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AUTOMOBILE SEATBELT USAGE:  
THE VALUE OF A STATISTICAL LIFE  
AND FATALITY RISK BELIEFS

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Abstract

This article examines the rationality of seatbelt usage using an original data set of 465 adult respondents. People with high stated values of statistical life, who do not smoke, and who have risk beliefs that are highly elastic with respect to actual risks are more likely to use seatbelts, as economic theory predicts. Respondents' stated values of statistical life were similar on average to the value of life range of \$2.2 million to \$7.9 million computed from their revealed preferences for seatbelt usage, providing empirical support for the mutual consistency of these two approaches.

Key Words: seatbelts, value of statistical life, risk

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# **The Rationality of Automobile Seatbelt Usage: The Value of Statistical Life and Fatality Risk Beliefs**

Jahn K. Hakes and W. Kip Viscusi

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## I. Introduction

Two principal ways by which people can reduce their health and safety risks are by choosing safer activities or by taking additional precautions while engaging in a risky activity. Use of seatbelts is a very effective precaution for reducing the occupants' risk of injury and death while riding in a motor vehicle.

A substantial economic literature has emerged analyzing the efficacy of seatbelts in affecting safety,<sup>1</sup> the desirability of using seatbelts from a benefit-cost standpoint,<sup>2</sup> and the implications of seatbelt use for making inferences about the individual's willingness to bear health risks, or the implicit value of a statistical life.<sup>3</sup> Most studies suggest that on balance wearing seatbelts is a safety precaution for which the benefits to the average individual exceed the costs.<sup>4</sup> There is now widespread usage of seatbelts, as reflected in the 79% seatbelt usage rate reported by the National Highway Traffic and Safety Administration (NHTSA, 2000).

Seatbelt usage reflects many rational elements. Seatbelts impose disutility costs from limiting range of motion and sometimes require time to fasten, but at the same time offer

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<sup>1</sup> See, among others, Peltzman (1975), Blomquist (1988), and Cohen and Einav (2003).

<sup>2</sup> See Arnould and Grabowski (1981) and Levitt and Porter (2001).

<sup>3</sup> See Blomquist (1979), Winston (1987), and Blomquist, Miller and Levy (1996).

<sup>4</sup> For some people, the disutility of seatbelt use may exceed the safety benefits. In addition, Peltzman's (1975) offsetting behavior hypothesis acknowledges the theoretical possibility that safety innovations could be negated by more aggressive driving habits so that the overall effect on safety is diminished. Cohen and Einav (2003) found somewhat different results, as there was no significant evidence of offsetting behavior for seatbelts after correcting their empirical model for simultaneity.

safety benefits. With the advent of mandatory seatbelt use laws in nearly all states, usage reduces expected penalties as well, and Cohen and Einav (2003) demonstrate that usage rates rationally increase when laws are imposed, and increase more for primary enforcement than for secondary enforcement.<sup>5</sup> Yet even with these rules, seatbelt usage is far from universal. Not all people may find that the safety and legal compliance benefits exceed the disutility costs. The observed tradeoffs between safety and disutility have been used to assess people's implicit value of life, beginning with estimates by Blomquist (1979). Estimates of the value of statistical life (VSL) implied by seatbelt usage decisions are consistent with the broad range of similar estimates based on labor market decisions. However, the seatbelt use estimates tend to be at the low end of the estimated value of life range.

In the process of estimating VSLs from seatbelt use, we introduce an element for which there has been no previous empirical analysis. If seatbelt usage is rational, mortality risk perceptions will influence the decision. People who assess the risk reduction benefits of seatbelts as being greater should be more likely to wear seatbelts, other things equal. Detailed data on a wide range of individual mortality risk beliefs will enable us to assess how risk beliefs affect seatbelt usage decisions. Our results suggest that the individuals whose risk beliefs are most responsive to changes in the actual risk level are indeed the most likely to buckle up.

In addition to estimating the implicit value of life from seatbelt use decisions, we also employ an alternative analytical strategy. We use value of life estimates from an original stated preference survey and link these to seatbelt usage. Stated preference values for improved traffic safety have been developed by economists such as Jones-Lee (1989), and

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<sup>5</sup> Secondary enforcement means that citations for seatbelt nonuse are only issued after a motorist has been pulled over for another offense, while primary enforcement allows law enforcement officers to stop a vehicle for seatbelt nonuse even in the absence of another misdemeanor.

there should be a relationship between these values and seatbelt usage. If people's attitudes toward risk are consistent across different choice domains, as theory indicates should be the case, people with higher values of statistical life should be more likely to use seatbelts.

Rather than simply assessing whether higher stated values of life increase the propensity to use seatbelts, we will also estimate the value of life implied by the safety-disutility tradeoff and compare the VSLs estimated implied by the two methods. Although meta-analyses such as Blomquist (2004) and Viscusi and Aldy (2003) have compared ranges of VSL amounts estimated in different studies, only one other study, a job fatality risk compensation study by Lanoie, Pedro, and Latour (1995) has previously attempted to reconcile VSLs from averting behavior with VSLs from stated preferences.<sup>6</sup> Whereas that paper derived market-based VSLs from the choice of risky jobs, our market evidence is derived from protective actions that reduce risk within a hazardous activity, the operation of a motor vehicle. In this paper we find mutual consistency in the stated values of life affecting seatbelt usage and the values of life based on revealed preferences. Furthermore, we also present broader evidence supporting the rationality of people's seatbelt use decisions by identifying significant relationships between seatbelt use and theoretically predicted covariates.

Section II explores previous research on the value of statistical life, with particular attention paid to studies that estimate willingness to pay for reduced risk of fatality through the averting behavior of seatbelt usage. Section III develops the theoretical framework linking seatbelt usage to the value of statistical life and the character of risk beliefs. Using an original data set of 465 adult respondents, Section IV develops several measures of the accuracy of

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<sup>6</sup> In the same vein, Viscusi and O'Connor (1980) compared the implicit value of job injuries based on market data and survey data regarding chemical risks.

mortality risk beliefs and their responsiveness to changes in actual risk levels. The regression results in Section V document the expected positive linkage between the individual's value of life and seatbelt use and explores the variety of ways in which the structure of mortality risk beliefs affects seatbelt usage. In Section VI, we reverse the analytical approach to examine the values of statistical life implied by the revealed preferences for seatbelt use, and in Section VII we demonstrate that this comparison yields results consistent with the stated preference findings. Section VIII presents concluding observations with respect to the rationality of seatbelt use decisions and the public policy implications of our research.

