Values of Risk Reduction Implied by Motorist Use of Protection Equipment

New Evidence from Different Populations

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1. Introduction

Workers receive wage premiums for jobs that carry risks to health and well-being, and consumers buy goods that reduce risks to life and health. From their implicit or explicit payments, willingness-to-pay measures of the values of risk reduction are derived, based on the magnitude of the change in risk from the good or activity relative to its cost. One such approach is to study choices made by motorists to avoid accidental death and injury. Choices include use of seat-belts, use of child restraint systems, and use of helmets by motorcyclists. Values are determined by examining the tradeoff of time and convenience for increased safety. These values incorporate potential losses of quality of life as well as potential losses of income.

Willingness-to- pay measures are important for public policy decisions. Almost every US regulatory analysis monetising life-saving benefits has used willingness-to-pay values since 1986 (Scodari and Fisher, 1988). Willingness-to-pay measures are now required by government directive (US Office of Management and Budget, 1989) in the valuation of governmental projects that affect life or health, including projects that affect traffic safety. These values are used for evaluating traffic safety in Canada, New Zealand, Sweden and the UK, and are gaining acceptance throughout European and Nordic countries. Willingness-to-pay measures are gaining wider acceptance in evaluation associated with health and medical policy also (Tolley, Kenkel and Fabian, 1994).

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A question that arises in evaluating different programmes is whether to apply the same valuation for all individuals.[1] Values of life, or more precisely the values of mortality risk reduction, are generally estimated for the average or representative individual from a sample of buyers or users. However, many life savings programmes are intended to benefit those whose characteristics are not likely to be typical. For example, individuals engaged in behaviour such as sky diving, riding motorcycles, smoking, heavy drinking, or crime might be expected to imply lower life valuations.[2] The problem also arises in other guises. For example, safety choices are made by one individual for others, such as when parents decide for their children.

Another issue in the application of personal loss evaluations is whether values derived for specific activities depend upon the amount of time spent upon the endeavour. In particular, some have questioned whether individuals evaluate small increments of time with the same degree of consideration and foresight as larger time commitments.[3] This issue has immediate relevance to the question of whether value of loss estimates from studies of activities involving small amounts of time, such as raising speed limits or requiring seat-belt use, are applicable to more general safety issues.

The purpose of this paper is to derive the implied values of reducing the risks of fatal and non-fatal injuries for different road user populations. Our analysis relies on an approach developed by Blomquist (1979) and empirical results from a recent study by Blomquist (1991) which examines the use of safety-belts, child restraint systems and motorcycle helmets. We use results from the recent study together with information on risks and time costs to derive the implicit value of life-saving and injury-reducing activity. Values for "typical" adults, for children as implied by their parents' actions, and for adults who ride motorcycles are obtained. Because the study examines activities involving small amounts of time, we also consider whether individuals evaluate small time increments consistently with larger time allocations.

2. Valuing Traffic Safety Risks

Blomquist (1979) has developed a model for the analysis of consumer activities which reduce risk, such as seat-belt use. If consumers engage in risk-reducing activity until the additional gain just equals the additional cost, and if the cost is known, the implied

1 The literature is predicated upon the assumption that individuals make informed or relatively well informed choices. While some behavioural studies indicate that risk is not always accurately assessed, much of the literature indicates that individuals do make informed decisions and that the implicit valuations appear reasonable and relatively consistent over the better studies (Hammerton *et al.*, 1982; Miller, 1990; Viscusi, 1992).

2 For further discussion on differences across populations, see Miller (1990) or Blomquist (1982). Some of the more general, philosophic implications regarding the use of different loss value measures are discussed below. The question also arises whether those engaged in risky behaviour are to be considered in estimating personal loss; for example, are those individuals atypical and, thus, inappropriate for consideration in estimating personal loss? For an attempt to control for risk propensities, see Garen (1988).

