Economics of Safety and Seat Belt Use

Glenn Blomquist

Multivariate probit analysis of automobile lap seat belt use of over 1800 drivers located throughout the U.S. yielded statistically significant and reasonable results in which seat belt use or nonuse was correctly predicted for 77% of the drivers. The variables included in the empirical analysis follow directly from a theoretical model of life-saving activity developed in the paper that views the seat belt use decision as primarily economic. Use of seat belts was expected to be greater when the productivity in preventing injury was greater. Seat belt productivity variables found to be important were age of driver, male sex, and rural speed limit, all of which increased seat belt use. Use was also expected to be greater when the value the driver places on his life is greater. Future labor earnings and health were thus found to significantly increase seat belt use. Higher costs of using seat belts were expected to reduce seat belt use. Indeed, high wage rates, short trips, extra adjustment and fastening due to family demands, and lack of education were found to decrease seat belt use. A useful policy implication is that consideration of such time costs (including inconvenience) is imperative in formulating any successful safety regulation.

Beginning with the benchmark California study (Manheimer, Mellinger, & Crossley, 1966), social scientists have strived to explain why some drivers use automobile seat belts and others do not. Most of the work consists of looking at two-way tables depicting the association of seat belt use with age, sex, race, marital status, driver attitudes, and driving conditions (Council, 1969; Marzoni, 1971; Morgan, 1967; Robertson, O'Neill, & Wixom, 1972). While insight has been gained, the task has become increasingly difficult as seat belt ownership has become nearly universal in contrast to seat belt use. In response, concerned parties have proposed several mandatory measures including ignition interlocks, seat belt use laws, and passive restraints such as air bags.

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This paper attempts to shed some light on these proposals by presenting from the individual's viewpoint a theoretical and empirical analysis of the life-saving activity, seat belt use. The approach is an economic one in which the individual seeks to obtain the most satisfaction he can with the limited amount of time and money at his disposal and is offered for consideration as an alternative to those found in the studies mentioned above. Consideration is given not only to the obvious benefits of seat belt use, but also to variation among individuals in the benefits and costs of seat belt use. Discussion of the results of multivariate probit (statistical) analysis features the *partial* effect of each explanatory variable, something not found in empirical studies based on simple correlations.

THEORETICAL MODEL

Life-saving activity. The seat belt use decision can be thought of as part of a general economic problem, that is, how much of limited resources shall be spent on current consumption, how much on future consumption, and how much on life-saving activity to increase the probability of survival. The individual strives to get the greatest possible utility (an abstract, quantitative measure of satisfaction with utils as the unit of account) from his expenditures on consumption of ordinary goods and services. Since he is not certain of experiencing consumption in future periods, he strives to obtain as much expected utility as possible. 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 in utils is:

1. $E(U) = U(C_1,S) + PU(C_2)$

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 any disutility of life-saving activity (S). The appearance of S in $U(C_1,S)$ allows for a disutility of life-saving activity over and above the resource cost of life-saving activity which appears in the budget constraint. P is the probability of survival to the end of period 2. $U(C_2)$ is the utility of period 2 consumption (C_2). Any bequeathment is part of C_2.

Life-saving activity is a matter of choice and is something that affects the probability of survival (P) and the probability of nonfatal injury (R). Life-saving activity increases the probability of survival:

2. $P = P(S) \quad P' > 0$

where P' is the first derivative of P with respect to S. It decreases the probability of a nonfatal injury:

3. $R = R(S) \quad R' < 0$

where R' is the first derivative of R with respect to S.

