Value of Life Saving: Implications of Consumption Activity

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This paper focuses on the typical individual's value of a small change in the probability of his survival. With a simple life-cycle model, the value is shown to be implied by consumption activity which affects risk. The premium an individual is willing to pay to reduce risk is estimated using probit analysis of automobile seat-belt use. The "value of life" is found to be about $370,000. This estimate is contrasted with the foregone-earnings approach by showing that a surplus value above earnings exists and the elasticity of the value with respect to earnings is less than one.

Society must inescapably place a value on life saving if it is to allocate its resources efficiently. The measure most frequently recommended by economists has been foregone earnings, which has been used in many variants (e.g., see Dowie 1970, Weisbrod 1971, and Faigin 1975). However, the relevance of the foregone-earnings measure has been increasingly questioned. Despite its numerical manageability, foregone earnings is unsatisfactory because there is little theoretical basis for its use. Foregone earnings neglect the value of nonmarket activity as well as the surplus value of living and unreasonably imply that the value of life saving for self-sufficient persons, housewives, and retirees is zero.

Schelling (1968) and Mishan (1971*b*) argue that the relevant benefit measure of an endeavor which affects human life is one based on an individual's willingness to pay for a marginal change in the probability of his survival. Empirical estimates of the value of life saving based

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on individual willingness to pay are nearly nonexistent. The notable exception is the work of Thaler and Rosen (1975), who analyze a sample of 900 individuals in 37 occupations and estimate risk-compensating wage differentials. When, for ease of reference only, the risk premiums are extrapolated to unit (0–1) changes in the probability of death, they imply what is conveniently referred to as a value of life of about $390,000 in 1978 dollars.[1] A possible source of upward bias in the Thaler and Rosen estimate is the neglect of disamenities associated with risky occupations. A possible source of downward bias is that those employed in risky occupations either cope with risk more efficiently or like risk more than the representative individual. It is desirable to try other approaches free from these biases.[2]

The purposes of the present paper are (*a*) to develop a simple model of individual life-saving activity and to show how the value of life saving is implied by observable behavior,[3] and (*b*) to estimate a value of life based on the premium individuals are willing to pay in the consumption activity automobile seat-belt use to reduce the risk of accidental death.[4]

Section I presents a life-cycle framework with risk of death in which an individual maximizes expected lifetime utility. The framework explains the derived demand for life-saving activity and implies a necessary relation among the productivity of life-saving activity, the costs of life-saving activity, and the value of life. This relation provides a basis for estimating the value of life. Section II gives empirical results and a brief description of the seat-belt survey data and the variables used along with the rationale for each. It is found that multivariate probit analysis, using the economic and traffic safety variables suggested by the model, provides a statistically highly significant explanation of the variation in seat-belt use among drivers. Value-of-life estimates are presented in Section III. The probit

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[1] "Value of life," as the term is used in this paper and in Thaler and Rosen (1975), is based on changing the probability of survival by a small amount. For easy comparison among situations where the changes are small but unequal and lack of an accepted unit of account only, the value of a marginal change is extrapolated to a unit (0–1) change. Clearly, it is inappropriate to apply any such value of life to a situation where an identifiable person faces certain death. All conversions to 1978 dollars are made using the average annual Consumer Price Index, except for 1978 when the June figure is used.

[2] Dillingham (1979) estimates risk-compensating wage differentials for male blue-collar workers in manufacturing and construction and finds a value of life of $290,000 in 1978 dollars. Jones-Lee (1976) summarizes existing empirical studies, few of which are based on willingness to pay.

[3] Independently of the work of this paper, Conley (1976) developed a theoretical model of the demand for safety based on the willingness-to-pay concept.

[4] Analysis of seat-belt use is suggested by Bailey (1968) in his discussion of Schelling's paper.

results are combined with estimates of average seat-belt productivity and average seat-belt use cost to estimate a value of life. Information from outside the sample is used to convert the standardized probit results to actual values. Disutility costs are estimated from the parameterized probit equation. The probit results are further used to establish a relationship between the estimated value of life and foregone earnings. Section IV contains the conclusions.

I. Theory of Life-saving Activity and the Value of Life

Life-Cycle Model with Risk of Death

For an individual concerned with the present period, which he is certain to survive, and one future period, which he will survive with some probability, the expected utility is

$$E(U) = U(C_1, S) + PU(C_2), \tag{1}$$

where $E(U)$ is expected lifetime utility and $U(C_1, S)$ is period 1 utility, which depends on period 1 consumption (C_1) and life-saving activity (S). The appearance of S in $U(C_1, S)$ allows for a disutility (it could be utility) of life-saving activity over and above the resource cost of life-saving activity which appears in the budget constraint. The variable P is the probability of survival to the end of period 2, and U (C_2) is the utility of period 2 consumption (C_2).

Life-saving activity is a choice variable which for the individual affects the probability of survival (P) and the probability of (nonfatal) injury (R). The production function for P is $P = P(S), P' > 0$; and the production function for R is $R = R(S), R' < 0$, reflecting the gain in avoiding injury costs.

