Consistency in preferences for road safety: An analysis of precautionary and stated behavior

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Abstract

This study analyzes stated willingness to pay (WTP) for traffic safety, the use of traffic safety equipments, and the consistency between the two. Using data from a Swedish contingent valuation study we find that the estimated value of a statistical life (VSL) based on the respondents' rear-seatbelt usage is similar to the estimate found using the respondents' stated WTP. However, when estimating VSL based on the respondents' use of bicycle helmets we find a significantly higher VSL; the VSL from bicycle-helmet usage is 7 times higher than the estimate based on seatbelt usage. Moreover, we do not find any strong relationship between risk perception and usage, or individual stated WTP and usage. Hence, the main conclusion, based on our analysis, is that stated and observed WTP are not consistent.

Keywords: Revealed preferences, Road safety, Stated preferences, Value of a statistical life, Willingness to pay
JEL classification: D61; J17; R41

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1. Introduction

Individuals face many risks to their health in their daily lives. Some are voluntary like engaging in risky sport activities, for instance skiing, but most are involuntary since they are part of activities undertaken to live a normal life; the food choices that we make can have short and/or long term effects on our health level, and traveling choices on how to get to and from our workplace, school, families and friends, etc, will affect our accident risk. In this paper we are interested in the latter, i.e. traffic accident risk. More specifically, we are interested in individuals' behavior and preferences for road safety.

To influence their health and accident risks individuals can, in principle, choose two approaches; choosing safer activities or by taking precautionary behavior. This is true in general and also for accident risk in the traffic environment. For instance, by choosing what mode to use to travel from A to B, e.g. train, car, or by bike, and under what conditions, e.g. time of day, and weather, the traveler can influence the risk level he will be exposed to. Moreover, individuals can also choose to take precautionary behavior by investing in safety, like choosing a safer car model, or deciding to use safety equipment. In this study we are interested in the latter. We will in our analysis examine individuals' rear-seatbelt and bicycle-helmet usage. We will not, however, only examine usage but also use the information from observing this behavior to derive monetary values for safety, and moreover, examine how observed relate to stated preferences.

However, due to market failures, such as externalities and that individuals may not be well-informed about the risk levels they face, public safety interventions are necessary. Benefit-cost analysis has proven to be a powerful tool to guide policy makers in their resource allocations. It requires, though, that benefits and costs are available in a common metric, which is usually money. Since no market prices exist for "traffic safety" analysts have to rely on non-market evaluation techniques to obtain monetary values. These can broadly speaking be classified as being either revealed- (RP) or stated-preferences (SP) methods. The former refers to methods where actual market behavior is used to reveal individual preferences. Our example above with the choice of a safer car is an example of the RP approach where the price premium of the safer car reflects the car owner's willingness to pay (WTP), i.e. preferences, for safety (Andersson, 2005; Atkinson and Halvorsen, 1990). The second approach, i.e. SP, is instead, as the expression suggests, based on the individuals' stated decisions. In this approach a hypothetical market is created in which respondents are asked how they would choose in a given situation, or their willingness to pay (WTP) for a given risk reduction (or alternatively their willingness to accept (WTA) as compensation to forgo the risk reduction). Both approaches have their strengths and weaknesses; the RP approach is based on actual behavior but market data may not be available or information on individuals' choice alternatives may not be available to the analyst, whereas the SP approach offers flexibility and full information on the choice alternatives, but is based on hypothetical decisions.

The aim of this study is to examine the consistency of the implied value of safety from observed behavior with the same individuals' stated WTP in a SP study. This question was analyzed in Hakes and Viscusi (2007) and Svensson (2009) and this study replicates their approach. Whereas Hakes and Viscusi found evidence of a consistent behavior Svensson found no such evidence. Hence, as a result of this conflicting evidence it is of interest to examine this question again using a different population. Moreover, whereas Hakes and Viscusi only examined seatbelt usage we also examine bicycle-helmet usage, and compared with Svensson, who examined several safety equipments using Swedish data, we also have information on the individuals' risk-perception. In line with Svensson we estimate two VSLs based on actual behavior, but whereas Svensson estimated for front-seatbelt usage we estimate for rear-seatbelt usage. We use data from a Swedish contingent valuation (CVM) study and in addition to estimate VSL the objectives are to examine: (i) self-protective behavior and individual characteristics, and (ii) the consistency between implied and stated VSL.

The following section first describes the theoretical model of the VSL and then the empirical findings in the literature. We thereafter present the survey used to obtain our data. In the result section we explore relationships between usage and stated WTP by first focusing on the results from the SP questions and then on the values from the actual behavior. Finally we discuss our findings and draw some conclusions.

2. The value of a statistical life

2.1. Theoretical model

The expression the value of a statistical life (VSL) refers to the population mean of the marginal rate of substitution between mortality risk and wealth.[1] The theoretical expression is derived in a state-dependent expected utility framework where the individual is expected to maximize his utility (Jones-Lee, 1974; Rosen, 1988). Let p denote the baseline mortality risk and $u_s(w),\ s \in \{a, d\}$, the state dependent utility of wealth (w) where the states are either alive (a) or dead (d). The individual is then assumed to maximize the following expression,

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

We assume that the utility functions are twice differentiable and we adopt the standard assumptions that the utility of wealth is larger if alive than dead, the marginal utility of wealth is also larger if alive

[1] This is true under the standard assumption in the literature that the marginal rate of substitution between mortality risk and wealth and the personal change in risk is uncorrelated. For a discussion see, e.g., Jones-Lee (2003).

than dead and nonnegative, and that individuals are weakly risk averse to financial risks, i.e.