Life-saving activity (S) affects expected lifetime utility in three ways: (1) An effect on period 1 disutility via S which enters directly in equation 1; (2) an effect on the probability, P, that the individual will experience period 2 utility as governed by equation 2; and (3) an effect on resources available for consumption as governed by injuries via equation 3 and the budget constraint which brings in resource costs of the life-saving activity. The fact that only a finite amount of resources is available is shown in the budget constraint which says that what is spent equals what is available to be spent. Assuming individuals possess some nonhuman assets, the budget constraint in dollars, where the price of C_1 is \$1, is:

4. $C_1 + qS + RI + \frac{C_2}{1+i} = WT + \frac{WT}{1+i} + A$

where the left-hand side (LHS) is the present value of expenditures on consumption and life-saving activity less the expected cost of morbidity (nonfatal injury) and the right-hand side (RHS) is the present value of labor earnings plus nonhuman assets. In equation 4, 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 (interest rate), W is the individual's value of time, T is total time in a period, and A is the present value of nonlabor income. Future quantities are discounted since with a positive interest rate a dollar next year is worth less than a dollar this year.

The individual chooses period 1 consumption, period 2 consumption, and life-saving activity to maximize expected lifetime utility subject to budget constraint. The first order conditions, necessary for maximization, can be obtained by differentiating the Lagrangian with respect to C_1, C_2, and S.[1] The condition of interest in this paper (shown in equation 5) is 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:

[1] The Lagrangian expression (J) is formed by combining equations 1 and 4 as follows:

$$J = U(C_1,S) + PU(C_2) - \lambda\left[C_1 + qS + RI + \frac{C_2}{1+i} - WT - \frac{WT}{1+i} - A\right]$$

where λ is the Lagrangian multiplier which can be interpreted as the addition to utility from a small increase in income, e.g., A. The first order conditions are $U_1 = \lambda$, $PU_2 = \frac{1}{1+i}$, and equation 5 in the text for C_1, C_2, and S, respectively.

5. $P'V - R'I = K$ where
6. $V = U(C_2)/\lambda$ and
7. $K = q - U_s/\lambda$

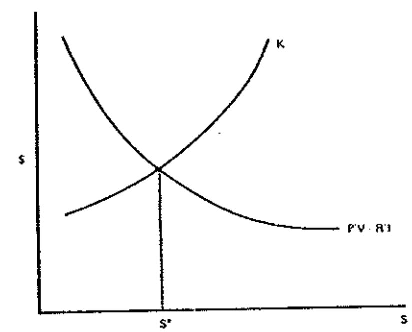
and where the unit in each equation is dollars per unit of C_1.

On the LHS of equation 5, P' is the change in the probability of survival due to a change in life-saving activity and is by definition the marginal physical product in reducing mortality. The "value of life" (V) as shown in equation 6 is the value of unit change in the probability of survival[2] and is equal to the monetary worth to the individual of his future utility from period 2 consumption. R' is the change in the probability of nonfatal injury due to a change in life-saving activity and is by definition the marginal physical product in reducing injury. I is the present value of the avoided morbidity loss. On the RHS of equation 5 is the cost of life-saving activity (K) and, as shown in equation 7, it is the dollar marginal cost (q) plus the monetary worth of the disutility cost ($-U_s/\lambda$) where U_s is the direct change in utility due to more life-saving activity and is negative.

The equilibrium condition is depicted in Figure 1 which shows the determination of the optimal amount of life-saving activity, S*. Holding constant the value of marginal product curve, anything that 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 ($-U_s/\lambda$) will cause a decrease in S*. Holding the marginal cost curve constant, anything that increases the value of marginal product of life-saving activity shifts the value of 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. These and other implications are presented elsewhere (Blomquist, 1977) where a model for persons who do borrow against future labor income is also considered. Thus, for seat belts we expect greater use by drivers for whom dollar and disutility costs are low and for whom seat belt productivity, value of life, and potential morbidity loss are high.

[2] "Value of life" as the term is used in this paper is based on the value of increasing the probability of survival by a small amount. For ease of reference and want of a better standard only, the value of a small change is extrapolated to a unit (0 to 1) change. Value of life in this context is the value a driver places on the small (but important) increase in his probability of survival if he uses a seat belt, *not* some value he places on avoiding being pushed off a cliff.