3 See, for example, Tipping (1968) or Thomas and Thompson (1970). For a review of the literature, see Miller (1989) or Waters (1991).

willingness to pay can be estimated. For example, consider an individual who incurs a cost of \$100 per year to obtain protection which reduces the risk of fatal accident per year by 0.0001. If the individual would pay just the \$100 and no more, and there are no other benefits than the reduction in fatality risk, then the implicit value of risk reduction is: (cost/risk reduction) = value of risk reduction, or \$100/.0001 = \$1 million. Actual estimation is more complex because the maximum amount individuals are willing to pay must be estimated and because there may be benefits in addition to reduction in fatality risk. The estimation approach used in this paper is based on consumer behaviour. The hypothesised behavioural model of protection is based upon the individual net benefit concept.

Blomquist begins with a representative individual who maximises current utility and a future utility contingent upon the probability of survival. Expenditures are made upon present and future consumption and upon activities which increase safety, all subject to the constraint of present and future income and assets. The individual can increase the probability of survival by incurring costs of reduced consumption (and disutility) associated with the activity. Of interest is the first-order condition for safety-increasing activity. The equation can be written as:

$$(P_F' V_F + P_{NF}' V_{NF}) - (q + U_s/z) = 0, \qquad (1)$$

where P'_F and P'_{NF} are the increases in annual probabilities (P) of survival (F) and avoiding non-fatal injuries (NF) due to the intrinsic increase in protection; V_F and V_{NF} are the values of decreases in fatal and non-fatal risks; q is the time-use cost incurred; U_s is the marginal disutility associated with the activity; and z is the marginal utility of income. U_s/z is the monetary value of the disutility cost associated with the activity. The equation simply states that the marginal benefits of a safety-increasing activity (the first term) are equated to the marginal time and disutility costs (the second term). Stated another way, on the left-hand side of equation (1) the safety benefits shown in the first bracket minus the costs shown in the second bracket equal zero.

Average implied values for V_F and V_{NF} can be obtained if we have an estimate of average individual net benefit. If we have micro data on individual use of protection equipment and we estimate a probit (regression) to explain individual usage, then we can estimate average individual net benefit. Specifically, equation (1) can be written for an average individual as:

$$(P_F' V_F + P_{NF}' V_{NF} - q - U_s/z) / \sigma = B', \qquad (2)$$

where B' is the standardised net benefit from the activity, and σ standardises net benefits for the average individual.[4] B' and σ are directly obtained from estimates of the net benefit equations for samples of individuals engaged in consuming risk-affecting goods. Blomquist

[4] If the individual can adjust safety activity in small enough increments, then the individual will engage in safety activity just up to the point where the marginal benefit equals the marginal cost. The net benefits of additional safety activity will be zero as shown in equation (1). In contrast, when observing safety activity for a sample of people for whom the safety activity is either engaged in or not, the net benefits will be zero for people who are indifferent about engaging or not and non-zero for the others. The net benefits will be positive for those engaging in the activity and negative for those not engaging in the activity. Hence, average B' is not necessarily zero and must be estimated.

(1979) uses probit analysis to estimate a net benefit equation for seat-belt use. B′ is estimated as β^*x', where $\beta^* = \beta/\sigma$ is a vector of coefficients from the estimation equation for net benefits and x' are the mean values of the independent variables. Income and education are used as proxy variables for V_F and V_{NF} since we do not have direct measures for them.[5] The estimated probit equation is evaluated at the means of the explanatory variables. Since the probit is normalised we must get an estimate of σ if we are to get an estimate of the net benefits in monetary units. To derive σ, we know the time-use costs of seat-belt use are:

$$q = awt, \tag{3}$$

where w is the wage rate and t is the amount of time used. The constant a allows the value of time to differ from the wage rate and also converts the hourly wage rate and daily time use costs (wt) to annual costs. We have estimates of a, w and t from other sources. Hence, we have a value for q. We also know that β^*_w, the coefficient of user cost at its mean value, equals β_w/σ. In turn, β_w yields an estimate of the effect of time-use costs on safety-belt use (the partial derivative of q with respect to w) so that $\beta_w = at$. Hence $\sigma\beta^*_w = at$, from which it follows that $\sigma = at/\beta^*_w$. Thus, values for B′ and σ in equation (2) can be obtained from estimates of a net benefits equation.

