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THE EFFECTS OF AGE AND FAMILY STATUS ON THE VALUE OF STATISTICAL LIFE – EVIDENCE FROM THE AUTOMOBILE MARKET AND A NATIONAL SURVEY OF AUTOMOBILE USE

William Schulze
Project Director

Cornell University
Ithaca, NY

Prepared by:
Timothy Mount, William Schulze
Weifeng Weng, and Ning Zhang
Department of Applied Economics and Management
Cornell University
Ithaca, NY 14853

Laurie Chestnut
Stratus Consulting

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Project Officer
Dr. Alan Carlin
National Center for Environmental Economics
Office of Policy, Economics and Innovation
U.S. Environmental Protection Agency
Washington, DC 204060

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Abstract

This study reports on a new national survey of individual automobile usage designed to provide information on automobile safety expenditures by family status and age. Noting that, for a family, the safety of an automobile is a public good, these data, when combined with an analysis of the FARS data set on fatal automobile accidents and a hedonic price function for automobiles, allows estimation of the value of statistical life for individual family members over their lifetime. The research also attempts to resolve the problem of an anomalous sign on the coefficient on fuel consumption in prior hedonic price studies of automobile safety. The principal result is that the value of statistical life remains relatively constant over the lifetime for all family members with the exception of parents with children living in the household, who have a lower value. Adults without children do not show a similar decrease in the value of statistical life. Estimates of income elasticity are also presented and a theoretical explanation for the results is provided.

Section 1
Introduction

Little work has been done either theoretically or empirically to value morbidity and mortality either for children or retired adults (for exceptions see Blomquist, et al., 1996, and Jenkins, et al. 1999). This paper attempts to address both of these issues by first presenting a theoretical model of how families value risk and then examining family automobile purchases. In particular, using a standard model of family decision-making, we show that parents may value risks to their children's lives (the model assumes two altruistic parents) through Nash cooperative bargaining to determine how much money to invest in the safety of their children. To allow empirical estimation of values, automobile safety is then shown to be a family public good, where the marginal cost of purchasing and operating a safer automobile is set equal to the usage-weighted sum of the values of statistical life (VSL) of family members. We use data on automobile purchases to estimate how much families with children spend on automobile safety, how much families with retired members and no children spend on automobile safety, and how much families without children or retired members spend on automobile safety. This not only allows estimation of an average value of a statistical life (VSL) for each type of family, but also allows estimation of an average value of a statistical life (VSL) for different age groups (children, adults and seniors) by family type and income level.

The research reported here combines primary data on automobile usage by family members with secondary data from both the automobile market and the FARS data set on automobile accidents. This allows calculation of the VSL for different family members from choices made concerning the type of vehicle and usage pattern by family members. An important issue that has clouded the potential reliability of the VSL obtained from estimated hedonic price functions for automobiles (that include risk of death) is that prior studies have shown what appears to be a positive correlation between fuel consumption and the price of automobiles rather than the expected negative correlation (people should be willing to pay less for cars with poor fuel economy). Our theoretical work in the next section provides a possible explanation that also suggests a revised estimation procedure.

The paper is organized as follows: Section 2 presents a theoretical model of family automobile purchase decisions focusing on safety, fuel usage, how safety values for each individual are determined in a family setting, and proposes a methodology for estimating the VSL of family members of different ages. Section 3 describes the survey methodology used to obtain new data on automobile usage by children, adults, and seniors. Section 4 addresses the problem of driver characteristics affecting estimates of the inherent risk of fatality of different automobiles and develops a procedure for identifying the driver independent level of risk, summarizes our empirical work estimating a hedonic price function for automobiles showing a negative correlation between risk of fatal accident and price and fuel costs, and addresses issues which arise with multiple vehicle families. Section 5 presents estimates of average implied values of life for different family groups and income levels by age as well as estimated income elasticities.

Section 2
Theoretical Issues

How willingness to pay (WTP) for health and safety may vary with the age of the person at risk is a very important policy question for which we have little well-established empirical data. Cropper and Freeman (1991) address this question with a life-cycle consumption-saving model that they apply with a quantitative example to examine how WTP for a risk reduction in the current time period can be theoretically expected to change over a person's lifetime. This model is based on the premise that a person makes consumption and saving decisions over time to maximize personal utility. Because this model is based on the premise that utility is a function of consumption, the authors note that, if there is additional utility derived from survival per se, then the life-cycle model provides a lower bound estimate of WTP. The quantitative example depends on assumptions regarding a lifetime pattern of earnings, endowed wealth, the rate of individual time preference, and other parameters of the model. These will all vary for different individuals, and uncertainty exists empirically about population averages for many of these factors. However, using reasonable values to calibrate the model is illustrative. Cropper and Freeman note that if consumption is constrained by income early in life, the model predicts that VSL increases with age until age 40 to 45, and declines thereafter. Shepard and Zeckhauser (1982) also illustrate this point with numerical examples for the life-cycle model. When they estimate the model with reasonably realistic parameters and assume no ability to borrow against future earnings or to purchase insurance, they find a distinct hump in the VSL function with a peak at around 40 years and dropping to about 50% of the peak by 60 years. When they allow more ability to borrow against future earnings and to purchase insurance, the function flattens and at 60 years drops only to 72% of the VSL at age 40. However, the hump shape to the VSL over a person's lifetime remains.

The conclusions reached by these theoretical analyses of the effect of age on WTP for mortality risk reduction using the life-cycle model are somewhat consistent with the empirical findings obtained by Jones-Lee et al. (1985). However, the empirical findings show that WTP varies with age much less than would be predicted by the life-cycle models. In this stated preference study, respondents gave WTP estimates for reductions in highway accident mortality risk and the answers showed a fairly flat hump-shaped relationship between VSL and age, peaking at about age 40. Although the directions of the changes in WTP with age are consistent with what the life-cycle models predict, the magnitudes of the changes are smaller. The Jones-Lee et al. results show that at age 65 the VSL is about 90% of the VSL of a 40-year-old person.

It is often suggested that WTP will be lower for the elderly than for the average adult because expected remaining years of life are fewer. This expectation is based on the presumption that WTP for one's own safety declines in proportion to the remaining life expectancy. Some analysts have suggested that effects of age on WTP might be introduced by dividing average WTP per statistical life by average expected years of life remaining (either discounted or not) to obtain WTP per year of life (Moore and Viscusi, 1988; Miller, 1989; Harrison and Nichols, 1990). Such a calculation implies very strong assumptions about the relationship between life expectancy and the utility a person derives from life; namely, that utility is a linear function of life expectancy and that the value of life year remains constant.

Determining appropriate WTP values for changes in mortality risks to children poses some particular analytical challenges. Children are not the economic decision makers whose preferences can be analyzed to determine an efficient allocation of society's resources regarding their own health and safety, so both revealed and stated preference approaches must rely on parental decisions to show what WTP for children's health and safety might be. Based on the expected relationship between WTP and expected life-years lost, it may be reasonable to assume that reductions in risks to children are valued equal to or greater than risks to adults. Blomquist, et al. (1996) support this view in their analysis of seat belt use for children. On the other hand, the life-cycle consumption-saving models show increasing WTP for risk reductions between the ages of 20 and 40, reflecting the typical pattern of increasing income and productivity during this stage of life. Extending this to children might suggest lower WTP for reducing risks to children, however, this pushes beyond the theoretical constructs of the life-cycle model regarding an individual as an economic decision maker. The only theoretical model that addresses these concerns, with respect to dependent children, has been developed by Chestnut and Schulze (1998). Their work treats the case of a family with non-paternalistic altruistic parents who engage in Nash cooperative bargaining to determine health and safety expenditures on their children and the implied VSL. We use this model as a starting point for our analysis.[1]

As indicated in the introduction, a secondary theoretical issue is that fuel consumption appears to have the wrong sign in existing hedonic price functions for automobiles that have been used to estimate the VSL (Atkinson and Halvorsen, 1990, and Dreyfus and Viscusi,1995). Atkinson and Halvorsen (1990) use the data for 112 models of new 1978 automobiles to obtain estimates of the VSL. Since the available fatality data is a function of both the inherent risk of the vehicle and the driver's characteristics, the drivers' characteristics are included in the regression as control variables. Their estimated VSL for the sample as a whole, based on willingness to pay, is $3.357 million 1986 dollars. The data used in Dreyfus and Viscusi (1995) differ from those used in earlier studies in that they reflect actual consumer automobile holdings. Dreyfus and Viscusi (1995) use the 1988 Residential Transportation Energy Consumption Survey together with data from industry sources. They generalize the standard hedonic models to recognize the role of discounting on fuel efficiency and safety. Their estimates of the implicit value of life range from $2.6 to $3.7 million. Both studies show a positive correlation between automobile price and fuel consumption.

Given the state of existing research, our first task is to develop a model that can potentially explain the positive correlation between automobile price and fuel consumption. The second task is to develop a model of the behavior of households with dependent children. This model is developed in the context of automobile safety to allow empirical estimation of the VSL for family members by age group, family status, and income group. The existing theoretical literature only considers individuals rather than families, with the exception of the work by Chestnut and Schulze mentioned above.

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[1] It should be pointed out that some interesting revealed preference empirical approaches based on a household production function framework to analyze household expenditure decisions as they relate to children's health have been attempted (Agee and Crocker, 1996; Joyce et al. 1989). These analyses infer implicit WTP for changes in children's health as revealed by expenditure decisions of the household. Limitations in available data and analytical difficulties in properly specifying and verifying modeled relationships pose challenges for this approach; however, its basis in actual household decisions and behavior is an important strength. Estimates of WTP for changes in mortality risk for children are not directly available from these two studies, but similar approaches might be applied to obtain such WTP estimates.

To begin, we address the problem of fuel consumption by considering the case of a single individual with no family who may, or may not, survive for a single period. The following notation will be useful:

c = consumption,

w = wage income,

r = risk of a fatal automobile accident per mile driven,

Π = probability of survival without automobile fatality risk,

Π-r = probability of survival with automobile fatality risk,

m = total miles driven

a = level of some other positive automobile attribute (e.g., acceleration)

P(r,a) = automobile price per mile driven (decreasing in r and increasing in a)

F*(r,a)) = fuel consumption per mile (increasing in r and a)

G = price of fuel

U(c,a,m) = strictly concave utility function.

Note: subscripts or primes denote derivatives where appropriate.

Note that we propose that the individual realizes that the fuel consumption of the car is itself a function of the attributes of the automobile. We will justify this proposal when we consider the manufacturer's decision below. Also, to abstract from the life cycle issues of owning and financing an automobile, we analyze the problem in terms of the annualized price per mile of owning the vehicle, P, without loss. In this setting, the individual must make four choices. First, the individual chooses the level of consumption, c. Second, this is traded off against the choice of automobile safety (how risky per mile a car to purchase, r) taking into account that lower r implies that both the price of the car itself over the m miles driven each year, P(r,a)m, and total cost for fuel with price per gallon G and fuel consumption F* driven m miles per year, GF*(r,a)m, are greater for a safer car since P_r, $F_r^*<0$. Third, the individual chooses the other characteristic of the car, a, realizing, for example, that increased acceleration will both increase the price of the car and increase fuel consumption since P_a, $F_a^*>0$. Fourth, the individual will choose how many miles to drive, m. The individual is assumed to maximize expected utility,

$$(\Pi - rm)U(c, a, m), \quad (1)$$

where it is assumed that the death state provides no utility because the individual has no family, subject to the budget constraint,

$$(\Pi - rm)(w-c) - P(r,a)m - GF^*(r,a)m = 0. \quad (2)$$

This budget constraint assumes that costless insurance (priced at expected value) is available both to cover the purchase price and operating costs of the automobile. Most car loans, in fact, carry life insurance for the amount of the loan, and life insurance could presumably cover other costs. The optimal choice for r, risk per mile, is determined by

$$VSL = -(P_r + GF_r^*), \quad (3)$$

where

$$VSL \equiv (U/U_c) + w - c. \quad (4)$$

Equation (4) sets the marginal increase in cost for purchasing and operating a safer car per mile equal to the VSL. The VSL is defined in (4) for the case of perfect insurance markets and is equal to the monetized value of utility, (U/U_c), which is lost in death, plus the excess of earnings over consumption. The interpretation of this relationship is much clearer in the family setting that we treat below, so we will defer discussion.

The optimal choice of the attribute, a, is determined by

$$U_a/U_c = m(P_a + GF_a^*) \quad (5)$$

which sets the marginal willingness to pay for the attribute (acceleration) equal to the incremental total cost.

The total miles driven, m, is determined by

$$U_m/U_c - rVSL - GF^* = P \quad (6)$$

so that the marginal willingness to pay for an additional mile driven, U_m/U_c, net of the risk cost of driving an additional mile, net of the cost of fuel for an additional mile, GF*, is set equal to the per mile capital cost of the car, P. It is this last condition that helps explain the peculiar result obtained in prior estimates of the hedonic price function for automobiles. All buyers have the same marginal value for improved fuel economy equal to G, the price of fuel.

Competitive automobile manufactures should attempt to minimize the cost per mile of driving their automobiles including both the capital and fuel cost per mile of automobile life given the choice of other characteristics (r and a). Thus, for any given vector of automobile characteristics, manufacturers optimize fuel economy at the fixed marginal value of G. There is no hedonic market for fuel economy *per se* because for any vector of attributes, there is only one optimal level of fuel economy, because all buyers have the same marginal valuation of fuel economy. This is unlike an other attributes, a, such as acceleration, where, for the same safety level, there are a variety of marginal values for different buyers for acceleration depending on tastes. For these attributes, makers respond by offering a variety of vehicles with the same level of risk but different levels of acceleration. In contrast, the marginal value for fuel economy is always G, so no hedonic market exists. Clearly, fuel consumption itself then becomes a function of other car attributes. This can be shown by considering the design problem of a particular manufacturer with a cost of production per mile of life for the cars that they offer of C(a,r,F). Given a particular choice of a and r by a buyer, the maker is forced by competitive pressure to minimize the total cost per mile to buyers,

$$C(a,r,F) + GF. \quad (7)$$

The condition for optimal fuel consumption in the engineering design of the vehicle is then

$$-C_F = G. \quad (8)$$

This implies that there is an optimum fuel consumption F*(a,r) for any choice by consumers of a and r and the cost function relevant for the hedonic price solution for profit maximization over a and r by the maker is C*(a,r,F*(a,r)). The maker faces a hedonic price function only defined in a and r, P(a,r), not fuel consumption which is optimized in the engineering design of the vehicle, and maximizes profits P(a,r) - C*(a,r,F*(a,r)) with respect to a, implying

$$P_a = C_a^*, \tag{9}$$

and with respect to r, implying

$$P_r = C_r^*. \tag{10}$$

So, a particular maker will pick a and r by setting marginal costs equal to the slope of the hedonic price function for r, given a, and for a, given r, implying a mix of cars with different levels of a and r available to consumers from different makers with different cost functions.

In summary, given G, the price of fuel, the choice of F will be made by the automobile maker and becomes a function of r and a, since fuel usage will be optimized by makers for any combination of these attributes chosen by consumers. Consumers and makers are faced with a hedonic price function P(r,a) which is the envelope curve of the cost tradeoffs for makers and value tradeoffs for consumers between attributes. Buyers face a pre-optimized choice of fuel consumption, F*(r,a), for each level of attributes that they choose in their purchase decision.

If these arguments are correct, then adding fuel economy as an explanatory variable in the estimated hedonic price function results in a mis-specification of the model. This mis-specification could easily result in an anomalous sign on the coefficient for fuel economy. Rather, the appropriate procedure may be to estimate F*(r,a) and P(r,a) and use (3) above to estimate the VSL for the individual from these relationships and the price of gasoline, G.

The model developed above can readily be extended to a family setting by using the Nash cooperative bargaining between parents approach employed by McElroy and Horney (1981). Following our previous work (Chestnut and Schulze, 1998), we modify the notation used above, again considering a single car family, as follows:

n = the size of the family,

$i = 1, 2, \ldots, n$ denotes individual family members,

$i = 1$ denotes the mother,

$i = 2$ denotes the father,

$i = k = 3, \ldots, n$ denotes children,

c_i = consumption of the ith family member,

w_i = wage of family member i,

r= automobile fatality risk per mile driven, the same for all family members,

Π_i = probability of survival, excluding automobile fatality risk, of i,

m = total vehicle miles driven

m_i = total miles of driving for family member i

P(r,a) = automobile price per mile driven,

F*(r, a) = fuel consumption per mile driven,

$U^k(c_k, a, m_k)$ = child's utility function,

$U^i(c_i; \ldots, m_i, a, (\Pi_k - r)U^k(c_k, m_k), \ldots)$ = parent's utility function (i = 1, 2), and

E^i = individual expected utility in separation (i = 1, 2).

The family must decide how much to allocate to each family member for consumption, on the risk level of the single automobile they purchase for all, attribute a. and the number of miles driven for the car itself and each person who rides in the car. The hedonic price and fuel consumption functions for the automobile are the same as in the previous model. Utility functions of both the father and mother are assumed to depend not only on their own consumption, driving and car attribute, but also on the expected utilities of each of their children. The children's utility is assumed to be a function of their own consumption, the car attribute, and the miles they ride in the car.

Investment in the safety of their children is a public good to the parents, which is the subject of negotiation, as is the level of consumption of each. The Nash cooperative bargaining model assumes that the solution maximizes the multiplication of the increase in the expected utility of the outcome over the threat point of expected utility in separation for the mother and the father. The threat points, E^i, are assumed, in models of the family, to be a function of divorce laws, job opportunities, etc. Thus, in the Nash cooperative bargaining solution,

$$[(\Pi_1\text{-}rm_1)U^1 - E^1]\,[(\Pi_2\text{-}rm_2)U^2 - E^2], \qquad (11)$$

is maximized with respect to c_i, r, a, m, and m_i, subject to the budget constraint,

$$\sum_{i=1}^{n} (\Pi_i\text{-}rm_i)\,(w_i - c_i) - (P - GF^*)m = 0, \qquad (12)$$

and constraints on the use of the car such as,

$$m - m_i \geq 0 \qquad i = 1,\ldots\ldots, n$$

so that no individual family member can ride more miles than the car itself travels, and

$$m_1 + m_2 - m_{12} - m_k \geq 0 \qquad k = 3,\ldots., n$$

so that no child can ride more miles than the parents can collectively drive the child. Note that, to avoid pointless complication of the model, m_{12} is taken to be a constant number of miles that the parents ride together, where it is assumed that $m_1, m_2 \geq m_{12}$.

The resulting conditions for choosing the level of automobile risk and miles driven imply that the individual VSLs of family members all take the form:

$$VSL_i \equiv U^i/U^i_c + w_i - c_i \qquad i = 1,\ldots\ldots\ldots,n. \qquad (13)$$

The remarkable fact is, that, in spite of the complicated structure of the problem specified above, the implied VSL_i for each family member shown in (13) is identical in form to that for the single individual shown in (4) above. The interpretation of the VSL_i can be illustrated with the following examples. Imagine that the mother is the sole breadwinner with a stay-at-home father.

In this case, assuming that the children are young, $w_i - c_i < 0$ for the other family members and $w_m - c_m > 0$ for the mother. Thus, if the mother were to die, this would be a severe financial blow to the rest of the family and the mother's VSL would reflect this relative to the VSL of other family members. For young children it is clear that $w_k - c_k < 0$ in the short run. However, in the inter-temporal version of the model, $w_k - c_k$ is replaced by its discounted present value, which may be positive. U^i/U^i_c depends primarily on c_i in the single period model and on the lifetime consumption pattern in the full inter-temporal model. The important point is that the child's consumption depends in youth on the parents' income and wealth. Further, if parents find the value of their child's smile to be high enough, the child's consumption will be maintained by them, at a high level, leading to a high VSL. A young child's utility and the utility they derive from that happiness may also be large in the parent's view from relatively small levels of money consumption, also leading to a high VSL. These arguments suggest that the VSL of children is a purely empirical question and depends not only on their own life cycle wealth but also on their family's wealth and the beliefs of the parents regarding their children's utility.

The choice of automobile risk, r, is determined by

$$\sum_{i=1}^{n} k_i VSL_i = -(P_r + GF_r^*) \tag{14}$$

where usage weights for the vehicle for each family member are defined as $k_i = m_i/m$. Thus, the safety of the shared family vehicle is determined by a public good condition that sets the sum of the usage weighted VSLs of individual family members equal to the marginal cost of obtaining a safer automobile. The marginal cost of a safer vehicle is the slope of the hedonic price function for automobile safety, $-P_r$, plus the marginal fuel cost penalty, $-GF_r$, which, by (14), is set equal to sum of the usage weighted VSL_i for the family, $\sum_{i=1}^{n} k_i VSL_i$, to determine the choice of per mile automobile risk, r.

Thus, if we obtain predicted values for the marginal cost of reduced risk per mile ($P_r + GF_r^*$) and the share of automobile use, k_i, for each family member by age group for different households, we can use equation (14) to obtain estimates of the VSL_i. Note that equation (14) is a single equation embedded in a system of simultaneous FOC equations. To each FOC equation, we appended an additive error term. Assume that each of these error terms is independently, identically distributed over families around a mean of zero. Because m_i and m are endogenous variables in the simultaneous FOC equations, consistent estimates will not be obtained by using the method of lest squares if m_i and m are correlated with the disturbance term in equation (14). A two-stage procedure is required to obtain the consistent estimates. In the first stage, reduced-form equations for m_i and m will be estimated using appropriate exogenous variables which reflect the family characteristics. The predicted m_i and m that are uncorrelated with the residuals in equation (14) will be used as the instrumental variables for m_i and m. In the second stage, expression (14) will estimated by least squares using predicted m_i and m (which provide predicted k_i) to obtain consistent estimates of the VSL for adults, children and seniors.