FIGURE 1
DETERMINATION OF OPTIMAL
LIFE-SAVING ACTIVITY



METHOD

Seat belt use data. A data set particularly well suited to explaining seat belt use is *A Panel Study of Income Dynamics, 1968-1974* by the Survey Research Center, Institute for Social Research, University of Michigan. The *Panel Study*, which is used in this paper, is a nationwide survey of 5517 households followed through the 7-year period, with approximately 500 variables for each household. The *Panel Study* focuses on employment, income, and education of the household and gives detailed information on driver characteristics not available in other surveys.

The seat belt use variable pertains only to household heads and only to the driver of the car and is for the year 1972. The variable takes the value of 1 if the driver claims to use seat belts all of the time and 0 if he claims use for none of the time. A preferred seat belt use variable would be based on observed or measured use vis-a-vis claimed use and would include part-time use to allow for use on some trips but not others. In other work (Waller & Barry, 1969), researchers observed driver use of seat belts from a passing van and then mailed a questionnaire about seat belt use to the driver. They found 23% of the drivers who claimed they always wore their seat belts were observed not wearing belts on local trips while 54% did not for long trips. Another study (Marzoni, 1971) using a similar technique found about the same upward bias for short trips, but found little bias at all for long trips.

A question about part-time seat belt use was asked in the *Panel Study*, but these observations are deleted from the sample used in this paper because survey reporting error is expected with many people feeling guilty about not wearing seat belts and claiming greater than actual use. Although the fraction of the time that each individual uses seat belts is not available, a crude method of determining the average use of part-time users is to assign several different percentages to all part-time users and see which phenomenon can be best explained (statistically) with the same independent variables. It was found that seat belt use was explained best when part-time users were assumed to use seat belts 20% of the time. When part-time users were deleted from the sample, explanation was better yet, indicating reporting error was less of a problem with the more exclusive sample. Using the 1972 national sample from the *Panel Study*, variables suggested by the model representing measurable characteristics of the value of life, cost of seat belt use, and seat belt productivity were used in probit analysis to explain variation in the use of seat belts.

Probit analysis. Probit analysis, like multiple regression analysis, is a statistical procedure in which variation in the dependent variable (seat belt use among drivers) is accounted for or explained by variation in several independent or explanatory variables (cost, productivity, etc.). The coefficient of a variable that prompts greater seat belt use (productivity) will have a positive sign whereas a variable that inhibits use (cost) will have a negative sign. If the variable is important, it will have a coefficient that is statistically significant, that is, significantly different from zero as indicated by a numerically large t value. Probit is used instead of regression analysis because of its superior statistical characteristics when the dependent variable is binary, taking on values of 1 when seat belts are used or 0 when not used. An attractive feature of both of these techniques is that the coefficient on a particular variable gives the separate effect of that variable on seat belt use exclusive of the effects of any other variables in the analysis, e.g., the effect of age when education is held constant. For further discussion, see Beales (1972) or Kmenta (1971).

Seat belt productivity variables. Automobile lap seat belts are recognized as effective devices for achieving injury reduction in an accident if they are worn (Griffen, 1973). Seat belts reduce injuries because they prevent ejection from the automobile, and they help prevent injuries that result from striking objects inside the car. The mortality productivity (P′) of seat belts is the product of the probability of a fatal accident and seat belt effectiveness for reducing fatalities where effectiveness is the decrease in that probability if seat belts are worn. The morbidity productivity (R′) of seat belts is the product of the probability of an injury (nonfatal) and seat belt effectiveness for reducing morbidity where effectiveness is the decrease in that probability if seat belts are worn. As indicated in the previous section, seat belt use is expected to be greater among drivers for whom seat belts are highly productive than among other drivers. The literature suggests several factors that determine seat belt productivity.

Analysis of traffic accident data and the noticeably higher fatality rates in rural areas are grounds for the commonly held belief that the probability of an accident involving fatality or injury increases with speed (Joksch, 1975). Speed also increases the effectiveness of seat belts, at least up to moderately high speeds (Campbell et al., 1974; Council & Hunter, 1974; Levine & Campbell, 1971). Thus, up to a certain point, speed increases seat belt productivity.