## II. The Value of Statistical Life

The primary variable of interest in our theoretical analysis is the value of a statistical life (VSL). Market-based estimates of VSLs pertain to the tradeoffs an individual makes between perceived or actual fatality risks and some cost measure that can either be pecuniary, as in the case of wages, or nonpecuniary, as in the case of the discomfort associated with seatbelts. Articles by Miller (2000), Viscusi and Aldy (2003), and Blomquist (2004) survey dozens of studies in this vein.

On a theoretical basis the VSL levels elicited in contingent valuation studies should be the same as those emerging from studies of actual behavior if the character of the deaths and the populations at risk are similar. Dionne and Lanoie (2002), however, have suggested that the VSL for transportation risks could differ from the VSL for job fatality risks because the nature of the deaths may differ. The difference in the character of the risks will not affect our analysis since both the contingent valuation and market-based estimates both focus on motor-vehicle fatality risks.

Several previous articles have done across study comparisons of the VSL amounts implied by averting behavior and contingent valuation methods. Miller (2000) found that VSLs derived using the contingent valuation method were higher than VSLs from averting behavior, whereas Viscusi (1993) found them to be similar in magnitude to the estimates implied by labor market studies. Blomquist (2004) surveyed the revealed preference literature and concluded that estimates of VSL based on consumption behavior “fall in the range of estimates based on averting behavior in the labor market (p. 104).”

The first study to derive an estimated VSL implied by the self-protection decisions people make was Blomquist (1979). His analysis, which estimated the VSL based on the tradeoff between reduced risk from seatbelt use and the value of time and disutility of using seatbelts, generated a VSL of \$0.9 million. Subsequent estimates in Blomquist, Miller, and Levy (1996) using three different sets of assumptions generated VSL amounts ranging from \$2.0 million to \$9.3 million.<sup>7</sup> These estimated VSLs implied by seatbelt use are broadly consistent with market evidence in a wide variety of contexts. The literature survey by Viscusi and Aldy (2003) found a median VSL in market situations of \$6.6 million, with many estimates from the labor market and product market being similar to those implied by seatbelt use.

People also reveal their risk-money tradeoff with respect to auto safety risks through decisions other than seatbelt use. An alternative approach to assessing the VSL with respect to motor-vehicle fatalities has been to examine the implied VSL using a hedonic price equation relating automobile prices to the fatality risks of those models. Based on that approach, Atkinson and Halvorsen (1990) derived VSL estimates of \$4.8 million to \$6.3

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<sup>7</sup> All estimates are in year 1998 dollars unless otherwise indicated.

million, while Dreyfus and Viscusi (1995) estimated a range from \$3.6 million to \$5.1 million.

A third set of analyses has focused on the values people place on reduced risks due to use of child safety seats.<sup>8</sup> These deaths are not comparable to the risks to adults, but the literature is of interest in that it involves protective behavior and uses estimation approaches similar to the seatbelt analysis. Carlin and Sandy (1991) estimated the VSL associated with child safety seats as \$1.0 million, while Blomquist, Miller, and Levy (1996) estimated a range from \$3.5 million to \$6.2 million.

These empirical studies necessarily require a variety of empirical assumptions to estimate the VSL. For example, the seatbelt use studies utilize information on the values of time based on the individual's wage multiplied by an estimate of the time to buckle up, an estimate of the person's disutility costs, and an assumed efficacy of seatbelt effectiveness to derive the VSL. A more direct approach is to directly ask survey respondents their willingness to pay for a small risk reduction, and mathematically scale these stated preferences into a VSL, as in Jones-Lee (1989). Lanoie, Pedro, and Latour (1995) both collected stated preferences for reductions in workplace fatality risks and estimated compensating wage differentials for the same sample of individuals. While they state that "the wage-risk values lie within the confidence interval surrounding the WTP [contingent valuation willingness-to-pay] value defined at the 5% level (p. 251)," but after using nonparametric bootstrap sampling methods finally concluded that "the values obtained from both methods were different from each other for the sample of unionized workers (p. 254)."

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<sup>8</sup> A final approach is to use highway speed limits to infer an implicit value of life. See Ashenfelter and Greenstone (2002).



Our approach here is similar to the Viscusi and O'Connor (1990) methodology for job injury risks and the Lanoie, Pedro and Latour (1995) methodology for job fatality risks in that we compare VSLs based upon stated willingness to pay for risk reductions to revealed preferences. However, the context of our analysis and the market decision reference point differs in that we focus not on the discrete decision to accept a dangerous job, but rather on risk averting behavior reflected in the decision to use seatbelts. Our comparison of the two VSL amounts demonstrates individuals' consistency between revealed preferences and stated preferences and provides evidence in support of the rationality of people's seatbelt use decisions.

### III. Theoretical Framework

Previous analyses have shown that the choice of wearing seatbelts involves striking an appropriate balance between the costs of safety precautions and the resulting benefits. We can formulate a person's expected utility level ( $Z$ ) associated with precautionary behavior as

$$Z = f(V, I, S, D, M), \quad (1)$$

where

$V$  = implicit value of life,

$I$  = implicit value of an accidental injury,

$S$  = the level of safety precaution taken (here a 0-1 decision to use seatbelts),

$D$  = the non-monetary level of physical discomfort from wearing a seatbelt while driving, and

$M$  = the amount of monetary cost due to noncompliance with seatbelt laws through fines, and potentially through insurance rates.