The next section describes the survey methodology used to collect the necessary primary data to employ the proposed methodology.

Section 3
Survey Design and Implementation

Secondary data describing the detailed usage of vehicles by family members has been unavailable, Since such data are necessary to implement the methodology proposed in the last section for measuring the VSL of family members, a national survey was undertaken to collect data on how families choose and use automobiles, as well as on their attitudes and beliefs regarding automobile safety. This survey consisted of two parts, a telephone screening survey used to develop an appropriate sample and collect information on usage, followed by a mail survey. Both the telephone and mail surveys were extensively pre-tested and revised prior to implementing a pilot aimed at 80 households to formally test the telephone/mail survey methodology. Only small changes were made to the survey instruments following this final test. Both surveys can be found in Appendix D.

The purpose of the telephone survey was to identify appropriate households and to obtain data on automobile usage that was judged too difficult for respondents to fill out themselves in a mail survey. Note that the mail surveys were customized for each respondent and included respondent specific information on automobile make, model, and purchase price. Both the telephone and the mail survey were developed following Donald Dillman's Tailored Design Method (1999).

The telephone survey begins by indicating that the interviewer is calling on behalf of Cornell University. The first five questions determine if the interviewer and household meets the requirements for the sampling. Question 6 asks for detailed information on automobiles owned or leased by the household while Question 7 elicits information on the residents' ages and relationships. Question 8 elicits the percentage of miles that each member of the household rides in each of the three most driven cars. Needless to say, this is a difficult question and necessitated a personal telephone interview with trained interviewers. Question 9 attempts to find out whether household members typically ride in the front or back seat of the three most driven vehicles. Questions 10 to 18 collect information on the reasons and distances to various destinations that people drive their cars to help in explaining driving patterns. Question 19 recruits respondents for the follow up mail survey. Questions 20 to 27 collect socioeconomic data on respondents including income.

The cover of the mail survey booklet is titled "WHAT ARE YOUR VIEWS ON AUTO SAFETY," shows a picture of a family next to a Ford Windstar (thanks to Ford for granting permission to use the photo), and has indicates that the survey is being conducted for Cornell University in the lower left hand corner. The first page thanks the respondent for "agreeing to complete this important survey on automobile safety," and repeats the information on the most, second most and third most driven automobiles taken from the telephone survey and asks the respondent to correct any errors. Question M1 asks if the respondent has read or heard about automobile safety in the last six months. Questions M2-M6 ask about insurance and repair costs and features of each of the vehicles. The mail survey was necessary to allow collection of subjective risk information from respondents that required use of a risk ladder as a visual aid. Thus, M7 asks for a subjective risk assessment of having a fatal accident (compared to the average driver in the same type of automobile) for the respondent. M8 asks for a subjective assessment of a child's risk of dying relative to an adult's risk in a serious automobile accident. The next questions ask the respondent for their perceived risk of the safety of the vehicles that they drive. The last two pages ask a Contingent Valuation question on the value of improved automobile safety for comparison to the hedonic price estimates of the VSL to be obtained from the study.

A random digit-dialing sample of 8519 telephone numbers was obtained from Sample Survey Inc., a well-known and respected source of survey information. Although the target number of completed mail surveys was only 600, past experience has shown that random digit dialing produces a large number of non-household, disconnected, or ineligible numbers for household surveys. The telephone screening survey was implemented between July 1 and August 5, 2001 and employed a minimum of 13 attempts to reach each telephone number. The completed telephone surveys averaged 14 minutes in length. After screening out businesses and other non-household phone numbers, ineligible households such as those with more than 5 people or three automobiles (it proved impossible to design a manageable survey for such households), those with no car, etc, but including those households which were unreachable after 13 or more tries, the overall response rate was about 40% for the telephone survey as shown in

Table 3.1. This produced 1,235 completed interviews. Of these, 926 or 75% agreed to participate in the mail survey.

Table 3.1 Disposition

				Final
Total Cases (T)				8, 519
Known non-household Ineligible (A)				2, 712
	Final Disconnect			1, 302
	Final Computer Tone			423
	Business/Government			897
	Non-Residential Number			90
Known Household Ineligible (B)				1, 093
	Ineligible - > 5 people, 0 autos, > 3 autos, employer vehicle, gift vehicle, don't know make			679
	Language Barrier			414
Known Household Eligible (C)				
	I	Completed Interview		1,235
	NC	Non-Contact – Respondent not available for duration of study		45
	Refusals (R)			168
	R	SCR-Soft Mid-Interview Terminate		0
	R	SCR-hard Mid-Interview Terminate		168
Unknown Household Status (D)				3,266
	UH	No Answer/Phone Busy		1,204
	UH	Initial Disconnect/Computer Tone		9
	UO_NON_HUDI			450
	UO	Non-HUDI	Answering Machine	308
	UO	Non-HUDI	Remainder Respondent not available	86
	UO	Non-HUDI	Interviewer Reject	18
	UO	Non-HUDI	Scheduled Callback	38
	UO_HUDI			1,603
	UO	HUDI	Soft Refusal	72
	UO	HUDI	Hard Refusal, Don't know/Refuse Q1 or Q2	1,531
Total Dialed				**8,519**
Known non-household Ineligible (A)				2,712
Known household (KH) = (I + P + R + NC + B)				2,541
Unknown Household Status (D)				3,266
	Working numbers (WN) = KH + D)			5,807
	Working % (WKG) = (WN / T)			68.17%
	Non-household % = (A / T)			31.83%
Known household Ineligible (B)				1,093
	Household Eligibility Rate (NEI) = (KH – B) / KH			56.99%

Table 3.1 (Continued)	
Completed recruitment Survey (AAPOR RR4*)	39.98%
AAPOR RR4 = I/ [I + R + NC + (WKG*NEI*UH) + (NEI * (UO_NON_HUDI + UO_HUDI))]	

The mail survey was sent in waves from July 6, 2001 to August 6, 2001. The survey packet included a letter from Cornell University describing the importance of their response and the nature of the study, a $5 cash incentive, the 12-page survey booklet, and a post-paid return envelope. A reminder post card was mailed 7 days after each survey packet was sent thanking those who had returned their survey and reminding those that had not to please complete the survey or ask for a replacement. Two weeks after each survey packet was sent, follow-up phone calls were made to non-respondent households with more than 6 attempts, if necessary. Table 3.2 presents the response data for the telephone follow up survey. The overall response rate for completed follow-up phone calls was 78%.

Table 3.2 Response Rate Data For Follow-Up Survey

	Count	**Percent of Starting Sample**
Starting Sample	394	
Nonworking Numbers		
Disconnected	7	1.78%
Computer Tone	1	0.3%
Ineligibles		
More than 5 people	13	3.3%
No autos	5	1.3%
Adjusted Sample	368	
Refusals (R)	4	1.0%
More than 6 attempts	55	34.7%
Active sample	0	0.0%
Completed Reminder Call (*completes/adjusted sample)*	309	78.4%
Will return survey	140	45.3%
Needs survey	45	14.6%
Won't return survey	9	2.9%
Already returned survey	114	36.9%
Completed survey over the phone	1	0.3%

Note: Response rate includes pretest calling

The detailed response rate information for each wave of the mail survey by date mailed is presented in Table 3.3. The overall response rate for the mail survey was 74% with 625 completed surveys, exceeding the initial target of 600.

Table 3.3 Detailed Response Rate Information

Filename	Total Quantity	Caseid range	Date Survey Mailed	Date Postcard Mailed	Date Reminder Calls Began	Response Rate Before reminder Calls Began	Number of Completed Mailed Survey	Final Response Rate
Pretest	80	1001-1080	7/2/01	7/9/01	7/20/01	65%	64	80.0%
list7-5f.xls	98	2001-2098	7/6/01	7/13/01	7/25/01	65%	74	75.5%
list7-9f.xls	242	3001-3242	7/9/01	7/16/01	7/25/01	49%	180	74.4%
list7-11f.xls	70	4001-4070	7/11/01	7/18/01	7/31/01	64%	51	72.9%
list7-13f.xls	42	5001-5042	7/13/01	7/20/01	7/31/01	62%	31	73.8%
list7-16f.xls	58	6001-6058	7/16/01	7/23/01	7/31/01	40%	45	77.6%
list7-18f.xls	30	7001-7030	7/18/01	7/25/01	8/3/01	40%	18	60.0%
list7-20.xls	36	8001-8037	7/20/01	7/25/01	8/3/01	57%	27	75.0%
list7-23f.xls	49	9001-9049	7/23/01	7/27/01	8/3/01	49%	37	75.5%
list7-25f.xls	53	10001-10053	7/25/01	7/30/01	8/9/01	51%	39	73.6%
list7-27f.xls	72	11001-11072	7/27/01	8/1/01	8/9/01	42%	53	73.6%
list7-30f.xls	22	12001-12022	7/30/01	8/3/01	8/15/01	41%	11	50.0%
list8-1f.xls	12	13001-13012	8/1/01	8/6/01	8/15/01	33%	6	50.0%
list8-3f.xls	42	14001-14042	8/3/01	8/9/01	8/17/01	67%	36	85.7%
list8-6f.xls	20	15001-15020	8/6/01	8/13/01	8/17/01	40%	17	85.0%
TOTALS	846						625	73.9%

Section 4
Econometric Analysis

For purposes of describing the econometric analysis, we use the following notation: Let

TPM = total annual personal riding miles of the family in the automobile,

TVM=total annual driving miles of the family in the automobile, which is generally less than TPM,

M_i = total annual personal riding miles of the ith family member,

MM= total annual mother riding miles in the automobile,

FM = total annual father riding miles in the automobile,

KM = total annual children riding miles in the automobile,

$$(\text{TPM}= \sum_i M_i = \text{MM+FM+KM})$$

r = average automobile inherent fatality risk per driving mile per occupant (the same for all family members),

P(r) = automobile price or capital cost per driving miles (decreasing in r),

P(r) $\times$TVM= annual automobile price or capital cost per family

F(r)= automobile fuel consumption expenses per driving mile (decreasing in r), and

F(r) $\times$TVM=annual fuel consumption expenses per family.

Using this notation, the approach used in the study to obtain the VSLs of family members requires estimation of

$$-[P'(r)+F'(r)]=\sum_{i=1}^{n} M_i \, VSL_i /TVM \qquad (15)$$

Thus, the safety of the shared family vehicle is determined by a public good condition that sets the marginal cost of obtaining a safer vehicle for the family equals to the usage-weighted average of individual family member's VSL where the weights are each family member's relative use. The marginal cost of a safer vehicle for an each occupant -P'(r) and -F'(r) can be derived from the slope of the hedonic price function HP(r,O) and hedonic fuel efficiency function HF(r,O) for automobile safety. r is still the automobile fatality risk per driving mile per occupant and O is the other automobile characteristics.

Each family will select the available automobile risk-price and risk-fuel efficiency combination that yields the maximum expected utility for the whole family. This is obtained where P(r) is tangent to the hedonic price function HP(r,O) and F(r) is tangent to the hedonic fuel efficiency function HF(r,O).The equilibrium obtains when P' (r)= HP_r and F'(r)=$-HF_r$. Hence, we can use the slope of the hedonic price and fuel efficiency functions with respect to r to get the marginal cost of obtaining a safer vehicle for each family.

By (15), the marginal cost of obtaining a safer vehicle for each family is set equal to the usage-weighted average VSL for the family, $\sum_{i=1}^{n} M_i VSL_i / TVM$, to determine the choice of automobile risk, r. If we use hedonic functions to represent the left hand side of equation (15), it reflects vehicle characteristics. The right hand side of equation (15) reflects the family characteristics. Based on this equation, the VSL for each family member can be estimated using the expected driving habits of individual family members.

4.1 Hedonic Price and Fuel Efficient Models

The first step is to obtain the marginal cost of a safer vehicle for a family owning vehicle j using hedonic models:

$$-[P'(r_j)+F'(r_j)] = -HP_{rj}(r_j,O_j)+HF_{rj}(r_j,O_j) \equiv \mathrm{St}(\mathrm{VSL}_j) \qquad (16)$$

The right hand side of equation (15) is the marginal cost of purchasing and operating a safer vehicle j, and it can also be regarded as the standard VSL for vehicle j ($\mathrm{St}(\mathrm{VSL}_j)$). Obviously, it should only depend on vehicle characteristics such as the make, model and year of a vehicle. We standardize the total annual driving mileage in each vehicle to 14000 miles. With the data on vehicle characteristics and average risk of a fatality per riding mile per occupant for different types of automobile, we can estimate hedonic indices of the purchase price and fuel efficiency for each vehicle. The standard expression for determining the marginal cost ($\mathrm{St}(\mathrm{VSL}_j)$) for any make, model and year of vehicle j from the hedonic price and fuel efficiency models is:

$$\mathrm{St}(\mathrm{VSL}_j) = -\beta_m \times \mathrm{P}_j / [\mathrm{r}_j \times 14000 \times \textstyle\sum_{t=1}^{L_j} (\frac{1}{1+i})^t\ ] + \alpha_m / \ (r_j \times fe\_city_j) \qquad (17)$$

Where β_m is the regression coefficient for inherent vehicle risk in the hedonic price model,

P_j is the purchase price of vehicle j,

r_j is automobile fatality risk per driving mile per occupant,

i is the discount rate, set to 10 percent,

L_j is the expected vehicle life, set to Max{1,10-(purchase year_j -model year_j)}, which standardizes the age effect of a vehicle on its price,

$\mathrm{fe\_city}_j$ is the fuel efficiency in miles per dollar of gasoline for vehicle j in year 2001, (ignoring the difference in gasoline price at different locations)

α_m is the regression coefficient for inherent vehicle risk in hedonic fuel efficiency model.

Now, given information on the characteristics of each vehicle j, and estimates of β_m and α_m from the hedonic functions, we can calculate St(VSL_j) by Equation (17). From Equation (15), $VSL_j \equiv -(P'+F')_j = \sum_{i=1}^{n} M_{ij} VSL_{ij} / TPM_j$. If we divide people into three groups according to age: adults (16-64), seniors (>=65) and kids (0-15), the VSL for each age group in the jth vehicle is VSL_{aj}, VSL_{sj} and VSL_{kj}, respectively.

Equation (15) becomes:

$$St(VSL_j)$$

$$=\sum_{i=1}^{n} (M_{ij} VSL_{ij} / TVM_j)$$

$$=(AM_j \times VSL_{aj} /TVM_j + KM_j \times VSL_{kj} /TVM_j + SM_j \times VSL_{sj} / TVM_j) \qquad (18)$$

where AM_j, KM_j and SM_j are the total riding miles of adults, kids and seniors in the jth, vehicle respectively.

4.2 Estimating the VSL for the Different Types of Families

If we assume that the VSLs of adults, kids and seniors are constant across different families, then VSL_a, VSL_k and VSL_s can be treated as parameters and estimated from Equation (18) directly. However, the VSL in different types of households will almost certainly vary. For example, an adult in a rich family is likely to have a higher VSL than one in a poor family. Thus, to estimate the VSL for different income groups the sample will be split into families with low, medium and high incomes.

Another way to remove the influence of family characteristics on VSL is to express VSL_{aj} , VSL_{kj} and VSL_{sj} as functions of family characteristics. Among all the family characteristics that might affect the VSL, income is the most important, and VSL is almost certainly positively related to the average income of a household. If EY is the average income per adult equivalent in household i, we assume VSL(i)= $\beta_i + \beta_{EY} \log(\frac{EY}{\overline{E}\overline{Y}})$ where $\overline{E}\overline{Y}$ is the average equivalent income for all households. β_i is the purified VSL for a household, and (18) becomes:

$$-[P'(r)+F'(r)] =$$

$$\beta_A \text{*AM/TVM+} \beta_K \text{*KM/TVM +} \beta_S \text{*SM/TVM +} \beta_{EY}[\log(\frac{EY}{\overline{E}\overline{Y}}) \text{*TPM /TVM]} \qquad (19)$$

where TPM=KM+SM+AM.

The VSL for adults, seniors and kids can be estimated directly by using OLS regression. Estimated parameters β_A , β_K and β_S correspond to the average VSL for adults, seniors and kids for a household with average equivalent income $\overline{E}\overline{Y}$, respectively. β_{EY} measures the income effect on VSL and it can be used to calculate the income elasticity.

4.3 VSL for Families with Multiple Members and Multiple Vehicles

Assume that a multiple-vehicle family bought all vehicles owed by the family, step by step, rather than simultaneously. For example, there were no other vehicles owned by a two-vehicle family when it determined the optimal risk-usage-price-fuel efficiency combination for the first vehicle. The expected utility maximization problem faced by the family for the choice of the first vehicle is not different from the problem faced by a one-vehicle family. We can derive the same formula for VSL associated with the first vehicle as Equation (15):

$$-[P'(r1)+F'(r1)] = \sum_{i=1}^{n} M1_i \, VSL_i / TVM1 \tag{20}$$

where the number "1" attached to variables represents the corresponding variables for the first vehicle. When the family determined to buy the second vehicle, the first vehicle's condition and all physical variables related with the first vehicle have been fixed and could be regarded as exogenous variables. The family chose the optimal risk-usage-price-fuel efficiency combination for the second vehicle conditional on the existing first vehicle. The expected utility maximization problem faced by the family for the second vehicle is:

$$[(\pi_m - r1MM1 - r2MM2)U^m(c_{m,}(\pi_k - r1KM1 - r2KM2)U^k(c_k, KM1 + KM2),...,$$

$$MM1 + MM2) - E^m] \times [(\pi_f - r1FM1 - r2FM2)U^f(c_{f,}(\pi_k - r1KM1 - r2KM2)$$

$$U^k(c_k, KM1 + KM2),..., FM1 + FM2) - E^f]$$

is maximized with respect to $M2_i$, TVM2, c_i, π_i, and r2, subject to the budget constraint,

$$\sum_{i=1}^{n} (\pi_i - r1 \times M1_i - r2 \times M2_i) \times (w_i - c_i) - P(r1) \times TVM1 - F(r1) \times TVM1$$

$$- P(r2) \times TVM2 - F(r2) \times TVM2 - H(\pi_1, \ldots, \pi_n) = 0$$

The FOCs for this problem give a result similar to Equation 15) for the second vehicle.

$$-[P'(r2)+F'(r2)] = \sum_{i=1}^{n} M2_i \, VSL_i / TVM2 \tag{21}$$

This implies that if we can obtain vehicle characteristics and the family usage variables for an individual vehicle, the same procedure for estimating VSL for a one-vehicle family can be applied to a multiple-vehicle family. In our empirical work, if the family has multiple vehicles, firstly we estimate the TPM and TVM in all vehicles owned by the family. Secondly, we allocate the TPM and TVM to each vehicle j to get TPM_j and TVM_j. Thirdly, we decompose TPM_j

into AM_j, KM_j and SM_j. Finally, the VSL for adults, kids and seniors can be estimated using Equation (18) for each vehicle.

4.4 Estimating the Components of a VSL Model

In order to get a consistent estimate of VSL_{aj} from Equation (18), we need to get the appropriate measures of TVM_j, AM_j, KM_j and SM_j accounting for the fact that these variables are determined by the family (i.e. endogenous). Decisions to purchase a vehicle are made on expectations about how the vehicle will be used. The new data set collects enough information on family characteristics and how vehicles are used, to estimate the mileage variables associated with each vehicle. In addition, the risk of having a fatality, r, must be determined for each type of vehicle, and used to estimate hedonic models for the purchase price and fuel efficiency.

4.4.1 Estimates of Risk by Vehicle

When a family makes a decision to buy a new or used vehicle, the selection is based on expectations about how the vehicle will be used. The most important factors considered for the analysis are how far the vehicle is driven each year and what is the typical occupancy rate. The price of the vehicle and the fuel efficiency, the two primary economic costs to the family, will be determined by the vehicle's physical characteristics. These characteristics include the size, power, and quality of the vehicle, and most importantly for the analysis, the safety of the vehicle. The safety ratings of each type of vehicle were estimated from an earlier analysis of data on traffic fatalities (Fatal Accident Reporting Service, FARS) and vehicle ownership (National Personal Transportation Survey, NPTS). This analysis has been presented in full in a report to the EPA (Environmental Protection Agency) and a research paper.

The safety rating of a vehicle was determined by estimating the probability per thousand miles traveled of having a fatality in an accident. This safety rating was determined by the probabilities of having different types of accidents (one-vehicle, two-vehicle and multi-vehicle), and the probabilities that the occupants will survive in these accidents. All of these probabilities are functions of the vehicle's characteristics and the characteristics of the driver and the occupants. For example, heavy vehicles are relatively safe in a two-vehicle accident, but may have a relatively high probability of having a one-vehicle accident. Wearing a seatbelt is more important for survival in an accident than having an airbag. The statistical framework for the different models underlying the safety rating of a vehicle is described in Appendix A, and the estimated models and definitions of the explanatory variables are presented in Appendix B.