To obtain values for V_F and V_{NF}, information on the parameters P'_F, P'_{NF}, t and U_s/z is still required. The values for P'_F and P'_{NF}, the increases in the probabilities of avoiding fatal and non-fatal injury, are obtained from outside sources. To distinguish V_F and V_{NF} below, we use information from outside sources on the relationship between fatal and non-fatal losses.[6] Two different approaches to obtain values for t and U_s/z are used. We either rely on other sources for values of these parameters, or use an indirect method adopted by Blomquist (1979).[7] With a value for the disutility cost from an outside source, equation (2) can then be solved for the values of risk reduction for the typical individual. The essence of this approach is reflected in the simple example given at the beginning of this

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5 Variation in the proxy variables does turn out to contribute to the variation in motorist use of safety equipment. Blomquist (1991) reports, for the equations in this paper, elasticities with respect to income of 0.19 for seat-belts and 0.11 for motorcycle helmet use. The elasticities with respect to years of schooling turn out to be 1.80 for seat-belts and 0.29 for child safety equipment. It should be noted that to the extent that these proxies represent factors other than the value of safety improvements, they may bias the estimated values of safety.

6 Blomquist (1979) bases estimates of non-fatal injury losses mostly on lost wages. The analysis here allows for other personal losses besides wages.

7 The indirect method used in Blomquist (1979) involves finding the disutility cost implied when everyone (actually 99 per cent of individuals) engages in the risk-reducing activity. If costs of use are zero, then everyone would use the protective equipment since there is a valuable gain in risk reduction. Using the estimated net benefits equation, we can calculate the values for the Vs when the time and disutility costs are zero. The term $(P_F'V_F + P_{NF}'V_{NF})/\sigma$ is simply equated to the value of B with complete (99 per cent) use, 2.326. Given the estimates of the Vs for the typical individuals, not for the users alone, and given that we already know q, we can then solve equation (2) for an estimate of disutility cost, U_s/z. The strength of this approach is diminished if the proxies for V_F and V_{NF} measure other determinants of the use of safety equipment. The extent to which the proxy variables work is indicated by whether or not they have the theoretically expected signs, and more broadly by whether or not the resulting estimates of the willingness to pay for safety compare in expected ways with estimates arrived at through other estimation methods. Such comparisons are noted in the text in discussing results.

section in which we calculated a value of fatal risk reduction of $1 million. However, the actual estimation is more complex, primarily because we must account for the fact that the typical individual does not use protective equipment and is not indifferent between bearing the costs of use and getting the benefits as we assumed in the example. The net benefits equation permits us to estimate B' and σ so that estimates of values of risk reduction for the typical individual are obtained.

A fundamental underlying assumption in the analysis is that individuals engage in risk-reducing activity when they believe that it is worthwhile. Since this idea is predicated upon informed, accurate decision-making, we consider the effect of differences in perception and information. Better perception and information is expected to increase the activity for the typical individual.

3. Loss of Life Valuations Implied by the Use of Seat-belts, Child Restraints and Motorcycle Helmets

To derive values of personal loss, we rely on estimates from the net benefits equations in Blomquist (1991). The sample is taken from the US Department of Transportation's FHWA (1985) *Nationwide Personal Transportation Study* (NPTS), supplemented with wages estimated with data from the 1980 Census of Population and Housing Public Use tapes. The NPTS surveyed a national probability sample of 7900 households in 50 States and Washington DC about travel in 1983. Separate equations were estimated for samples of potential users of seat-belts, child restraint systems and motorcycle helmets.