To capture the effect speed has on the incentive for different drivers to use seat belts, the variable used is the 1972 rural speed limit for the state in which the driver resides, RSPEED. The limits used vary from 43 to 70 miles (69 to 113 kilometers) per hour and are based on those in an atlas (Rand McNally, 1973) and those used in another study (Peltzman, 1975). RSPEED should have a positive sign. As an approximation to a rather complex rural-urban definition, the RURAL variable takes on a value of 1 if the driver resides in a county that is not part of a Standard Metropolitan Statistical Area (SMSA) and a value of 0 if the driver lives in a county that is. Since average speed is higher in rural areas, the expected sign of RURAL is positive. INTER takes on a value of 1 if an interstate highway passes through the county in which the driver resides and 0 if not according to the Rand McNally maps. The fact that the average speed is higher for interstates than for other roads makes for a positive effect of INTER on seat belt productivity. However, the fact that interstates are designed for high speed travel and are inherently less dangerous to travel makes for a negative effect. INTER can have an additional effect through seat belt cost as will be discussed below.

Seat belt productivity is different for men and women, since women drive under less hazardous conditions than men (Weber, 1975). While the accident rates for women and men are about the same for the sample, men are involved in more fatal accidents (63 per billion miles) than women (27 per billion miles). This is primarily because men do most of the pleasure and night driving when the probability of a fatal accident is highest. SEXF takes on the value of 1 if the driver is female and 0 if male and should have a negative coefficient.

Seat belt use is expected to be high for older drivers because they have higher accident rates and they are less resistant to injury. Accident rates for those under 25 and those over 60 are higher than the middle age group (Weber, 1975). The conditional probability of a fatality given the driver has an accident increases with age for those over 25 and increases faster as one gets older (Preston, 1975). Older people are also more likely to be injured in an accident (Brooks, Nahum, & Siegel, 1970). Since seat belt productivity definitely appears to increase with age past 25, the sign of AGE should be positive.

There is a notion that seat belts are more effective in cars of a certain size and weight than in other cars, but a rather surprising finding (Campbell, O'Neill, & Tingley, 1974) is that seat belt effectiveness does not vary significantly with these car characteristics. While a fatal injury is more likely to occur in a small, light car than in a large, heavy one, the reduction in fatalities with seat belts is not greater for the small car than the large. Apparently seat belts do not protect quite as well in small, light cars and this offsets the higher potential for increased seat belt effectiveness. Data on car size and weight are not available in the sample, however. Consequently, the hypothesis that their coefficients are zero will not be tested.

Another hypothesis that will not be tested concerns alcohol consumption which is considered a major factor in fatal accidents, implying a high productivity of seat belts for drinkers. Nevertheless, according to one study (Sterling-Smith & Fell, 1972), the accident rates of drinkers and nondrinkers are the same. The appropriate alcohol variable is one that indicates whether a person drives while under the influence of alcohol. Unfortunately no such variable is available in the *Panel Study*.

Variables for the cost of seat belt use. Seat belt use is expected to be less among drivers for whom the costs of seat belt use are high than among other drivers. The cost of seat belt use is composed of two parts: (1) time costs, q, involved in finding, untangling, fastening, adjusting, and unfastening seat belts, and (2) disutility costs, $-U_j/\lambda$, which include discomfort, inconvenience, and information costs.[3]

[3] The problem of fixed costs associated with installation costs is circumvented by limiting the sample to

The literature suggests that the time cost (q) is an important element in the seat belt use decision. A perfect correlation (+1) between seat belt use rate by car make and the convenience rating given to the seat belt configuration of that make was found (Hix & Ziegler, 1974). Swedish reports show that belt use is higher for cars equipped with automatic belt retractors because they prevent misplacement and entanglement (Ventre, Rullies, Tarriere, Hartemann, & Fayon, 1975). In another study (Cohen & Brown, 1973), seat belt use in North Carolina rental cars was measured with mechanical counters, and it was found that convenient design increased seat belt use. While the belt could be fastened at the first stop light or sign, the time cost does appear to be important.