$$u_a > u_d,\ u'_a > u'_d \geq 0,\ \text{and}\ u''_s \leq 0. \tag{2}$$

The expression for the VSL is obtained by totally differentiating Eq. (1) and keeping utility constant,

$$\text{VSL} = \left.\frac{dw}{dp}\right|_{EU\ \text{constant}} = \frac{u_a(w) - u_d(w)}{pu'_d(w) + (1-p)u'_a(w)}, \tag{3}$$

which is the standard expression for the MRS(w, p). It is straightforward to show that under the properties of (2), VSL is positive and increasing with w and p (Jones-Lee, 1974; Pratt and Zeckhauser, 1996; Weinstein et al., 1980).[2]

Equation (3) is the VSL for "true" marginal changes in WTP (or WTA) and mortality risk. In this study, as in many studies using the SP approach, we deal with discrete changes, though. That is, in the SP survey used to obtain stated WTP respondents are asked about a finite change in the probability of death and the RP data used refer to situations where they take the decision to either use the safety device or not. Let Δw and Δp denote finite changes in wealth and risk and Eq. (3) is given by,

$$\text{VSL} = \frac{\Delta w}{\Delta p}. \tag{4}$$

The expression in Eq. (4) is an approximation of the true marginal WTP and reveals that Δw should be near-proportional to Δp, a necessary (but not sufficient) condition for WTP from CVM-studies to be valid estimates of individuals' preferences (Hammitt, 2000). We use this theoretical prediction in our validity test of the respondents' stated WTP in our empirical analysis. We run two tests on scale sensitivity (Corso et al., 2001): (i) a weak test where we examine whether WTP is increasing, and (ii) a strong test where we examine whether WTP is proportional to the size of the risk reduction.

When analyzing observed behavior we are studying discrete choices where an individual will use a safety device only if the benefits of using it are larger than the costs. Hence, by rearranging Eq. (4) it can be shown that,

$$\Delta w < \text{VSL} \times \Delta p, \tag{5}$$

i.e. estimates from data on self-protection and averting behavior will provide a lower-bound estimate of the WTP of those using the safety device. Note, however, that it will provide an upper-bound for the non-users (consumers) of the device. Thus, it is unclear what is the average VSL when self-protection and averting behavior are discrete.

[2]The assumption of weak risk aversion, i.e. $u''_s \leq 0$, is sufficient but not necessary for VSL to be increasing with w.

2.2. Empirical evidence from observed and stated choices

Today the WTP approach is well established but before it became widely accepted among economists as the appropriate evaluation method another approach dominated. That approach is usually referred to as the the human capital approach in which the "value of life" is the value of the individual's market productivity, a value assumed to be reflected by the individual's earnings (Mishan, 1982). The value of human capital is calculated as the individual's present value of future expected earnings and it has two major drawbacks: (i) it assigns a zero value to non-market production implying that, e.g., unemployed and retired persons have a value equal to zero, and (ii) it does not reflect individual preferences for safety. Attempts to also incorporate non-market earnings have been made (Keeler, 2001; Max et al., 2004), but it does not solve the main objection against the approach, i.e. the estimates do not reflect preferences, and it has therefore today been almost completely abandoned and replaced by the WTP approach.

Since the seminal papers on the WTP approach in the 1960s and early 1970s (Drèze, 1962; Jones-Lee, 1974; Mishan, 1971; Schelling, 1968) there has been a huge amount of work on the evaluation of health risks, both theoretical and empirical. In this brief review we are interested in the latter and two areas in which there is a vast empirical literature on the evaluation of health risks are workplace and traffic safety (Blomquist, 2004; Viscusi, 1993; Viscusi and Aldy, 2003). By using information on the compensation workers require to accept riskier jobs it is possible to derive the VSL (Viscusi and Aldy, 2003). Hence, the approach of compensation wage differentials is based on observed behavior, i.e. it is an RP approach. Studies to evaluate traffic safety using an RP approach have been conducted using, for instance, protective behavior such as seatbelts, motorcycle helmets, etc. (e.g. Blomquist, 1979; Blomquist et al., 1996; Hakes and Viscusi, 2007; Jenkins et al., 2001), or car ownership (Andersson, 2005; Atkinson and Halvorsen, 1990; Dreyfus and Viscusi, 1995). The SP approach dominates when evaluating risks in the traffic environment, however (Andersson and Treich, 2011). One reason for the popularity of the SP approach may be the public good nature of traffic safety (Andersson and Lindberg, 2009; Hultkrantz et al., 2006; Johannesson et al., 1996). Whereas the RP approach is able to elicit individual and household WTP (e.g. all drivers and passengers benefit from a safer car), the SP approach is able to elicit altruistic preferences toward others. If altruism were pure then private WTP would also reflect social WTP (Bergstrom, 1982). However, evidence suggest that when it comes to health risks individuals are safety paternalistic (e.g. Andersson and Lindberg, 2009) and then private and social WTP will differ (Jones-Lee, 1991).

Studies on road fatality risk have dominated the elicitation of preferences for transport safety (Andersson and Treich, 2011), which is not surprising considering that it is the transport mode responsible for most fatalities (Evans, 2003). In the recent review by Andersson and Treich (2011) estimates of the

VSL were in the range from US$ 150 000 to 36 million, in 2005 price level. Since individuals' WTP is context dependent we expect some variation in estimated VSL. Many differences in values are in line with the expectations, e.g. a higher WTP in richer countries and for risk perceived as not controllable by the individuals. Other findings, however, are not in line with theoretical predictions; Andersson (2007) provided a large interval of VSL estimates due to insensitivity of the WTP to the size of the risk reduction (a result in line with other findings in the literature (Hammitt and Graham, 1999)), and the estimates in McDaniels (1992) depended whether a WTP or WTA framework was used. Moreover, the empirical evidence also suggest that SP studies produce higher estimates than RP studies (de Blaeij et al., 2003; Miller, 2000).