The safety rating of each type of vehicle is computed using the same set of characteristics for the driver and the occupants. The rationale is to standardize the effects of driving behavior. Some types of vehicle, for example, have higher probabilities of accidents because the drivers are more likely to fail tests for sobriety. Similarly, very young drivers have higher probabilities of having an accident. In general, the overall probability of having a fatality in a vehicle is proportional to the number of miles driven and the total number of occupants. The safety rating used in the hedonic models for each type of vehicle was computed under the assumption that there are two adults in each vehicle who drive 14,000 miles in a year. The effect of making this assumption is that some vehicles, which have high-observed rates of fatalities, such as pickup trucks, have lower predicted rates of fatalities. The reason is that the specified occupants are more safety conscious (e.g. by wearing seat belts) than the typical behavior of the actual occupants in the fatality data.

Using a standardized set of characteristics for the occupants is an important distinguishing feature of this analysis compared to other studies in the literature. A discussion of other studies and the estimated safety ratings from our analysis are presented in Appendix C. The safety rating of a vehicle measures the probability of having a fatality for a specified number of miles driven. This measures the value of r in the hedonic models for the price and the fuel efficiency of each type of vehicle (make, model and year). The two estimated hedonic models are also presented in Appendix C. The estimated elasticities for r used to compute the standard VSL in Equation (11) are $\alpha_m = 0.0258$ for the fuel efficiency and $\beta_m = -0.069$ for the price of the vehicle.

4.4.2 Household Types in the Survey Data

The 2001 National Auto Safety Survey (Full Scale) includes two parts: a recruitment survey and a mail survey. It obtains information on household characteristics related with the choice of automobiles and the use of automobiles, and vehicle characteristics such as the make, model, year, price and perceived risk of a fatality (i.e. safety factor).

The main characteristics of the survey data are:

- It merges information about household characteristics and vehicle characteristics into the same data set;
- It provides detailed information on the usage of different vehicles by individuals in a family. Hence, the expected total personal riding miles of a family in each vehicle (TPM), total vehicle driving miles in each vehicle (TVM) and the riding miles of each age group of family members, such as AM, SM and KM can all be estimated.
- It includes a risk ladder of different types of vehicles. The ladder assumes that each type of automobile is driven an average of 14,000 miles per year by someone with average driving ability. Since the drivers' characteristics are standardized by average driving ability, the effects of drivers' characteristics are removed and this risk ladder reflects the inherent risk associated with each type of vehicle. The risk is measured by the number of fatalities occurring in each year for every 100,000 automobiles per occupant using the models described in Section 3.1. Therefore, we can derive the automobile fatality risk per driving mile per occupant by using the formula: [risk value/($14{,}000 \times 100{,}000$)].

The survey covers 1147 sampled households, with no more than five family members, owning 1 vehicle, 2 vehicles or 3 vehicles. For each household, there are 349 variables, each one corresponding to a question. Only 623 households completed both surveys, and only 487 households answered all of the important questions about family member's age, total riding miles, each person's riding percentage, and the cost of gasoline. There were five households that reported at least one vehicle driven over 80,000 miles per year (the average miles driven per year for the vehicle with the highest VMT per family is less than 16,000 miles), and three households reported a vehicle with zero miles driven. These households were regarded as outliers and deleted. Therefore, the final sample had complete information about 479 families and 791 vehicles, and a description of this data set follows.

Table 4.1 Distribution of Six Types of Household (HH) by the Number of Vehicles Owned

Type of HH	1-vehicle HH	2-vehicle HH	3-vehicle HH	Total
PA HH	75	127	48	250
AK HH	29	97	29	155
SK HH	0	1	0	1
ASK HH	1	0	1	2
SA HH	6	11	2	19
PS HH	25	23	4	52
Total	136	259	84	479

Kid: 0<=age<=15

Adult: 16<=age<=64

Senior: 65<=age

PA HH: every family member is an adult

AK HH: household is composed of adults and kids

SK HH: household is composed of seniors and kids

ASK HH: household is composed of adults, seniors and kids

SA HH: household is composed of seniors and adults with at least one member younger than 60

PS HH: all family members are no less than 60 years old, and at least one member is a senior

From the Table 4.1, we can define three types of representative household that have a relatively large number of families in the sample. These are:

(1) 2-vehicle PA HH: Pure adults household with 2 vehicles;

(2) 2-vehicle AK HH: 2-vehicle household with both adults and kids;

(3) 1-vehicle PS HH: 1-vehicle household with every family member no less than 60 and at least one member is a senior.

The basic demographic characteristics of the three representative households in the survey data are listed in Table 4.2.

Table 4.2 Demographic Characteristics of Representative Households

Type of HH	Number of HH	Total Adults	Total Kids	Total seniors
2-vehicle PA HH	127	260	0	0
2-vehicle AK HH	97	206	176	0
1-vehicle PS HH	25	2	0	30

Table 4.3 Total Annual Riding Miles of the Family in Each Vehicle (TPM)

Type of HH	Number of HH	AVG(TPM1)	AVG(TPM2)	AVG(TPM3)	AVG(TPM)
1-vehicle HH	136	15256	0	0	15256
2-vehicle HH	259	23516	14756	0	19136
3-vehicle HH	84	27589	15156	6599	16448
all HH	479	21885	14854	6599	17806

AVG(TPMj)-------average TPM in the jth vehicle owned by the household (j=1, 2, 3)

AVG(TPM) -------average TPM in all vehicles owned by the household

Table 4.4 Total Annual Miles Driven per Vehicle (TVM)

Type of HH	number of HH	AVG(TVM1)	AVG(TVM2)	AVG(TVM3)	AVG(TVM)
1-vehicle HH	136	12055	0	0	12055
2-vehicle HH	259	16038	10182	0	13110
3-vehicle HH	84	18976	11510	5768	12085
all HH	479	15422	10507	5768	12666

AVG(TVMj)-------average TVM in the jth vehicle owned
by the household(j=1, 2, 3)

AVG(TVM)--------average TVM in all vehicles owned by the household

The data in Tables 4.3 and 4.4 summarize how the vehicles are used. The first vehicle in each type of household is driven more in households with more vehicles. The same relationship holds for the miles ridden and driven in the second vehicle between 2-vehicle and 3-vehicle households. This implies that one reason for buying another vehicle is to use at least one of the vehicles more intensively. However, the AVG (TPM) (average TPM per vehicle) and AVG(TVM) (average TVM per vehicle) are similar for households with 1, 2 or 3 vehicles. In other words, the total distance ridden and driven by a household is roughly proportional to the number of vehicles owned. Nevertheless, the distribution of the TPM and TVM among the first, second and third vehicles is not even. The first vehicle is always the vehicle ridden and driven most by the family. This illustrates how important the survey data were for determining how to allocate TPM and TVM to each vehicle in multi-vehicle households.

The annual average driving miles for all vehicles is 12,666 in our sample. This is slightly smaller than the average miles per year used in the risk ladder (14,000 miles per year). The ratio of AVG (TPM)/ AVG (TVM) is 1.4, implying that vehicles have a driver only for at least 60 percent of the miles driven.

Table 4.5 Household Characteristics

Type of HH	Number of HH	average household size	average number of adults	average number of adult equivalents	average household income ($)	average income per adult equivalent EY($)
1-vehicle HH	136	1.75	1.103	1.226	46213.24	39225.59
2-vehicle HH	259	2.76	1.873	1.541	67432.43	46149.25
3-vehicle HH	84	3.02	2.393	1.629	87738.1	56813.37
all HH	479	2.52	1.745	1.467	64926.47	46053.57

The demographic and income characteristics for each type of household are summarized in Table 4.5. For households with more than one member, household income is converted to income per adult equivalent using the standard weights adopted by the U.S. Bureau of the Census. The equivalence scale is based on the official weighted average poverty thresholds for 1992 (Data Source: Bureau of the Census (1993: Table A)), following the Table 3-1 of Citro and Michael (1995). The values of the equivalence scales are 1, 1.279, 1.566, 2.007, 2.323, 2.679, 3.023, 3.367 and 4.024 for family size 1, 2, 3, 4, 5, 6, 7, 8 and 9 or more, respectively. Using this measure, the income per adult equivalent is over $39 thousand, $46 thousand and $57 thousand for 1-vehicle, 2-vehicle and 3-vehicle households, respectively, and the overall average is $46 thousand.

4.4.3 Estimating How Vehicles Are Used

Given estimates of the hedonic models for the price of a vehicle and the fuel efficiency presented in Appendix C, the final component of the VSL model in Equation (18) is to estimate the mileage (TVM) and the occupancy (TPM) for each vehicle. These estimates are treated as the expected levels of use of a vehicle when it is purchased, and are, therefore, the appropriate levels to use when estimating the VSL for adults, seniors and kids. The summary of the survey data in the previous section shows strong positive relationships between the number of vehicles owned and household income and household size (see Table 4.5). In addition, the total mileage and occupancy for a household are roughly proportional to the number of vehicles owned, and the composition of a family is also a potential factor in determining how vehicles are used.

The first models of how vehicles are used by each household determine the mileage in all vehicles (TVM), the total occupancy in all the vehicles (TPM), and the proportion of miles traveled by kids. These variables are determined by the economic and demographic characteristics of each household and the number of vehicles owned. The estimated equations have the following form:

$$\log(\text{TPM}) = \alpha_0 + \sum_i \alpha_i A_i + e$$

$$\log(\text{TVM}) = \beta_0 + \sum_i \beta_i B_i + u$$

$$\log(\text{KM}/(\text{TPM}-\text{KM})) = \gamma_0 + \sum_i \gamma_i C_i + v$$

Where A_i, B_i and C_i are vectors of representative measured regressors reflecting family characteristics, α_i, β_i and γ_i are the corresponding parameters and e, u and v are unobserved residuals. The least square estimates of these equations are presented in Table 4.6.

Table 4.6 Parameter Estimates for Mileage and Occupancy

(1) Parameter Estimates for log(TPM)			(2) Parameter Estimates for log(TVM)		
Variable	Parameter Estimate	t Value	Variable	Parameter Estimate	t Value
Intercept	6.53983	12.48	Intercept	6.5161	12.63
Seniorratio	-0.54969	-1.94	Seniorratio	-0.46013	-1.66
lnEY	0.25296	5.16	lnEY	0.25614	5.31
lnT	0.27909	2.58	lnT	0.06833	0.87
lnN	1.00904	9.43	lnN	1.03166	10.36
D	-0.11621	-0.38	D	-0.28313	-0.94
Dratio	1.05343	2.48	Dratio	1.07935	2.57
Kinverse	3.13611	3.08			
Square(Kinverse)	-4.11556	-2.06			

Table 4.7 Parameter Estimates for Occupancy by Kids

Parameter Estimates for log(KM/(TPM-KM))		
Variable	Parameter Estimate	t Value
Intercept	-1.43278	-1.08
lnkidnonkidratio	0.8454	6.22
lnEY	0.52692	1.58
lnN	0.04631	0.19

where: Seniorratio=(seniors)/(total family size)

lnEY=log(Average equivalent income)

lnT=log(number of household members)

lnN=log(number of vehicles owned)

D: Dummy variable for a senior household

(D=1 if the household is a senior household)

Dratio=D/(the age of the oldest person in the household-64)

Kinverse=1/(1+the age of the youngest kid in a household)

if the household has at least 1 kid

Square(Kinverse)=Square of Kinverse

lnkidratio=log((K/(T-K)), and K is the number of kids

The estimates in Table 4.6 show that both TVM and TPM are almost proportional to the numbers of vehicles (N), as expected. In contrast, the effect of household size is much smaller, particularly on TVM. Given a high enough income, most adults (and seniors) would like to have their own vehicle, and total mileage is proportional to the number of vehicles. The effect of income is inelastic, but it is clearly statistically significant.

The effects of the composition of a household require some further explanation. For total occupancy, (TPM), the positive coefficient for Kinverse (3.13611) and the negative coefficient for Square(Kinverse) (-4.11556) implies that the TPM for kids increases until the youngest kid is 2 and then decreases. The survey data indicate that average KM decreases with age. Since the TPM for "young seniors" should not drop a lot compared to adults, and the TPM for "old seniors" drops dramatically in the survey data, we include three variables: Seniorratio, D and Dratio. The coefficient for Seniorratio and D are both negative (-0.54969 and -0.11621) and the coefficient for Dratio is relatively large and positive (1.05343). Hence, if the household is a senior household (everyone is older than 60 and at least one member is a senior) and the oldest person is only 65 years old, then the total senior effect will be (-0.54969-0.11621+1.05343) > 0. In other words, for a senior household with young seniors, the TPM will be higher than it is in an adult household. Nevertheless, when a senior household is composed of "old seniors", Dratio will decrease and the TPM will also decrease as age increases. This is exactly the type of behavior observed in the survey data. The TPM for seniors does not drop in one step. It drops at ages above 65, slowly for "young seniors" and then more rapidly. One reason for the implied increase in TPM at age 65 is that these people typically have more free time for travel and are still healthy. The effects of seniors dominate the effect of household composition on TVM, and the effects of kids were not significant. In general, older seniors have lower values of both TPM and TVM, as expected.

Given predictions of TPM and TVM, it is necessary to allocate these values among adults, seniors and kids. For all adult and all senior households, there are no problems with this allocation. For mixed households with adults and seniors, the estimates in Table 3.6 imply that SM = Exp (-0.56) AM = 0.57 AM (i.e. when Seniorratio = 1), and consequently, TPM can be allocated between adults and seniors. For kids, a separate equation is estimated (see Table 4.7) for occupancy by kids. For a given household, KM increases with the number of kids and with income, but has only a small positive relationship with the number of vehicles. For a given income, the total mileage traveled by kids is not affected by the number of vehicles. For adult households, however, the total mileage traveled is twice as large in a two-vehicle household than a one-vehicle household.

The next step is to allocate TPM, TVM and KM to individual vehicles for households that own more than one vehicle. When a household makes a choice about which vehicle to drive given the estimated TVM, the main concerns affecting the choice are the vehicle's characteristics, such as its size and level of safety. Hence, the explanatory variables for the allocation will only reflect the vehicle's characteristics. We assume that the optimal vehicle characteristics for each vehicle were chosen when the vehicle was purchased. Hence the vehicle's characteristics are predetermined explanatory variables for the observed data in the survey.

For a 2-vehicle household, the dependent variables for allocating TPM, TVM and KM between the first and the second vehicle are log odds ratios:

lnTPMratio2---log(TPM in the first vehicle/TPM in the second vehicle),

lnTVMratio2---log(TVM in the first vehicle/TVM in the second vehicle),

lnKMratio2 ---log(KM in the first vehicle/KM in the second vehicle).

The explanatory variables are:

lnVehicleage1---log(the model year of the first vehicle),

lnVehicleage2---log(the model year of the second vehicle).

The least square estimates are presented in Table 4.8.

Table 4.8 Parameter Estimates for Allocating TPM, TVM and KM for a 2-Vehicle Household

Variable	TPM		TVM		KM	
	Parameter Estimate	t ratio	Parameter Estimate	t ratio	Parameter Estimate	t ratio
Intercept	367.06428	1.21	493.45121	2.01	1114.50482	0.82
lnVehicleage1	82.48443	2.31	25.33822	0.88	359.34027	2.38
lnVehicleage2	-130.71572	-5.21	-90.21446	-4.46	-506.03159	-4.87

In all three models, the coefficients have the expected signs. The proportions of TPM, TVM and KM driven in the first vehicle are higher in newer vehicles and lower if the second vehicle is newer. Given these predicted proportions, it is possible to determine TPM, TVM and KM in the first vehicle and second vehicle respectively using the observed model year of the vehicles owned by each 2-vehicle household. In other words, we can get TPM_j, TVM_j and KM_j for a 2-vehicle household. The corresponding values of SM_j are determined by the following rule for households with adults and seniors.

SM_j = [0.57*(TPM_j-KM_j)*total seniors number]/(0.57*total seniors + total adults) If the seniors are in a senior household, then SM_j=TPM_j. Note that the difference in safety between the two vehicles was not statistically significant in these models, and this variable is not reported in Table 4.8.

For a 3-vehicle household, the final model allocated the miles between the first vehicle and the other two vehicles. TPM_j, TVM_j and KM_j for the first vehicle. Efforts to model the allocation between the second and third vehicle were not successful.

lnTPMratio3---log(TPM in the first vehicle/TPM in the other two vehicles),

lnTVMratio3---log(TVM in the first vehicle/TVM in the other two vehicles),

lnKMratio3---log(KM in the first vehicle/KM in the other two vehicles).

The logarithm of model year of each vehicle are explanatory variables and a new variable, which is lnriskratio---log(minimum risk rate among the three vehicles/the risk rate of the first vehicle). This new variable measures the relative risk of the first vehicle when one of the other vehicles is safer (ratio $\leq$ 1). A bigger ratio implies a safer first vehicle. Therefore, positive coefficients for lnriskratio are expected. The least square estimates of the models are given in Table 4.9.

Table 4.9 Parameter Estimates for Allocating TPM and KM to the First Vehicle in a 3-Vehicle Household

Variable	TPM		TVM		KM	
	Parameter Estimate	t ratio	Parameter Estimate	t ratio	Parameter Estimate	t ratio
Intercept	557.82765	1.72	279.86044	0.91	552.07303	0.31
InVehicleage1	43.30447	1.16	70.2771	1.99	606.17145	2.62
InVehicleage2	-79.85588	-3.65	-80.21175	-3.87	-557.17158	-2.96
InVehicleage3	-36.84872	-1.92	-26.92953	-1.49	-121.61599	-0.9
Inriskratio	0.38974	1.97	0.31179	1.67	3.1269	2.71

The positive coefficients for the model year of the first vehicle and the negative coefficients for the other two vehicles are consistent with our expectations. In addition, the risk coefficients have the expected positive sign. This model allocates TPM, TVM and KM between the first vehicle and the other two vehicles.

There are no formal models for explaining the allocation of miles between the second and third vehicles. From the Tables 4.3 and 4.4, the average TPM in the third vehicle is approximately 44% of that in the second vehicle, and the average TVM in the third vehicle is approximately 50% of that in the second vehicle. Therefore, the following rule is used to allocate the miles between the second and third vehicles:

TPM in the third vehicle =0.44*TPM in the second vehicle

TVM in the third vehicle =0.5*TVM in the second vehicle

KM in the third vehicle = 0.44*KM in the second vehicle

Finally, the same rule for determining the allocation between AM and SM described for two vehicle households is used for households with both adults and seniors, and three vehicles. Combining all of the vehicles in this section gives estimates of the mileage traveled by adults, seniors and kids in each vehicle, and TVM for each vehicle.

Section 5

Conclusions: Estimates of Average VSL By Group and Income Level

Three typical family groups own most of the total 783 vehicles:

1) PA: pure adults family (424 vehicles);
2) AK: family with both kids and adults (267 vehicles);
3) PS: pure senior family (57 vehicles).

To address possible income effects on the VSL, we divide each type of family into three types according to per capita income, low income, middle income and high income. Specifically, income type is defined as:

Low income family: Per Capita Income<=$15000;

Middle income family: $15000<Per Capita Income<=$37500;

High income family: Per Capita Income>$37500.

Three no intercept OLS regressions were run, one for each of three family groups. (If we run regressions with intercepts, the intercepts are insignificant). The estimated results without intercepts are shown in the following table.

Table 5.1 Estimated VSL for Families

Family Type	Income Type	Sample Size	Person Type*	VSL (million)	t value
PA	Low	67	Adult low	6.81	9.37
	Middle	188	Adult middle	6.07	13.63
	High	169	Adult high	7.27	14.88
AK	Low	133	Adult low	3.36	8.36
			Kid low	2.54	3.64
	Middle	120	Adult middle	3.79	8.96
			Kid middle	5.12	6.46
	High	14	Adult high	-	-
			Kid high	-	-
PS	Low	9	Senior low	7.67	4.60
	Middle	31	Senior middle	8.42	6.85
	High	17	Senior high	8.25	3.35

Note:
1. *Person Type is Defined as:
   Adult low: adults from low-income families;
   Adult middle: adults from middle-income families;
   Adult high: adults from high-income families;
   Kid low: kids from low-income families;
   Kid middle: kids from middle-income families;
   Kid high: kids from high-income families;
   Senior low: seniors from low-income families;
   Senior middle: seniors from middle-income families;
   Senior high: seniors from high-income families.
2. - means insufficient sample size to obtain reliable estimates.

Since the average ages for adults, seniors and kids in our data set are 39.8, 74.2 and 7.8 respectively, the VSL for each group can be interpreted as the VSL for that group at the average group age.

The estimated results are inconsistent with discounted present value of life-year model. Seniors are more valuable than adults in all families for any of the income levels. For families with both adults and kids, the VSL of kids is higher than that of adults in the middle-income family, but lower in low income families.

An alternative procedure is to estimate VSL in a pooled model that assumes identical VSLs across family types by age group.

From our theoretical model, the VSL can be estimated according to equation:

$$-[P'(r)+F'(r)]*TVM = [VSL(A)*AM+VSL(K)*KM+VSL(S)*SM]+(y-y)*TP$$

Using this approach, (which also allows calculation of income elasticities) the VSL for different age groups for individuals of average income and driving miles is shown in the following table.

