. In the first model, the certainty level is treated as an approximately continuous variable. In model two through four, different dummy variables are used to see if there is a break point on the confidence scale, over which the preference uncertainty has a significant effect. D10 equals one if the certainty level is 10, D9 equals one if the certainty level is equal or larger than 9 and D8 indicates a level of eight or above. Tables A1 and A2 present the results for the private good and public good, respectively.

Table A1. Test of the effect of confidence on the acceptance probability. Private safety.

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Constant	.18922743 (.244)	-.03497010 (-.054)	-.00078620 (-.001)	-.12109485 (-.183)
Bid	-.00015936** (-4.543)	-.00016201** (-4.588)	-.00016017** (-4.535)	-.00016303** (-4.605)
Arrival	.46459265 (1.379)	.45792843 (1.367)	.45337712 (1.352)	.47258453 (1.404)
Acc exp	.45240833 (1.176)	.39484253 (1.041)	.40851286 (1.074)	.36265210 (.947)
Sex	-.13634195 (-.380)	-.16766546 (-.469)	-.18143891 (-.506)	-.14836601 (-.413)
Age	.00221298 (.193)	.00200209 (.176)	.00261354 (.230)	.00048451 (.042)
High risk	.04050203 (.076)	.05662068 (.106)	.07782709 (.145)	.03403378 (.064)
Low risk	-.44526931 (-1.028)	-.40492497 (-.939)	-.42071986 (-.972)	-.39280154 (-.910)
Disp inc	-.730041D-05 (-1.028)	-.536949D-05 (-.205)	-.575311D-05 (-.221)	-.454508D-05 (-.173)
Confidence	-.03327751 (-.484)			
D10		-.06946573 (-.190)		
D9			-.19648429 (-.972)	
D8				.19835036 (.564)

* Significant for a = 0.1 **Significant for a = 0.05. t-values in parentheses.

Table A2. Test of the effect of confidence on the acceptance probability. Public safety.

Variable	Model 1	Model 2	Model 3	Model 4
Constant	-.00958732 (-.016)	-.87058010 (-1.740)	-.72330519 (-1.423)	-.52761465 (-1.024)
Bid	-.00020861** (-4.651)	-.00021396** (-4.688)	-.00020053** (-4.490)	-.00019736** (-4.477)
Arrival	-.38754593 (-1.471)	-.34155659 (-1.313)	-.30919939 (-1.175)	-.33250824 (-1.259)
Acc exp	.07973260 (.255)	.04254100 (.137)	.02190221 (.070)	.00013776 (.000)
Sex	.21724772 (.825)	.18574765 (.708)	.18839297 (.710)	.14866439 (.558)
Age	.00513591 (.604)	.00508760 (.595)	.00520966 (.607)	.00543277 (.633)
High risk	-.40349535 (-.683)	-.40432888 (-.688)	-.51512158 (-.868)	-.42480185 (-.710)
Low risk	.00531105 (.017)	.03271929 (.107)	.11933099 (.385)	.03139953 (.102)
Disp inc	.214375D-04 (1.059)	.176020D-04 (.875)	.184296D-04 (.897)	.180127D-04 (.884)
Confidence	-.14190872** (-2.620)			
D10		-.51797289* (-1.732)		
D9			-.95390482** (-3.353)	
D8				-.97933432** (-3.644)

* Significant for a = 0.1 ** Significant for a = 0.05
t-values are in parentheses

Scale-bias test

Table A3. Test of the effect of the magnitude of a risk reduction on the acceptance probability.

Variable	Full sample		Confidence level 5		Confidence level 8	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	-1.07073	-0.77773	-2.61785	-1.63245	-4.29264*	-1.78896
Bid	-0.00035**	-3.62777	-0.00034**	-3.5041	-0.00038**	-2.82954
Sex	0.017721	0.060267	0.08031	0.248701	0.075668	0.168704
Age	0.031073	0.491749	0.093901	1.30924	0.137742	1.30704
Age sq.	-0.00035	-0.51395	-0.00092	-1.21215	-0.0013	-1.17505
Disp inc	3.87E-05	1.54384	3.44E-05	1.27692	5.99E-05*	1.66247
Arrival	-0.64362**	-2.17588	-0.69524**	-2.13883	-0.73551*	-1.65081
Acc exp	0.116554	0.323977	0.116982	0.29894	0.044407	0.079162
High risk	-0.1602	-0.25382	0.298078	0.441545	-0.46472	-0.39605
Low risk	-0.34606	-0.96061	-0.23986	-0.62562	-0.21168	-0.4192
Scale	-0.25641a	-0.78517	-0.50875b	-1.3657	-0.72918c	-1.36831

* Significant for a = 0.1 ** Significant for a = 0.05.
a; p=0.43, b; p=0.17 , c; p=0.17

Strategy bias

Table A4. Test of the effect of a provision condition on the acceptance probability. Public safety.

Variable	Full sample	Without outliers
Constant	-.16684158 (-.261)	-.04960190 (-.075)
Bid	-.00020589** (-4.597)	-.00031262 (-4.686)
Arrival	-.39529457 (-1.497)	-.42125800 (-1.546)
Acc exp	.10969238 (.348)	.22568580 (.692)
Sex	.23560340 (.890)	.31440762 (1.149)
Age	.00596301 (.694)	.00424489 (.480)
High risk	-.37548635 (-.634)	-.73617548 (-1.106)
Low risk	.01995854 (.065)	.05949727 (.190)
Confidence	-.14529254** (-2.670)	-.14018829** (-2.490)
Disp inc	.215689D-04 (1.062)	.215754D-04 (1.039)
PC	.20421177 (.753)	.26488261 (.938)

t-values in parentheses.

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Figure 1. Frequency of yes-responses (survivor function) at various bid levels.