Even though many studies have been conducted eliciting preferences for traffic safety, most of them have only used one elicitation approach, i.e. RP or SP. In this study we are interested in the consistency between observed and hypothetical behavior and two studies that examined this was Hakes and Viscusi (2007) and Svensson (2009). Whereas Hakes and Viscusi only examined the use of seatbelts on a US sample, Svensson examined six different precautionary activities (front and rear seatbelt, bicycle helmet, bicycle light, reflector, and no speeding) on a Swedish sample and estimated a VSL for front-seatbelt and bicycle-helmet usage. The two studies came to different conclusions; Hakes and Viscusi found evidence of a consistent behavior, whereas Svensson did not.

3. Survey – Seatbelt and bicycle-helmet usage, and stated preferences

3.1. General description

The data originate from a CVM-study that was conducted as a postal questionnaire in Sweden in 1998. Following the standard procedures for SP studies, the questionnaires were tested on focus groups and in a pilot study before the main study was conducted. The questionnaire was sent to 5 650 randomly chosen individuals between 17 and 74 years of age with 2 884 respondents returning their questionnaires, i.e. a response rate of 51 percent. Not all respondents were asked to state their WTP for a road mortality risk reduction, however. In total 3 050 questionnaires on road-mortality risk were distributed with 977 respondents completing and returning their questionnaires, i.e. the response rate in this subsample was equal to 32 percent. When analyzing the descriptive statistics of the respondents of the survey and comparing them with the drop out sample ($n = 659$) we found that the mean and median income, the representation of men, access to a car in the household, annual mileage driven, accident experience, and level of education were all higher among those who answered the survey than those who did not.

The questionnaire consisted of three main sections. The first section contained questions on background information such as gender, age, and self-perceived health status, and questions related to the respondents' behavior in the road environment. The respondents were, e.g., asked whether they had access to a car, how long they traveled by car or public transport, rode a bike, etc. This section also contained the questions on the use of safety equipment used later in our analysis. In the second part of the questionnaire the respondents were presented with the risk of dying as a result of a traffic accident and were asked about their perception of their own risk and their WTP to reduce this risk. We describe this part of the questionnaire in more detail in the next section. In the last section of the questionnaire respondents were asked some additional questions on background information, i.e. education and income level, and a question on car ownership.

The data from the survey has previously been analyzed in detail on stated WTP in Persson et al. (2001) and Andersson (2007), risk perception in Andersson and Lundborg (2007), and car ownership and WTP for car safety in Andersson (2005). In this study we focus on the relationship between stated WTP and the use of safety equipments and the WTP revealed by using them.

3.2. Scenario description and WTP

The survey was designed by Persson et al. (2001) and when choosing between different elicitation format for the WTP question the open-ended format was chosen as the main format in favor of closed-ended questions in order to avoid the problem of anchoring (Persson et al., 2001, p.125). Thus, respondents were asked a direct question on their maximum WTP for a given risk reduction. Before answering the WTP question respondents were asked to state both their perception regarding their own annual risk of dying from any cause (baseline risk) and of dying as a result of a traffic accident. The questionnaires provided the respondents with the objective fatality risk from any cause ($300 \cdot 10^{-5}$) and from a road-traffic accident ($5 \cdot 10^{-5}$) for a fifty-year old individual in Sweden. These probabilities were also presented using a visual aid. The visual aid chosen was a grid consisting of 100 000 white squares where the number of squares corresponding to the different risks were blacked out. This type of aid has been successful in improving respondents comprehension of small changes in risk (Corso et al., 2001).

Each respondent answered one open-ended WTP question in which he was asked to state his maximum WTP for a safety device that would reduce his or her road-mortality risk by a given relative risk reduction (1/10, 1/3, 1/2, or 99/100) during one year. The respondent's own subjective risk perception was used as the initial risk exposure, and the magnitude of the risk reduction, for which he stated his WTP, was, therefore, equal to the individual's subjective risk-level multiplied with the relative risk reduction given in the question. The description of the average annual risk and the safety device, and the questions on perceived own risk level and WTP to reduce this risk was as follows:

> In an average year the risk of dying in a traffic accident for an individual in her/his 50s is 5 in 100 000. What do you think of your own annual risk of dying in a traffic accident? Your

risk may be higher or lower than the average. Consider how often you are exposed to traffic, what distances you travel, your choice of transportation mode and how safely you drive.

I think that the risk is ...... in 100 000.

The safety device is not inconvenient, ugly or complicated to use. Actually you do not notice it. However, it is only you personally who can benefit from it. The risk reduction has a duration of just one year and will only affect your death risk. Other people's risk is not affected and an accident will not have any impact on your financial situation as we assume that all expenditures and financial losses will be covered by the insurance system.

How much would you at the most be willing to pay for reducing your own annual risk of dying in a traffic accident by one third?