Table 5.2 Income Elasticity Estimates

Family Type	Sample Size	Per Capita Income	Person	VSL* (million)	t value	$ß_{EY}$	t value	elasticity
PA	424	40776	Adult	6.67	22.28	18.19	2.05	0.111
AK	267	18709	Adult	3.59	12.25	0.62	-0.02	-0.003
AK	267	18709	Kid	3.64	6.80	65.08	1.14	0.335
PS	57	26462	Senior	8.18	8.97	7.97	0.14	0.026

Comparing the estimated VSL between tables 5.2 and 5.1, the difference is not surprising. The VSL estimated here (pool model) is for people from a standardized household with average driving miles, occupancy and income. The VSL estimated previously (three group model) refers to people with average income only and differing average driving miles and occupancy.

The average estimated income elasticity for the VSL for each group is:

ε_{income} (for adults)=0.14

ε_{income} (for kids)=0.13, and

ε_{income} (for seniors)=0.11

These results provide estimates of income elasticity for each age group that is smaller than Blomquist's estimates of about 0.3.

The estimated VSL from both the group and pooled model show that seniors have the highest value among all age groups, given the same income. Moreover, the relative value of kids' VSL compared to adults depends on income class in the first model and is slightly higher in the second estimate than adults' VSL. The overall pattern is somewhat inconsistent with the discounted present value of life-year model, which suggests that VSL at age t is equal to the value of a life-year times the discounted present value of remaining years of life at age t. Because the average ages for adults, seniors and kids in our data set is 39.8, 74.2 and 7.8 respectively, we would expect the VSL for kids is to be somewhat lower than for adults. Similarly, the VSL for seniors should also be lower than for adults according to discounted present value of life-year model. However, since the VSL for kids depends on parents' tastes and preferences and may not be stationary over the life cycle, the discounted present value of life year model may well be misleading.

However, it should be noted that the analysis so far has omitted an important effect that has not previously been considered, fragility. For estimating the hedonic models, we use a standardized or inherent automobile risk ladder for each occupant in the vehicle that removes the effects of drivers' and occupants' characteristics on the risk. In other words, we assume that each occupant in the same vehicle has the same risk rate. However, seniors are, on average, more fragile than adults and kids are, on average, less fragile than adults. The effect of perceived fragility is that seniors will regard themselves more risky than adults in the same vehicle and will be induced to buy a less risky (more expensive) vehicle even if their VSL is the identical. Therefore, the fragility unadjusted VSL estimates obtained above may well over-estimate the actual VSL for seniors. The same logic implies that the fragility unadjusted VSL obtained above underestimates the actual VSL for kids since they are less fragile than adults in accidents (except for infants). If we express fragility unadjusted VSL as VSL1 and fragility adjusted VSL as VSL2, then the following relationship holds between VSL1 and VSL2 for people from PA and PS households:

VSL2(a)PA=VSL1(a)PA*r/r(a)

VSL2(s)PS=VSL1(s)PS*r/r(s)

Where r is the average driver value used in the standardized automobile risk ladder we used in hedonic models, r(a) is the risk for adults and r(s) is the risk for seniors, if we assume an adult at average age is an average driver, then r is equal to r(a). Hence, VSL2(a)PA equals VSL1(a)PA, i.e. the fragility adjusted VSL for adults from PA household is the same as the fragility unadjusted value. From the survey data, people's perception of the likelihood of a 70-year-old person dying compared to an average adult when involved in a serious accident is about 39% higher. For households earning the average income, VSL1(a)PA and VSL1(s)PS are 6.62 and 8.44 respectively. If we consider the fragility effect on VSL, fragility adjusted VSL (VSL2) of seniors from pure senior households will be less than that of adults from pure adults households by 8.3%. Because the fragility adjusted VSL of adults from PA household, VSL2(a)PA, is 6.62, the fragility adjusted VSL of seniors from PS household, VSL2(s)PS, is 6.07.

For the AK family, it is more complicated to adjust VSL by fragility because the household's real risk is an appropriate weighed average risk with both kids and adults. To simplify problem, we still assume VSL2(k)AK=VSL1(k)AK*r/r(k). For children, the survey data shows that the perception of the likelihood of a 8-year-old child dying compared to an average adult when involved in a serious accident is about 12% lower. VSL1(k)AK is 3.63, therefore the fragility adjusted VSL for kids, VSL2(k)AK, is 4.13.

The fragility adjusted VSL shows that, for the average household in the sample, kids are more valuable than adults in a family with both kids and adults. We compare the VSL for seniors from pure senior family with adults from pure adults family in order to remove the overestimated income effect from adults in AK family. Seniors' VSL is 6.07 which is less than adults' VSL 6.62. Thus, our results are now much more consistent with the simple discounted present value of life years approach when we include the effect of fragility on the VSL. However, parents have a relatively low VSL which may simply reflect imperfect capital markets and the cost of children, factors not considered in the discounted present value of life years approach.

Table 5.3 lists both the fragility unadjusted and adjusted VSLs for people from different family groups.

Table 5.3 Fragility Adjusted VSL ($million) by Family Group

Age Group	Fragility Unadjusted VSL	Fragility Adjusted VSL
Kids(AK)	3.63	4.13
Adults(AK)	3.72	3.72
Adults(PA)	6.62	6.62
Seniors(PS)	8.44	6.07

Similarly we can adjust for fragility in estimating the VSL using the pooled model. The fragility-adjusted VSLs obtained from the pooled model are consistent with the discounted present value of life years model.

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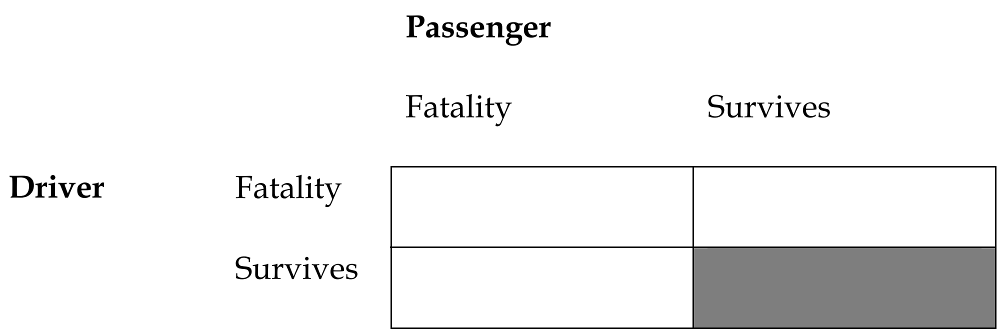
Appendix A

The Statistical Framework for Modeling Automobile Fatalities

The basic data on fatalities in automobile accidents provide a census of accidents with at least one fatality. Hence, the probability of an accident being included in the data set depends on the number of individuals involved in an accident as well as the characteristics of the vehicles and driving behavior (e.g. the use of seat belts). This can be illustrated by the following examples for a one-vehicle and a two-vehicle accident. For a one-vehicle accident, assume that the driver and one passenger have the same probability of survival $P^* = P\{\text{survival}\} = .5$. The four possible events are illustrated below, and in this example, each event has the same probability of occurring of $0.5^2 = .25$.



Accidents in which both the driver and the passenger survive (shaded) are not included in the data set. Hence, the probability of either the driver or the passenger surviving in an accident with a fatality corresponds to the probability of one of three possible events with a probability of $P = P\{\text{survival} \mid \text{at least one fatality}\} = 0.25 / (1 - 0.25) = 0.33$. The observed probability of survival in the data set, P, is much lower than the unconditional probability, P^*. The observed probabilities of survival, P, are 0, 0.33, 0.43 and 0.47 for 1, 2, 3 and 4 occupants, respectively, and the values of P increase and get closer to P^* as the number of occupants increases.

In the one-vehicle accident with two occupants and $P^* = 0.5$, the expected number of fatalities is one (the modal type, corresponding to 91% of one-vehicle accidents in the data set). In a two-vehicle accident with two occupants in each vehicle, the same expected number of fatalities would occur if $P^* = 0.25$ (for multiple-vehicle accidents, 54% of vehicles have no fatalities, and 40% have one fatality). The probability of an accident having at least one fatality, and being in the data set, is $(1 - 0.75^4) = 0.68$. There are 16 possible permutations of survival / fatality for the four individuals and 15 of them are in the data set. For any selected individual, 7 of the 15 observed events correspond to surviving with a probability $P = 0.63$. While this is lower than the unconditional probability of survival $P^* = 0.75$, it is much larger than the corresponding probability for the one-vehicle accident $P = 0.33$. Setting the severity of the two types of accident at the same level (E [number of fatalities] = 1) makes the probability of a specific individual surviving in a fatal accident almost twice as large in the two-vehicle accident as in the one-vehicle accident. The reason is simple, for any unconditional probability of survival P^*, the expected number of fatalities is $P^* \times$ number of individuals in the accident. Since the data set includes all accidents in which at least one fatality occurs, a fatality is more likely to occur if more people are involved.

In reality, the unconditional probabilities of survival for individuals differ by individual characteristics such as age, whether or not a seat belt was used and the location of the seat in a vehicle. In addition, these probabilities differ by the type of vehicle, and for two-vehicle accidents by the relative size and type of the other vehicle. For an individual *i* riding in vehicle *j*, the unconditional probability of survival in a two-vehicle accident, for example, can be written:

$$P_{ij}^* = f\left(x_i, v_{i1}, v_{i2}\right) = f\left(z_{ij}\right)$$

where x_i are the characteristics of individual *i*
v_{i1} are the characteristics of individual *i*'s vehicle ($j = 1$)
v_{i2} are the characteristics of the other vehicle ($j = 2$)
z_{ij} is the vector of all explanatory variables

The probability of observing at least one fatality in the accident is

$$\left(1 - \prod_{j=1}^{2} \prod_{i=1}^{n_j} P_{ij}^*\right)$$

where n_j is the number of individuals in vehicle *j*.

If $P_{ij}^* = f\left(z_{ij}\right)$ is specified as a logistic function, then it can be written:

$$P_{ij}^* = \frac{e^{z_{ij}'\beta}}{1 + e^{z_{ij}'\beta}}$$

where β is a vector of unknown parameters that are the same for all individuals and vehicles. Using this form, it would be possible to recover the unconditional probabilities of survival using the available data on accidents with at least one fatality. In the simplest case with one individual in each vehicle, for example, the probability of observing two fatalities in the data set would be:

$$\frac{1}{1 + e^{z_{11}'\beta} + e^{z_{12}'\beta}}$$

and the unconditional probability of two fatalities would be:

$$\frac{1}{1 + e^{z_{11}'\beta} + e^{z_{12}'\beta} + e^{(z_{11}' + z_{12}')\beta}}$$

The unconditional probability of the individual in vehicle 1 surviving would be:

$$P_{11}^* = \frac{e^{z_{11}'\beta} + e^{(z_{11}' + z_{12}')\beta}}{1 + e^{z_{11}'\beta} + e^{z_{12}'\beta} + e^{(z_{11}' + z_{12}')\beta}} = \frac{e^{z_{11}'\beta}}{1 + e^{z_{11}'\beta}}$$

An equivalent expression for P^*_{12} can be derived in exactly the same way. Since β could be estimated from the available data on fatal accidents, the unconditional probabilities of survival could be calculated.

The parameters in β can be estimated by maximum likelihood. estimation. The likelihood function for the probability of survival in two-vehicle accidents, for example, can be specified as:

$$L = \prod_{k=1}^{K} \frac{\prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*\,Y_{ijk}} (1 - P_{ijk}^{*})^{1-Y_{ijk}}}{(1 - \prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*})},$$

where K = 1, …, m, number of accidents;

n_{jk} is the number of individuals in vehicle j, accident k;

Y_{ijk} = 1 if individual i survived, else 0.

The basic structure of the model of the risk of having a fatality in an accident is to distinguish between one-vehicle, two-vehicle and multiple-vehicle accidents. The expectation is that the characteristics of drivers contribute more to the probability of having a one-vehicle accident than to a two- or multiple-vehicle accident. On the other hand, vehicle characteristics, particularly the weight relative to the weight of the other vehicle, will affect the survival rate in two-vehicle accidents but may be less important for one-vehicle accidents. In addition, the earlier discussion of why survival rates are likely to differ systematically between one-vehicle and two-vehicle accidents provides another reason for modeling one-vehicle and two-vehicle accidents separately. The justification for separating multiple-vehicle accidents from two-vehicle accidents is that it is impossible to identify the "other" vehicle from the data for multiple-vehicle accidents.

If r is the overall fatality rate, then the model's components can be written as follows:

$$r = \left[P\{V1\}(1 - P_1 *) + P\{V2\}(1 - P_2 *) + P\{Vm\}(1 - P_m *)\right]M,$$

where r is the annual fatality rate per occupant;

$P\{V1\}$ is the probability of having a one-vehicle accident per 10,000 miles;

$P\{V2\}$ is the probability of having a two-vehicle accident per 10,000 miles;

$P\{Vm\}$ is the probability of having a multiple (three or more) vehicle accident per 10,000 miles;

P_1* is the probability of surviving in a one-vehicle accident;

P_2* is the probability of surviving in a two-vehicle accident;

P_3* is the probability of surviving in a multiple-vehicle (three or more) accident;

M is the average annual mileage traveled (13,989 miles from the NPTS).

The units for r, $P\{V1\}$, $P\{V2\}$ and $P\{Vm\}$ are all standardized to measure the probability of having a fatal accident per 1000 vehicles.

Conceptually, all six components of the observed values of r may be functions of the characteristics of the driver (and the passengers) and the vehicle driven (and the other vehicle for two-vehicle accidents). For computing a hedonic price index, the characteristics of an average driver and passenger are used to predict r for different types of vehicle (make, model and year), and each type of vehicle is assumed to have an accident with a typical other vehicle in a two-vehicle accident. Hence, the effects of drivers' characteristics are removed prior to estimating the hedonic price equation. The effect of standardizing the other vehicle in a two-vehicle accident is relatively small because the observed combinations of vehicles in two-vehicle accidents are approximately random. Standardizing drivers' characteristics, however, matters a lot for the probabilities of being in a fatal accident. It is the primary reason for the difference between our estimated value of a statistical life compared to a conventional model in which drivers' characteristics are added as additional regressors in the hedonic price equation.

The structure of the equations for the six components of r can be written as follows:

$$P\{V1\} = g_1(V_1, D_1)$$

$$P\{V2\} = g_2(V_1, D_1)$$

$$P\{Vm\} = g_m(V_1, D_1)$$

$$P_1^* = f_1(V_1, O_1)$$

$$P_2^* = f_2(V_1, V_2, O_1)$$

$$P_m^* = f_m(V_1, O_1)$$

where V_1 are the characteristics of a selected vehicle.

D_1 are the average driver's characteristics for the selected vehicle and include factors such as the use of seat belts and whether alcohol was a factor.

O_1 are the characteristics of the occupants of the selected vehicle, including the driver.

V_2 are the characteristics of the other vehicle, its weight relative to the weight of the selected vehicle being the most important.

Since all six dependent variables are probabilities, appropriate statistical models for limited dependent variables are used. P_1^*, P_2^* are specified as logistic functions and estimated by maximum likelihood in GAUSS. For P_m^*, we assume the unconditional probability P_m^* is the same as the observed probability P_m, and P_m is specified as a regular logit model and estimated in SAS. $P\{V1\}$, $P\{V2\}$ and $P\{Vm\}$ are determined by a censored regression model to allow for a probability mass at zero. Note that P_m^* is determined by the characteristics of the own-vehicle only because it is not possible to identify the "other" vehicle in a multiple-car accident.

The complete econometric analysis for determining the fatality rate, r, for a specified type of vehicle, consists of the following three steps:

Step 1. Augment the FARS data on observed fatal accidents with additional characteristics about the vehicles (e.g. weight and safety features), and use these data to estimate equations for the unconditional probabilities of survival in one-vehicle, two-vehicle and multiple-vehicle accidents (P_1^*, P_2^* and P_m^*). Derive the estimated numbers of serious accidents (including accidents with no fatalities) for one-vehicle, two-vehicle and multiple-vehicle accidents.

Step 2. Calculate the average drivers' characteristics in fatal accidents from the FARS data by make, model and year of the vehicle driven, and combine with survey data on the composition of the fleet of vehicles. Use these data to estimate equations for the probabilities of having one-vehicle, two-vehicle and multiple-vehicle accidents by the make, model and year of vehicle (P{V1}, P{V2} and P{Vm}).

Step 3. Use the average drivers' characteristics from the FARS data, and the average other vehicle in two-vehicle accidents, to standardize the unconditional probability of a driver and/or passenger being killed in a fatal accident by make, model and year of the vehicle.

Appendix B

The Estimated Models Used to Determine the Fatality Rates for Different Types of Vehicle

The inherent fatality rate for an individual in a vehicle can be decomposed as follows:

$$r = [P\{V1\}(1 - P_1 *) + P\{V2\}(1 - P_2 *) + P\{Vm\}(1 - P_m *)]M ,$$

where r is the annual fatality rate per capita;

P{V1} is the probability of having a one-vehicle accident per 10000 miles;

P{V2} is the probability of having a two vehicle accident per 10000 miles;

P{Vm} is the probability of having a multiple (three or more) vehicle accident per 10000 miles;

P_1* is the probability of surviving in a one-vehicle accident;

P_2* is the probability of surviving in a two-vehicle accident;

P_m is the probability of surviving in a multiple-vehicle (three or more) accident;

M is the average annual mileage traveled (13989 miles from the NPTS).

The likelihood function for the probability of survival can be specified as:

One-car accidents:

$$L = \prod_{k=1}^{K} \frac{\prod_{i=1}^{n_k} P_{ik}^{*\,Y_{ik}} (1 - P_{ik}^{*})^{1-Y_{ik}}}{(1 - \prod_{i=1}^{n_k} P_{ik}^{*})}$$

Two-car accidents:

$$L = \prod_{k=1}^{K} \frac{\prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*\,Y_{ijk}} (1 - P_{ijk}^{*})^{1-Y_{ijk}}}{(1 - \prod_{j=1}^{2} \prod_{i=1}^{n_j} P_{ijk}^{*})}$$

Multiple-car accidents:

$$L = \prod_{k=1}^{K} \prod_{j=1}^{m_k} \prod_{i=1}^{n_{jk}} P_{ijk}^{\;Y_{ijk}} (1 - P_{ijk})^{1-Y_{ijk}}$$

where i = 1, …, n, individuals;

j = 1, …, m, vehicle;

k = 1, …, K, accidents;

Y_{ijk} = 1 if survived, else 0.

Survival rates P_1* , P_2* and P_m are specified as logit functions and estimated by maximum likelihood in GAUSS using data from the Fatality Analysis Reporting System (FARS) augmented with additional data about vehicle characteristics (step 1 in Appendix A). The explanatory variables are summarized in Table B1, and the estimated equations are shown in Tables B2 , B3 and B4, respectively. For the survival rate in a one-vehicle accident, the effect of using a restraint (seat belt or car seat) is very important and clearly positive, but the effect of an airbag was not significant. The number of occupants is significant, but without a clear explanation. The survival rate is relatively high in pickup trucks (Class 7). A very inexperienced driver, 16 years or younger, has a strong negative effect on the survival rate.

The equation for P_2* in Table B3 implies that the weight ratio is the most important explanatory variable. Being in a larger vehicle increases the chance of survival and visa-versa. Weight also has a positive effect on survival in multiple car accidents (see Table B4). The number of occupants is also important. The positive effect of using a restraint (seat belt or car seat) is substantially larger than the effect of airbags. In general, the effects of the class of vehicle are consistent with the effect of the weight ratio. Seating in a small vehicle (Class1) reduces the probability of survival, while hitting a small vehicle increases the probability of survival.

The equation for P{V1}, P{V2} and P{Vm} are specified as censored regression models to allow for a point mass at zero (18% and 27% of the vehicle types having no recorded fatalities for one-vehicle and two- vehicle accidents, respectively). This specification worked much better than a linear probability model. The data used corresponds to observations of make, model and year augmented by average driving characteristics from the FARS. Since the observed probabilities of having a fatal accident per 1000 vehicles are very small, it was unnecessary to impose an explicit upper limit of one on the dependent variable. The equations were estimated in SAS.

In order to be consistent with the unconditional probability of survival, each fatal accident is scaled by the inverse of the probability of observing the accident, i.e. at least one fatality occurred. The scaling is very easy for one-vehicle accidents. But for two-vehicle accidents, we need to know the characteristics, e.g. weight, of both vehicles. Among the 25126 two-vehicle accidents that occurred in 1995-1997 involving at least one of the vehicles we studied, there are 8282 accidents having complete information for both vehicles' characteristics. Thus, only one-third of the accidents have complete information about both vehicles' characteristics. There are two possible solutions: one is to find out the complete information of the other vehicle, the other is to scale the accidents with unknown characteristics of the other vehicle by the same scalar used to scale accidents with both vehicles' characteristics known. If the pattern of hitting the other vehicle is the same for each make/model/year vehicle whether the characteristics of the other vehicle is known or not, then the second way is a reasonable approximation.

A goodness-of-fit test is used to test whether the pattern of accidents is the same or not. The probability of having a two-vehicle accident is calculated by each make/model/year, but due to the limited number of observations, accidents for each make/model/year were aggregated to 23 types of vehicle. The overall χ^2 test is rejected, but when we only consider the first 21 types, the χ^2 test cannot be rejected. The remaining two types are small and large pick-up trucks. After comparing the distribution of the other vehicles hit by the 21 types, and by small and large pick-ups, pick-up trucks were found to hit a high proportion of old vehicles, whose characteristics are not included in this study. Since old and new vehicles are similar in weight, and the age of vehicle isn't a significant factor determining the probability of survival, all accidents by make/model/year were inflated by the scalar derived from the subset with complete vehicle characteristics.