Life-saving activity (S) affects expected lifetime utility in three ways: (*a*) an effect on period 1 disutility via S which enters directly in equation (1), (*b*) an effect on the probability, P, that the individual will experience period 2 utility, and (*c*) the budget constraint, which brings in the resource costs of life-saving activity as well as avoidable injury costs. Assuming individuals possess some nonhuman assets, the budget constraint is

$$C + qS + RI + [C/(1 + i)] = WT + [WT/(1 + i)] + A, \tag{2}$$

where the left-hand side (LHS) is the present value of expenditures on consumption and life-saving activity less the expected cost of morbidity, that is, nonfatal injury; and the right-hand side (RHS) is the present value of labor earnings plus nonhuman assets. In equation (2), q is the cost of life-saving activity in terms of consumption, I is the present value of the morbidity loss in period 2, i is the rate of return on nonhuman capital, W is the individual's value of time, T is total time in a period, and A is the present value of nonlabor income.

The individual chooses period 1 consumption, period 2 consumption, and life-saving activity to maximize expected lifetime utility subject to the budget constraint. The first-order conditions are obtained by differentiating the Lagrangian with respect to C_1, C_2, and S. The condition of interest in this paper is that for life-saving activity, one form of which yields the statement that the value of marginal product in reducing mortality plus the value of marginal product in reducing injury loss equals marginal cost.

$$P'V - R'I = K, \tag{3}$$

where $V = U(C_2)/\lambda$, $K = q - U_s/\lambda$, and $R' < 0$. On the LHS of equation (3), P' is the change in the probability of survival due to a change in life-saving activity and is the marginal physical product in reducing mortality. The value of life (V) is the value of a unit change in the probability of survival[5] and is equal to the monetary worth to the individual of his future utility from period 2 consumption; λ is the marginal utility of income; R' is the (negative) change in the probability of nonfatal injury due to a change in life-saving activity and is the marginal physical product in reducing injury; I is the present value of the avoided morbidity loss. On the RHS of equation (3), K is the cost of life-saving activity, which is the dollar marginal cost (q) plus the monetary worth of the disutility cost (U_s/λ); U_s is the marginal disutility of S.

The equilibrium condition depicts the determination of the optimal amount of life-saving activity, S. Holding constant the value of the marginal product curve, anything which increases the cost of life-saving activity shifts the marginal cost curve up and reduces S. Thus, an increase in either the dollar cost (q) or the disutility cost (U_s/λ) will cause a decrease in S. Holding the marginal cost curve constant, anything which increases the value of marginal product of life-saving activity shifts the value of the marginal product curve up and increases S. Thus, an increase in the marginal product (P'), the value of life (V), the marginal product (R'), or the value of avoided morbidity loss (I) will increase S. The value of life can be expected to increase as there are increases in the present values of labor and nonlabor income and the amount of time available (T); T may be influenced by health.[6]

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[5] See n. 1.

[6] In Blomquist (1977) where the model of life-saving activity is presented in detail, the first- and second-order conditions are derived for both borrowers and nonborrowers against future labor income. For both, it is shown that the value of life can be expected to vary directly with the present values of labor and nonlabor income. The partial effects of other variables, like P', are also considered.

Implied Value of Life

Taking equation (3), if life-saving productivities (P' and R'), morbidity loss (I), and cost (K) are known, the individual's value of life can be solved for and is $(K + R'I)/P'$. The value of life equals the costs less the morbidity benefits, all divided by the change in the probability of survival.[7]

The starting point for the empirical work of this paper is the observation that some information can be obtained on the optimal amount of life-saving activity. Observing that S varies among individuals means that the comparison in equation (3) is not identical for all individuals. The theory suggests reasons for such differences, including differences in characteristics of value of life (V), morbidity loss (I), productivities (P' and R'), and cost (K). Because it is not possible to measure all differences among individuals with the same values for each measurable characteristic, some individuals engage in some life-saving activity and others will not. If the myriad of unobservable characteristics upon which value of life depends (i.e., basically characteristics other than income) are more important than those for I, P', R', and K, then the problem is to find the value of life for the average individual rather than the value for those (possibly atypical) individuals who engage in some life-saving activity.

The seat-belt-use decision is based on the net benefit of seat belts such that if the net benefit is positive seat belts are used, and if it is nonpositive seat belts are not used. In terms of the preceding paragraph, the decision can be viewed in terms of an index, $s = \beta x + u$, where β is a vector of fixed parameters, x is a vector of measurable benefit and costs variables, and u is a random term for unobservable differences among individuals with $E(u) = 0$ and $E(u^2) = \sigma^2$. If $s > 0$, seat belts are used; and if $s \leqslant 0$, they are not used. For probit analysis of the life-saving activity, automobile seat-belt use, where additivity of both benefits and costs is retained, a standardized index is used. The index is $s^* = \beta^* x + u^*$, where $s^* = s/\sigma$, $\beta^* = \beta/\sigma$, $u^* = u/\sigma$, $E(u^*) = 0$, and $E(u^{*2}) = 1$. Since the probit coefficients are estimates of β^* and $E(u^*) = 0$, it follows that