The marginal expected utility with respect to seatbelt usage will depend upon the perceived reductions in mortality and injury risks from using seatbelts, the time and discomfort costs of seatbelt usage, and the likelihood of being caught while not wearing one's seatbelt. We have chosen parameters so as to adapt the framework articulated by Blomquist (1979) and Blomquist, Miller and Levy (1996) for estimating VSL amounts from seatbelt usage decisions. Based on their analyses, the first-order condition for undertaking a safety measure (that is, with respect to S), taken at the means of all variables, and after rearrangement of terms, is

$$\frac{P'V + R'I + LM - awt - \left(\frac{D'}{\lambda}\right)}{\left(\frac{at}{\beta_w^*}\right)} = B, \quad (2)$$

where

$P'$  = the perceived marginal reduction in mortality risk,

$R'$  = the perceived marginal reduction in injury risk,

$L$  = the perceived likelihood of incurring financial cost  $F$  conditional upon seatbelt nonuse,

$a$  = a factor converting work hour wages to monetary value of leisure hours,

$w$  = the wage rate,

$t$  = the time spent on the safety precaution,

$D'$  = the marginal nonpecuniary disutility of undertaking the safety precaution,

$\lambda$  = the marginal utility of money,

$\beta_w^*$  = the probit coefficient on wages, and

$B$  = the overall probit score where the probit results pertain to the probability of using seatbelts.

We have above defined  $P'$  and  $R'$  as changes in perceived risks rather than changes in actual risk. How risk perceptions  $P$  and  $R$  respond to the chosen level of precautions ( $c$ ) such as seatbelt use will affect the optimal level of precautions. If this relationship is flat and risk beliefs  $P(c)$  and  $R(c)$  are not greatly affected by  $c$ , precautions will appear to be ineffective, and a low level of precautions will be desired. Thus, a key concern from an empirical standpoint is developing measures of how risk beliefs change in response to changes in the actual risk level that result from differing levels of precautions.

For concreteness consider the fatality risk case, as the nonfatal risk perception analysis is similar. Suppose that it is possible to characterize risk beliefs  $P(c)$  by the beta distribution, which is quite flexible and can assume a wide variety of shapes. In particular, let

$$P(c) = \frac{\eta p + \xi q(c)}{\gamma + \xi}, \quad (3)$$

where  $p$  is a prior risk belief of the fatality risk that will prevail with standard precautions,  $q(c)$  is the actual risk associated with precautions of level  $c$ ,  $\gamma$  is the informational content associated with  $p$ , and  $\xi$  is the informational content associated with  $q$ .<sup>9</sup> This formulation is consistent with rational Bayesian learning as well as other models of risk beliefs.

Figure 1 illustrates the relationship between perceived risks and actual risks.<sup>10</sup> The 45 degree line indicates how perceived risks would track actual risks if risk beliefs were accurate. The perceived risk line shown is consistent with the results of a large number of empirical studies on the subject.<sup>11</sup> The relationship between perceived risks and actual risks is flatter than what would prevail if perceptions accorded with actual risk beliefs. The vertical

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<sup>9</sup> It is also possible to make the prior risk belief  $p$  a function of  $c$  with no change in the principal predictions that will be the basis for the empirical work that follows. In particular, people whose risk beliefs are very elastic with respect to the level of safety precautions  $c$  will be more likely to take precautions.

<sup>10</sup> This figure is a variant on the analysis in Viscusi (1998) based on his prospective reference theory model.

<sup>11</sup> See Lichtenstein et al. (1978) for the basic estimation model. More recent treatments can be found in Viscusi (1998) and Hakes and Viscusi (2004).

intercept of the risk perception curve is given by  $\gamma p / (\gamma + \xi)$ , which could equal zero if people assessed actual risk levels of zero correctly. Thus, there may be a discontinuous downward jump in risk beliefs when the actual risk is zero. The slope of  $P(c)$  is given by  $\xi / (\gamma + \xi)$ , which makes the perception curve flatter than the line for which perceived risks equal actual risks. In the specification of the model where risks are measured in logarithmic units, this slope represents the elasticity coefficient of risk perceptions with respect to changes in actual risk.

The practical consequence of a relationship following the shape of that shown in Figure 1 is that people may underestimate the efficacy of seatbelts. Suppose the actual risk level is given by  $q_0$  if seatbelts are not worn and  $q_1$  if seatbelts are used. The actual change in risk that results from seatbelt use is shown in Figure 1 as  $r_0^* - r_1^*$ . However, due to the inelasticity of risk perceptions with respect to the actual risk level, the perceived difference is smaller and is given by  $r_0 - r_1$ . As an individual's perceived risk curve becomes flatter, the quantity of safety he thinks he is "buying" becomes smaller. If people underestimate the relative safety improvement associated with seatbelt use, they will under-invest in safety precautions and will be less likely to wear seatbelts. In terms of the previous model, if

$$r' = \frac{\xi q'}{\gamma + \xi}, \quad (4)$$

where  $q'$  is the marginal effect of safety precautions on the fatality risk, then the desired level of safety chosen will be below what would be efficient in the full information situation if  $(\xi / (\gamma + \xi)) < 1$ , or if  $\gamma > 0$ . Thus, whether there people will fail to use seatbelts to a sufficient degree will hinge in part on whether people's risk perceptions are sufficiently elastic with respect to changes in the actual risk level.

Finally, if risk beliefs are always accurate, then under the assumptions of this model, protective actions will be efficient based on the true probabilities. How risk belief structures

actually affect seatbelt use consequently is an empirical issue that hinges on the shape of the risk perception function. As Figure 1 and the theoretical development indicate, developing a measure of how accurately people perceive the safety benefits of seatbelt use depends on how responsive their risk beliefs are to changes in the actual risk level.