The remaining part of the fatality rate model is to estimate the probabilities for multiple vehicle accidents P{Vm} and P_m. Unlike two-vehicle accidents, the pattern of collision is very hard to identify in multiple-vehicle accidents. Some of the vehicles may have no direct impact on each other. Therefore, the model for P_m is more like the model for a one-vehicle accident, i.e. no information of the other vehicles is included. In addition, we assume that all multiple-vehicle accidents are observed. Since the total number of vehicle occupants involved in a multiple-vehicle accident could be quite large (at least 3), this is a reasonable approximation. Also, the fatalities in multiple-vehicle accidents are only 8.5% of the total fatalities that occurred in 1995-1997. The equation for the survival rate P_m is specified as a regular logit model and estimated by maximum likelihood in SAS. The equation for P{Vm} is specified as a censored regression model to allow for a point mass at zero (24% of the vehicle type) and estimated by SAS.

Explanatory variables in the censored models for P_1, P_2, P_m that are not listed in Table B1 are described in Table B5. The basic differences are that additional subdivisions of the classes of vehicles are made, for example, to identify sports cars from non-sports cars for one-vehicle accidents. In addition, variables such as styling ((length plus width/height) are included to provide more information about the type of vehicle.

Before estimating the censored regression of P{V1}, P{V2}and P{Vm}, 12 of the total of 1261 vehicle types were dropped because they had sales less than 500 vehicles. With a very small number of vehicles on the road, even one fatal accident for that make/model/year will count as a big probability of having a fatal accident. The increase in the number of subclasses of vehicle for P{V1} was prompted by inspection of the raw data. The effects of variables such as alcohol and previous convictions are partly responsible for the high rates of accidents for some types of vehicles. For P{V1}, P{V2} and P{Vm}, shown in Tables B6, B7 and B8, the accident rate increases for young drivers, for older drivers and, surprisingly, for female drivers. Accidents are more likely to occur at highway speeds (Sp), and for all three types of accidents, powerful vehicles (Acceleration) are more likely to have accidents, especially for one-vehicle accidents. The use of alcohol and previous convictions increases P{V1}, P{V2} and P{Vm}. The overall conclusion is that driving behavior does matter and affects the probabilities of having a fatal accident for different types of vehicle.

Table B.1: Variable Definitions for Estimating the Probability of Survival

VARIABLE NAME	Definition
Restraint	**CODED AS 1 IF THE PASSENGER USED RESTRAINT, 0 OTHERWISE.**
Age0_5	Coded as 1 if the passenger age is ≤5, 0 otherwise.
Age15	Coded as 1 if the passenger age is ≥6 but ≤15, 0 otherwise.
Age21	Coded as 1 if the passenger age is ≥16 but ≤21, 0 otherwise.
Age24	Coded as 1 if the passenger age is ≥22 but ≤24, 0 otherwise.
Age_o	Coded as 1 if the passenger age is ≥65, 0 otherwise.
female	Coded as 1 if the passenger is female, 0 otherwise.
Occupants Number	logarithm of number of occupants.
ClassX	Discrete variables coded as 1 for the appropriate class. Class1 to class7 represent small, middle, large, luxury, SUV, van, and pick-up truck, respectively, class40, class41 represents luxury non-sports and luxury sports, respectively.
Weight	Weight of the vehicle (1000lb).
Weight Ratio	Weight ratio of the vehicle to the other vehicle in a two-vehicle accident.
Acceleration	Horsepower to weight ratio.
Vehicle Age	The age of the vehicle when the accident happened.
O_classX	The class code for the other vehicle.
Female Driver	Code as 1 if the driver is female.
Driver 16	Code as 1 if the driver is ≤ 16.
Young Driver	Coded as 1 if the driver is ≥16 but ≤24, 0 otherwise.
Older Driver	Coded as 1 if the driver is 65 or older.
Alcohol	Coded as 1 if the alcohol involvement is reported
Late Night	Code as 1 if the accident occurred between 12:00am to 5:59am.
No Previous Offenses	Code as 1 if the driver had no previous offenses.
Sp_limit	Speed limit (10 miles).
Seatfp	Coded as 1 for front seat non-driver passenger.
Seatb	Coded as 1 for back seat passenger.
airbag	Coded as 1 for airbag in that seat position.

Table B2: The Probability of Survival in a One-Vehicle Accident

Parameters	Estimates	t ratio	Prob.
Constant	1.485	5.067	0
Restraint	1.0943	25.028	0
Age0_5	0.2011	2.407	0.0161
Age15	0.6061	9.552	0
Age21	0.4501	8.547	0
Age24	0.3464	5.701	0
Age_o	-1.0999	-10.49	0
female	-0.2026	-5.948	0
Occupants Number	0.3961	5.999	0
Weight	-0.0737	-1.176	0.2395
Acceleration	-8.913	-2.539	0.0111
Vehicle Age	0.0025	0.154	0.8777
Class2	-0.0018	-0.022	0.9821
Class3	-0.0028	-0.016	0.9875
Class40	-0.1111	-0.739	0.4602
Class41	0.2465	0.924	0.3555
Class5	0.4951	3.601	0.0003
Class6	0.2715	1.992	0.0463
Class7	0.62	5.024	0
Sp_limit	-0.0627	-2.792	0.0052
airbag	-0.0054	-0.109	0.9132
Seatfp	-0.0612	-1.854	0.0637
Seatb	0.1249	2.535	0.0112
Driver 16	-0.4153	-4.046	0.0001
Young Driver	-0.2345	-3.42	0.0006
Older Driver	0.5054	3.625	0.0003
Female Driver	0.2059	3.248	0.0012
Alcohol	-0.0607	-0.965	0.3347
No Previous Offenses	-0.1916	-3.417	0.0006
Late Night	-0.1014	-1.672	0.0945

Table B3: The Probability of Survival in a Two-vehicle Accident

Parameters	Estimates	t ratio	Prob.
Constant	2.0436	6.544	0
Restraint	0.9234	18.053	0
Age0_5	0.0402	0.297	0.7663
Age15	0.4342	3.81	0.0001
Age21	0.4615	4.758	0
Age24	0.4571	4.14	0
Age_o	-1.5055	-13.25	0
female	-0.1744	-3.467	0.0005
Occupants Number	0.2572	4.65	0
Weight	0.1566	1.431	0.1523
Weight ratio	1.3538	6.626	0
Vehicle Age	-0.0018	-1.02	0.3077
Class2	0.0684	0.735	0.4624
Class3	0.0407	0.254	0.7993
Class40	-0.28	-1.773	0.0762
Class41	-0.4624	-1.136	0.2561
Class5	0.4542	2.837	0.0046
Class6	0.4554	3.184	0.0015
Class7	0.6685	5.06	0
O_class2	-0.1202	-1.167	0.2431
O_class3	-0.0789	-0.47	0.6387
O_class4	-0.289	-1.792	0.0732
O_class41	-1.7245	-5.119	0
O_class5	-0.3271	-2.064	0.039
O_class6	-0.3155	-2.067	0.0387
O_class7	-0.4214	-3.12	0.0018
Sp_limit	-0.447	12.714	0
airbag	0.1316	2.395	0.0166
Seatfp	-0.114	-1.306	0.1915
Seatb	0.2585	2.418	0.0156
Driver 16	-0.613	-4	0.0001
Young Driver	-0.0165	-0.177	0.8597
Older Driver	0.172	1.445	0.1484
Female Driver	-0.0423	-0.696	0.4862
Alcohol	-0.6062	-7.997	0
No Previous Offenses	-0.0599	-1.15	0.2501
Late Night	-0.6222	-6.02	0
Acceleration	-2.2826	-0.594	0.5523

Table B4: The Probability of Survival in a Multiple-vehicle Accident

Parameters	Estimates	Wald χ^2	Prob.
Constant	0.0075	0.001	0.9774
Restraint	0.9570	437.001	0.0001
Age0_5	-0.0337	0.066	0.7978
Age15	0.2592	5.312	0.0212
Age21	0.2673	6.274	0.0123
Age24	0.4072	10.560	0.0012
Age_o	-1.5429	177.689	0.0001
female	-0.1232	4.486	0.0342
Occupants Number	0.5399	100.273	0.0001
Weight	0.3223	35.925	0.0001
Acceleration	7.7231	4.251	0.0392
Vehicle Age	-0.0072	0.216	0.6424
Class2	0.2409	11.420	0.0007
Class3	0.4135	11.050	0.0009
Class40	0.2486	3.611	0.0574
Class41	-0.0749	0.042	0.8380
Class5	0.7535	33.524	0.0001
Class6	0.6679	36.716	0.0001
Class7	0.7384	52.197	0.0001
Sp_limit	-0.2297	116.802	0.0001
airbag	0.1788	8.380	0.0038
Seatfp	-0.0683	1.050	0.3055
Seatb	0.2892	8.380	0.0038
Driver 16	-0.3106	2.337	0.1264
Young Driver	-0.0581	0.354	0.5518
Older Driver	0.2642	4.784	0.0287
Female Driver	0.0268	0.199	0.6557
Alcohol	-0.8750	108.279	0.0001
No Previous Offenses	0.0627	1.844	0.1745
Late Night	0.0192	0.045	0.8316

Table B5: Variable Definitions for Estimating the Probability of Having an Accident

Variable Name	Definition
TypeXX	Coded as 1 for the appropriate type. Type1 to Type23 represent lower, upper small, small specialty, lower, upper middle, middle specialty, large, large specialty, lower, middle, upper luxury, luxury specialty, luxury sport, small, middle, large, luxury suv, small, middle, large, luxury van, small, large pickup, respectively.
Alcohol	Proportion of accidents in this make/model/year vehicle in which the alcohol involvement was reported.
No Previous Offenses	Proportion of accidents in this make/model/year vehicle in which the driver had no previous offense.
Late Night	Proportion of accidents in this make/model/year vehicle which occurred between 12:00am to 5:59am.
Driver 16	Proportion of accidents in this make/model/year vehicle in which the driver is 16 or younger.
Young Driver	Proportion of accidents in this make/model/year vehicle in which the driver is younger than 25 years, but older than 16..
Older Driver	Proportion of accidents in this make/model/year vehicle in which the driver is 65 or older.
Female Driver	Proportion of accidents in this make/model/year vehicle in which the driver was female.
Sp	Proportion of accidents at highway speed.
Acceleration	The horsepower-to-weight ratio.
Traditional Styling	Length plus width divided by height.
D_airbag	Coded as 1 for the driver-side airbag.
P_airbag	Coded as 1 for the passenger-side airbag.

Table B6: Censored Regression for the Probability of Having a One-Vehicle Accident

PARAMETER	Estimate	std. Error	ChiSquare
constant	-0.2231	0.097	5.25
Alcohol	0.0925	0.019	22.69
No Previous Offenses	-0.1255	0.017	51.53
Late Night	-0.0056	0.022	0.07
Driver 16	0.1232	0.048	6.69
Young Driver	0.1814	0.022	69.42
Older Driver	0.1038	0.028	13.44
Female Driver	0.1018	0.019	28.28
Sp	0.1247	0.017	53.40
Acceleration	3.9825	0.654	37.08
Traditional Styling	0.0280	0.025	1.24
Weight	-0.0059	0.018	0.11
D_airbag	-0.0360	0.012	8.74
P_airbag	-0.0159	0.013	1.42
Type2	-0.0702	0.023	9.11
Type3	-0.0604	0.029	4.21
Type4	-0.0965	0.027	12.94
Type5	-0.0805	0.028	8.17
Type6	-0.0632	0.031	4.23
Type7	-0.0969	0.038	6.44
Type8	-0.0996	0.054	3.40
Type9	-0.0985	0.034	8.45
Type10	-0.1095	0.033	10.70
Type11	-0.1558	0.041	14.47
Type12	-0.0797	0.043	3.40
Type13	0.0725	0.038	3.64
Type14	0.1634	0.044	13.98
Type15	0.1194	0.045	7.07
Type16	0.0569	0.060	0.91
Type17	0.1454	0.057	6.58
Type18	-0.0232	0.040	0.33
Type19	-0.0491	0.054	0.82
Type20	0.0110	0.062	0.03
Type21	-0.0366	0.065	0.31
Type22	0.1359	0.032	18.32
Type23	0.0932	0.052	3.23
Sigma	0.1526	0.003	

Table B7: Censored Regression for the Probability of Having a Two Vehicle Accident

parameter	Estimate	std. Error	ChiSquare
constant	0.0197	0.061	0.11
Alcohol	0.0063	0.023	0.08
No Previous Offenses	-0.1561	0.015	109.11
Late Night	0.0448	0.024	3.54
Driver 16	0.1449	0.051	7.94
Young Driver	0.0980	0.018	30.26
Older Driver	0.1098	0.019	32.47
Female Driver	0.1102	0.014	61.16
Sp	0.1067	0.014	58.72
Acceleration	0.0858	0.428	0.04
Traditional Styling	0.0074	0.015	0.23
Weight	0.0261	0.010	6.22
D_airbag	-0.0119	0.007	2.88
P_airbag	-0.0062	0.008	0.61
Type2	-0.0258	0.013	3.84
Type3	-0.0377	0.017	4.75
Type4	-0.0630	0.015	16.87
Type5	-0.0476	0.016	8.36
Type6	-0.0549	0.019	8.73
Type7	-0.0577	0.022	6.68
Type8	-0.0887	0.031	8.28
Type9	-0.1069	0.020	28.49
Type10	-0.0972	0.021	22.06
Type11	-0.1146	0.026	19.86
Type12	-0.0909	0.027	11.46
Type13	-0.0939	0.026	13.39
Type14	-0.0438	0.026	2.75
Type15	-0.0274	0.026	1.09
Type16	-0.0196	0.035	0.31
Type17	-0.0679	0.034	3.98
Type18	-0.0469	0.023	4.03
Type19	-0.0627	0.031	3.98
Type20	-0.0193	0.036	0.29
Type21	-0.0590	0.036	2.64
Type22	0.0338	0.018	3.35
Type23	0.0218	0.030	0.52
Sigma	0.0851	0.002	

Table B8: Censored Regression for the Probability of Having a Multiple (three or more) Vehicle Accident

parameter	Estimate	std. Error	ChiSquare
constant	-0.0067	0.013	0.25
Alcohol	0.0051	0.005	1.10
No Previous Offenses	-0.0192	0.002	68.94
Late Night	0.0118	0.005	6.58
Driver 16	0.0291	0.008	11.76
Young Driver	0.0130	0.003	17.97
Older Driver	0.0180	0.004	26.31
Female Driver	0.0213	0.002	93.38
Sp	0.0214	0.002	103.77
Acceleration	0.1539	0.092	2.79
Traditional Styling	0.0012	0.003	0.13
Weight	0.0038	0.002	2.58
D_airbag	0.0006	0.002	0.12
P_airbag	0.0004	0.002	0.06
Type2	-0.0100	0.003	10.86
Type3	-0.0133	0.004	11.30
Type4	-0.0128	0.004	13.05
Type5	-0.0078	0.004	4.30
Type6	-0.0124	0.004	9.00
Type7	-0.0099	0.005	3.80
Type8	-0.0139	0.007	3.77
Type9	-0.0164	0.005	12.73
Type10	-0.0163	0.004	13.13
Type11	-0.0203	0.006	12.85
Type12	-0.0020	0.006	0.12
Type13	-0.0173	0.005	10.03
Type14	-0.0005	0.006	0.01
Type15	-0.0006	0.006	0.01
Type16	-0.0035	0.008	0.20
Type17	-0.0136	0.008	3.13
Type18	-0.0086	0.005	2.65
Type19	-0.0049	0.007	0.49
Type20	-0.0036	0.008	0.20
Type21	-0.0031	0.008	0.16
Type22	0.0030	0.004	0.50
Type23	-0.0018	0.007	0.07
Sigma	0.0200	0.000	

Appendix C

The Hedonic Price and Fuel Efficiency Models

The econometric model used for the hedonic price of a vehicle is based on the work of Rosen (1974), Atkinson and Halvorsen (1990), and Dreyfus and Viscusi (1995) on hedonic pricing. Atkinson and Halvorsen (1990) use the data for 112 models of new 1978 automobiles to obtain estimates of the VSL. Since the available fatality data is a function of both the inherent risk of the vehicle and the driver's characteristics, the drivers' characteristics are included in the regression as control variables. Their estimated VSL for the sample as a whole, based on willingness to pay, is $3.357 million 1986 dollars.

The data used in Dreyfus and Viscusi (1995) differ from those used in earlier studies in that they reflect actual consumer automobile holdings. Dreyfus and Viscusi (1995) use the 1988 Residential Transportation Energy Consumption Survey together with data from industry sources. They generalize the standard hedonic models to recognize the role of discounting on fuel efficiency and safety. The estimates of the implicit value of life range from $2.6 to $3.7 million and the estimates of the discount rate range from 11 to 17 percent.

The hedonic price equation for automobiles can be written, following Atkinson and Halvorsen (1990), as follows:

$P_{auto} = f(R, A)$,

where P_{auto} is the price of an automobile, R is the inherent risk of mortality (a similar measure for injury could also be included) associated with the automobile, and A is a vector of other characteristics. The available mortality rate, F, is a function of both R and a vector of the involved driver's characteristics D. Assuming that F is monotonic in R, the above equation can also be written as:

$P_{auto} = g(F, A, D)$,

The standard functional form used for the estimation of a hedonic price equation is:

$$\log(P_{auto}) = \beta_0 + \sum_i \gamma_i D_i + \sum_k \beta_k \log(X_k) + e$$

where X_k is a representative measured regressor (e.g. horsepower to weight ratio), D_i is a dummy variable for vehicle type, γ_k, β_k are the corresponding parameters and e is an unobserved residual.

A different approach was used in this research, and it involves predicting the inherent mortality rate using standardized driver's characteristics. In other words, the unobserved values of R are predicted directly. Since the specified number of occupants of a vehicle is two, the observed mortality rate F is twice the size of the average mortality rate per occupant. The corresponding value of R should also reflect the fact that there are two occupants on average. Consequently, the predicted value $\hat{R} = \hat{r}_1 + \hat{r}_2$ (i = 1 is the driver and i = 2 is the passenger), where $\hat{r}_i$ is the predicted probability of a fatality for an individual, defined in the previous section. The standardized inherent mortality rates for two male occupants for year 1995 automobiles are summarized by type of vehicle in Figure C1. The minimum, average and maximum risks of mortality for each type of vehicle are illustrated. Figure C2 provides the corresponding scales for the raw (unadjusted) mortality data based on 1996-1997 FARS data. Comparing the two figures, the relative ranking among different types of vehicle are quite

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consistent, but the standardizing procedure significantly reduces the ranges of the risk of mortality.

One might be surprised by the implication from Figures C1 and C2 that large sports utility vehicles (SUVs) are not safer than small sedans and wagons. From Table C1, the average standardized and risks of mortality show that large SUVs are safer in two-vehicle and multiple-vehicle accidents (1.6+0.7=2.3 compared to 4.4+1.4=5.8 for small sedans). However, they are much less safe in one-vehicle accidents (7.1 compared to 3.4 for small sedans) because the probability of having an accident is higher. This point can be further illustrated by the information in Table C3. For two-vehicle accidents, large SUVs have the lowest observed mortality rate per occupant (0.186) among all types of vehicle, which is about a third of the rate for small sedans (0.512). However, the observed accident rates for large SUVs and small sedans are the same (0.193). The impression that large SUVs are safer than other vehicles comes from observing that occupants in a large SUV are more likely to survive in a fatal accident with another vehicle than the occupants of other types of vehicle.

Another cost associated with reducing the risk of mortality and injury is buying more fuel because heavier vehicles are safer but have lower fuel efficiencies. Consequently, a hedonic model of fuel efficiency augments the standard hedonic model of the purchase price in our model. In this model, the cost of additional safety has a capital component and an operating component. In the latter case, the cost penalty corresponds to the reduced fuel efficiency when a heavier vehicle is purchased. The hedonic model of fuel efficiency has the same form as the hedonic model of the purchase price, and it can be written:

$$\log(fe\_city) = \alpha_0 + \sum_i \delta_i D_i + \sum_k \alpha_k \log(X_k) + e$$

where fe_city is the rated miles per gallon for city driving, X_k is a representative measured regressor, D_i is a dummy variable for vehicle type, δ_i , and α_k are the corresponding parameters and e is an unobserved residual.

The primary source of the data for estimating the hedonic price and fuel efficiency models was the 1995 National Personal Transportation Survey (NPTS). This data was used to obtain information on each household's choice of automobiles. The 1995 NPTS was conducted by the Research Triangle Institute (RTI) under the sponsorship of the U.S. Department of Transportation (DOT). The survey covers 42,033 sampled households. A sub-data set of 4036 one-car households holding a 1990-1995 model year vehicle were merged with vehicle attribute data collected from industry and other sources for the same years. The vehicle price data were gathered from *NADA Official Used Car Guide*, and other attribute data were collected from *NADA Official Used Car Guide*, *Ward's Automotive Yearbook*, and *Consumer Reports*. The mortality rate is measured by the number of fatalities occurring in each make/model/year vehicle per 1000 vehicles sold. The number of fatalities is based on the models described in Appendix B. Since the observed mortality rate is jointly determined by the inherent risk associated with the type of automobile and the driver's characteristics and behavior, driver's characteristics were also collected from the data on fatal accidents for each make, model and year to provide control variables.