3.3. Exclusion criteria

Following Andersson (2007) three exclusion criteria are adopted in this study. Observations are excluded from the regressions if respondents stated either of the following: (i) a WTP that exceeded 5 percent of household income (exclusion criterium also used by Persson et al. (2001)), (ii) that their road-mortality risk was equal to zero, or (iii) that their road-mortality risk was higher than their baseline risk. Criteria (ii) and (iii) are used to exclude "protest answers" and as a test of probability comprehension, respectively. In addition to these criteria, two observations, one in which the respondent stated that his/her road-mortality risk was higher than 50 percent, and one in which the respondent stated that his/her annual baseline risk was 99 999/100 000, are regarded as irrelevant.[3]

4. Results

This section is divided into three subsections. We first describe the descriptive statistics and present regression results on stated WTP. We then show the results from the analysis of the use of safety equipment. In the last section we show the VSL estimates based on the use of the safety equipment.

4.1. Descriptive statistics and stated VSL

4.1.1. Dependent and explanatory variables

The descriptive statistics from the answers passing the exclusion criteria are presented in Table 1. Most of the descriptive statistics are close to the averages of the Swedish population. However, the mean

[3] A probit analysis of the excluded observations showed that older respondents and respondents with a university degree were less likely to be excluded.

income found in the survey is about 34 percent higher than the mean household income in Sweden, respondents are slightly younger, with males overrepresented, and have a higher level of education, compared to the Swedish population at the time of the survey (Andersson, 2007). The mean value of the respondents' perception of their road fatality risk reported in Table 1 is the arithmetic mean. The analysis in the following section of risk perception and the use of safety equipment is based on geometric means. The geometric mean is less influenced by outliers and has been used in several studies analyzing mortality risk perception (Andersson, 2011; Andersson and Lundborg, 2007; Hakes and Viscusi, 2004, 2007).

[Table 1 about here.]

Self-reported health status presented in Table 1 was elicited using the EuroQol health-thermometer (EuroQol Group, 1990). This is constructed by using a thermometer-scale ranging from 0-100, where 100 is the best imaginable health state. Its simplicity makes it especially useful in postal questionnaires, since it is sufficiently short not to jeopardize completion and/or return of the questionnaires. The mean estimate of own current health status is almost identical to results in several other Swedish studies (Andersson et al., 2011; Brooks et al., 1991; Koltowska-Häggström et al., 2007).

4.1.2. WTP equation

We expect WTP to be near-proportional to the magnitude of the risk reduction, and we therefore want a functional form for the WTP equation that allows for non-linearity between WTP and the magnitude of the risk reduction to test for near-proportionality. We also want a form that allows us to treat "zero answers", i.e. answers where the respondent stated a zero WTP, as an answer reflecting his/her true preferences for safety. The following specification fulfills both these requirements,

$$\text{WTP}_i = \beta_0 x_i^{\beta_1} y_i^{\beta_2} \exp\left(\sum_k \beta_k z_{ki}\right) + \varepsilon_i, \tag{6}$$

where x, y, and z, is the risk reduction, income and respondent characteristics, respectively. Since Eq. (6) has an additive residual it is estimated by non-linear least squares. We expect β_1 and β_2 to be positive and β_1 to also be close to one.[4]

The results from the regression analysis are shown in Table 2. Three regressions were run; *Model 1* includes only the change in risk as explanatory variable, *Model 2* adds demographic and socio-economic variables, and *Model 3* in addition to those also adds variables related to risk perception and traffic

[4] Andersson (2007) showed that the results were sensitive to the assumptions on functional form and how to treat the zeros. In this study we are, however, interested in the consistency between stated and observed behavior, and the functional form is therefore of minor interest.

behavior. The results in all the three regressions reveal a weak but not strong scale sensitivity of WTP to the magnitude of the risk reduction. That is, the coefficient estimate for *Risk change* is positive and statistically significant in all regressions, but also statistically significantly different from one. We, thus, reject the hypothesis that WTP is proportional to the magnitude of the risk reduction and on the basis of the absolute values of the coefficient estimates, and the strong significance level at which we can reject the hypothesis of proportionality, we conclude that near-proportionality is not satisfied. This result is in line with other findings in the literature, i.e. weak but not strong scale sensitivity (Hammitt and Graham, 1999).

[Table 2 about here.]

We find the expected relationship between WTP and *Income*, which is used as a proxy for wealth since information on respondents' wealth level is not available. That is, respondents' WTP is increasing with the income level. The results suggest that safety is a normal good, which is in line with previous findings (Hammitt and Robinson, 2011). Other variables are not statistically significant, with one exception. *Health status* is negative and statistically significant in *Model 3*. However, since it was statistically insignificant in *Model 2* we conclude that the relationship between WTP and the individuals' health status is weak. The empirical results for the different covariates are mixed in the literature but the insignificance of, e.g., *Age* and *Health status* are in line with both theoretical and empirical findings (Andersson and Treich, 2011). Based on the results from *Model 1* and using the mean risk reduction of the sample, i.e. $\Delta p = 4$, the VSL of the sample is estimated to be SEK 37.36 million (US$ 4.70 million), with a 95 % confidence interval equal to SEK 31.71 − 43.02 million.[5]

4.2. Averting behavior – Analysis of seatbelt and bicycle-helmet usage

We report the distribution of the respondents' precautionary behavior in Table 3. Whereas only a small proportion always use a bicycle helmet, i.e. 10 %, most respondents always use the seatbelt when traveling in the rear seat of the car, almost 82 %. The results also reveal that almost all of those who use a bicycle helmet also use the seatbelt, 71 out of 73 individuals. Moreover, only 4.4 % never use a bicycle helmet and the rear seatbelt (32 out of 728).

[Table 3 about here.]