$$E(s/\sigma) = \beta^* \bar{x}, \tag{4}$$

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[7] A caveat about the implied value of life concerns the correctness of an individual's perceptions. When changes in risks and costs are small, one can reasonably doubt the accuracy of perceptions (and the implied value of life), for they may be beyond some threshold where changes go unnoticed. The problem is fairly widespread in economics, and Mishan (1971*a*, p. 163) offers this cogent thought: "People's imperfect knowledge of economic opportunities, their impudence and unworldliness, has never prevented economists from accepting as basic data the amounts people freely choose at given prices. Such imperfections therefore cannot be consistently invoked to qualify people's choices when, instead, their preferences are exercised in placing a price on some increment of a good or 'bad.' "

where $\bar{x}$ are the observed independent variables evaluated at the sample mean. From the data, we will know the value taken by $\beta^*\bar{x}$; call it $\bar{B}$, which is defined by $Pr\,(\bar{s} > 0) = \int_{-\infty}^{\bar{B}} n(s)ds$, where n is the standard unit normal density function. Variable B is the value along the abscissa in a graph of the function, and variable $\bar{B}$ is the standardized net benefit for the average driver.

The average value of life is obtained by using equation (4), the theory of life saving, and information from outside the sample of drivers statistically analyzed. According to the theory, the net benefit of seat-belt use (s) is $P'V - R'I - K$. When estimates of P', R', I, and K for the typical driver are substituted for s in equation (4), the result is

$$(\bar{P}'V - \bar{R}'I - \bar{K})/\sigma = \beta^*\bar{x} = \bar{B}, \tag{5}$$

where the bar over each variable indicates its average value. The LHS of equation (5) is the standardized net benefit, and the RHS is the value of the probit equation evaluated at the sample mean. While estimates of $\bar{P}'$, $\bar{R}'$, and $\bar{I}$ are available and the value of $\bar{B}$ is easily found, the value of life cannot be determined because $\bar{K}$ and σ as well as $\bar{V}$ itself are unknown, that is, equation (5) solved for $\bar{V}$ is $\bar{V} = (\bar{B}\sigma + \bar{R}'I + \bar{K})/\bar{P}'$, where σ and $\bar{K}$ are unknown.

An estimate of σ is made by using β^* from the probit equation and information about $\bar{K}$. Seat-belt-use costs consist of money costs (q) and disutility costs (U_s/λ). If, ignoring installation costs, the cost consisted entirely of time cost, K would in fact be observable as it would consist of the value of time multiplied by the time required to use seat belts (t) or

$$q = awt, \tag{6}$$

where w is the driver's wage rate and a is a constant which allows the value of time to differ from the wage. With information on a and t, the way in which cost varies with wage is known, $\partial q/\partial w = at$. This same relationship is estimated by the probit coefficient of the wage rate, $\beta^*_w = \beta_w/\sigma$. By substitution, it follows that $\beta^*_w = at/\sigma$, and the estimate of the standard deviation of s is $\sigma = at/\beta^*_w$. With this estimate of σ and with cost broken down into its components, equation (5) for the net benefit of seat-belt use becomes

$$(\bar{P}'\bar{V} - \bar{R}'\bar{I} - \overline{awt} + \overline{U_s/\lambda})/(\overline{at}/\beta^*_w) = \bar{B}, \tag{7}$$

which is one equation with two unknowns, the value of life ($\bar{V}$) and disutility cost (U_s/λ).

The disutility of seat-belt use can result from disutility in the common usage of the word, as due to discomfort of using belts or the distastefulness. These include a resistance to use due to habit. The distastefulness of the activity of buckling and unbuckling. Other influences can have the same effect on behavior as discomfort and payment that would be necessary to overcome habit is a fixed cost that would have to be paid to induce seat-belt use and is indistinguishable in observed behavior from discomfort. Another influence is knowledge. People lacking knowledge of the beneficial effects of seat belts will fail to use them even when warranted and in observed behavior will act as if there were a discomfort. Indeed, people conceivably could act as if there were positive consumption value if, as a result of propaganda, they were led to believe that seat belts are more effective than they really are. If disutility costs depend on the time involved, then it is reasonable that the disutility associated with the discomfort of restricted movement, wrinkled clothing, and chaffing from minutes and hours of driving with the seat belt fastened will be greater than the disutility associated with the bother of a few seconds or minutes of buckling and unbuckling or the value of that time. In this case, the majority of drivers will not use seat belts even if the time cost (awt) is negligible.