Annual time cost varies with the driver's value of time. The value of time variable used is the driver's average annual hourly wage rate, WAGE, obtained by dividing 1972 earnings by 1972 hours worked.[4] With an increase in the wage rate, cost increases so that the expected coefficient on WAGE is negative. It does not matter if the value of time is equal to WAGE, however, since as long as it is proportional to WAGE any difference will be captured in the constant term of the probit equation.

Annual time spent increases with the number of times the driver goes through the buckling and unbuckling procedure. Drivers who take longer trips are expected to use seat belts more since time cost is lower if annual mileage is constant. WORKLN is the distance from residence to work if the individual drives to work and is 0 if other transportation is used. VACLN is the number of weeks of vacation taken in 1972, indicating the length of a possible automobile trip. WORKLN and VACLN should have positive signs. INTER may indicate lower costs since one suspects seat belt use is higher for

those drivers who drive cars with seat belts already installed in them which for 1972 was about 80% of drivers.

[4]Since WAGE is a crucial variable representing the cost of seat belt use, the sample is limited to drivers who worked in 1972 in order to avoid the problem of estimating the individual's shadow wage.

interstate travelers because greater trip length reduces the number of fastenings and unfastenings for a given number of miles driven per year. The net effect of INTER is ambiguous, however, because, as pointed out earlier, seat belt productivity may be lower on interstates.

Difficulty in adjusting seat belts leads to greater time costs. Elsewhere (U.S. Department of Transportation, 1972) it is posited that time costs increase with complexity of the belt system, lack of familiarity with belt, the number of drivers using the car, and difficulty in finding belt ends. If the driver must completely readjust the seat belt as well as find, untangle, fasten, and unfasten it, he incurs a greater time cost than if he only has to make a minor adjustment. A married driver is likely to incur such cost because of the spouse's different dimensions. MARR takes on a value of 1 if the driver is married and 0 if the driver is single and should have a negative sign. KIDS is the number of children the individual has and the expected sign is negative for reasons similar to those for marital status. While adjustment cost may not change with the presence of children, the difficulty in finding and untangling belts will. In addition, extra buckling and unbuckling by the driver may be necessary to tend to children. In this economic framework, marital status and children can be expected to affect seat belt use through value of life as well as cost, but this will be discussed later.

Education increases the efficiency of the consumer in production and allocation (Michael, 1972; Welch, 1970). Allowing that there is a production effect of education that enables a more educated driver to fasten and unfasten seat belts more quickly than average, he incurs a smaller cost (at any given frequency of seat belt use and value of time). Practically, this production effect is likely to be negligible. Allowing that there is an allocation effect, educated drivers acquire, evaluate, and use information about seat belts easily and will use seat belts more than less educated drivers. This cost is unobservable and indistinguishable from a low $-U_i/\lambda$.

TABLE 1
AGE-EARNINGS PROFILE

EDUCATION[a]	EQUATION
0-4	$E_i = -5109 + 497.9\ AGE_i - 4.46\ AGE_i^2 + 0.0581\ AGE_i^3$
5-8	$E_i = -6880 + 653.3\ AGE_i - 11.65\ AGE_i^2 + 0.0662\ AGE_i^3$
9-11	$E_i = -986.2 + 264.7\ AGE_i - 2.62\ AGE_i^2$
12	$E_i = -10210 + 929.2\ AGE_i - 16.92\ AGE_i^2 + 0.1008\ AGE_i^3$
13-15	$E_i = -13330 + 1036.1\ AGE_i - 15.74\ AGE_i^2 + 0.0708\ AGE_i^3$
16	$E_i = -15330 + 1145.9\ AGE_i - 15.77\ AGE_i^2 + 0.0623\ AGE_i^3$
17+	$E_i = -35790 + 2382.9\ AGE_i - 38.98\ AGE_i^2 + 0.2055\ AGE_i^3$

Note.—E_i is the labor earnings in year *i*.
[a]Education is by grade level completed.