In Table 4 we examine the relationship between the respondents' risk perception and the use of safety equipment. We first focus on the use of the rear seatbelt and we find that risk perception is increasing

[5] All estimates are in year 1998 SEK unless otherwise stated. (US$ 1 = SEK 7.95, stats.oecd.org, 12/1/2011)
VSL $= \frac{WTP}{\Delta p} = \frac{\beta_0 x^{\beta_1}}{x/100\ 000}$

with usage for both females and males. That is, the mean risk perception is highest among those who always use the seatbelt and lowest among those who never use it. This is in line with our expectations, and we find the same results when we pool the two genders. However, none of the differences are statistically significant which in part could be explained by a small number of observations in some of the subsamples. Focusing then on the use of the bicycle helmet we do not find any monotonic relationship between usage and risk perception. This is true for both genders and when they are pooled. Again, though, the estimates are not statistically significantly different.

[Table 4 about here.]

The aim of this paper is to examine the relationship between actual and stated behavior. Table 5 shows the relationship between the proportion of users of seatbelts and bicycle helmets and the individual VSL. Individual VSL is divided into 6 different groups with zero WTP being one of these groups. Different cutoff points were tested and since the results were robust we only report the VSL ranges presented in the table. The findings in Table 5 suggest that there is no relationship between the individual VSL and the usage of safety equipment. For instance, the seatbelt and bicycle helmet proportion of users in the group with a zero WTP to reduce their mortality risk is positive for both safety equipments and higher than in some groups with a positive WTP.

[Table 5 about here.]

The following two tables report results from regression analyzes on protective behavior. In Table 6 we report the results on rear-seatbelt usage and in Table 7 on bicycle-helmet usage. For each safety equipment we run both probit and ordered-probit regressions. In the former "Always" is coded as one and "Sometimes" and "Never" as zero. For each type of regression we run three models; in the second we in addition to the original variables include VSL as a continuous variable and in the third and final model we include VSL as a group variable with VSL equal to or lower than SEK 10 million as the reference group. In Table 6 on seatbelt usage we find that results are robust between models. Whereas those respondents who have a higher income are less likely to use the seatbelt, older respondents and those with a higher self-perceived health level are more likely to use it. All other covariates, e.g. gender or accident experience, have no statistically significant effect on the usage. When VSL is included as a continuous variable in *Seatbelt 2* and *Seatbelt 5* it is positive and insignificant in the former and negative and statistically significant on the 10 percent level in the latter. Moreover, when it is included as a group variable it is negative and statistically significant for the group with the highest VSL in *Seatbelt 3* but statistically insignificant in *Seatbelt 6*. Hence, overall the results suggest that the level of VSL is not related to the probability of seatbelt usage.

[Table 6 about here.]

The results on bicycle-helmet usage in Table 7 differ from those on rear-seatbelt usage in Table 6. Whereas *Income* is not statistically significant we find that males are less likely and that those with a university degree are more likely to use a helmet. We still find, though that the respondents' age is positively correlated with the usage of the safety equipment. Moreover, we also find a weak positive relationship between usage and health status and distance traveled by bike during the summer; the relationship is not statistically significant in the probit regressions, but statistically significant in two of the ordered probit regression for *Health status* and in all three for *Bicycle distance*. Regarding VSL, it is statistically insignificant in all regressions.

[Table 7 about here.]

4.3. VSL from seatbelt and bicycle-helmet usage

4.3.1. The Blomquist approach

The framework used to estimate VSL from protective behavior is based on the approach developed by Blomquist (1979). Blomquist analyzed seatbelt usage and the same framework was also used in Blomquist et al. (1996), Hakes and Viscusi (2007), and Svensson (2009), when different types of protective behavior were analyzed.

We start by defining an individual's expected utility level by,

$$Z = z(V, I, M, L, S, D), \tag{7}$$

where V, I, and M denote the implicit value of avoiding a fatal, a non-fatal moderate, and a non-fatal severe accident, and L, S, and D the financial loss due to fines from not obeying any law requiring the use of the safety equipment, precautionary behavior taken, and the disutility associated with the use of the safety equipment, respectively. The rearranged first order condition, taken at the means of all variables, is then given by (Blomquist, 1979),

$$\frac{P'V + R'V + Q'M + LF - awt - (D'/\lambda)}{at/\hat{\beta}_w} = B, \tag{8}$$

where P', R', and Q' are the marginal reduction in fatality, moderate, and severe injury risk. The variables F, a, w, and t are the probability of incurring the cost L conditional upon nonuse, a factor that converts the wage rate to "the value of time", the wage rate, and the time spent on safety precaution. The ratio (D/λ) is the monetary value of the disutility associated with the use of the safety equipment where λ is the marginal utility of money. Finally, β_w and B are the probit coefficient on *Income* and the net utility of the precautionary behavior, which is also obtained from the probit regressions.

Equation (8) has several unknowns and we therefore follow Svensson (2009) and use established relationships between individual preferences for mortality and morbidity risk. These relationships are based on the concept of death-risk equivalents (DREs) and in line with Svensson we use the official Swedish DREs. Solving Eq. (8) for V, with $\hat{P}'$ taking into account WTP for the non-fatal risks, VSL is estimated by,

$$V = \frac{\frac{Bat}{\hat{\beta}_w} + awt + (D'/\lambda)}{\hat{P}'}. \tag{9}$$

The expected financial loss from being fined (LF) is excluded from Eq. (9). Rear-seatbelt usage was mandatory at the time of the survey, whereas bicycle-helmet usage was not (and still is not for adults).[6] Thus, the fine was indeed zero for the latter, and our decision to exclude LF is therefore only of interest for the former. Whereas the information on L for failure to use the seatbelt is easily available, good measures of F are not. We assume, though, that F is sufficiently small for LF to be negligible and it is therefore excluded from the empirical analysis.