While these disutility costs (U_s/λ) prevent estimation of an average value of life, we can obtain information on a lower bound. If time and disutility costs were zero, this would be sufficient inducement to get all drivers to use seat belts because there clearly are benefits of using the belts. In terms of the probit equations, since B_{all} is the B which satisfies $Pr\ (s > 0) = \int_{-\infty}^{B} n(s)ds = 1.0$, B_{all} would have to be infinitely large if literally all drivers were to use belts. However, if 99 percent, which is virtually all drivers, is a good approximation, then $B_{\text{all}} = +2.326$, and a value of life can be found. The net benefit equation (7), using $\hat{\sigma}$ for $\overline{al}/\beta^*_{\bar{w}}$, becomes $(\bar{P}'V - \bar{R}'\bar{I})/\hat{\sigma} = B_{\text{all}}$, which when solved for the implied value of life yields

$$V = (B_{\text{all}}\hat{\sigma} + \bar{R}'\bar{I})/\bar{P}', \tag{8}$$

where B_{all} is the value of the probit equation when all individuals use seat belts. Everything on the RHS is known. In the sense that zero cost is sufficient inducement to get all drivers to use seat belts but it is necessary only that net benefits be positive for universal usage, the estimate is a lower bound on the value of life.

Thus, following the theory of life-saving activity and using available information on several parameters, the probit analysis yields an estimate which is a lower bound on the value of life vis à vis a rudimentary calculation for an atypical person who finds it just worthwhile to use seat belts. The value of life can be conveniently thought of as time cost plus disutility costs less morbidity benefits, all divided by the change in the probability of survival.

II. Probit Results

Seat-Belt-Use Data

A data set particularly well suited to explaining seat-belt use in conjunction with estimating the value of life is *A Panel Study of Income Dynamics, 1968–1974* (Survey Research Center 1972, 1973, 1974). The *Panel Study,* which is used in this paper, gives detailed information on user characteristics not available in other surveys. It is a nationwide survey of 5,517 households followed through the 7-year period, with approximately 500 variables for each household. The seat-belt-use variable is for 1972 and takes on a value of 1 if the driver claims to use seat belts all of the time and 0 if he claims to use them none of the time. Passenger use of seat belts, part-time use of seat belts, and use in other years are not considered due to various data limitations. The sample is limited to drivers whose cars have seat belts already installed in them to avoid the problem associated with the costs of purchasing a car with seat belts or with having seat belts installed. Also, since a crucial variable in estimating $\overline{V}$ is the driver's wage rate, the sample is limited to drivers who worked in 1972 so as to avoid the problem associated with estimating the driver's shadow wage. Seat-belt use is analyzed statistically with measurable seat-belt productivity, cost of seat-belt use, and value-of-life variables, as the model suggests.

Probit Analysis

Estimation of the value of life depends on probit analysis of seat-belt use, the results of which are presented in table 1, with definitions and means of the variables given in table 2. The calculated statistic, $-2 \times$ the likelihood ratio, is 261, which is significant at the 99.5 percent level. The ratio of the homogeneity χ^2 divided by degrees of freedom is 1.03.[8] While an extended discussion of the rationale for each variable based on the traffic safety literature can be found elsewhere, we now briefly consider the results for each variable.[9] The use of seat belts can be expected to be greater, the greater their productivity in preventing injury. Seat-belt-productivity variables found to be important are age of driver (because older drivers are more likely to be involved in an injury accident), male sex (because women tend to

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[8] Assuming a lognormal distribution does not yield improved results, as is indicated by ordinary least squares regressions of seat-belt use on the same variables used in probit analysis.

[9] For a discussion of the seat-belt-use results including alternative explanations as well as, looking ahead, a detailed justification of the most reasonable values used in estimation of the value of life, see Blomquist (1977).

TABLE 1

PROBIT RESULTS FOR SEAT-BELT USE AND NONUSE

Variable	Coefficient	t-Value	Significance Level
RSPEED	.00664	1.15	75
SEXF	−.525	−3.16	99
AGE	.0211	3.94	99
EDUC	.309	8.01	99
WAGE	−.0796	−1.89	94
EARN	.00706	2.95	99
WORKLN	.00621	2.06	96
VACLN	0288	2.56	99
PROPY	−.0440	−2.08	96
HEALTH	.992	3.12	99
KIDS	−.0650	−3.18	99
MARR	−.292	−2.15	97
CHURCH	.00523	3.57	99
CONSTANT	−7.217	−4.86	99

NOTE.—The value of the log-likelihood ratio × −2 is 261 with 13 degrees of freedom. The number of observations is 1,854 The percentage of correct predictions is 77 The definitions of the variables are given in table 2

drive under safer conditions than men), and rural speed limit (because high-speed driving is relatively dangerous).[10]

Higher costs of using seat belts can be expected to reduce seat-belt use, for example, Hix and Ziegler (1974) find a perfect correlation (+1) between seat-belt-usage rate by car manufacturer and the comfort-convenience rating given to the seat-belt configuration of that manufacturer. Cost variables found to be important are driver's wage rate (because high-wage users face greater time costs),[11] length of work-commutation trip and length of vacation (because longer trips entail less fastening and unfastening), married driver and number of children (because each implies greater time and disutility costs due to extra adjustment and fastening associated with the spouse's different dimensions and tending to youngsters), and education (primarily because more-educated drivers gather information more easily [indistinguishable from low U_s/λ]).[12]

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[10] One suspects that the age–seat-belt-productivity relationship is nonlinear. While a quadratic relationship with AGE and AGE^2 produced a negative sign on AGE^2 with a t-value near −1, stratification of drivers into 17–34, 35–55, and 56–69 groups was significant according to a restriction F-test and showed seat-belt use was indeed most sensitive to changes in age for the oldest group.