In addition to the risk of mortality, a second safety measure, injury rate, is introduced. The injury rate by make and model of vehicle is published annually by the Highway Loss Data Institute. It is measured by the frequency of insurance claims filed under Personal Injury Protection coverages. The raw injury rates are adjusted by the same factors used to standardize raw mortality rates. The implicit assumption is that the “bad” driving characteristics that contribute to fatal accidents also affect injuries.

The variables used in the hedonic price equation are summarized in Table C4, and Table C5 shows the descriptive statistics of selected vehicle attributes. The selection of vehicle attributes and driver’s characteristics is similar to Dreyfus and Viscusi (1995) and Atkinson and Halvorsen (1990). It should be noted that the observed mean mortality rate is higher than the standardized mean and the observed standard deviation is also higher. The reason is that the standardized mortality is based on one average male driver and one average male passenger. Even though average values of the other regressors are used, the elimination of young drivers, for example, results in lower average mortality rates. The effect of standardizing drivers’ characteristics to predict the inherent mortality rate has the effect, as expected, of reducing the variability of mortality among vehicles.

The Estimated Hedonic Models

Least square estimates of the hedonic price model and the fuel efficiency model are presented in Table C6. Model A is the hedonic equation of fuel efficiency, using the standardized mortality rate. Model B is the hedonic equation of capital cost, using the standardized mortality rate. In Model A and B, variables with small t ratios and perverse signs have been dropped.

The most important parameter for computing the VSL is the coefficient for the mortality rate, and the values in Model A and B have the right signs and are both significant. In other hedonic price models, fuel efficiency is included as a regressor in Model B, but it often has a large t ratio and a perverse negative sign (fuel efficiency is a positive attribute). Hence, some explanation is needed to explain why fuel efficiency is omitted in Model B. The implication of Model A is that fuel efficiency is a dependent variable, like the price, and is a function of the vehicle’s characteristics. The model corresponds to a simplified reduced form for a system of two equations. If the predicted fuel efficiency from Model A is used as a regressor in Model B, the coefficient has a logical positive sign. The overall effect on the estimated VSL is small, however, if the direct effects of mortality on price and fuel efficiency are combined with the indirect effect on the price through fuel efficiency. This is not really surprising because the model presented in Table C6 is equivalent to a solved reduced form for a structural model which has fuel efficiency as a regressor in the hedonic price equation (the equation for fuel efficiency remains the same).

Table C1: The Standardized Risk of Mortality by Vehicle and Type of Accident

Vehicle Type	Total Risk	One-Car Accidents	Two-Car Accidents	Multiple-Car Accidents
small sedans & wagons	9.2	3.4	4.4	1.4
middle sedans & wagons	6.9	3.3	2.5	1.0
large sedans & wagons	6.5	3.5	2.1	0.8
luxury sedans & wagons	7.2	4.7	1.7	0.8
small & mid. specialties	9.5	5.6	3.0	1.0
luxury sports	25.3	21.8	2.6	0.9
small suv	17.1	12.0	3.6	1.6
large suv	9.4	7.1	1.6	0.7
van (minivan)	5.0	2.7	1.5	0.8
small pickup	12.4	7.7	3.5	1.2
large pickup	8.6	5.8	2.0	0.8

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Table C2: The Observed Risk of Mortality by Vehicle and Type of Accident (Year 1996-1997 Average)

Vehicle Type	Total Risk	One-Car Accidents	Two-Car Accidents	Multiple-Car Accidents
small sedans & wagons	30.8	12.2	14.1	4.6
middle sedans & wagons	22.5	12.1	8.8	1.6
large sedans & wagons	17.7	5.4	11.2	1.2
luxury sedans & wagons	9.3	4.9	3.2	1.2
small & mid. specialties	33.8	20.5	10.3	3.0
luxury sports	26.2	23.6	2.6	0.0
small suv	53.4	26.6	25.6	1.2
large suv	21.1	16.2	3.5	1.4
van (minivan)	24.6	12.8	8.8	3.0
small pickup	26.1	17.6	7.2	1.4
large pickup	17.6	11.6	4.8	1.2

Table C3: The Observed Mortality Rates Per Occupant and Accident Rates per 1000 Vehicles for Fatal Two-vehicle Accidents (Average 1996-1997)

Vehicle Type	Mortality Rate	Accident Rate
small sedan & wagons	0.512	0.193
middle sedan & wagons	0.435	0.169
large sedan & wagons	0.370	0.159
luxury sedan & wagons	0.369	0.113
small & mid. specialties	0.429	0.171
luxury sports	0.329	0.109
small suv	0.430	0.189
large suv	0.186	0.193
van (minivan)	0.218	0.221
small pickup	0.368	0.188
large pickup	0.201	0.244

Table C4: Variable Definitions

Variable Name	Definition
Price	Vehicle price as of end-of-year 1995.
Value Retained	Original sales value retained, as of end-of-year 1995.
Mortality Rate, Observed	Number of fatalities occurring in that make/model/year vehicle per 1000 of that vehicle sold.
Mortality Rate, Standardized	Predicted number of fatalities in that make/model/year vehicle per 1000 of that vehicle sold with average 2 occupants.
Injury Rate	An Index based on the frequency of insurance claims. The lower, the safer.
CityFuel efficiency	Miles per gallon in city area.
CityFuel efficiency Predicted	Predicted Miles per gallon in city area.
Reliability Rating	A discrete variable coded from 1 to 5, 5 is the highest while 1 is the lowest.
Acceleration	The horsepower-to-weight ratio.
Traditional Styling	Length plus width divided by height.
ClassX	Discrete variables coded as 1 for the appropriate class. Class1 to class7 represent small, middle, large, luxury, SUV, van, and pick-up truck, respectively.
YearXX	Discrete variables coded as 1 for the vehicle model year.
Young Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was younger than 25 years.
Older Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was 65 or older.
Alcohol	Proportion of fatalities in this make/model/year vehicle in which the alcohol involvement was reported.
Gender of Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was male.
Seat Belt	Proportion of fatalities in this make/model/year vehicle in which the driver was wearing a seat belt.
Previous Offenses	Proportion of fatalities in this make/model/year vehicle in which the driver had no previous offense.
Late Night	Proportion of fatalities in this make/model/year vehicle which occurred between 12:00am to 5:59am.
One-car Accident	Proportion of fatalities in this make/model/year vehicle in which only one vehicle was involved.
Ford, GM, Chrysler, Germany, Japan	Discrete variables coded as 1 for the manufacturer and 0 otherwise.
MB	Dummy variable coded as 1 for Mercedes Benz, 0 otherwise.

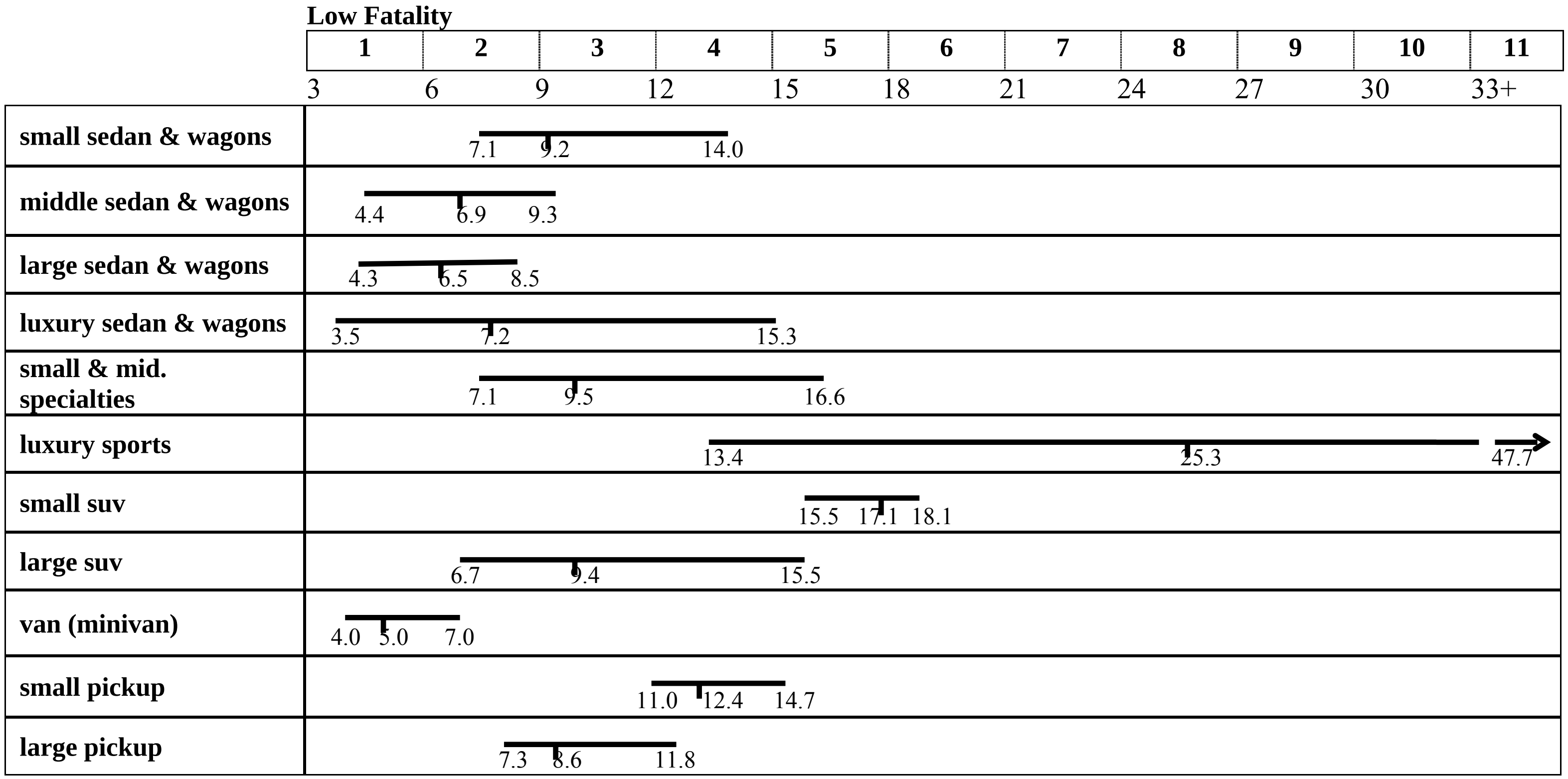
Table C5: Summary Statistics of Selected Variables

Variable	Mean	Standard Deviation
Price	15703.53	9371.57
Value Retained	0.7720	0.1753
Mortality Rate, Observed	0.1345	0.0994
Mortality Rate, Standardized	0.0939	0.0401
Injury Rate	73.72	42.12
City Fuel-efficiency	20.26	4.82
Reliability Rating	3.019	1.321
Acceleration	0.0475	0.0102
Traditional Styling	4.451	0.519

Table C6: Parameter Estimates for the Hedonic Equations

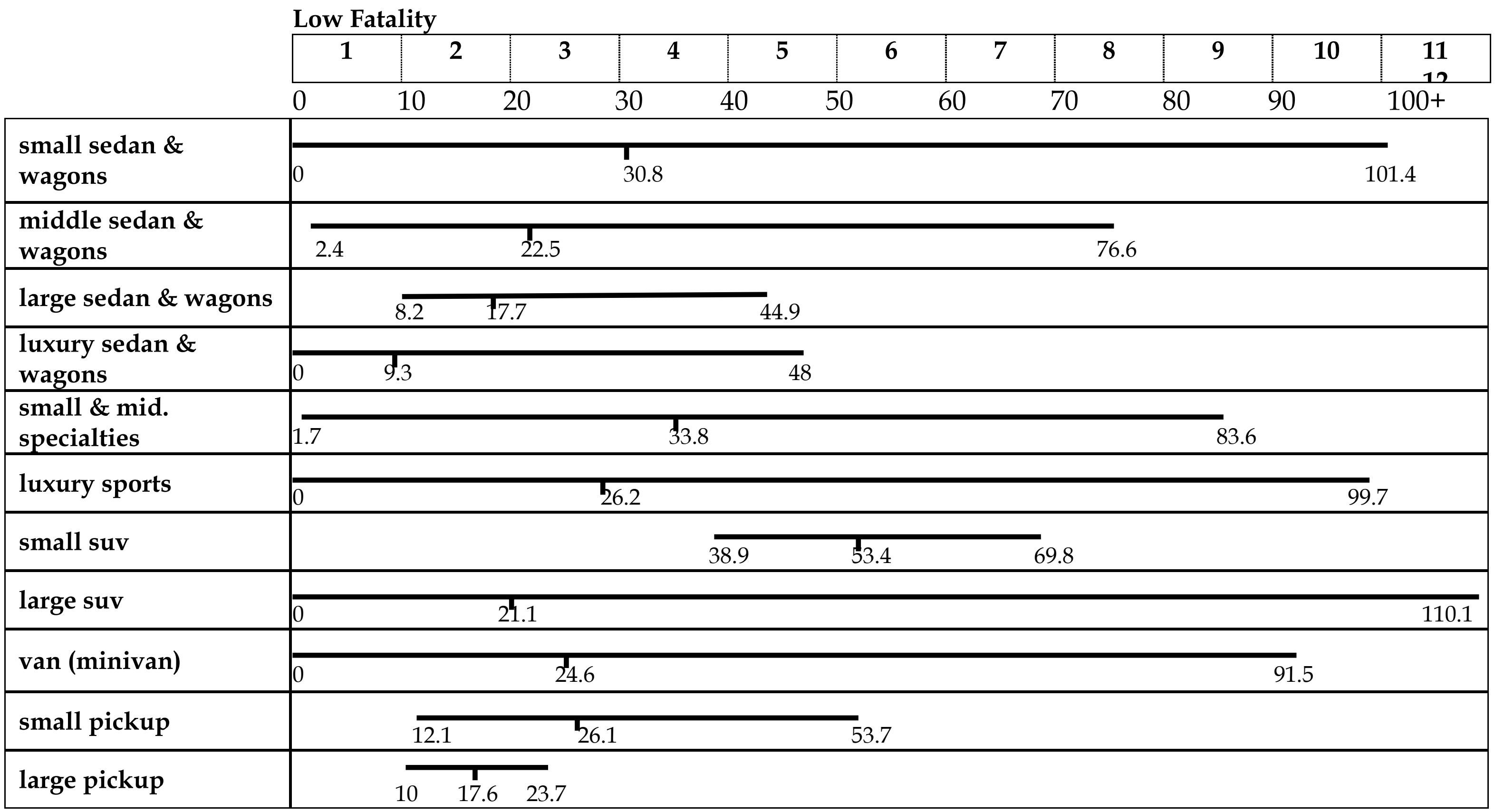
Variable	Model A Estimated Coefficient	t ratio	Model B Estimated Coefficient	t ratio
Dependent	**Fe_city**		$\mathbf{P_{auto}}$	
Constant	2.5689	14.13	7.7174	25.45
Value Retained	0.0549	3.35	0.4594	11.10
Mortality Rate	0.0258	1.99	-0.0690	-3.53
Injury Rate	0.0330	4.01	-0.0161	-1.31
Reliability Rating	0.0170	5.05	0.0617	5.23
Acceleration	-0.2290	-8.04	0.6014	13.99
Traditional Styling	-0.2786	-5.21	0.6035	7.56
Class2	-0.1873	-16.56	0.2426	14.34
Class3	-0.2751	-14.69	0.3734	13.28
Class4	-0.2852	-19.29	0.6752	29.76
Class5	-0.6397	-37.47	0.8127	31.94
Class6	-0.4846	-24.84	0.6558	22.67
Class7	-0.4352	-27.49	0.3398	14.31
Year91			0.1137	6.31
Year92			0.2100	10.53
Year93			0.2977	13.16
Year94			0.3880	15.30
Year95			0.4474	16.14
Ford	0.0347	1.90	-0.0972	-3.58
GM	0.0334	1.94	-0.0879	-3.44
Chrysler	0.0196	1.12	-0.1148	-4.43
Germany	-0.0562	-2.84	0.1489	5.05
Japan	0.0470	2.73	-0.0430	-1.71
MB	-0.0078	-0.33	0.5237	14.89
R^2	0.7626		0.8996	

Figure C1: Standardized Scales for the Risk of Mortality



Note: The scale is based on predicted total fatalities per 100,000 vehicles (1995 model year) per 10,000 miles driven with 2 occupants.

Figure C2: Unadjusted Scales for the Risk of Mortality



Note: The scale is based on the observed total fatalities in year 1996-1997 per 100,000 vehicles (1995 model year) on road per 10,000 miles driven (average annual miles driven is 13989 miles

Appendix D: Auto Safety Survey (Full scale)

NOTE:

1. Variable names are in bold type.
2. A code of system missing (•) means the question was not applicable (NA).
3. Questions were asked of all respondents unless indicated otherwise.
4. (A) after variable name indicates a string variable.
5. For cases where the answers were not clear, we entered that data as missing (e.g. a respondent circled both 2 and 5 on M2a so we entered -9).
   For cases where the answers were ranges, we entered the midpoint (e.g. a respondent wrote in $50-$80 on M3_1 so we entered $65)
   All cases with unclear answers or ranges are detailed along with their caseids in "DEissues.xls" file.

Sample Information

RESPOND Unique identification number for completed recruitment screeners

CASEID Unique case identification number for mailed surveys

DATE_C Date recruit completed

DATE_R Date mail survey returned

VERSION Version number of survey mailed
1 Version 1
2 Version 2

STATUS Level of mail survey completion
0 Refused to be recruited for mail survey
1 Agreed to mail, but did not return survey
5 Partial mail complete
10 Full recruit and mail complete

STATE (A) State where respondent resides

ZIP (A) Zip code where respondent resides

FIPSTATE Numeric FIPS state code

FIPCONTY Numeric FIPS county code

REMAIL Whether or not respondent received follow-up survey mailing

0 No reminder survey mailing (either because had returned completed survey or said during follow-up call that they would return the survey they had)
1 Sent follow-up survey mailing

Recruitment Survey

Hello, my name is (*FILL IN*) and I am calling on behalf of Cornell University. May I speak with an adult head of your household?

My name is (*FILL IN*) and I am calling from Discovery Research. We are conducting a study for Cornell University of people's use of automobiles and their opinions about automobile safety. I'd like to assure you that this is a research project and I am <u>not</u> trying to sell you anything.

(*IF NEEDED):* You are part of a small group of U.S. residents who have been scientifically selected for this study. Your opinions will represent other people like you. This should take about 15 minutes.

For this survey, when I say automobiles, I mean all types of passenger automobiles including station wagons, sport utility automobiles (SUVs), mini-vans, and light trucks that were purchased or leased by someone in your household and are used regularly by someone in your household. Do *not* include motorcycles, or automobiles, such as antique cars, that are rarely driven.

(VERIFY THAT RESPONDENT IS AN ADULT HEAD OF HOUSEHOLD.)

Q1 Including yourself, how many people live in your household? Please count yourself and any family members or partners who live with you. Do not include unrelated adult roommates who make their own automobile purchase decisions.

(INTERVIEWER NOTE: WE WANT HOUSEHOLDS THAT ARE JOINT DECISION MAKING UNITS, SO THIS SHOULD INCLUDE PARTNERS, BUT NOT UNRELATED ADULTS WHO ARE JUST ROOMMATES AND MAKE THEIR OWN SEPARATE CAR PURCHASE DECISIONS. IF THE LATTER, THEN SAY TO RESPONDENT: "For the remainder of this survey, I only want you to tell me about yourself and anyone else in this household who is part of your decision making for automobiles purchases."*)*

_____ People (including respondent)

(NOTE: IF Q1 GREATER THAN 5, THANK AND TERMINATE.)
57 Households with more than 5 people.

Q2 How many automobiles does your household currently own or lease?

(IF NEEDED): When I say automobile, I mean all types of passenger automobiles including station wagons, sport utility automobiles (SUVs), mini-vans, and light trucks that were purchased or leased by someone in your household. Do not include motorcycles, or automobiles that are not driven more than 500 miles per year.

_____ automobiles

(NOTE: IF Q2 EQUALS 0, OR Q2 GREATER THAN 3, THANK AND TERMINATE.)

235 Households with 0 autos.
181 Households with more than 3 autos.

Q3 Does anyone in your household regularly use an automobile that was purchased by his or her employer?

1 Yes *(NOTE: IF YES, THANK AND TERMINATE.)*
2 No *118 Households had an employer-purchased auto.*

Q4 Does anyone in your household regularly use an automobile that was given to them by someone outside your household?

1 Yes (NOTE: IF YES, THANK AND TERMINATE.)
2 No *74 Households had a gift auto.*

Q5 Do you drive any of your household's automobiles?

1 Yes
2 No *(ASK TO SPEAK WITH AN ADULT DRIVER)*

Q6 I'd like you to tell me about each of the automobiles that are owned or leased by members or your household. Starting with the automobile that is driven the most, . . .?