4.3.2. Empirical estimates

To estimate the VSL based on Eq. (9) we need, in addition to β_w and B which we obtain from the probit regressions, estimates for the factor converting work hour value to leisure hour value (a), time spent on safety precaution (t), the monetary disutility of safety precaution (D'/λ), and the risk change ($\hat{P}'$). Moreover, we also need information about the mean wage rate (w). Table 8 describes the variables used in Eq. (9), and shows the mean values used and their origins. The mean wage is based on the respondents' stated income in the survey and is the net individual hourly wage rate.[7]

[Table 8 about here.]

Regarding a, t, and (D'/λ) we follow Hakes and Viscusi (2007) and Svensson (2009) and use estimates from Blomquist (1979) and Blomquist et al. (1996). One consequence of following this approach is that we will use the same values for rear-seatbelt and bicycle-helmet usage. It is reasonable to assume that the time spent on safety precaution (t) and the disutility of using it (D'/λ) differ between seatbelts and bicycle helmets.[8] However, data is not easily available and obtaining new estimates is outside the aim of the paper and not necessary for examining the consistency between stated and observed preferences for

[6] In Sweden it became mandatory to use the front seatbelt in 1975, whereas usage of the rear seatbelt became mandatory for adults (15 years and older) in 1986 and for all passengers in 1988 (Cederlund and Henriksson, 2010). The fine if caught not using the seatbelt was SEK 600 (ca. US$ 100) (Cederlund and Forward, 2007).

[7] Based on 1 800 annual hours worked, converted to consumption units using official weights (respondents were asked about household income), and an average tax rate equal to 31.65% (www.scb.se, 12/1/2011).

[8] The value of time of using the rear seatbelt could be either related to the trip taking longer time, if the driver waits until everyone is buckled up, or to time that is not available for other activities during the trip itself to the backseat passenger. Here we make no distinction between the two.

safety. We, therefore, follow Hakes and Viscusi (2007) and Svensson (2009) and use estimates already available. We use the estimates of changes in risk ($\hat{P}'$) from Svensson (2009), which are based on Swedish accident data and estimates of DREs, and are available for both seatbelts and bicycle-helmets. The mean net utility (B) is positive for seatbelt usage but negative for bicycle-helmet usage. The latter is not surprising given that only 10 percent always use a helmet when riding a bike. Using these estimates together with the other values in Table 8 we obtain a VSL of SEK 20.96 and 147.10 million (US$ 2.64 and 18.50 million) for rear-seatbelt and bicycle-helmet usage, respectively. Hence, the VSL for seatbelt usage is lower than the mean stated WTP, whereas the estimate for bicycle-helmet usage is significantly higher.

5. Discussion

This study employs data from a Swedish CVM study and analyzes stated WTP for traffic safety, the use of traffic safety equipments, and the consistency between the two. We find that the estimated VSL based on the respondents' rear-seatbelt usage is similar to the estimate found using the respondents' stated WTP. However, when estimating VSL based on the respondents' use of bicycle helmets we find a significantly higher VSL; the VSL from bicycle-helmet usage is 7 times higher than the estimate based on seatbelt usage. Moreover, we do not find any strong relationship between risk perception and usage, even if there is a positive, but statistically insignificant, relationship for seatbelt usage. The most important finding for the aim of this study is, though, that we do not find that stated and observed WTP are consistent.

Hence, our finding that stated and observed WTP are not consistent, i.e. there is no correlation between stated WTP and usage, contradicts the finding in Hakes and Viscusi (2007) on US data but is in line with the findings in Svensson (2009) on Swedish data. Two interesting findings were: (i) that the proportions who used the seatbelt and bicycle helmet were positive and on the same levels among those who stated a zero WTP as among those with a stated positive WTP, and (ii) that the regression analysis suggested, if any, a weak negative relationship between stated WTP and usage. These two findings could suggest weaknesses with the hypothetical elicitation approach, i.e. respondents who either stated a zero or a very high WTP did not take the scenario seriously and their responses either reflect protest answers or an exaggerated WTP. However, we did not find any trend between usage and VSL, and thus, even if we would exclude zero answers and those with the highest WTP we would still not find any consistency between stated and observed preferences.

We find that several individual characteristics influence both stated WTP and precautionary behavior. For instance, respondents' income is positively correlated with WTP, in line with the theoretical prediction, but is negatively correlated with seatbelt usage and not statistically significantly correlated with bicycle-helmet usage. A possible explanation for the result regarding seatbelt usage is that wealthier respondents may already have invested in safer car and therefore do not increase their utility by increasing their safety level, since the additional safety comes at a cost. Whereas respondents age has no effect on stated WTP it increases the probability of using both seatbelts and bicycle helmets. Moreover, whereas perceived health status has a positive effect on seatbelt usage in all regressions, we find only a weak positive relationship between health status and bicycle-helmet usage. A positive relationship between health status and the use of safety equipments could be interpreted as healthier individuals having more to lose from an accident and therefore are more likely to use safety equipments.