[11] The negative sign of the WAGE coefficient could reflect that drivers with high wages drive newer, safer cars and hence use seat belts less. However, when value of car was tried as a variable, it was statistically insignificant.

[12] Since EDUC is based on Welch's (1966) weights (derived by finding the rates of return of education levels), one wonders if those weights are better than giving each additional year of schooling an equal weight. Using ordinary least squared regressions

TABLE 2

MEANS OF PROBIT VARIABLES, 1972

Variable	Definition	Mean Value	Units
SBU	Seat-belt use–nonuse	.23	Belt users/all drivers
RSPEED	Rural speed limit	60.0	Miles per hour
SEXF	Sex	.119	Female drivers/all drivers
AGE	Driver age	39.2	Years
EDUC	Education	2.30*	Welch index
WAGE	Wage rate	4.66	Dollars per hour
EARN	Labor wealth	94.19	Thousands of dollars
WORKLN	Length of work trip	7.98	Miles
VACLN	Length of vacation	2.02	Weeks
PROPY	Nonlabor income	1.19	Thousands of dollars
HEALTH	Health	4.515	Thousands of healthy hours
KIDS	Children	1.83	Number of children
MARR	Marital status	.823	Married drivers/all drivers
CHURCH	Religious attendance	23.2	Services per year

* The average driver has just a bit more than a high school education

Finally, we turn to the value-of-life variables (V), expecting that drivers with high V will use seat belts more. Wealth increases the amount of life-saving activity in which a person will engage. Human wealth, which typically is most of a driver's wealth, is measured by EARN, the present value of expected future labor earnings. The value of EARN is based on the concept of the age-earnings profile, and by utilizing these earnings patterns some of the obvious errors in measuring income by observing people at different stages of the life cycle are avoided. In generating EARN, we parameterize the age-earnings profile for each of the seven education levels for which Mincer (1974) gives data. The information available for each driver from the *Panel Study* is utilized, for while each individual is assumed to have a typically shaped (sloped) profile for his respective education level, the intercept of the equation which describes the profile is allowed to vary by individual. Each year's earnings is predicted and

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for comparison, one finds that the regression with EDUC has a higher R^2 and larger t on education than a similar regression with an education variable which has equal weights. To explore the usefulness of the EDUC weighting scheme further, the drivers were stratified by grade of school completed. Several stratification schemes were tried among the eight education levels. Using restriction F-tests for similarity of coefficients, it was found that the first four levels could be lumped together, grades 1–12, but the remaining four could only be grouped in twos, grades 13–15 and 16 or more grades. The larger group at moderate education levels and the small groups at high education levels are consistent with the increasing weights used in EDUC.

multiplied by a factor which accounts for time preference and probability of survival.[13] The positive sign of the EARN coefficient is evidence of the higher value of life for drivers with greater human wealth. However, as will be shown later, the value of the life–foregone-earnings relationship is not dollar for dollar.

Other value-of-life variables found to be important are healthy hours (because of their wealth effect), church attendance (because of life-style effects or possibly the tendency of these drivers to overstate both church attendance and seat-belt use), and nonlabor income. The negative sign of PROPY is not so much to be considered evidence that drivers with much nonlabor income have low V but, rather, that there is a data problem. Unfortunately, the definition of PROPY is based on net taxable asset income, which is conceivably (and in some observations actually) negative—a not surprising result, especially for wealthy people, in view of rapid allowable depreciation and other tax provisions. Consideration of the driver's desire to leave an estate could shed light on PROPY, as shown by Blomquist and Tolley (1977). The PROPY variable does not affect the coefficients of WAGE, EARN, or other variables except AGE, the coefficient of which falls by 10 percent if PROPY is deleted from the probit equation. The negative signs of MARR and KIDS are taken as evidence that the negative cost effect outweighs any positive effect of dependents of the value of life due to interdependent utility functions or household production advantages.

III. Estimation of the Value of Life

Most Reasonable Case

Upon establishing reasonable values for the parameters $\bar{a}$ and $\bar{t}$, the probit coefficient of WAGE is used to determine the standard deviation of net benefits, σ. Using the means of sample drivers for $\bar{w}$ and $\bar{B}$ and establishing reasonable values for $\bar{P}'$, $\bar{R}'$, and $\bar{I}$, the implied value of life ($\bar{V}$) can be written as a function of disutility costs (U_s/λ) in accordance with equation (7). Using the value of B, which induces

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[13] To test the sensitivity of the EARN finding to the definition of foregone earnings, several definitions of the earnings variable were investigated. Four different intercepts of the age-earnings profile were considered, including actual 1972 labor earnings and a 7-year average of actual labor earnings and three different discount rates—5, 10, and 15 percent. In addition, the age-earnings profile was constrained never to fall once a peak is reached, in accordance with the idea that it is a decline in labor force participation, not the wage rate, which causes earnings to fall as a worker ages. Using ordinary least squares regressions, it was found that EARN (1972 wage times 2,000, 10 percent and unconstrained) produced the best results, i.e., the highest t-value for an earnings variable and the highest R^2.

virtually all drivers to use seat belts, disutility costs can be estimated and V imputed from equation (8).