EDUC is based on years of schooling completed by the driver and is formed using weights derived in another study (Welch, 1966); the weights increase with schooling, reflecting increasing learning efficiency.[5]

Labor wealth variable—foregone earnings. Wealth increases the amount of lifesaving activity in which a person will engage according to the model presented above. Human wealth, which typically is most of a driver's wealth, is measured by EARN, the present value of expected future labor earnings. EARN is based on the concept of age-earnings profile. By using these earnings patterns, some of the obvious errors in measuring income by observing people at different stages of the life cycle will be avoided.

In generating the labor wealth variable, we define the age-earnings profile for each of the seven education levels for which data are available (Mincer, 1974). The estimated profiles are given in Table 1. The information available for each individual driver is used, for while each individual is assumed to have a typically shaped (sloped) profile for his respective education level, the intercept of the equation that describes the profile is allowed to vary by individual. Exceptional opportunity or ability is reflected in high earnings. The individual's age and average annual hourly wage rate are known for 1972. Full-time earnings are calculated by multiplying the 1972 average hourly wage rate by 2000 hours (40 hours per week for 50 weeks), and these earnings are the intercept of the individual's profile at his 1972 age. As with the wage rate, if 2000 is not the correct constant to use, at least earnings across individuals will be proportional to full-time earnings and the difference will be incorporated in the probit constant. (In the next section, the definition of EARN based on 1972 full-time earnings is tested against several other definitions, including actual 1972 earnings.) Using 1972 age and full-time earnings, the appropriate age-earnings profile is obtained for each individual because the intercept is unique for each individual. The age coefficients are different for each education level as well.

We predict the earnings for each year and multiply each year's earnings by the appropriate probability of survival and discount factor. The sum of each year's expected discounted full-time labor earnings is the variable EARN:

$$8.\ EARN_a^{b,c,d} = \sum_{j=a+1}^{70} E_j \frac{1}{(1+i)^{j-a}} \prod_{k=a}^{j-1} p_k^{b,c}$$

where a is age in 1972, b indicates race, c indicates sex, d indicates education level, p_k is the annual probability of survival for age k, and E_j is predicted annual labor earnings at age j. EARN is determined for each individual using calculated annual probabilities of survival (Schrimper, 1974). Although they are based on Chicago area mortality data, a comparison of Schrimper's 5-year survival probabilities for Chicago and those for the U.S. (Duffy, 1975) shows little difference. EARN is computed using three discount factors, 5, 10, and 15%, and the question of which

[5]The categories for grades completed are: 0, 1-5, 6-8, 9-11, 12, 12 plus training, 13-15, and 16 plus; and the respective weights are: 0.00, 0.25, 0.75, 1.63, 2.26, 2.50, 3.05, and 4.27.

TABLE 2
PROBIT RESULTS FOR
SEAT BELT USE AND NONUSE

VARIABLE	COEFFICIENT	t
RSPEED	0.00661	1.15*
SEXF	−0.525	−3.16****
AGE	0.0211	3.04****
EDUC	0.309	8.01****
WAGE	−0.0796	−1.89**
EARN	0.00706	2.95****
WORKLN	0.00621	2.06***
VACLN	0.0288	2.56****
PROPY	−0.0440	−2.08***
HEALTH	0.992	3.12****
KIDS	−0.0650	−3.18****
MARR	−0.292	−2.15***
CHURCH	0.00523	3.57****
CONSTANT	−7.217	−4.86****

*p = .25.
**p < .10.
***p < .05.
****p < .01.

discount factor is more appropriate is investigated.

Other value of life variables. An implication of the economic model is that the derived demand for life saving (S) is high for individuals with high values of life (V), that is, who value highly small increases in the probability of survival. The effects of nonhuman wealth and good health should be similar to that of human wealth in that each increases the value of life through permitting more consumption.