The VSL estimates from stated WTP and seatbelt usage are in line with other Swedish findings (e.g. Andersson, 2005; Andersson and Lindberg, 2009; Hultkrantz et al., 2006; Johannesson et al., 1996; Persson et al., 2001; Svensson, 2009), whereas the estimate based on bicycle-helmet usage was considerably higher. However, the rejection of proportionality for the stated mean WTP means that the VSL is sensitive to the choice of risk reduction used to estimate it, which was shown in Andersson (2007). For instance, if VSL instead was evaluated at the median risk reduction of the sample, i.e. $\Delta p = 1/100\ 000$, our estimate would instead be SEK 117.35 million, i.e. close to the estimate from the bicycle-helmet usage. Moreover, we have in this paper assumed that individuals' preferences for the three types of risks are similar since they are all related to road safety. The higher level of VSL for bicycle safety compared with car safety (the survey scenario and seatbelt usage) could reflect differences in preferences between the types of risks. We do believe that the large difference found here do not reflect differences in preferences, but is more likely related to the underlying assumptions of the elicitation model used. For instance, the risk reduction of using the bicycle helmet is an order of magnitude smaller compared to the risk reduction of using the seatbelt. Therefore, and to summarize, due to the rejection of non-proportionality of stated WTP and since the estimation of VSL from helmet usage was based on information on time and disutility of using seatbelts, we have most confidence in our estimate based on seatbelt usage. Thus, our preferred VSL based on our analysis is SEK 20.96 million. The lack of consistency between observed and stated WTP raises concern, though.

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Table 1: Summary statistics

Variable	**Description**	**Mean**	**Std. Dev.**	**N**
Income	Household income per consumption unit.	149,602	80,546	713
Male	Binary variable coded as 1 if male	0.56	0.5	730
Age	Age of respondent.	42.87	13.82	730
University	Binary variable coded as 1 if respondent has a university degree	0.36	0.48	730
Health status	Stated health status on a 0-100 scale where 100 is best imaginable health state.	85.06	15.43	720
Road risk	Own perception of the risk of a fatal road accident per 100 000.	9.42	41.79	717
Background risk	Mortality risk per 1 000 from other sources than road traffic	4.19	47.58	490
Car distance	Annual miles by car. 1 Swedish mile equals 10 kilometers.	1,404	752	723
Bicycle distance	Distanced cycled during "normal week" during summer (April-September)	37.85	38.19	721
Accident	Binary variable coded as 1 if respondent has been involved in a road traffic accident.	0.17	0.37	729

Table 2: Regression results: Stated WTP

Variable	Model 1	Model 2	Model 3
Risk change	0.174***	0.162***	0.144***
	(0.047)	(0.046)	(0.047)
Income		0.335**	0.314**
		(0.135)	(0.137)
Male		-0.107	-0.141
		(0.142)	(0.148)
Age		-0.002	-0.001
		(0.005)	(0.005)
University		-0.055	-0.049
		(0.151)	(0.149)
Health status		-0.005	-0.007*
		(0.004)	(0.004)
Background risk			-0.014
			(0.032)
Car distance[a]			0.015
			(0.009)
Accident			0.144
			(0.167)
Intercept	1173.490***	39.098	49.355
	(95.101)	(62.154)	(79.136)
N	532	532	532
R^2	0.267	0.278	0.284

Standard errors in parentheses
Significance levels: * 10%, ** 5%, *** 1%
a: Car distance divided by 100 in the regression.

Table 3: Distribution of precautionary behavior

Bicycle helmet	Rear seatbelt Always	Sometimes	Never	Total
Always	71	2	0	73
	97.26	2.74	0.00	100.00
	11.95	1.96	0.00	10.03
Sometimes	58	6	0	64
	90.63	9.38	0.00	100.00
	9.76	5.88	0.00	8.79
Never	465	94	32	591
	78.68	15.91	5.41	100.00
	78.28	100.00	92.16	81.18
Total	594	102	32	728
	81.59	14.01	4.40	100.00
	100.00	100.00	100.00	100.00

Note: Column values are in the order: number of observations, row percentages, and column percentages.

Table 4: Precautionary behavior and risk perception

	Rear seatbelt			Bicycle helmet		
	Always	Sometimes	Never	Always	Sometimes	Never
Females	3.47	3.33	2.63	3.93	4.03	3.52
	(3.10-3.88)	(2.02-5.49)	(1.68-4.13)	(2.52-6.12)	(2.79-5.81)	(3.09-4.02)
	303	38	16	40	30	250
Males	3.32	3.23	3.18	2.76	3.27	3.38
	(2.98-3.71)	(2.48-4.21)	(1.99-5.10)	(1.73-4.40)	(2.30-4.64)	(3.01-3.79)
	360	68	24	35	34	333
Total	3.88	3.27	2.95	3.33	3.60	3.44
	(3.13-3.67)	(2.56-4.16)	(2.14-4.08)	(2.42-4.57)	(2.81-4.62)	(3.15-3.75)
	663	106	40	75	64	583

Note: Values refer to the geometric mean, the 95% confidence interval in parentheses, and number of observations.

Table 5: Relationship of VSL and averting behavior

VSL	Rear seatbelt		Bicycle helmet	
(Million SEK)	Proportion	(std.err.)	Proportion	(std.err.)
$VSL = 0$	0.80	(0.05)	0.12	(0.04)
$10 \geq VSL > 0$	0.88	(0.04)	0.07	(0.03)
$40 \geq VSL > 10$	0.73	(0.04)	0.08	(0.03)
$100 \geq VSL > 40$	0.93	(0.03)	0.15	(0.04)
$200 \geq VSL > 100$	0.76	(0.04)	0.09	(0.02)
$VSL > 200$	0.81	(0.02)	0.10	(0.01)