First, let us estimate σ. For $\bar{a}$, there exists considerable evidence that the value of time in a vehicle which is relevant to the valuation of benefits of time-saving projects is less than the average wage rate. The most reliable work (e.g., Lisco 1967 and Domencich and McFadden 1975) indicates that a is about 0.40. For $\bar{t}$, no formal studies have been done of the time required per trip to find, perhaps untangle, fasten, perhaps adjust, and unfasten seat belts. Several highway safety people contacted during the course of this work suggest that a simple time and motion study will give a sufficiently good estimate of the time expenditure per trip. I carried out such a study and found that on pre-1973 cars it takes 4–6 seconds to find and fasten seat belts if there is no entanglement or adjustment and about 2 seconds to unfasten the belt. Entanglement and adjustment caused an additional 3–8 seconds to be spent fastening the belt, with the median time added being about 4 seconds. The average time per one-way trip spent to use seat belts is the sum of 5 seconds for finding and fastening, 1 for adjustment, and 2 for unfastening. Total time per trip is about 8 seconds. The 8 seconds must be multiplied by the number of one-way trips per year to get average annual time expenditure (t) on seat-belt use. The estimate of the number of annual trips the driver takes is based upon the average annual miles driven by the driver and his family and the length of the trip to work. The estimate, 1,504, comes out to a little more than two round trips per day. The average annual time expenditure ($\bar{t}$) on seat-belt use is about 3.342 hours. Using the coefficient of WAGE from table 1 and recalling that $\sigma = at/\beta_w^*$, the estimate of σ is $(0.40)(3.342)/(0.0796) = 16.79$. The value of σ may seem a bit small, but note that u is the difference between two random effects (those for interpersonal differences in costs) and that the covariance term may make σ small.

Second, let us determine the relationship between $\bar{V}$ and U_s/λ. The increase in probability of survival (P') and probability of avoiding morbidity loss (R') is due to the effectiveness of seat belts in the reduction of injury. Weighing the results from different studies, effectiveness with respect to fatalities is taken to be 0.50, while effectiveness with respect to nonfatal injuries is 0.25.[14] While seat belts can help save a driver's life, their effectiveness matters only if the driver has a potentially injurious accident. Based on 1972 accident and driver data, the estimate of the probability of a driver being killed in an accident is 3.027×10^{-4}. Thus, $\bar{P}'$ is 1.514×10^{-4}. In a similar

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[14] The estimates of seat-belt effectiveness made by Levine and Campbell (1971), Campbell, O'Neill, and Tingley (1974), and Council and Hunter (1974) range from 0.40 to 0.60, while for R' they range from 0.20 to 0.35.

manner, the probability of a driver incurring a nonfatal injury accident is calculated to be 1.392×10^{-2}. Thus, $\bar{R}'$ is -3.481×10^{-3}.[15] While one might expect a reduction in the severity of injury given that an accident occurs, the traffic safety literature gives no evidence that such a reduction occurs.

For $\bar{I}$, judging from the traffic safety literature (esp. U.S. Department of Transportation 1975), the average nonfatal injury loss which can be avoided by seat-belt use is $950. Included are $850 of labor productivity loss and a small, admittedly arbitrary, amount of $100 for pain and suffering. Excluded are costs, such as property damage and insurance administration, which the individual cannot avoid through seat-belt use.

Substituting into equation (7) the values for $\bar{P}', \bar{R}', \bar{I}, \bar{a}, \bar{w}, \bar{t}, \sigma$, and $\bar{B}$ gives an equation with $\bar{V}$ and U_s/λ as variables:

$$\begin{aligned}&[(1.514 \times 10^{-4})\bar{V} - (-3.481 \times 10^{-3})(950) \\ &- (0.40)(4.66)(3.342) + U_s/\lambda]/16.79 = -0.748,\end{aligned} \tag{9}$$

where $4.66 is the sample mean of WAGE from table 2. The value for $\bar{B}$ is $\beta^*\bar{x}$, which can be computed from tables 1 and 2 and is the value corresponding to about 23 percent of drivers using seat belts, that is, $Pr(s > 0) = \int_{-\infty}^{-0.748} n(s)ds \doteq 0.23$. For the average driver, net benefit is negative, -0.748, and seat belts are not worth using. Solving equation (9) for the value of life in terms of disutility cost gives

$$\bar{V} = -63{,}653 - 6605 U_s/\lambda. \tag{10}$$

This equation illustrates that the utility component of seat-belt use, U_s/λ, must indeed be negative (algebraically less than -9.64), that is, a disutility cost, if the value of life is positive. An indication that disutility costs are important is that when time costs are assumed to be zero ($t = 0$), the probit equation predicts that the majority (65 percent) of drivers do not use seat belts.