PROPY, the variable used to measure nonhuman wealth, is the driver's share of 1972 family income from transfers, home ownership (implicit and explicit), bonds, stocks, and other assets.

The variable for good health is based on a question concerning annual hours of illness. For the first 8 weeks of illness, a sick day counts as 16 sick hours; thereafter each day counts as 12 sick hours. Consequently, the maximum number of healthy hours in a year is 4592. HEALTH is a measure of good health in that it equals 4592 less the reported annual hours of sickness in 1972. Healthy drivers are expected to wear seat belts because they have high values of life.

EARN, PROPY, and HEALTH affect seat belt use because from our economic viewpoint they are determinants of the value of life, but these are not the sole determinants of the value of life. One can interpret the previously introduced variables, MARR and KIDS, in this light, as there is a notion that, because of interdependent utility functions (love) or household production advantages (specialization), married people with children have a higher value of life. If true, seat belt use need not be lower for married drivers or drivers who are parents despite the higher cost they incur to wear seat belts. Another value of life variable that is available and that is tempting to try is church attendance. If churchgoers attach a high value to life or for life style reasons behave as if they do, then they will tend to use seat belts more than otherwise expected. CHURCH takes on the value 52 if the respondent answered that he attended a service at least once a week, 24 if he answered that he attended 1 to 3 times per month, 5 if he answered that he attended less than once a month, and 0 if he answered that he never went to a service. While there are certainly other interpretations of the productivity, cost, and especially value of life variables, the discussion of each follows the economic model developed.

RESULTS AND DISCUSSION

Following the theoretical model of individual consumption and life-saving activity, and using the variables available in the *Panel Study* for seat belt productivity, cost of seat belt use, and value of life, seat belt use is studied statistically through multivariate probit analysis. The results are presented in Table 2, with definitions and means of the variables given in Table 3, and summary statistics of the probit equation given in Table 4. The overall performance of the estimated equation is best judged by a generalized likelihood-ratio test using the statistic minus two times the likelihood-ratio. The calculated statistic is 261 which is significant at $p < .01$.

In considering the results for each variable, we will first examine the seat belt productivity variables (P′ and R′) anticipating that the greater are P′ and R′ the more the driver uses seat belts.

TABLE 3
MEANS OF PROBIT VARIABLES, 1972

VARIABLE	DEFINITION	MEAN VALUE	UNIT OF MEASURE
SBU	Seat belt use-nonuse	0.26	Belt users/all drivers
RSPEED	Rural speed limit	60.0	Miles per hour
SEXF	Sex	0.119	Female drivers/all drivers
AGE	Driver age	39.2	Years
EDUC	Education	2.30[a]	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	0.823	Married drivers/all drivers
CHURCH	Religious attendance	23.2	Services per year

[a]The average driver has just a bit more than a high school education.

It should be kept in mind that each probit (or regression) coefficient represents the partial effect of the appropriate variable, something not detectable from correlation coefficients used in earlier studies. For example, the probit coefficient for AGE gives the effect of AGE on seat belt use, holding constant the effect of WAGE, EDUC, etc.

In Table 2, the positive sign of RSPEED (state rural speed limit) reflects the high productivity of seat belts for drivers who reside in states where high speed driving is allowed. These drivers are more likely to be involved in potentially injurious accidents and accordingly are more likely to use seat belts. The negative sign for SEXF (female driver) reflects low productivity of seat belts for women, who tend to drive under safer conditions than men. Since women are less prone to involvement in injury accidents, they are less likely to use seat belts.

The positive sign for AGE reflects the high productivity of seat belts for older drivers who are more likely to be involved in an injury accident. It was suggested above that the age-seat belt productivity relationship is nonlinear. While a quadratic relationship with AGE and AGE-squared produced a negative sign on AGE-squared with a t value near −1, stratification of drivers into 17-34, 35-55, and 56-69 age groups was significant according to a restriction F test and showed seat belt use was indeed sensitive to changes in age for the oldest group.