#### IV. Stated VSLs and Mortality Risk Beliefs

We estimate the VSL amounts from a survey of 465 adult respondents undertaken in 1998 as part of a broader survey on risk issues. Because only 89 people in the sample did not use seatbelts, the sample size is relatively small, but nevertheless we will find significant effects for the key matters of concern. The general approach of using a survey to elicit willingness to pay for safety is in the same vein as the stated preference approach to valuing traffic safety used by Jones-Lee (1989) and Viscusi, Magat, and Huber (1991). A marketing firm in Phoenix, Arizona recruited subjects through random-digit dialing and paid each \$40 to come to a central location to fill in a half-hour long survey questionnaire pertaining to a series of risk issues.<sup>12</sup> The sample reflected a broad cross section of society, but not a random sample of the entire U.S. population, so that it is important to control the estimates for differences in demographic characteristics. Because the sample is all drawn from a single city, state differences in sanctions for failure to use seatbelts do not enter the analysis.

Table 1 provides the demographic characteristics and VSL amounts for three groups: the full sample, people who always use seatbelts, and those who never or only sometimes wear seatbelts.<sup>13</sup> On average, the sample was 44.3 years old, had 14.6 years of schooling, was 10 percent nonwhite, and was 69 percent female. Subsequent regression analysis will control for these personal characteristics.

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<sup>12</sup> Overall, 493 people were surveyed, but 10 respondents did not answer the seatbelt use question and 18 did not give sufficient mortality risk perception responses, producing a sample size of 465.

<sup>13</sup> The three possible responses were for wearing seatbelts “always”, “sometimes” or “never.”

The VSL variable is calculated from respondents' expressed willingness to pay for a one year reduction in their risk of death due to an automobile accident. The wording of the question was as follows:

“Suppose you could reduce your annual risk of death in a car crash by 1/10,000. Thus, if there were 10,000 people just like you, there would be one less expected death per year in your group. This risk reduction would cut your annual risk of death in a car crash in half.

How much would you be willing to pay each year either for a safer car or for improved highway safety measures that would cut your motor-vehicle risks in half?”

Respondents chose from a range of responses: \$0 to \$50, \$50 to \$200, \$200 to \$500, \$500 to \$1,000, and above \$1,000. A final possible option was that respondents could indicate that their willingness to pay was “infinite—all present and future resources.” Such responses are inconsistent with private risk taking behavior and suggest that the respondent did not think carefully about the question. The 9 percent of the sample who indicated an infinite value did not appear to be extraordinarily safety conscious in other respects.

The median respondent indicated a willingness to pay that implied a VSL of \$2 million to \$5 million. This range is consistent with other stated preference results for motor-vehicle risks. For example, the survey by Jones-Lee (1989) found a VSL for traffic safety in the U.K. of \$5 million, while the U.S. survey by Viscusi, Magat, and Huber (1991) found that people valued reduced risks of automobile fatality at a median value of \$3.6 million.

The sample had an average stated VSL of \$5.1 million, using the midpoints of the ranges for purposes of calculation. Seatbelt users had a VSL of \$5.3 million, as compared to \$3.9 million for those who sometimes or never wear seatbelts. Of those in the sample who always wear seatbelts, 70.9 percent are women, as compared to 58.9 percent of those who sometimes or never wear seatbelts. Seatbelt users are more likely to be better educated, and

much less likely to smoke, as smoking rates are 18.9 percent among seatbelt users and 37.8 percent among those who sometimes or never use seatbelts.

Table 2 provides a different summary perspective on the data in terms of seatbelt usage rates for people with the demographic characteristics indicated in the first column. The breakdown in Table 2 indicates that 80.6 percent of the sample reported that they always use seatbelts. Thus, 83.4 percent of women always use seatbelts, as compared to 74.7 percent of all men. The seatbelt usage statistics are roughly in line with national seatbelt usage at the time.<sup>14</sup> In a National Highway Transportation Safety Administration (NHTSA) survey in 2000, men report using seatbelts 74 percent of the time, and women use seatbelts 84 percent of the time, which are almost identical to the usage rates in our sample. Seatbelt usage is higher than in previous studies of seatbelt use due to our oversampling of females and increasing legal penalties over time for failure to buckle up that were not present in earlier eras. Other patterns in Table 2 are that the rate of seatbelt use generally increases with age and that people with more education use their seatbelts more often, which one would expect due to the higher present values of their lifetime wealth. Due to the relatively small number of minorities in our sample, we find no statistically significant patterns of seatbelt use by race.

Two differences between those who always use seatbelts and those who never use seatbelts are most noteworthy. Seatbelt wearers are more likely to be female, which is consistent with gender differences in risk taking behavior.<sup>15</sup> Second, people who always wear seatbelts are less likely to be current smokers. Cigarette smoking is an extremely dangerous

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<sup>14</sup> NHTSA (2000, at Table 4) reports survey results from 1998. See the report on <http://www.nhtsa.dot.gov/people/injury/research/SafetySurvey/index.html#Part2>.

<sup>15</sup> See Hersch (1998) for a review of gender differences in willingness to bear health and safety risks.

personal consumption activity that is strongly connected with a variety of forms of risky behaviors.<sup>16</sup> Failure to use seatbelts consequently reflects consistent risk taking behavior.

Table 3 presents the distribution of the VSL responses for this survey for broad categories of VSL ranges. Over half of the sample was in the 0-\$5 million range of VSL amounts. The percentage of respondents who always use seatbelts is 12 percent higher for those with a VSL of \$5 million or more as compared to those with a VSL of \$5 million or less.<sup>17</sup> These results are consistent from the standpoint of costs and benefits of seatbelt use; seatbelts represent a highly cost-effective way of reducing mortality risks.<sup>18</sup> Whether seatbelt nonuse is rational has been a continuing concern in the literature,<sup>19</sup> and at least from the standpoint of valuation there is evidence of rationality as higher VSL's are linked to greater seatbelt usage.

Note that the respondents who expressed an infinite VSL do not seem to reflect such a high value of safety in their personal protective decisions. Their seatbelt use rate of 73.8 percent is well below the sample mean and is statistically similar to respondents with low stated VSLs. This behavior suggests that this group of respondents either did not understand the VSL question or were not attending to the survey task.