Now, let us estimate the value of life, taking as given that all drivers will use seat belts if all costs, disutility, and time are zero. Taking 99 percent of the drivers to be virtually all means that B_{all} is 2.326. Substituting this and values for $\sigma, \bar{R}', \bar{I}$, and $\bar{P}'$ into equation (8) gives an implied average value of life of

$$V = [(2.326)(16.79) + (-3.307)]/(1.514 \times 10^{-4}) = \$236{,}107 \tag{11}$$

in 1972 dollars (or about $370,000 in 1978 dollars).

The estimate of V when substituted into the relationship between V and U_s/λ means that disutility costs are $45.38 per year, that is,

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[15] Calculations are based on data from the National Safety Council (1973), the U.S. Dept. of Transportation (1973), and the Illinois Dept. of Transportation (1975). Detailed calculations are available from the author upon request.

solving equation (10) gives $U_s/\lambda = -45.38$. The amount is the annual subsidy (bribe) which must be paid to the average driver to offset disutility costs. Since the important disutility cost is that which is associated with wearing (vis à vis fastening) the seat belt, the disutility cost per trip hour might lend some perspective. In determining fastening time (t), it was found that the typical driver would make 1,504 one-way trips per year. For the sample of drivers, the average trip length was about 9 miles, which implies 13,536 miles are driven each year. Recognizing that high average speeds are unlikely for short trips, it is assumed that the average speed for these miles was 40 miles per hour. For the 338 hours of travel per year, the $45.38 annual disutility cost reduces to about 13¢ per trip hour, which does not seem unreasonable. That the disutility cost is reasonable is pertinent since, in contrast to the relationship between the value of life and disutility which is based on the probit equation evaluated at the sample mean, the value-of-life estimate is based on B_{all} (+2.326), which is far from the sample mean (−0.748). As such, the estimate could be sensitive to the specific functional form and has a wide confidence band around it in any case.

The implied value of life depends on the point estimate of several terms as well as on the value chosen for B_{all}, which determines disutility costs. Table 3 shows the sensitivity of the most reasonable estimate of V ($368,000) to each of these parameters.

Value of Life and Foregone Earnings

The positive coefficient on EARN indicates that drivers with high earnings place a high value on their lives and in turn are more likely to use seat belts. The foregone-earnings approach to value of life holds that the value of life (V) and EARN are equal and should change on a dollar-for-dollar basis, implying that the elasticity of V with respect to EARN is one. For the 1972 sample of individuals, the mean of EARN is $94,188, which is only 40 percent of V instead of equal to it. It should be noted that a value of life greater than foregone earnings is possible because, as defined above, the value of life is merely a convenient way of expressing the value-of-life saving for a small change where that change is extrapolated to unit change. Since only marginal changes are considered, there is no violation of the budget constraint.

An elasticity of V with respect to EARN can be calculated by performing the following hypothetical experiment. For average drivers, the net benefit of seat-belt use is negative and seat-belt use is only 23 percent, that is, $Pr(\bar{s} > 0) = \int_{-\infty}^{-0.748} n(s)ds = 0.23$. The benefits of seat-belt use are small relative to the costs, including time costs which

TABLE 3

SENSITIVITY OF V

	V	
VALUE OF TERM	1972$	1978$
B_{all}:		
1.645 (95%)	160,585	250,000
2.326 (99%)	236,107*	368,000*
3.090 (99.9%)	320,833	500,000
Seat-belt effectiveness (part of P'):		
.60	196,842	307,000
.50	236,107*	368,000*
.40	295,182	460,000
I:		
1972$ = 1,500; 1978$ = 2,339	223,461	348,000
1972$ = 950; 1978$ = 1,481	236,107*	368,000*
1972$ = 500; 1978$ = 780	246,456	384,000
β^*_{WAGE}:		
−.1217 (SD = −1.0)	146,907	229,000
−.0796 (SD = .0)	236,107*	368,000*
−.0375 (SD = 1.0)	525,827	820,000
a:		
.30	171,734	268,000
.40	236,107*	368,000*
.50	300,632	469,000
t:		
2.500	170,751	266,000
3.342	236,107*	368,000*
4.000	286,959	447,000

NOTE.—V = value of life, B_{all} = value of the probit equation when all individuals use seat belts, P' = the change in the probability of survival due to a change in life-saving activity and is the marginal physical product in reducing mortality; I = the present value of the morbidity loss in period 2; β^*_{WAGE} = the vector of the fixed parameters of the wage rate, a = a constant which allows the value of time to differ from the wage; and t = the time required to use seat belts.