Table 6: Rear seatbelt usage

	Probit			Ordered probit		
Variable	Seatbelt 1	Seatbelt 2	Seatbelt 3	Seatbelt 4	Seatbelt 5	Seatbelt 6
Income	-0.004*	-0.004*	-0.004*	-0.004*	-0.004*	-0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Male	-0.170	-0.145	-0.129	-0.161	-0.126	-0.111
	(0.140)	(0.142)	(0.144)	(0.135)	(0.138)	(0.139)
Age	0.016***	0.016***	0.016***	0.015***	0.015***	0.015***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
University	0.154	0.166	0.181	0.175	0.195	0.212
	(0.139)	(0.141)	(0.142)	(0.135)	(0.137)	(0.138)
Health status	0.012***	0.012***	0.012***	0.010***	0.011***	0.010***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Road risk[a]	0.133	0.050	-0.291	0.331	0.188	-0.008
	(1.381)	(1.382)	(1.416)	(1.325)	(1.325)	(1.352)
Background risk[a]	0.002	0.002	0.001	0.001	0.000	-0.000
	(0.006)	(0.006)	(0.006)	(0.003)	(0.005)	(0.005)
Car distance[a]	-0.092	-0.083	-0.073	-0.070	-0.065	-0.060
	(0.090)	(0.092)	(0.092)	(0.087)	(0.089)	(0.089)
Accident	0.035	0.012	0.012	0.031	0.012	0.008
	(0.176)	(0.178)	(0.178)	(0.170)	(0.172)	(0.173)
VSL		$1 \cdot 10^{-4}$			$-2 \cdot 10^{-4}$*	
		$(1 \cdot 10^{-4})$			$(1 \cdot 10^{-4})$	
$10 < \text{VSL} \leq 100^{b}$			-0.098			-0.061
			(0.171)			(0.166)
$100 < \text{VSL}^{a}$			-0.299*			-0.260
			(0.176)			(0.170)
Intercept	-0.384	-0.422	-0.298			
	(0.415)	(0.419)	(0.438)			
Intercept 1				-0.549	-0.543	-0.631
				(0.396)	(0.403)	(0.422)
Intercept 2				0.271	0.291	0.199
				(0.393)	(0.400)	(0.419)
N	538	518	518	538	518	518
Pseudo-R^2	0.045	0.046	0.051	0.033	0.037	0.037

Standard errors in parentheses
Significance levels: * 10%, ** 5%, *** 1%
a: Variables divided by 1,000 in regressions.
b: Denotes million SEK.

Table 7: Bicycle helmet usage

	Probit			Ordered probit		
Variable	Helmet 1	Helmet 2	Helmet 3	Helmet 4	Helmet 5	Helmet 6
Income	-0.004	-0.004	-0.004	-0.002	-0.002	-0.003
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Male	-0.394**	-0.444***	-0.441***	-0.284**	-0.324**	-0.314**
	(0.165)	(0.169)	(0.170)	(0.133)	(0.136)	(0.137)
Age	0.016**	0.015**	0.014**	0.013**	0.010*	0.010*
	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)
University	0.631***	0.605***	0.608***	0.580***	0.588***	0.576***
	(0.175)	(0.178)	(0.179)	(0.140)	(0.143)	(0.143)
Health status	0.005	0.011	0.011	0.007	0.013**	0.013**
	(0.006)	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)
Road risk[a]	0.870	0.950	0.799	0.574	0.701	1.108
	(1.748)	(1.819)	(1.876)	(1.476)	(1.503)	(1.530)
Background risk[a]	$-5 \cdot 10^{-4}$	-0.076	-0.077	$-2 \cdot 10^{-6}$	0.002	0.003
	(0.004)	(0.070)	(0.070)	(0.002)	(0.004)	(0.004)
Bicycle distance	0.001	0.001	0.001	0.003*	0.003*	0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Accident	0.182	0.152	0.155	-0.000	-0.067	-0.066
	(0.205)	(0.214)	(0.214)	(0.176)	(0.184)	(0.184)
VSL		$-2 \cdot 10^{-5}$			$-3 \cdot 10^{-5}$	
		$(2 \cdot 10^{-4})$			$(2 \cdot 10^{-4})$	
$10 < \text{VSL} \leq 100^a$			-0.036			0.220
			(0.211)			(0.178)
$100 < \text{VSL}^a$			-0.109			0.159
			(0.231)			(0.190)
Intercept	-2.311***	-2.633***	-2.600***			
	(0.633)	(0.733)	(0.748)			
Intercept 1				2.105***	2.422***	2.569***
				(0.517)	(0.559)	(0.575)
Intercept 2				2.557***	2.884***	3.032***
				(0.520)	(0.563)	(0.579)
N	478	459	459	478	459	459
Pseudo-R^2	0.085	0.095	0.095	0.055	0.061	0.063

Standard errors in parentheses
Significance levels: * 10%, ** 5%, *** 1%
a: Variables divided by 1,000 in regressions.
b: Denotes million SEK.

Table 8: Values used to estimate revealed VSLs

Variable	Description	Value used	Source
$\hat{P}'$	Marginal reduction in risk	1.16×10^{-4} (seat belt)	Svensson (2009)
		1.26×10^{-5} (bicycle helmet)	Svensson (2009)
a	Factor converting work hour value to leisure hour value	0.6	Blomquist et al. (1996)
w	Mean wage rate	56.00	Survey
t	Time spent on the safety precaution	1.67 hours/year	Blomquist et al. (1996)
D'/λ	Monetary disutility of undertaking safety precaution	2,128	Blomquist (1979) and Hakes and Viscusi (2007)
β_w	Probit coefficient on wages	0.004 (seat belt)	Seatbelt 1 (Table 6)
		0.004 (bicycle helmet)	Helmet 1 (Table 7)
B	Overall probit score	0.932 (seatbelt)	Survey responses
		-1.383 (bicycle helmet)	