To identify the determinants of an individual's stated value of statistical life, Table 4 shows the results of an ordered probit regression estimating the stated VSL category or amount as a function of the demographic variables. While the VSL measures are fairly coarse, nevertheless there are two significant relationships with demographic variables. Females indicate higher VSLs at the 90% confidence level, and education is significantly

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<sup>16</sup> See Hersch and Viscusi (1998) and Viscusi and Hersch (2001) for statistics on smokers' risk taking, including their use of seatbelts.

<sup>17</sup> The t-statistic for the difference in proportions test is 3.0, assuming equal variations.

<sup>18</sup> See Arnould and Grabowski (1981) and Levitt and Porter (2001).

<sup>19</sup> Blomquist (1991) provides evidence that is generally in support of rationality in terms of risk competence.



positive at the 95% level, two-tailed test. These effects are consistent with other studies on gender differences in risk taking and the influence of education on risky behaviors.

How people perceive the efficacy of seatbelts plays a critical role in the decision to use seatbelts. To operationalize the accuracy of risk belief concerns reflected in our analysis of Figure 1 we develop a series of measures of risk beliefs based on a mortality risk perception component of the survey in which respondents estimated the total number of people who died in a recent year in the United States from 23 various causes of death.<sup>20</sup> To provide a reference point for the risk assessment, each respondent was told the total number of people—about 47,000—in the United States who had died in automobile accidents in that reference year, which is the standard anchor that previous studies of risk beliefs have given to respondents.

To capture the influence of risk beliefs on seatbelt use we develop variables that capture the slope of the relationship in Figure 1. The measures for characterizing the responsiveness to risk beliefs utilize the elasticity of responsiveness of risk beliefs with respect to mortality risk levels, as people with more elastic risk perceptions should be more likely to use seatbelts than people with less elastic perceptions. The empirical strategy for constructing these measures is based on estimation of individual mortality risk perception curves. For each respondent  $i$  we estimated a risk assessment equation of the form

$$\ln(\text{Perceived Risks}_i) = a_i + b_i \ln(\text{Actual Risks}_i). \quad (5)$$

The slope coefficient,  $b_i$ , is the estimate of the risk perception elasticity with respect to actual risks.<sup>21</sup>

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<sup>20</sup> For a list of these causes see Hakes and Viscusi (2004), which details the correlation of mortality risk perceptions with demographic characteristics.

<sup>21</sup> The  $a_i$  intercept terms across individuals had a mean of 4.283 for those individuals used in our analysis, with an average standard deviation of 2.281. The mean  $b_i$  elasticity coefficient across individuals was 0.475, with a standard deviation of 0.201.

These individual regressions are based on person-specific data sets of 23 data points, where each observation represents the respondent's assessed number of fatalities due to a particular ailment.<sup>22</sup> Due to the relatively large standard errors associated with regressions containing 21 or fewer degrees of freedom, the point estimates for the elasticity are imprecise. Rather than use the point estimates from the risk perception regressions directly, we have chosen to characterize each individual's mortality risk perceptions by quartile, using 0-1 variables to indicate whether the estimate of the risk perception elasticity was in the top quartile or bottom quartile of the sample, so as to isolate the qualitative effects of extreme values for that characteristic.

The elasticity 0-1 dummy variables will capture extremely high and low values of  $b_i$ , and will serve to indicate individuals in the top and bottom quartiles of elasticity of risk perceptions to changes in actual risk. Individuals with larger values for  $b_i$  in equation (5) will perceive higher benefits from reducing actual risk a given amount, other things equal, and should accordingly be more willing to wear their seatbelts to reduce fatality risks. The opposite is the case for people with low risk perception elasticities.<sup>23</sup>

## V. Seatbelt Use Regression Estimates

Seatbelt usage is strongly linked to the respondent's willingness to bear risk and their perception of risks. Table 5 presents the probit estimates for whether the respondent always uses seatbelts for two models. The coefficients reported have been transformed to correspond to the marginal probabilities of usage. Model 1 includes only the value of statistical life

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<sup>22</sup> A small number of respondents refused to estimate fatalities from one or more ailments, so that some of these individual regressions are based upon fewer than 23 observations. Individuals assessing fatalities from fewer than 10 ailments were dropped from the analysis.

<sup>23</sup> If, however, responses at these extremes reflect irrational responses to risk more generally, one would have somewhat different predictions. Assuming seatbelt use is rational, extreme responses that are irrational would tend to be correlated with failure to always use seatbelts.

(VSL) variables and the constructed variables for elasticity of risk perceptions. Model 2 also includes a series of personal background variables. The results are quite robust across the two specifications.

Consistent with the central theoretical prediction, respondents with a higher stated value of statistical life are more likely to always wear seatbelts. As an example, people stating a value of statistical life between \$5 million and \$10 million will have a 3.2 percent greater likelihood of always using seatbelts than people stating a VSL between \$2 million and \$5 million.<sup>24</sup> Interestingly, those who refused to name any finite price for being willing to bear fatality risks were not significantly more likely to use seatbelts. This result is consistent with the hypothesis that those responses reflect a failure to be engaged in the survey task rather than an underlying risk attitude.

The elasticity of perceived risks with respect to actual mortality risk levels indicates a constructive role of risk beliefs. Respondents for whom the slope of the relationship between  $\ln(\text{Perceived Risks})$  and  $\ln(\text{Actual Risks})$  is in the top quartile have a steeper risk belief curve and are more likely to assess the risk reduction effects of seatbelts as being substantial. Those in the top risk perception elasticity quartile are almost 10 percent more likely to always use seatbelts. This result is consistent with the theoretical model in which the effect of precautions on risk, as reflected in  $P'$  and  $R'$ , should be critical determinants of seatbelt usage. The dummy variable indicating the bottom elasticity quartile is not statistically significant.

The demographic variables perform as expected. Females are more likely to use seatbelts, which is consistent with their lower rates of risk taking behavior in other contexts. Better educated respondents will have higher levels of lifetime wealth, which should lead

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<sup>24</sup> At first glance, this may not seem like a large increase, but given the high prior levels of seatbelt use, a 3 percentage point increase from 80% usage to 83% usage reduces the proportion of nonusers by 15%.

them to be more safety conscious, but this influence will be captured in part by the value of statistical life variable. Similarly, better educated people will be more knowledgeable about risk, but this effect will be reflected at least in part by the series of risk belief variables. There is nevertheless a positive effect of education on seatbelt usage even after controlling for these correlated influences.