Seat-belt use

Blomquist's sample for the seat-belt use equation is all car drivers. Variables included in the logit analysis are: family income; number of children under 16; number of licensed drivers in the household; years of schooling; motorist age; miles driven in the last year; use cost (which is the number of daily trips multiplied by estimated wage rate); vehicle weight; vehicle age; and dummy variables for marital status, vehicle-air-bag equipped, vehicle-passive-belt equipped, and vehicle-combined-belt equipped. The index value for B' with mean safety-belt use of 27 per cent is –0.613. The average net benefits are positive for 27 per cent of drivers, but they are negative for the typical driver. The dollar value of the time use cost coefficient is –0.007572 (from Blomquist, 1991, Table 4). From Blomquist (1979), the time for fastening and unfastening safety-belts is four seconds per trip. This estimate is consistent with survey results by Winston (1987), who finds that the average time, not including unfastening, is three seconds. Time-use cost equals the constant *a* times the sample average of the value of time-use cost ($22.23). The value for *a* is $0.46 per year, estimated as 0.6(365 days/year)(4 seconds/trip)(1/3600 hours/second)(1.89). We use the value of travel time (rather than waiting time), which is 0.6 of the wage rate according to a literature synthesis by Miller (1989). Using the higher value of waiting time would increase the values of fatal and non-fatal injury in proportion to the increase in time value. The wages in 1979 dollars are converted to 1991 dollars using the fractional increase in the Employment Cost Index (for Private Industry) of 0.89.

The value for P'_F is 0.0000739, derived as safety-belt effectiveness (0.45) multiplied by the ratio of driver fatalities in 1982 (24,690) to the number of licensed drivers in 1982 (150,310,000). The value for P'_{NF} is 0.0008977, derived as safety-belt effectiveness in non-fatal accidents (0.55), multiplied by the ratio of moderately and seriously life-threatening injuries to drivers in 1982 (245,337) to the number of licensed drivers in 1982 (150,310,000). The sources are the US Department of Transportation's National Highway Traffic Safety Administration's (NHTSA) *Final Regulatory Impact Analysis, Rescission of Automatic Occupant Protection Requirements* (1981) for effectiveness; NHTSA's *Fatal Accident Reporting System* (1984), Tables 3-1 and 3-4, for driver fatalities; and NHTSA's *National Accident Sampling System* (1984), Table 19, for driver injuries.

Substituting the above parameters into equation (2) yields:

$$(0.0000739\, V_F + 0.0008977\, V_{NF} - 10.226 - U_s/z) \,/\, \{0.46/[-0.625(-0.007572)]\} = -0.613. \quad (4)$$

Since Blomquist (1991) employs a logit procedure, the constant 0.625 converts the logit to a probit coefficient (Maddala, 1983, p.23). The coefficient β^*w is multiplied by –1 to convert it from a cost to a benefit.

Equation (4) has three unknowns, the two values of risk and the disutility cost. To distinguish V_F and V_{NF}, we assume $V_{NF} = 0.0315\, V_F$, based on impairment estimates from Miller (1993). The non-fatal injury estimates are for moderately and seriously life-threatening injuries, Maximum Abbreviated Injury Scale 2-5 (see Association for Advancement of Automotive Medicine, 1985). The impairment estimates are derived from physician ratings for each injury considering typical functional losses over time along six dimensions: cognitive, mobility, daily living, sensory, cosmetic, and pain. To these dimensions Miller adds permanent disability probabilities derived from worker injury data and applies survey-based utilities of functional capacity loss to derive total impairment loss per statistical injury. The total impairments are multiplied by the injury incidence from US Department of Transportation NHTSA's (1984) *National Accident Sampling System* to obtain average impairment across accident injuries.

We use three different methods to incorporate time and disutility costs. The first method is from Blomquist (1979). We find the V_F implied by complete belt use (implying a value for B of 2.326), so that time and disutility costs are zero. Substituting into equation (4), risk values to the nearest thousand dollars are:

$$(0.0001022\, V_F^*) \,/\, 97.2 = 2.326, \text{ so that} \quad (5)$$

$V_F^* = \$\, 2{,}213{,}000$ in 1991 dollars, which implies

$V_{NF} = \$\, 70{,}000$ for moderate to serious non-fatal injury.