The results shown in Table 2 do not contain the variables RURAL (non-SMSA county of residence) or INTER (interstate highway), because each had a t value well below 1 in preliminary regressions and their deletion caused little change in the coefficients of the remaining variables. The low level of significance of RURAL could well be due to the fact that the SMSA/non-SMSA definition used does not correlate well with the highway department's definition of urban-rural roadway. A farm-nonfarm variable was tried, but with similar results. The result that INTER was not significantly different from zero is not surprising, since the productivity effect of high speed and the cost effect of long trips is probably offset by the safe design of interstates.

Peltzman (1975) found that per capita automobile accident death rates can be explained in part by average urban traffic density and average rural traffic density

TABLE 4
PROBIT SUMMARY STATISTICS

STATISTIC	VALUE
Log likelihood ratio times minus two	261
df	13
Percent correct predictions	77
Number of observations	1851

with death rates higher for increases in urban density and lower for increases in rural density. One might expect seat belt productivity to be high for densely populated urban areas, but when two such density variables were tried the t values were quite low and further refinement was not pursued.

Considering the probit results, we turn next to cost (K) variables, expecting that drivers who face high costs will be less likely to use seat belts.

The negative sign of WAGE (Table 2) evidences the high time cost (q) for drivers who have a high value of time and indicates that they are less likely to wear seat belts. The result emphasizes the importance of convenience in the design of safety products. The positive signs of WORKLN (work trip length) and VACLN (vacation length) reflect the low time cost of seat belt use for drivers who do not have to continually buckle and unbuckle because of longer and fewer trips. The negative cost effects of MARR (married driver) and KIDS (number of children) indicate that the effect of high time costs due to extra adjustment, fastening, and unfastening is greater than any effect in value of life since it more than offsets the positive effect of family interdependence (high V).

The positive sign of EDUC (education) reflects primarily low costs to those who gather information easily (indistinguishable from low $-U_s/\lambda$) and, as a second order effect, low costs to those who organize their tasks efficiently. Since EDUC is based on weights derived from 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 squares regressions for comparison, the regression with EDUC has a higher R^2 and larger t than a similar regression with an education variable that has equal weights. To further explore the usefulness of the EDUC weighting scheme, 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 is consistent with the increasing weights used in EDUC.

Finally, we turn to the value of life variables (V) expecting that drivers with high V are more likely to use seat belts.

The positive sign of EARN (present value of expected future labor earnings) is evidence of the higher value of life for drivers with greater human wealth. Indeed, it appears that people with high potential foregone earnings do have a higher value of life, as might be expected from the emphasis placed on foregone earnings in much of the value of life literature.[6] 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, a 7-year average of actual labor earnings, and three different discount rates, 5, 10, and 15%. In addition, the age-earnings profile was constrained to never fall once a peak was reached in accordance with the idea that it is a decline in labor force participation, not wage rate, that causes earnings to fall as a worker ages. Using ordinary least squares regression, it was found that EARN (1972 wages times 2000, 10% and unconstrained) produced the best results, i.e., the highest t value for an earnings variable and the highest R^2.

The negative sign of PROPY (nonlabor income) may not actually be 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 greater the property income the more the individual has fulfilled his bequest motive, possibly lowering the value to him of his own life insofar as he is living for family or others. The PROPY variable does not affect the coefficients of WAGE, EARN, or other variables except AGE, the coefficient of which falls by 10% if PROPY is deleted from the probit equation.

In general, this paper gives some indication that an economic approach to safety and seat belt use is worth consideration. The paper also illustrates the advantages of multivariate analysis which isolates the partial effect of each explanatory variable barring statistical problems.

[6] Although foregone earnings is an important determinant of the value of life, as shown elsewhere (Blomquist, 1977), the value of the life-foregone earnings relationship is not dollar-for-dollar.

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