The negative smoking status effects are of particular interest. Smokers incur considerable smoking-related fatality risks and engage in a wide variety of other risky behaviors.<sup>25</sup> That smokers are 12 percent less likely to always use seatbelts, controlling for all other factors, is reflective of these differences in attitudes toward health and safety risks.

## VI. VSLs as Revealed through Seatbelt Use

The preceding analysis used the respondents' stated risk premiums for automobile safety to examine whether the person's expressed VSL levels are consistent with seatbelt use. In contrast, the majority of the previous literature uses seatbelt use decisions to infer a VSL for some population. Here we will examine the VSL amounts implied by seatbelt use to see whether they are consistent with the stated preference values.

The established framework for estimating VSL amounts from seatbelt usage decisions is articulated by Blomquist (1979) and Blomquist, Miller and Levy (1996). We adapted this framework to introduce possible financial penalties imposed by law enforcement officials and insurance companies and to allow for subjective risk perceptions which differ from objective risk levels.

To facilitate the computations of VSL for the traditional range of disutility costs, and to maintain comparability to the previous literature, we also adapt several parameter estimates

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<sup>25</sup> See Hersch and Viscusi (1998) and Viscusi and Hersch (2001) who link smoking and seatbelt usage to the willingness to incur job risks and riskiness on the job

from Blomquist, Miller and Levy (1996), who drew on several outside sources. For instance, they assume  $t$  is 4 seconds per trip times 1,504 trips/year, or 1.67 hours/year, and that  $a = 0.6$ . They use federal highway survey data to estimate that  $I = 0.0315 V$ , and that  $R' = 12.145 P'$ . Using those statistical relationships, they collapse  $P'V$  and  $R'I$  into one term in two parameters while solving for  $V$ .

Blomquist (1979, at 546) uses the parameter estimates from his probit model of observed seatbelt use to calculate the model at the hypothetical point where the probability of buckling up is near 1.00 ( $p_{\text{buckle}} = 0.99$ , so that  $B = 2.326$ ), and assumes that at that point  $U_s = 0$  so that that term will drop out. He is then able to solve for a lower-bound on the average  $V$  using just the average wage rate and the  $\beta_w^*$  term from the probit regression.

The complete list of parameters used in the Blomquist model, and the assumptions we have used to construct our VSL estimates, is presented in Table 6. The modifications introduced are made so the model will be applicable to our survey context. For instance, using the context of the survey question on willingness to pay for risk reduction, wherein the probability of a fatal accident was reduced by 1 in 10,000, we set  $P'$  at 0.0001.

Nonetheless, several of the original assumptions are retained. For instance, we accept that the ratio of mortality risk reductions to nonfatal injury reductions has remained unchanged, and use Blomquist's value of 0.382. Similarly, we use Blomquist's values of 0.6 for  $a$  and 1.67 hours/year for  $t$ .

A key component of the analysis is the annual disutility cost of using seatbelts. Estimates for disutility are on the order of hundreds of dollars. Blomquist (1979) estimated this value at \$265 (1998 dollars). Winston (1987) estimated disutility costs as \$1,012 (CPI-adjusted into 1998 dollars), which seem high, as Blomquist noted. We use these estimates as

hypothetical upper-bounds and lower-bounds on disutility costs. This method will, of course, abstract from some individual differences in VSL across the sample since we are assuming the disutility costs to be identical for individuals, but still allows us to obtain a sense of the range of individual VSLs.

Since Blomquist's initial article, passage of mandatory seatbelt laws and primary enforcement laws have added an additional consideration in seatbelt use decisions. The expected penalties paid through failure to use seatbelts would appear as a positive term in the numerator of equation (2), and would be equal to the average fine paid when caught times the expected number of tickets received per year. Our sample was drawn from Arizona in 1998. In that year Arizona had secondary enforcement laws in place. Cohen and Einav (2003) report that the implementation of secondary enforcement in 1991 temporarily raised seatbelt usage from 55% to 65%, but that by 1998, usage had fallen back to 62%, indicating that the law was not a significant deterrent to nonuse. Consequently, for ease of estimation we assume that LM is sufficiently near zero to disregard that term in the model.<sup>26</sup>

Although our survey did not collect wage or income data, it did obtain responses for age, education, gender and race, all of which are significant determinants of wages. Using the values of those demographic characteristics, we imputed wages for our sample respondents. To convert demographics into an estimated wage, we took wage and demographic data from the 1998 Current Population Survey's March Demographic supplement and ran a log-wage

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<sup>26</sup> A hypothetical average fine of \$50 and one expected ticket per year would decrease the marginal VSL required to decide to use seatbelts by about \$360,000. Estimating the perceived risk of being caught over an annual period, however, is problematic. Periods of heightened enforcement, such as "Click it or ticket" programs over holiday weekends can temporarily raise the perceived number of tickets received *at an annual rate* by a significant amount, perhaps to higher than 1.0. It is thus possible to argue both that during "business-as-usual" periods of traffic enforcement, when the probability of being caught is very low, the expected penalties are not high enough to encourage universal seatbelt use and have negligible effect, and also that periods of heightened enforcement can be effective at temporarily increasing seatbelt usage.

regression on all civilians in the full-time labor force.<sup>27</sup> The coefficients from the wage regression were applied to our survey respondents to estimate each person's wage level.