The second method adopts Winston's (1987) estimate of the time and disutility cost of safety-belt use ($q + U_s/z$) and solves equation (4) with the net benefit index for actual use, –0.613. Winston estimates belt-use cost from the marginal rate of substitution between vehicle weight and capital costs in a vehicle-type choice statistical model and the marginal rate of substitution between vehicle weight and fastening time in a seat-belt-use statistical model. His estimate of use cost is a seemingly large 60 cents per trip, which is $845.82 per year in 1991 dollars. Substituting into equation (4), risk values are:

$$(0.0001022\ V_F{**} - 856.05) / 97.2 = -0.613 \quad (6)$$

$V_F{**}$ = \$7,795,000 in 1991 dollars, which implies

$V_{NF}{**}$ = \$246,000

The third method is similar to the second, except that an estimate of disutility costs of \$68.09 (\$221.79 in 1991 dollars) is obtained from Blomquist (1979). Substituting into equation (4), risk values are:

$$(0.0001022\ V_F{***} - 232.02)/ 97.2 = -0.613 \quad (7)$$

$V_F{***}$ = \$1,688,000 in 1991 dollars, which implies

$V_{NF}{***}$ = \$53,000

This estimate of disutility costs is for 1972 when safety-belts lacked integral shoulder harnesses. Since the comfort of modern safety-belts probably differs, this method may impart some unknown bias. This estimate illustrates the insensitivity (still a 64 per cent difference) of the value estimates to the use of 1983 and 1972 disutility costs from Blomquist's "all use" method to Winston's "marginal rate of substitution" method.

Child safety-seat use

Blomquist's sample for child safety-seat use includes parents with children under five years of age. Separate equations were estimated for child safety-seat use and for all child safety equipment (seats, harnesses and seat-belts). Variables included in the logit analysis are: family income; number of children under 16; years of schooling; motorist age; miles driven in the previous year; use cost (which is the number of daily trips multiplied by the mean value of adult estimated wage rates); vehicle weight; vehicle age; age of child; and dummy variables for marital status and mandatory safety-seat-use law in the State of residence. The mean value for the household is used for adult personal characteristics when more than one adult is present in the household. We use the first approach in the previous section for inferring disutility and time costs. The coefficient on time-use costs from Blomquist's (1991) child safety-seat equation is –0.002697 (from Table 7). The value for P'_F is 0.00002579, derived as the safety-seat effectiveness in fatal accidents (0.71) times the ratio of fatal injuries to children under five in car accidents (600) to the number of children under five (16,521,000). The value for P'_{NF} is 0.003091= [(0.69)(74,000/ 16,521,000)]. The source for deaths is *US Department of Transportation News*, 8 February 1988; for the number of children under five the source is the US Department of Transportation, FWHA (1986): *Personal Travel in the US*, given as [(0.072)(229,453,000)]; and for measures of effectiveness the source is Kahane (1986). The relationship between V_F and V_{NF}, and the value for time costs are assumed to be the same as for seat-belts for drivers. Substituting into equation (2), the risk values are:

$$(0.0001231\ V_F^c) / 272.9 = 2.326 \quad (8)$$

V_F^c = \$5,154,000 in 1991 dollars, which implies

V_{NF}^c = \$162,000 in 1991 dollars.

The analysis of child safety equipment, which includes safety-belts, also yields implied values if we assume that the time cost is the same. For toddlers, safety-belts have an average effectiveness of 0.295 for fatalities and 0.345 for hospitalised injuries (Miller, Demes and Bovbjerg, 1993). We weighted the effectiveness of seats and belts by their relative use rates in the NPTS to arrive at group effectiveness estimates for safety equipment. The coefficient on time-use costs is –0.005589 (from Blomquist, 1991, Table 7). Substituting these values into equation (2), the risk values are:

$$(0.000106\ V_F) / 131.69 = 2.326 \quad (9)$$

$V_F{}^c$ = \$2,889,000 in 1991 dollars, which implies

$V_{NF}{}^c$ = \$91,000 in 1991 dollars.

Of concern, the asymptotic t value on the wage coefficient is only near one for child seat use, although it is near two (and significant at the 95 per cent confidence level) for equipment use. The difference in the two values of fatal risk reduction may be explained by the large standard error. The second estimate warrants more confidence.