	Characteristics	Most Driven Automobile (in terms of miles/year)	2nd Most Driven Automobile	3rd Most Driven Automobile
a.	What make or brand is this automobile? (e.g., Chevrolet, Mercedes)	**Q6a1 (A)**	**Q6a2 (A)**	**Q6a3 (A)**
b.	What model is it? (e.g., Camaro, S-Class) (If don't know, please ask respondent to check.)	**Q6b1 (A)**	**Q6b2 (A)**	**Q6b3 (A)**
c.	Type of model? (e.g., LE, LX, SE) (If don't know, please ask respondent to check.)	**Q6c1 (A)**	**Q6c2 (A)**	**Q6c3 (A)**
d.	What model year is the automobile?	**Q6d1** -8 Don't Know	**Q6d2** -8 Don't Know	**Q6d3** -8 Don't Know
e.	What year did you purchase or lease the automobile?	**Q6e1** -8 Don't Know	**Q6e2** -8 Don't Know	**Q6e3** -8 Don't Know
f.	What was the approximate purchase price of this automobile/equivalent price that was used in calculating your lease payments?	$ **Q6f1** -8 Don't Know -9 Refused	$ **Q6f2** -8 Don't Know -9 Refused	$ **Q6f3** -8 Don't Know -9 Refused
g.	Have you had this automobile for less than 12 months?	**Q6g1** 1 Yes 2 No	**Q6g2** 1 Yes 2 No	**Q6g3** 1 Yes 2 No
h.	About how many miles (was this automobile driven over the last 12 months/*IF HAD FOR LESS THAN 12 MONTHS*: will this automobile be driven in a 12-month period?)	**Q6h1** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused	**Q6h2** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused	**Q6h3** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused
	Range of miles *(if Q6h is DK)*	**Q6h1f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA	**Q6h2f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA	**Q6h3f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA

(PROGRAMMING NOTE: FROM NOW ON, FILL "MOST DRIVEN AUTOMOBILE," "2ND MOST DRIVEN VEHICLE", "3RD MOST DRIVE AUTOMOBILE" WITH ACTUAL MAKE AND MODEL AND MODEL YEAR OF AUTOMOBILE.")

(PROGRAMMING NOTE: FROM NOW ON, IF AN AUTOMOBILE HAS BEEN IN THE HOUSEHOLD LESS THAN 12 MONTHS, USE THE SECOND PHRASE IN THE PARENTHESIS WHICH REFERS TO THE AMOUNT THE VEHICLE WILL BE USED IN A 12-MONTH PERIOD.)

Recruit: Automobile Use

Q7 To understand auto safety, we need to know how your household uses your automobiles. I'd like to get the first name or initial, age and gender of all the people living in your household. We will be referring to these family members in the next set of questions, so it will be easier if we have a way to identify each individual. You can use nicknames if you prefer. First, what is your first name?

Person	First Name	Age __ -9 Refused • NA	Gender 1 Male 2 Female • NA	Relationship with Respondent 1 Spouse 2 Partner 3 Son 4 Daughter 5 Mother 6 Father 7 Other relative 8 Friend • NA
Person A (Yourself)	NA	**Q7aage**	**Q7amf**	NA
Person B	**Q7bname (A)**	**Q7bage**	**Q7bmf**	**Q7brelat**
Person C	**Q7cname (A)**	**Q7cage**	**Q7cmf**	**Q7crelat**
Person D	**Q7dname (A)**	**Q7dage**	**Q7dmf**	**Q7drelat**
Person E	**Q7ename (A)**	**Q7eage**	**Q7emf**	**Q7erelat**

(PROGRAMMING NOTE: FROM NOW ON, FILL "PERSON A" WITH "YOU," AND "PERSON B-E" WITH THE FIRST NAME).

Q8 In this next question, I would like to know how much each person in your household (was in each automobile during the past 12 months/*IF HAD FOR LESS THAN 12 MONTHS*: will be in this automobile in a 12-month period), either as a driver or a passenger. For the *[FILL WITH AUTOMOBILE MAKE AND MODEL]*, you mentioned it (was/will be) driven about *[FILL WITH ANNUAL MILEAGE]* miles in a 12-month period. What percentage of these miles (did/will) *[FILL WITH PERSON NAME]* drive or ride in this automobile? We know that this is a difficult question, and it is okay to give approximate answers. *(PROBE):* For example, did this person drive or ride in this automobile for all the miles (it was driven/it will be driven), for about 50% of the miles, for about 25% of the miles, or some other amount?

For Q8a_1 to Q8e_3: ____ %
-8 Don't Know
-9 Refused
• NA

Most Driven Auto:

Approximate percentage of annual miles each person rides in the Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_1	**Q8b_1**	**Q8c_1**	**Q8d_1**	**Q8e_1**

2nd Most Driven Auto:

Approximate percentage of annual miles each person rides in the 2nd Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_2	**Q8b_2**	**Q8c_2**	**Q8d_2**	**Q8e_2**

3rd Most Driven Auto:

Approximate percentage of annual miles each person rides in the 3rd Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_3	**Q8b_3**	**Q8c_3**	**Q8d_3**	**Q8e_3**

(ADDITIONAL CLARIFICATION): The following example may help you think through the question. Suppose that the "Most Driven Car" in your household is your car that you drive alone to work most days. Also, most household outings and longer vacation trips are in that car. Thus, you may estimate that of the total annual miles that the "Most Driven Car" is driven, about 70% you are driving alone, and about 30% are family trips when you are all in the car. Thus, you may estimate that you are in the "Most Driven Car" 100% (70% + 30%) of the miles it is driven and your spouse and each of your children are in the car 30% of the

miles it is driven. In this case you will fill in the box of the “Most Driven Car,” under A-yourself, 100%, and under persons B (your spouse), C and D (your children) 30%.

Q9 You said that *[FILL WITH PERSON NAME]* (rode in or drove/will ride in or drive) [*FILL WITH AUTOMOBILE MAKE AND MODEL]* about *[FILL WITH PERCENT OF MILES]* of the miles it is driven in a 12-month period. What percent of this time (did they/will they) occupy the front seat and the back seat?

For Q9a_f1 to Q9e_b3:____ %
-8 Don't Know
-9 Refused
- NA

(*NOTE: THIS MUST TOTAL 100% IF THEY RODE AT ALL IN THE AUTOMOBILE.)*

Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f1**	Front	**Q9b_f1**	Front	**Q9c_f1**	Front	**Q9d_f1**	Front	**Q9e_f1**
Back	**Q9a_b1**	Back	**Q9b_b1**	Back	**Q9c_b1**	Back	**Q9d_b1**	Back	**Q9e_b1**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

2nd Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f2**	Front	**Q9b_f2**	Front	**Q9c_f2**	Front	**Q9d_f2**	Front	**Q9e_f2**
Back	**Q9a_b2**	Back	**Q9b_b2**	Back	**Q9c_b2**	Back	**Q9d_b2**	Back	**Q9e_b2**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

3rd Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f3**	Front	**Q9b_f3**	Front	**Q9c_f3**	Front	**Q9d_f3**	Front	**Q9e_f3**
Back	**Q9a_b3**	Back	**Q9b_b3**	Back	**Q9c_b3**	Back	**Q9d_b3**	Back	**Q9e_b3**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

(ADDITIONAL CLARIFICATION): The following example may help you think through the question. Suppose that of the total miles that you ride in the "Most Driven Car," 90% of these miles you drive and 10% you occupy a back seat while another family member drives. In this case you will fill in the box of the "Most Driven Car," under A-yourself, 90% Front and 10% Back.

Recruit: Reasons For Using Your Automobiles

Q10 In the next set of questions, I am interested in learning the main reasons why you and other members of the household use your automobiles, either as a passenger or a driver. *(Not asked if person was younger than 14. If younger than 14, Q10a=No.)*

Use of Automobiles for Work	Person A - Yourself	Person B	Person C	Person D	Person E
a. Do/Does *[FILL WITH NAME]* work outside the home?	**Q10a_a** 1 Yes 2 No (SKIP TO Q10a_f) • NA	**Q10b_a** 1 Yes 2 No (SKIP TO Q10b_f) • NA	**Q10c_a** 1 Yes 2 No (SKIP TO Q10c_f) • NA	**Q10d_a** 1 Yes 2 No (SKIP TO Q10d_f) • NA	**Q10e_a** 1 Yes 2 No (SKIP TO Q10e_f) • NA
b. Do/Does *[FILL WITH NAME]* travel to work in one of your household's automobiles?	**Q10a_b** 1 Yes 2 No (SKIP TO Q10a_f) • NA	**Q10b_b** 1 Yes 2 No (SKIP TO Q10b_f) • NA	**Q10c_b** 1 Yes 2 No (SKIP TO Q10c_f) • NA	**Q10d_b** 1 Yes 2 No (SKIP TO Q10d_f) • NA	**Q10e_b** 1 Yes 2 No (SKIP TO Q10e_f) • NA
c. What automobile do you/they use most often to get to work?	**Q10a_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10b_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10c_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10d_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10e_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA
d. How many miles is it (one-way) from your house to the workplace? (*INTERVIEWER NOTE: THE PRIMARY WORKPLACE IF MORE THAN ONE.)*	**Q10a_d** -8 Don't Know -9 Refused • NA	**Q10b_d** -8 Don't Know -9 Refused • NA	**Q10c_d** -8 Don't Know -9 Refused • NA	**Q10d_d** -8 Don't Know -9 Refused • NA	**Q10e_d** -8 Don't Know -9 Refused • NA
e. Who usually drives you/*[FILL WITH NAME]* to work?	**Q10a_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10b_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10c_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10d_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10e_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA

Use of Automobiles for School/Day Care	Person A - Yourself	Person B	Person C	Person D	Person E
a. Do/Does *[FILL WITH NAME]* go to school or day care?	**Q10a_f** 1 Yes 2 No (GO TO Q10b_a) • NA	**Q10b_f** 1 Yes 2 No (GO TO Q10c_a) • NA	**Q10c_f** 1 Yes 2 No (GO TO Q10d_a) • NA	**Q10d_f** 1 Yes 2 No (GO TO Q10e_a) • NA	**Q10e_f** 1 Yes 2 No (GO TO Q11) • NA
b. Do/Does *[FILL WITH NAME]* travel to day care or school in one of your household's automobiles?	**Q10a_g** 1 Yes 2 No (GO TO Q10b_a) • NA	**Q10b_g** 1 Yes 2 No (GO TO Q10c_a) • NA	**Q10c_g** 1 Yes 2 No (GO TO Q10d_a) • NA	**Q10d_g** 1 Yes 2 No (GO TO Q10e_a) • NA	**Q10e_g** 1 Yes 2 No (GO TO Q11) • NA
c. Which automobile is used most often to get to school or day care?	**Q10a_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10b_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10c_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10d_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10e_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA
d. How many miles is it (one-way) from your house to school or day care?	**Q10a_I** -8 Don't Know -9 Refused • NA	**Q10b_I** -8 Don't Know -9 Refused • NA	**Q10c_I** -8 Don't Know -9 Refused • NA	**Q10d_I** -8 Don't Know -9 Refused • NA	**Q10e_I** -8 Don't Know -9 Refused • NA
e. Who usually drives you/*[FILL WITH NAME]* to school or day care?	**Q10a_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10b_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10c_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10d_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10e_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA

Q11 What is the approximate distance, one way in miles, from your house to the grocery store where you most often do your grocery shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-8 Don't know
-9 Refused

Q11a Does your household use your automobile(s) for grocery shopping?

1 Yes
2 No (SKIP TO Q12)

(IF ONLY 1 AUTOMOBILE, SKIP TO Q12. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q11b.)

Q11b Which of your automobiles is used most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q11c Which of your automobiles is used second most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used (SKIP TO Q12)
• NA

(IF NO THIRD AUTOMOBILE, SKIP TO Q12)

Q11d Which of your automobiles is used third most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used
• NA

Q12 What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-8 Don't know
-9 Refused

Q12a What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go second most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q13)
-8 Don't know
-9 Refused

Q12b What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go third most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q13)
-8 Don't know
-9 Refused
• NA

Q13 Does your household use your automobile(s) for getting to the shopping centers, malls, or stores?

1 Yes
2 No (SKIP TO Q14)

(IF ONLY 1 AUTOMOBILE, SKIP TO Q14. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q13a.)

Q13a Which of your automobiles is used most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q13b Which of your automobiles is used second most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile

4 No second car is ever used (SKIP TO Q14)
-7 Not asked
• NA

(IF NO THIRD AUTOMOBILE, SKIP TO Q14)

Q13c Which of your automobiles is used third most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used (SKIP TO Q14)
-7 Not asked
• NA

Q14 What is the approximate distance, one way in miles, from your house to the theater where your household most often watches movies?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q15)
-8 Don't know
-9 Refused

Q14a Does your household use your automobile(s) to get to the theater?

1 Yes
2 No (SKIP TO Q15)
• NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q15. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q14b.)

Q14b Which of your automobiles is used most often for going to the theater?

1	Most driven automobile	
2	Second most driven automobile	
3	Third most driven automobile	
-7	Not asked	
•	NA	

Q14c Which of your automobiles is used second most often for going to the theater?

1	Most driven automobile	
2	Second most driven automobile	
3	Third most driven automobile	
4	No second car is ever used	(SKIP TO Q15)
-7	Not asked	
•	NA	

(IF NO THIRD AUTOMOBILE, SKIP TO Q15)

Q14d Which of your automobiles is used third most often for going to the theater?

1	Most driven automobile	
2	Second most driven automobile	
3	Third most driven automobile	
4	No third car is ever used	(SKIP TO Q15)
-7	Not asked	
•	NA	

Q15 Does anyone in your household use one of your automobiles on the job for more than just commuting to and from work?

1	Yes	(IF YES, GO TO Q15_R)
2	No	(SKIP TO Q16)
•	NA	

For Q15_R to Q15_C:

0	Not mentioned
1	Mentioned
•	NA

Q15_R = Respondent uses auto on the job (Ask Q15a1 and Q15b1)
Q15_B = Person B uses auto on the job (Ask Q15a2 and Q15b2)

Q15_C = Person C uses auto on the job (Ask Q15a3 and Q15b3)

Q15a1 Which of your automobiles is used by *(Respondent)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q15b1 About how many miles did *(Respondent)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Q15a2 Which of your automobiles is used by *(Person B)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q15b2 About how many miles did *(Person B)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Q15a3 Which of your automobiles is used by *(Person C)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q15b3 About how many miles did *(Person C)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Recruit: Household Travel

Q16 Some households have certain places that they often drive to on weekends such as a lake, a park, or relative's home. In this question, I would like to learn about your household's travel as a group on weekend trips. Please think about how far it is (one way) from your home to the three <u>farthest</u> places you went on weekends over a typical year, and how many times you visited.

(NOTE: RESPONDENTS OFTEN DID NOT ANSWER THIS QUESTION IN THE ORDER INTENDED. MANY WERE LIKELY TO ANSWER IN THE ORDER OF HOW OFTEN THEY MADE THESE TRIPS.)

Q16a What is the approximate distance, one way in miles, from your house to the <u>farthest</u> place you go on weekends over a typical year?

____	miles *(NOTE: less than 1 mile = 1)*	
-7	Don't go on weekend trips	(SKIP TO Q17)
-8	Don't know	
-9	Refused	

Q16aa About how many times do you go to this place each year?

____	miles *(NOTE: less than 1 mile = 1)*
-8	Don't know
•	NA

Q16b What is the approximate distance, one way in miles, from your house to the second <u>farthest</u> place you go on weekends over a typical year?

____	miles *(NOTE: less than 1 mile = 1)*	
-7	No other place	(SKIP TO Q17)
-8	Don't know	
-9	Refused	
•	NA	

Q16bb About how many times do you go to this place each year?

____	times
-8	Don't know
•	NA

Q16c What is the approximate distance, one way in miles, from your house to the third farthest place you go on weekends over a typical year?

- ____ miles *(NOTE: less than 1 mile = 1)*
- -7 No other place (SKIP TO Q17)
- -8 Don't know
- -9 Refused
- • NA

Q16cc About how many times do you go to this place each year?

- ____ times
- -8 Don't know
- • NA

Q17 Does your household use your automobile(s) on these weekend trips?

- 1 Yes
- 2 No (SKIP TO Q18)
- • NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q18. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTO WAS RECORDED DURING DATA CLEANING INTO Q17a.)

Q17a Which of your automobiles is used or will be used most often for these weekend trips?

- 1 Most driven automobile
- 2 Second most driven automobile
- 3 Third most driven automobile
- -7 Not asked
- • NA

Q18 In a typical year, do you drive your automobile(s) on any longer vacations?

- 1 Yes
- 2 No (IF NO, SKIP TO Q19)

Q18a What is the approximate distance, one way in miles, from your house to the farthest place your household drove in a typical year on a longer vacation?

- ____ miles *(NOTE: less than 1 mile = 1)*
- -8 Don't know
- • NA

Q18aa About how many times do you drive to this place each year?

- ____ times *(.5 = every other year)*
- -8 Don't know
- • NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q19. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q18b.)

Q18b Which of your automobiles is used or will be used most often for longer vacation trips?

- 1 Most driven automobile
- 2 Second most driven automobile
- 3 Third most driven automobile
- -7 Not asked
- • NA

Recruit: Recruitment

Q19 As I mentioned earlier, Cornell University is conducting a study to learn about people's opinions on automobile safety. You have just told me about your household's use of your automobiles. The opinion questions on auto safety are best presented on paper, since we have a couple figures or graphs that we want you to actually see. I would like to send you a brief survey containing these opinion questions. Can I get your name and address so I can send you the materials?

(IF RESPONDENT IS HESITANT): You have been scientifically selected to participate in this study. By helping us out with this mail survey you will be representing the opinions of other households in the U.S. like yours that were not chosen for this study. Since we cannot afford to call every household, your responses are very important. We can't afford to pay you for your time to

complete the survey, but we will include a token of our appreciation along with the survey. Would you be willing to help us out?

1	Yes (IF YES, PLEASE SPECIFY):	name address city state zip
2	No	*(IF NO, GO TO Q20)*

Recruit: About Your Household And Your Cars

Q20 I just have a couple final questions that will help our researchers better understand automobile use by different types of households. What is your present marital status? Are you . . .? *(READ LIST)*

1	Single, never married	
2	Married	
3	Separated	
4	Divorced	
5	Widowed	
7	Other (PLEASE SPECIFY)	(SEE Q20oth BELOW)
-9	Refused	

Q20oth Other marital status (FROM Q20 ABOVE)

1	Domestic partner	
2	Engaged	
3	Living with someone	
4	Widowed and divorced	
•	NA	

Q21 Are you presently . . .? *(READ LIST)*

1	Employed full-time	
2	Employed part-time	
3	A full-time homemaker	(SKIP TO Q23)
4	Unemployed	(SKIP TO Q23)
5	Retired	(SKIP TO Q23)
6	A student	(SKIP TO Q23)
7	Other (PLEASE SPECIFY)	(SEE Q21oth below)
-9	Refused	

Q21oth Other employment (FROM Q21 ABOVE)

1 Disabled
2 Self-employed
• NA

Q22 Which <u>one</u> of the following occupational categories most closely reflects the type of work you do in your job? (If you had more than one job in 2001, we only need to know about your main job.)

1 Service worker, such as retail sales or hair stylist
2 Transportation operator, such as taxi, bus, train, or limo driver
3 Equipment operator
4 Craft worker, such as plumber or electrician
5 Traveling salesperson
6 Farm worker
7 Clerical worker
8 Laborer
9 Manager or administrator
10 Professional or technical
11 Other (PLEASE SPECIFY) (SEE Q22oth below)
-9 Refused
• NA

Q22oth Other occupations (FROM Q22 ABOVE)

1 Actor
2 Child Care
3 Communications
4 Correctional Officer
5 Custodian
7 Disabled
9 Hotel
10 Mail Carrier
11 Manufacturing
12 Meat Department
13 Parent Liaison
15 Self-employed
16 Teacher Aid
17 Truck Driver
18 U.S. Military
19 Works with Handicapped
20 YMCA
• NA

Q23 What is the highest grade or year of school that you have completed?

1 No school
2 Grade school (1-8 years)
3 Some high school (9-11 years)
4 Completed high school (12 years)
5 Some college, but no degree (13-15 years)
6 Associate degree
7 Bachelor's degree
8 Post graduate
-9 Refused

Q24 What was your approximate gross household income from all sources (before taxes and other deductions) in 2000?

1 Under $10,000
2 $10,000 to $19,999
3 $20,000 to $29,999
4 $30,000 to $39,999
5 $40,000 to $49,999
6 $50,000 to $59,999
7 $60,000 to $69,999
8 $70,000 to $79,999
9 $80,000 to $89,999
10 $90,000 to $99,999
11 $100,000 to $119,999
12 $120,000 to $139,999
13 $140,000 to $179,999
14 $180,000 to $219,999
15 $220,000 to $259,999
16 $260,000 to $300,000
17 More than $300,000
-9 Choose Not To Answer

(IF NEEDED FOR Q25 - Q27): We are studying household choices and automobile safety so it is important for us to know if there is a parent outside the household who provides financial support for one or more of the children.

Q25 Does any of your household's income come from child support?

1 Yes
2 No (SKIP TO CLOSING)
-9 Refused (SKIP TO CLOSING)

Q26 How many children receive support? ______

Q27 How regularly are the full support payments received? Would you say . . .? *(READ LIST)*

1 All of the time
2 Most of the time
3 Some of the time
4 None of the time
-9 Refused
• NA

CLOSING:

(IF RECRUITED, READ): You will be receiving your opinion survey by priority mail within the next few days. I would appreciate it if you could return it as soon as possible. It is very important that we collect the opinion data in this mail survey so we can use it to better understand usage and opinions.