In order to obtain an estimated slope coefficient for wage, the imputed wages were included in a probit regression model of seatbelt use alongside the female indicator variable and educational attainment and the respondent's risk perception indicators, resulting in a probit coefficient of 0.047.<sup>28</sup>

Gathering together the estimates into equation 7 we can solve for  $V_i$ :

$$\frac{0.0001382V_{i,low} - \hat{w}_i - 265}{\left(\frac{1}{\beta_w^*}\right)} = \beta_i, \quad (7a)$$

and

$$V_{i,low} = \frac{\left(\left(\frac{\beta_i}{\beta_w^*}\right) + w_i + 265\right)}{0.0001382}. \quad (7b)$$

The equations for the  $V_{i,high}$  estimates differ only in using the annual disutility cost of \$1,012 instead of \$265 as the final term in the numerator. Both models are parameterized so that the predicted VSL increases by \$14,614 for each \$1 increase in estimated wages. Using the 10<sup>th</sup> and 90<sup>th</sup> percentiles of wages in the CPS March Demographic Supplement at \$5/hour and \$30/hour, this creates computed VSLs which vary by more than \$365,000 even when holding disutility costs constant. Finally, the responsiveness of stated VSLs to imputed wages is

<sup>27</sup> That regression, based on a sample of 50,845 observations, explained 28.34 percent of the variation in log-wages, with an F-statistic of 1827. The estimated equation is  $\text{LN(WAGE)} = 0.556 + 0.086 \text{ AGE} - 0.000856 \text{ AGE SQUARED} - 0.349 \text{ FEMALE} - 0.134 \text{ BLACK} - 0.149 \text{ HISPANIC} - 0.072 \text{ ASIAN} - 0.172 \text{ AMERICAN INDIAN OR PACIFIC ISLANDER} - 0.272 \text{ HIGH SCHOOL DROPOUT} + 0.140 \text{ SOME COLLEGE} + 0.209 \text{ COLLEGE GRADUATE} + 0.550 \text{ GRADUATE SCHOOL}$ . All coefficients were statistically significant at the 99 percent confidence level, with  $|t| > 4.5$ . The omitted baseline group was white male high school graduates.

<sup>28</sup> As the imputed wages are a linear combination of the demographic variables, the least statistically significant demographic variables, race and age, were omitted from the model. As a test of robustness, various combinations of the demographic variables were included in the probit regression, but the wage coefficient remained fairly stable in the range 0.43-0.48. The respondent's stated VSL was omitted from this model, as the point of this exercise is to test the reliability of those responses.

positive, with a point estimate of \$64,778, but given the large standard error associated with the wage estimation, this result is not statistically significant. As the stated VSL question asked for a categorical response, a traditional correlation coefficient between stated VSL and estimated wage is not appropriate, but an ordered logit regression resulted in a positive coefficient for estimated wage, although it was significant only at the 75 percent confidence level. This is consistent with the regression results in Table 4, which show little correlation between the stated VSLs and the demographic variables.

#### VII. Comparison of Stated Preference and Revealed Preference VSLs

The resulting VSL estimates are well within the accepted ranges for value of statistical life, and are shown in Table 7. Our  $V_{i, \text{low}}$  estimates, which are based on the disutility costs of \$265/year from Blomquist (1979), yield a mean of \$2.15 million, with individual estimates ranging from \$1.87 million to \$2.45 million. By way of comparison, the stated VSL value for the median respondent in the sample was \$2 million to \$5 million. When Winston's (1987) disutility costs of \$1,012/year are used instead, the mean  $V_{i, \text{high}}$  is \$7.56 million, with individual estimates ranging from \$7.27 million to \$7.86 million. Roughly one-third of all respondents had stated VSL values in this range, as 18 percent had VSL amounts from \$5 million to \$10 million, and 15 percent had a stated VSL above \$10 million.

Comparison of the computed VSLs to the mean and confidence interval of the stated VSL also reveals strong similarities. In our survey sample, the mean stated VSL—conditional on giving a response other than “infinite value”—was \$5.11 million, with a standard error of \$0.23 million. The 95 percent confidence interval for the conditional mean lies entirely within the computed VSL range.



## VIII. Conclusion

Individual self-protection through seatbelt usage embodies many aspects of rationality, which provide empirical support for previous efforts to impute values of statistical life to seatbelt usage. People with high values of statistical life will be more likely to use seatbelts. The values of statistical life obtained through stated preferences for one aspect of automobile safety were comparable in this survey to values of statistical life obtained through the respondents' observed behavior. The estimates for the revealed VSL amounts from seatbelt use bracketed the stated preference VSL amounts. This result provides evidence of the mutual consistency that should be observed between stated preference values for expressed willingness to pay for safety and revealed preference values based on actual risk taking decisions. Other determinants of seatbelt use were of interest as well. People with risk beliefs that are very elastic with respect to actual risks will be more likely to use seatbelts, as theory predicts. Demographic variables such as education, gender, and current smoking status also perform in the expected manner.

Nevertheless, all people do not use seatbelts all the time, which is seemingly inconsistent with economic calculations indicating that the benefits of seatbelt use outweigh the costs. Such calculations, however, ignore possible heterogeneity in the costs of precautions and the likely benefits, which will vary with the type of vehicle driven, where the vehicle is driven, and how the vehicle is driven.

Individuals' failure to perceive the benefits of seatbelt usage has long been a policy concern. To the extent that decisions can be altered through informational campaigns it is by increasing the extent to which people will perceive accurately the risk reduction achievable through seatbelts. Whether there is a major informational failure that must be remedied can be

assessed by examining the broader implications of our results. If seatbelt usage is in fact inadequate, one would expect the stated VSL levels to exceed the VSL amounts revealed through seatbelt usage. However, our estimated VSL amounts based on seatbelt usage, which reflect the implications of decisions of whether or not to use seatbelts, yielded VSLs comparable to the stated preference values. This consistency in stated and actual risk tradeoffs suggests that there is no major market failure in this domain of preventive activity. Protective actions are being undertaken in a manner that is consistent with people's preferences toward risk. This pattern is exactly what we would expect if people are making rational decisions.