* For the most reasonable case, V is approximately $236,000 in 1972 dollars or $368,000 in 1978 dollars. The Consumer Price Index is used to convert 1972 to 1978 dollars.

depend on the value of time. When EARN increases, the net benefit increases, and seat-belt use increases if costs remain constant. (Although EARN and WAGE would usually vary together, EARN could increase with WAGE unchanged through an increase in the annual probabilities of survival or a decrease in the discount rate.) The experiment consists of hypothetically increasing EARN, in this way keeping all other variables at their mean values, finding the new higher level of seat-belt use with the estimated probit equation, finding the new higher level of WAGE which will increase costs by an amount enough to offset the increase in benefits exactly, and calculating the implied value of life using the parameterized equation (9) for the net benefit of seat-belt use.

If EARN for the average driver is increased 10 percent from the mean of $94,188 to $103,607, seat-belt use would increase from 23 to

25 percent, that is, $Pr(s > 0) = \int_{-\infty}^{-0.682} n(s)ds \doteq 0.25$. If concurrently WAGE is increased from the mean, \$4.660, to \$5.495, cost increases enough to make standardized net benefit again equal −0.748 and seat-belt use 23 percent. Using equation (9) with WAGE equal to \$5.495 and $\overline{U_g/\lambda}$ equal to −\$45.38 and solving for V, we get $V = [(-0.748)(16.79) + (-3.481 \times 10^{-3})(950) + (0.40)(3.342)(5.495) - (-45.38)]/(1.514 \times 10^{-4})$ = \$243,461 in 1972 dollars. Therefore, V for the average driver is \$236,107, meaning that V increased \$7,354 or 3.1 percent. Since the 10 percent increase in EARN produced a 3.1 percent in V, the elasticity of the average value of life with respect to foregone earnings is about +0.3. Contrary to the foregone-earnings approach, the elasticity is 0.3, not 1.0.

The above elasticity and value-of-life estimate are consistent with the theoretical work of Usher (1973) and Conley (1976). Although the connection between the expected present value of future labor earnings and consumption is not direct, the finding that the elasticity of value of life with respect to earnings is about 0.3 is consistent with the notion that people get more from life than what they derive from market consumption.

IV. Conclusions

The value of life saving is derived from a simple life-cycle model with a partly endogenous risk of death and estimated through analysis of the consumption activity, automobile seat-belt use. The life-cycle model is developed to yield a method of estimating the value of life saving. The time cost of seat-belt use is estimated from estimates of the time required and the wage rate of the driver. The life-saving benefit of seat-belt use is the reduction in probability of death multiplied by the value of life, as that term has been used in this paper. Thus, with no benefits other than mortality benefits and no costs other than time costs, the value of life is the time cost divided by the reduction in the probability of death. The method accommodates morbidity benefits as well as disutility costs, broadly defined to include discomfort, inconvenience, and lack of knowledge, and these benefits and costs are included. Since only 23 percent of drivers use seat belts, probit analysis is used to find the implied value of life for the typical driver who does not use seat belts. The value is imputed using the theory about seat-belt-use time costs, information on these costs, and the probit coefficient of WAGE to convert standardized to actual costs.

Probit analysis of seat-belt use produces statistically extremely significant and reasonable results. Use of seat belts is found to be greater, the greater their productivity in preventing injury. Higher costs of using seat belts are found to reduce seat-belt use. Seat-belt use is found to be greater, the greater the value the driver places on his life. The future-earnings variable, an important value-of-life variable, was based on age-earnings profiles by education level, positioned to an individual's actual earnings, discounted and reduced to allow for the probability of survival.

Following the approach just outlined, this paper adds further evidence that people are willing to pay (accept) a determinable, finite amount for an increase (a decrease) in the probability that they will continue living. Using a different theory and a different body of evidence, the value of life estimated in this paper is of the same general order of magnitude as that of the other existing study based on a willingness-to-pay approach. By choosing a sample from the population at large (automobile drivers), the problem has been avoided of basing inferences about the willingness to pay on categories of persons, such as those in hazardous occupations, who may by self-selection have atypical risk attitudes. Morbidity, as well as mortality, has been systematically included. Disutility, the counterpart to occupational disamenity, has been allowed. Indications of the importance of disutility are that a subsidy would be required to induce the average driver to use seat belts and that an individual's education affects seat-belt use more than can be accounted for by its wealth effect.

The estimate of the value of life in 1978 dollars for the most reasonable case is approximately $370,000. It is to be contrasted with what would be obtained with a foregone-earnings approach in that the estimate is more than twice the average foregone earnings of the drivers studied. Moreover, the elasticity of the value of life with respect to future labor earnings is about 0.3, far less than the 1.0 which is inherent in the foregone-earnings approach to value of life. For benefit-cost analysis, the estimate, which is for the entire population of drivers, is of interest as it is usually impractical to place different values on different lives for decisions concerning public expenditures. The estimate is based on individual willingness to pay. Any adjustment for the value of life of the individual to others not internalized by him, an externality not considered herein, would raise the estimated value of life.

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