Motorcycle helmet use

The same basic approach as the two earlier cases is used for inferring values of reducing accident risks for motorcycle riders. Variables included in the logit analysis are: family income; number of children under 16; years of schooling; motorist age; miles driven in the previous year; use cost; a dummy variable for marital status; a dummy variable for whether or not the motorcycle is ridden to work; and a dummy variable for whether or not the State of residence requires the use of a helmet. The value for P'_F is 0.0002234, the effectiveness of helmets in reducing fatal injury in an accident (0.29), times the number of rider fatalities in 1983 (4302), divided by the number of registered motorcycles (5,585,112). Fatalities and registrations are taken from US Department of Transportation, NHTSA, *Traffic Safety* (1984), Table A-4, and helmet effectiveness in fatal accidents is taken from Wilson (1989). The time to put on and take off a helmet is assumed to be twelve seconds based on a small trial study. The value of a is 1.3481. The time-use cost coefficient from the motorcycle equation is –0.01446. US Department of Transportation, NHTSA (1988) gives the incidence of non-fatal motorcycle injuries in terms of severity and helmet effectiveness. As with seat-belt use, we applied the impairment data by severity from Miller (1993) to convert non-fatal injuries to fatal equivalents. Substituting into equation (2), the risk values are:

$$(0.0002664\ V_F{}^m) / 152.7 = 2.326 \quad (10)$$

$V_F{}^m$ = \$ 1,333,000 in 1991 dollars, which implies

$V_{NF}{}^m$ = \$42,000 for moderate to serious non-fatal injury.

A limitation of these estimates is that the wage coefficient is not statistically significant at usual levels. It is almost significant at the 0.10 level using a one-tailed test. This calculation is merely illustrative for a population about which more should be learned.

Sensitivity, discounting and the value of time

The estimated values of traffic safety risks depend upon various assumptions and parameters. One is that consumers accurately assess risk. If motorists think they are safer on the road than they really are or think that equipment is less safe than it actually is, the perceived expected benefit of equipment use is lower than its actual value. As a consequence, such users have higher values than our estimates. Users who overestimate accident risks or overestimate equipment effectiveness have lower values than our estimates. Using the correction factor for under-perception of 1.634 from Blomquist (1982) to adjust the safety-belt-use estimates, we obtain a value of approximately $3.6 million (in 1991 dollars). Even if parents perceive the risk to themselves less accurately than the risk to their children, they still probably value their young children's lives more than their own. If the same misperception about seat-belts applies to child safety equipment and motorcycle helmet use, then those implied values should also be greater by the same 63.4 per cent.

The safety of child safety-seats depends upon proper installation and use. If the seats are incorrectly fastened, the effectiveness is impaired. Our estimates, however, are unaffected as long as parents think they are getting the full protection. A potentially more important concern is that we used the same estimates for fastening a child's safety equipment as for an adult's seat-belt. The time use may be higher for fastening children than adjusting one's own belt. It may also involve additional aggravation or loss of enjoyment (from not holding the child) or greater enjoyment (from seeing the child safe or more confined). Higher time costs and disutility would imply higher losses.

The value estimates are also affected by the value of time relative to the motorist's wage rate. If the value of time is actually 0.5 of the wage instead of the 0.6 used here, the estimated risk values reported here should be multiplied by 0.833. If the value of time is actually equal to the wage, then our estimates should be multiplied by 1.667. If the four seconds required to use a child safety-seat were an underestimate, the effect on the value of safety gains would again be multiplicative (that is, $V_F \times$ usage time/4 seconds).

The estimates may also be affected by differences in the number of years of life remaining for each of the populations. Controlling for differential life spans, adults still tend to value children more than themselves, although the difference shrinks. To show this, we computed the value per statistical life year. This value equals the value of statistical life divided by the average expected life span. The latter value was computed using a life table, and the age and sex distribution of the fatally injured. Without discounting future years, children have an average of 73.8 life years remaining and a value of $39,000 to $70,000 per life year. Crash-involved adults have an average of 42.6 years of life remaining and a value of $52,000 per life year. The value overlap between children and adults shrinks if we discount future years, disappearing entirely at a 2.5 per cent interest rate. That rate is probably below the discount rate that is typically applied in valuing future life years (Moore and Viscusi, 1990; Cropper *et al.*, 1992). Motorcyclists have more life years remaining than the average crash-involved driver. Thus, compared to a statistical life, the gap between them and other drivers widens for the value of a statistical life year.