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Table 1  
Summary Statistics, by Seatbelt Usage Group

Variable	Mean (Std. Errors of the Mean)		
	All groups	People Who Always Use Seatbelts	People Who Sometimes or Never Wear Seatbelts
Age	44.3 (0.7)	44.8 (0.8)	42.5 (1.8)
Female = 1	0.686 (0.022)	0.709 (0.023)	0.589 (0.052)
Education (in years)	14.64 (0.12)	14.86 (0.13)	13.70 (0.22)
Nonwhite = 1	0.095 (0.014)	0.099 (0.015)	0.078 (0.028)
Current smoker = 1	0.226 (0.019)	0.189 (0.020)	0.378 (0.051)
Value of Statistical Life (\$ millions)	5.085 (0.244)	5.345 (0.277)	3.949 (0.484)
Infinite VSL	0.090 (0.013)	0.083 (0.014)	0.122 (0.035)
Sample size	465	375	90

Table 2  
Percentage of People Who Always Wear Seat Belts, by Demographic Group

Demographic Group	Observations	Mean (Std. Error of Mean) Always use belts
All respondents	465	0.806 (0.018)
Male	146	0.747 (0.036)
Female	319	0.834 (0.021)
White	420	0.802 (0.019)
Nonwhite	44	0.841 (0.056)
Current smoker	105	0.676 (0.046)
Former smoker or non-smoker	360	0.844 (0.019)
Education: less than high school diploma	17	0.706 (0.114)
Education: high school diploma	84	0.679 (0.051)
Education: some college	189	0.799 (0.029)
Education: college degree	125	0.864 (0.031)
Education: graduate degree	50	0.940 (0.034)
age: 18 – 24	49	0.694 (0.067)
age: 25 – 44	182	0.797 (0.030)
age: 45 – 64	172	0.872 (0.026)
age: 65 and over	59	0.746 (0.057)

Table 3  
Relationship of Value of a Statistical Life to Seatbelt Use

Respondent's Value of Statistical Life (\$ millions)	Percentage of sample in VSL range	Percentage (Std. error of mean) of individuals in VSL range who always wear seatbelts	Percentage (Std. error of mean) of individuals in VSL range who never wear seatbelts
0 to 5.0	58.3	77.1 (2.6)	4.1 (1.2)
5.0 to 10+	32.7	88.8 (2.6)	3.9 (1.6)
"Infinite – all present and future resources"	9.0	73.8 (6.9)	4.7 (3.3)

Notes:

N = 465.

Tests: Paired two-tailed t-tests of the equality of seatbelt use among individuals in the \$0 to \$5.0M range; \$5.0 to \$10.0M range, and infinite value category gave the following results, assuming equal variances:

\$0 to \$5.0M vs. \$5.0M to \$10.0M:  $t = 2.985$ ,  $p = 0.003$ ;

\$5.0M to \$10.0M vs. infinite value:  $t = 2.476$ ,  $p = 0.014$ ;

\$0 to \$5.0M vs. infinite value:  $t = 0.471$ ,  $p = 0.638$ .



Table 4  
Ordered Probit Estimates of the Stated Value of Statistical Life (VSL)

	Coefficient (Standard error)
Age	-0.006 (0.020)
Age-squared	$3.50 \times 10^{-5}$ ( $21.63 \times 10^{-5}$ )
Female	0.175* (0.106)
Education	0.041** (0.021)
Nonwhite	-0.133 (0.170)
Current Smoker	-0.017 (0.119)
Observations (Pseudo)	461
R-squared	0.01

Note: The dependent variable ranks categories from lowest to highest willingness-to-pay, with “infinite value” receiving the highest order.

\* -- Significant at 90% confidence level; two-tailed test

\*\* -- Significant at 95% confidence level, two-tailed test.

Table 5  
 Probit Estimates for Whether Always Use Seatbelts

	Coefficient (Asymptotic Std. Error)	
	<u>Model 1</u>	<u>Model 2</u>
Value of Statistical Life (VSL)	0.009 (0.004)**	0.008 (0.004)**
Infinite VSL	-0.016 (0.065)	-0.017 (0.063)
Top 25% most elastic mortality perceptions	0.097 (0.039)**	0.096 (0.038)**
Bottom 25% least elastic mortality perceptions	-0.020 (0.044)	-0.003 (0.042)
Age		0.0007 (0.0012)
Female		0.113 (0.042)***
Education		0.028 (0.008)***
Nonwhite		0.071 (0.048)
Current Smoker		-0.121 (0.049)***
Observations	465	461
Pseudo R-squared	0.029	0.102

Notes: Probit coefficients have been converted into slope coefficients, with an assumed 0-1 change for dummy variables. Significance levels for two-tailed tests are \*\*\* -- 99 percent, \*\* -- 95 percent, and \* -- 90 percent.

Table 6.  
Values Used in Estimation of Revealed VSL Using Blomquist (1979) Method

Variable	Description	Value used	Source
P'	marginal reduction in mortality risk	0.0001	survey question context
V	value of statistical life		
R'	marginal reduction in injury risk	12.145 P'	Blomquist (1979)
I	value of injury prevention	0.0315 V	Blomquist (1979)
a	fudge factor converting work hour value to leisure hour value	0.6	Blomquist (1979)
w	wage rate	individual specific, based on demographic variables	1998 Current Population Survey
t	time spent on the safety precaution	1.67 hours/year	Blomquist (1979)
L	perceived annual number of times caught for nonuse	jointly considered de minimis, based on Arizona seatbelt usage before and after 1991 law, and small magnitude relative to D'	Cohen and Einav (2003)
M	monetary penalty for seatbelt nonuse, conditional upon being caught		
D'	marginal nonpecuniary disutility of undertaking the safety precaution	\$280 and \$1069 for ratio (D'/ $\lambda$ )	Blomquist (1979) and Winston (1987), respectively
$\lambda$	marginal utility of money		
$\beta_w^*$	probit coefficient on wages	0.047	auxiliary regression, using 1998 Current Population Survey and survey responses
B	overall probit score	individual specific, as estimated earlier	survey responses

Table 7.  
Estimated VSLs, Using Blomquist (1979) Method

Disutility value used	Mean	Low end of range	High end of range
\$265 (Blomquist, 1979)	\$2.15 million	\$1.87 million	\$2.45 million
\$1012 (Winston, 1987)	\$7.56 million	\$7.27 million	\$7.86 million

Figure 1

Relationship of Perceived and Actual Risks