I'd like to thank you for taking the time to help me and Cornell University out with this important study.

Mail Survey

Mail: What Are Your Views on Auto Safety?

Important Information Before You Start

Thank you for agreeing to complete this important survey on automobile safety. When talking with you on the telephone we asked several questions about the automobiles that your household owns or leases.

Please look over the information below and fill in anything that is incomplete as best you can. Cross out any incorrect information and write in correct information as best you can. Please continue to answer the remaining questions about the automobiles you had at the time of the phone survey, even if there have been changes since then.

Characteristics	Most Driven Automobile	2nd Most Driven Automobile	3rd Most Driven Automobile
Make or brand	**make_f1 (A)* make_c1 (A)****	**make_f2 (A) make_c2 (A)**	**make_f3 (A) make_c3 (A)**
Model	**model_f1 (A) model_c1 (A)**	**model_f2 (A) model_c2 (A)**	**model_f3 (A) model_c3 (A)**
Type of model	**type_f1 (A) type_c1 (A)**	**type_f2 (A) type_c2 (A)**	**type_f3 (A) type_c3 (A)**
Model year	**year_f1 year_c1**	**year_f2 year_c2**	**year_f3 year_c3**
Year you purchased or leased the automobile	**purch_f1 purch_c1**	**purch_f2 purch_c2**	**purch_f3 purch_c3**
Approximate purchase price or equivalent price used in calculating lease payments	**price_f1 price_c1**	**price_f2 price_c2**	**price_f3 price_c3**
Miles this automobile driven over the last 12 months. (If you've had this auto for less than 12 months, please estimate the miles it will be driven in a 12-month period.)	**miles_f1 miles_c1**	**miles_f2 miles_c2**	**miles_f3 miles_c3**

* The _f# variables contain the information provided in the recruit screener (series Q6a1 to Q6h3f) that were used to customize the mail survey. Respondents could change or update this information if necessary.

** The _c# variables contain any new data that was added by the respondent. Sometimes this included the addition of another automobile.

Mail: Automobile Safety and Your Household

M1 The purpose of this survey is to find out how important automobile safety is to you. About how often have you seen, heard, or read about automobile safety from TV, radio, newspapers, or magazines in the past 6 months? (*Please circle one number.*)

1 Never
2 A few times (1 to 4)
3 Several times (5 to 10)
4 Many times (11 to 20)
5 Very many times (More than 20)
-9 Missing

M2 Below is a list of factors that might affect your decision when purchasing or leasing an automobile for use by yourself and your household. For each factor, please indicate how important that factor would be to you when selecting an automobile for purchase or lease. Circle the number that most closely corresponds to your answer, where 1 = not at all important, and 7 = extremely important. *(Please circle one number for each factor.)*

		Not at all Important						Extremely Important	Missing
M2a	Passenger capacity	1	2	3	4	5	6	7	-9
M2b	Cargo space	1	2	3	4	5	6	7	-9
M2c	Comfort	1	2	3	4	5	6	7	-9
M2d	Fuel economy	1	2	3	4	5	6	7	-9
M2e	Four wheel drive	1	2	3	4	5	6	7	-9
M2f	Engine power	1	2	3	4	5	6	7	-9
M2g	Price	1	2	3	4	5	6	7	-9
M2h	Safety	1	2	3	4	5	6	7	-9

M3 Please tell us the approximate monthly costs for gas for each of your automobiles. *(Please fill in the dollar amounts.)*

For M3_1 to M3_3: $___
-9 Missing
• NA

MONTHLY COST	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto
Gas	**M3_1**	**M3_2**	**M3_3**

M4 Please tell us the approximate annual (yearly) insurance and maintenance and repair costs for each of your automobiles. *(Please fill in the dollar amounts.)*

For M4a_1 to M4a_3 and M4b_1 to M4b_3: $___
-9 Missing
• NA

ANNUAL COST	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto	Totals
Insurance	**M4a_1**	**M4a_2**	**M4a_3**	**M4a_t**
Maintenance and repair	**M4b_1**	**M4b_2**	**M4b_3**	**M4b_t**

M5 Please tell us if your automobiles are equipped with the following features: *(For each automobile, please circle either "Yes" or "No" for your answer for each feature.)*

For M5a_1 to M5p_3:
1 Yes
2 No
-9 Missing
• NA

DO YOU HAVE THESE FEATURES ON YOUR AUTOMOBILES?	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto
Automatic Transmission	**M5a_1**	**M5a_2**	**M5a_3**
Sun roof/Moon roof	**M5b_1**	**M5b_2**	**M5b_3**
Air Conditioning	**M5c_1**	**M5c_2**	**M5c_3**
Compact Disc Player	**M5d_1**	**M5d_2**	**M5d_3**
Driver Side Air Bag	**M5e_1**	**M5e_2**	**M5e_3**
Passenger Side Air Bag	**M5f_1**	**M5f_2**	**M5f_3**
Side Door Air Bag	**M5g_1**	**M5g_2**	**M5g_3**
Anti-Lock Brakes	**M5h_1**	**M5h_2**	**M5h_3**
Two Doors (i.e., not 4 door)	**M5i_1**	**M5i_2**	**M5i_3**
Wagon	**M5j_1**	**M5j_2**	**M5j_3**
Convertible	**M5k_1**	**M5k_2**	**M5k_3**
Anti-theft/Recovery System	**M5l_1**	**M5l_2**	**M5l_3**
Cruise Control	**M5m_1**	**M5m_2**	**M5m_3**
Alloy Wheels	**M5n_1**	**M5n_2**	**M5n_3**
Leather Seats	**M5o_1**	**M5o_2**	**M5o_3**
Special Package (Sport, Limited, GTS, etc.)	**M5p_1**	**M5p_2**	**M5p_3**

M6 Has anyone in your household bought any roadside assistance packages such as AAA, in the last five years? *(Circle the number of your answer.)*

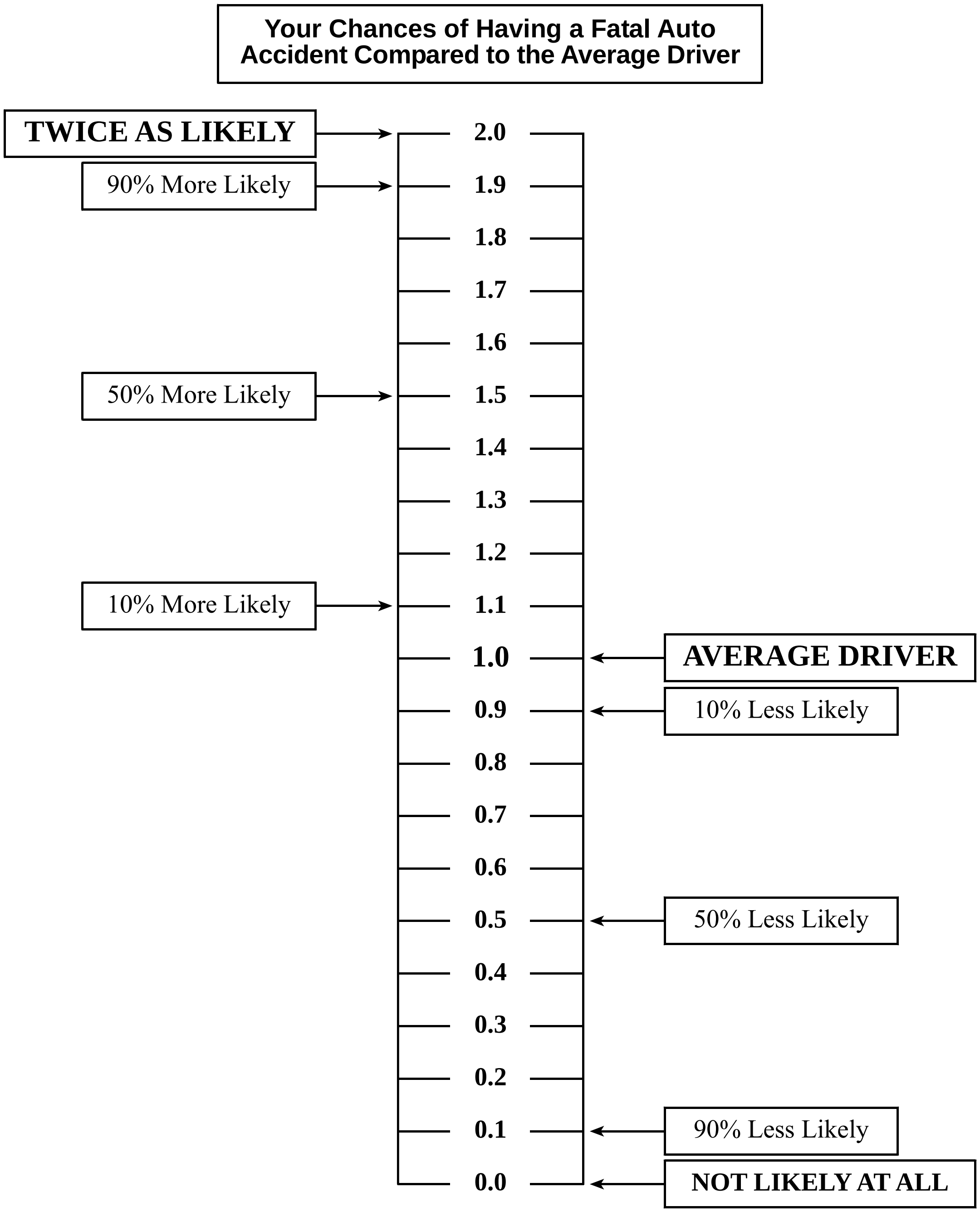
1 Yes (If Yes, ASK M6a)
2 No
-9 Missing
• NA

M6a Approximately how much did/do you pay per year?
I paid/pay $____ per year.
-8 Don't know

-9	Missing
•	NA

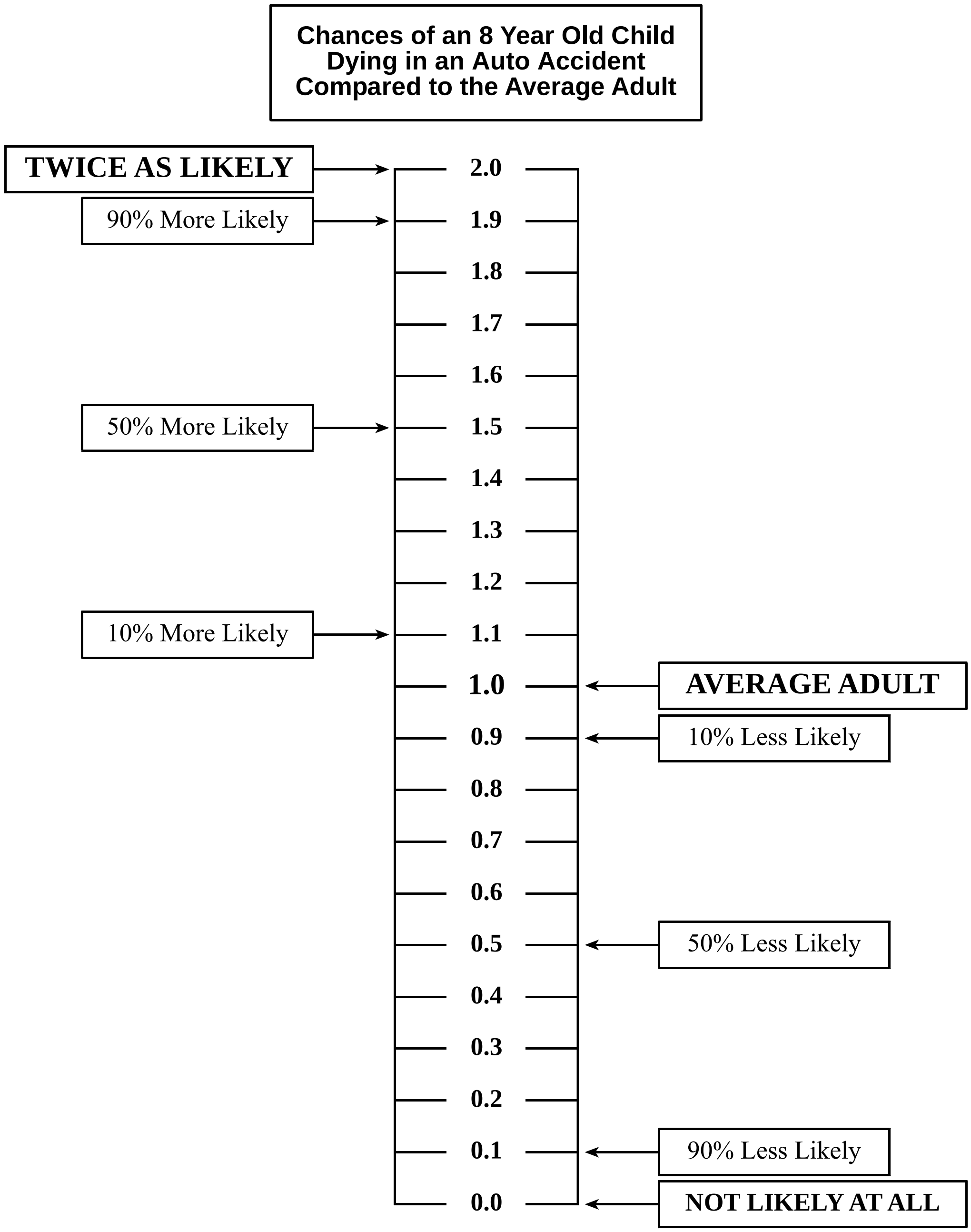
M7 We are interested in your perception of the likelihood of you having a fatal accident while driving, compared to the average driver in the same type of automobile. On the scale below, the likelihood that an average driver will have a fatal accident is equal to 1.0.

Please compare yourself with the average driver and tell us how likely you think it is that you will have a fatal accident compared to the average driver. *(Please circle the number in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*



M8 In this question, we are interested in your perception of the likelihood of an 8-year-old child dying compared to an average adult when involved in a serious automobile accident. Assume they are both riding in the back seat of the same type of automobile.

Using the scale below, where the chance that an adult will die in a serious accident is equal to 1.0, tell us how likely you think it is that an 8-year-old child would die in an equally serious automobile accident compared to an average adult. *(Please circle the <u>number</u> in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*



M9 Next, we are interested in your perception of the likelihood of a 70-year-old person dying compared to an average adult when involved in a serious accident.

Assume that they are riding as a passenger in the front seat of the same type of automobile.

Using the scale below, tell us how likely you think it is that a 70-year-old person would die in an equally serious automobile accident compared to an average adult. *(Please circle the number in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*

Mail: How Safe Is Your Automobile?

In this section, we are interested in knowing about the safety of your automobiles.

Please look at the risk ladder on the facing page.

- The ladder shows the average annual fatality risk for different types of automobiles.
- The risks vary somewhat for individual makes and models. These are averages for the automobile categories.
- The ladder assumes that each type of automobile is driven an average of 14,000 miles per year by someone of average driving ability.
- Each step of the ladder is one fatality each year for every 100,000 automobiles per occupant. Thus, a single step represents 1 fatality each year for every 100,000 automobiles with 1 occupant, 2 fatalities each year for every 100,000 automobiles with 2 occupants, and so forth.

For example, based on 1997 automobile accidents in the United States, there was an average of about 5 fatalities for every 100,000 large sport utility vehicles (SUVs) with 1 occupant, and about 10 fatalities for every 100,000 large SUVs with 2 occupants.

M10 Please indicate the step number from the risk ladder that you think is closest to describing the annual fatality risk per occupant for each of your automobiles. *(Please mark an X on the line indicating the value for your automobile listed on the left side.)*

For M10_1 to M10_3: -8 Don't know
-9 Missing
- NA

	Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M10_2	2nd Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M10_3	3rd Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Mail: Your Value for Improved Automobile Safety

M11_v1 (*Version 1):*

Several promising safety features are being developed that would improve automobile safety. Experts estimate that these features can reduce average fatality risk per occupant by 1 or 2 steps on the risk ladder on the previous page for all types of automobiles.

If safety features were added to your household's most driven automobile that reduced the risk by 1 step, what would be the new fatality risk for that automobile? Please indicate the step number that is 1 step below your answer to Q10 for your household's most driven automobile. *(Please mark an X on the line indicating the new value for your most driven automobile.*

For M11_v1: -8 Don't know
-9 Missing
• NA

Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

M11_v2 *(Version 2):*

Several promising safety features are being developed that would improve automobile safety. Experts estimate that these features can reduce average fatality risk per occupant by 1 or 2 steps on the risk ladder on the previous page for all types of automobiles.

If safety features were added to your household's most driven automobile that reduced the risk by 2 steps, what would be the new fatality risk for that automobile? Please indicate the step number that is 2 steps below your answer to Q10 for your household's most driven automobile. *(Please mark an X on the line indicating the new value for your most driven automobile.)*

For M11_v2: -8 Don't know
-9 Missing
• NA

Most Driven Auto

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

M12_v1 *(Version 1):*

How important to you would it be to have the fatality risk for your [MOST DRIVEN AUTOMOBILE] reduced by 1 step on the risk ladder? *(Circle the number of your answer.)*

Not at all Important						Extremely Important	Don't Know	Missing	NA
1	2	3	4	5	6	7	-8	-9	•

M12_v2 *(Version 2):*

How important to you would it be to have the fatality risk for your [MOST DRIVEN AUTOMOBILE] reduced by 2 steps on the risk ladder? *(Circle the number of your answer).*

Not at all Important						Extremely Important	Don't Know	Missing	NA
1	2	3	4	5	6	7	-8	-9	•

M13_v1 (*Version 1):*

Please imagine that when you purchased or leased your [MOST DRIVEN AUTOMOBILE] you could have selected an automobile with additional safety features but otherwise exactly the same. The annual fatality risk per occupant would be decreased by 1 or 2 steps on the risk ladder, depending on the safety features you selected.

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 1 step on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ _______ EXTRA FOR 1 STEP.

-8 Don't know
-9 Missing
• NA

M13a_v1 (A) Other comments on payment amount.

M13_v2 *(Version 2):*

Please imagine that when you purchased or leased your [MOST DRIVEN AUTOMOBILE] you could have selected an automobile with additional safety features but otherwise exactly the same. The annual fatality risk per occupant would be decreased by 1 or 2 steps on the risk ladder, depending on the safety features you selected.

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 2 steps on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 2 STEPS.

-8 Don't know
-9 Missing
• NA

M13a_v2 (A) Other comments on payment amount.

M14_v1 (*Version 1):*

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 2 steps on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 2 STEPS.

-8 Don't know
-9 Missing
• NA

M14a_v1 (A) Other comments on payment amount.

M14_v2 (*Version 2):*

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 1 step on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 1 STEP.

-8 Don't know
-9 Missing
• NA

M14a_v2 (A) Other comments on payment amount.

M15 Below are some reasons why people choose the amounts they do when answering Questions 13 and 14. Please read each statement and indicate whether you agree or disagree. If you agree with the statement, please then indicate how much it influenced your answer of how much you would be willing to pay. *(Circle agree or disagree for each statement, and then, if you agree, circle the number of your answer.)*

NOTE: This section was data entered as it was answered. There were many respondents who filled in a rating but who did not indicated whether they agreed or disagreed. We made no assumptions about what their answers should have been because some respondents who circled Disagree also circled a rating. Therefore, we entered only what was circled.

M15a_a I could not afford to pay more for my automobile. . . .

1 Disagree (SKIP TO M15b_a)
2 Agree
• NA

M15a_b I could not afford to pay more for my automobile . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15b_a I believe it is important to increase automobile safety. . . .

1 Disagree (SKIP TO M15c_a)
2 Agree
• NA

M15b_b I believe it is important to increase automobile safety. . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15c_a I don't believe that the safety features would actually save lives . . . .

1 Disagree (SKIP TO M15d_a)
2 Agree
• NA

M15c_b I don't believe that the safety features would actually save lives . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15d_a I don't believe it is my responsibility to pay for automobile safety improvements. . . .

1 Disagree (SKIP TO M15e_a)
2 Agree
- NA

M15d_b I don't believe it is my responsibility to pay for automobile safety improvements . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
- NA

M15e_a I was thinking more about the cost of the safety features than about the reductions in fatality risk . . . .

1 Disagree (SKIP TO M15f_a)
2 Agree
- NA

M15e_b I was thinking more about the cost of the safety features than about the reductions in fatality risk . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
- NA

M15f_a I need more information before committing any money . . . .

1 Disagree (SKIP TO M15g_a)
2 Agree
- NA

M15f_b I need more information before committing any money . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
- NA

M15g_a Automobile safety is good enough now – improvements are not necessary . . . .

1 Disagree (SKIP TO M16)
2 Agree
- NA

M15g_b Automobile safety is good enough now – improvements are not necessary . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
- NA

M16 Is there anything we have overlooked? Please use this space for additional comments you would like to make.

(Verbatim comments are located in a separate section of the User Guide.)

YOUR PARTICIPATION IS GREATLY APPRECIATED!

Please return your completed survey in the enclosed envelope or return to:
William Schulze
Cornell University
c/o PA Consulting Group
2711 Allen Boulevard, Suite 200
Middleton, WI 53562