Equation (4) may also be used to estimate the value of time by substituting the mean value of statistical life from the meta-analysis of Miller (1990) and the value of U_s/Z from Blomquist (1979). In 1991 dollars, the mean value of life from Miller (1990), adjusted from actual to perceived highway risk, is $1,541,000.

The resulting equation, where t is the value of travel time as a fraction of the wage rate, is:

$$[0.0001022(1{,}541{,}000) - 221.79 - 17.04t]/\{0.7665t/[0.625(-0.007572)]\} = -0.613 \quad (11)$$

Solving for t, we find that the value of travel time is 0.7864 of the wage rate. However, since the estimate of disutility costs is based on belt usage in 1972, the comfort of more modern safety-belts may imply some variation in the estimate.

Our results on time values have some interesting implications for evaluating activities involving small amounts of time. The estimate that the time value for seat-belt use is 0.78 of the wage rate for four-second increments of travel time suggests that the small increments are valued comparably to larger amounts of travel time. To our knowledge, this admittedly crude evidence is the first empirical estimate of the value of small time allocations.

4. Conclusions

The individual net benefit approach yields implicit values which are estimates for the values of reducing fatal and non-fatal injury risk. Before adjusting for risk perception, our best estimate of the value of fatal risk for car drivers is approximately \$2 million. This estimate is well within the range suggested by other studies (Miller 1990; and Viscusi, 1993). It is less than our estimates of \$3-5 million for children by parents and greater than the illustrative example of about \$1 million for motorcyclists. Our best estimate of the value of non-fatal risk for all drivers is approximately \$70,000 for moderate to serious injuries, with a range from \$160,000 for children to \$40,000 for motorcyclists.

The value for children is much higher than that found by Carlin and Sandy (1991).[8] It is more consistent with other studies. Cropper and Sussman (1988), building upon Arthur's (1981) theoretical framework, estimate that US willingness to pay for other family members is 40 to 53 per cent of total willingness to pay, which translates to 70 to 110 per cent of willingness to pay for oneself. Needleman (1976) examines kidney transplant data from the UK. Some manipulation of his data suggests that the willingness to pay of other family members in the household is 55 to 78 per cent of one's own willingness to pay. Miller and Guria (1992) found New Zealanders value other immediate family members' lives at about 119 per cent of willingness to pay for their own.[9]

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[8] The Carlin and Sandy estimate is about \$500,00 in 1985 dollars. The reasons for their estimate being lowr than ours include their more limited sample, their use of human capital measures, their failure to incorporate disutility costs, or, of course, the limitations of our estimates.

[9] Using surveys, others have sought values for passengers' lives. Jones-Lee *et al.* (1987) found British willingness to pay for a (possibly unrelated) passenger was 23 to 41 per cent of willingness to pay for oneself. Maier *et al.* (1989) found an Austrian driver's willingness to pay for a passenger was 24 to 27 per cent of willingness to pay for oneself. In Sweden, Persson (1989) found a value for passengers in a car of 26 to 50 per cent. Jones-Lee (1991, 1992) concludes that individual values and the values of others are only partially additive when estimating societal willingness to pay. Under some special conditions, only own willingness to pay counts. Jones-Lee (1992) suggests societal willingness to pay probably exceeds individual willingness to pay by 10 to 40 per cent.

The finding of lower personal evaluations for those displaying a preference for high risk activity is consistent with findings by Hersch and Viscusi (1990) on wage-risk tradeoffs.

Our study suggests that there are differences in valuation depending upon who is making choices regarding risk avoidance activities. The magnitude of divergence for the different populations merits further attention; though it should be noted that the value for motorcyclists is within one standard deviation of the values obtained by others — for example, Miller (1990). Such information may affect the decision of whether different values should be used in benefit-cost analysis depending on who is affected by a particular government programme or regulation. Other issues, however, also come into play. For example, adults acting on behalf of their children may not take into account all the relevant social costs and benefits to future generations. Those engaging in dangerous activities, such as crime or alcohol abuse, may be viewed as the victims of society, and, therefore, should not be implicitly penalised for their lower life valuations. Of course, one can ask whether or not it is appropriate to value individuals differently in a society that claims to be democratic or egalitarian.

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