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ABSTRACT

An analysis was made of the extent to which the safety characteristics of new vehicles affect consumer purchase decisions. Using an extensive data set that combines vehicle data collected by the Automobile Club f Southern California Target Car Program with the responses from a national household survey of new car buyers, a statistical model of vehicle type choice was estimated. The basic finding from the analysis is that individuals do express a demand for safety. Holding constant all other factors that influence a consumer's vehicle purchase decision, a safer vehicle is found to increase the probability of purchase. Among the specific findings of the anal'sis are the following: (1) an index of crashworthiness is a strong determinant of purchase decisions; (2) passive restraint systems enhance the likelihood of purchase of a given model; (3) safety-related recalls in the previous year are found to produce a positive effect on purchase behavior; (4) longer vehicles offer more crash protection to the occupants and increase the likelihood of purchase; and (5) other characteristics found to be important are purchase price and fuel costs, interior comfort and roominess, performance, and brand loyalty. (33 references.) (KC)

EXECUTIVE SUMMARY

Recent upward trends in highway fatality statistics, Federal legislation which has resulted in smaller and lighter new vehicle fleets, and rising real per capita incomes are among the factors that have contributed to increasing national concerns with vehicle safety. Although there has been considerable research on the effects of vehicle safety regulation, little research has been devoted to consumer demands for vehicle safety. The objective of this analysis is to analyse the extent to which the safety characteristics of new vehicles affect consumer purchase decisions.

Using an extensive data set which combines vehicle data collected by the Automobile Club of Southern California Target Car Program with the responses from a national household survey of new car buyers, a statistical model of vehicle type choice was estimated. The basic finding from the analysis is that individuals do express a demand for safety. Holding constant all other factors which influence a consumer's vehicle purchase decision, a safer vehicle is found to increase the probability of purchase. Among the specific findings of the analysis are the following:

1. Based upon government vehicle crash tests, an index which summarizes the crashworthiness of a vehicle is a strong determinant of purchase decisions. It is estimated that a vehicle defined by this index as "very safe" more than doubles it purchase probability. This has important policy implications which argue in favor of posting such indices on new car models.

2. Passive restraint systems enhance the likelinood of purchasing a given model. This suggests that consumers will react favorably to increased implementation of passive restraint systems. However, although encouraging from a vehicle safety standpoint, the results are tentative. Due to the paucity of data, a passive restraint system included passive seat belts and air bags. As more vehicles are produced with passive restraint systems, it will be possible to re-examine this issue as well as to analyse separately the effects of passive seat belts and air bags.

3. Safety related recalls in the previous year are found to produce a net positive effect on purchase behavior. Since safety defects identified in one year (through recalls) will be fixed in the subsequent model year, consumers perceive the "recalled" vehicle to be safer.

4. To the extent that exterior length of vehicle is related to a vehicle's front crush (distance from the radiator to firewall), longer vehicles offer more crash protection to the occupants and increases the likelihood of purchase.

5. Other characteristics which are found to be important determinants of vehicle choice include a vehicle's purchase price and fuel costs, interior comfort and roominess of the vehicle, and performance. In addition, the make of vehicle previously owned, that is, brand loyalty, plays an important role in a consumer's purchase decision.

The results of the analysis also have implications for recent developments in the vehicle safety arena. For example, more vehicles are being fitted with anti-skid braking mechanisms. Although, due to liability concerns, manufacturers are not promoting such systems as a safety feature, one would expect that, all else held constant, the presence of anti-skid brakes would increase the purchase probability of the vehicle.

Introduction

Since passage of the National Traffic and Motor Vehicle Safety Act in 1966, the federal government has been heavily involved in regulating the safety content of new vehicles. As of 1985, automobile manufacturers must meet federal standards regulating 45 separate areas related to safety, including, but not limited to, windshields, brake systems, tires, accelerator control systems, steering control, occupant restraint systems, head restraints, and fuel system integrity.[1] On balance, it has generally been argued that government automobile safety mandates have contributed to the reduction in highway fatalities. For example, in 1967 the number of passenger car occupant deaths per 100 million passenger car miles was 5.52. In 1983, the corresponding figure was 1.92. Although it is recognized that other factors, including the state of the economy, alcohol consumption, and speed limits also affect the fatality rate, recent cost-benefit analyses indicate that the benefits of safety improvement are greater than the associated costs, that is, vehicle safety regulations have yielded net benefits to society.[2]

Coincident with the federal government's involvement in vehicle safety, there have been additional regulatory policies with indirect effects on vehicle

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[1]For a discussion of the current safety regulations, see Crandall et al., Regulating the Automobile, 1986.

[2]From the results of a statistical analysis of the highway death rate from 1947 to 1981, Crandall et al. estimate that the net benefit to society of automobile safety regulation is 7.53 billion dollars. See Crandall et al., 1986, 74-79.

safety. Prominent among these has been the Energy Policy and Conservation Act. Enacted by Congress in 1975, this piece of legislation was a response to the oil price shock of the early seventies. Requiring the U.S. automobile fleet of new cars to average 18 and 27.5 miles per gallon by 1978 and 1985 respectively, this act had an immediate result on vehicle size. When the law was passed, average new vehicle weight was 4,058 pounds; by 1978 it had dropped to 3,587 and in 1981 average weight on new vehicles was 3,099 pounds. In an analysis of automobile safety, Meyer and Gomez-Ibanez (1980) conclude that automobile fleet downsizing increases the probability of serious injury in a multiple car accident. Thus, although new vehicles produced subsequent to the introduction of the CAFE (corporate average fuel economy) standards satisfied federal safety regulations, the overall reduction in vehicle weight resulted in new vehicle fleets that afforded less protection to its occupants. This may be showing up in fatality statistics. Between 1974 and 1984 vehicle fatality rates per 100 million vehicle miles and per 100,000 population exhibited an average annual decrease of 2.5% and 1.0% respectively. But the percentage change from 1983 to 1984 was a decrease of less than .5% and an <u>increase</u> of 3% respectively.[3]

The smaller and lighter fleet of vehicles along with rising real incomes (assuming that vehicle safety is a normal good) may be the genesis of increasing consumer concerns with vehicle safety.[4] A recent market research study by Ford

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[3]National Safety Council, <u>Accident Facts</u>, 1985.

[4]Between 1980 and 1985 real per capita income rose at an average annual rate of 1.73%. An additional factor may also be the Motor Carrier Deregulation Act of 1981. The Act significantly relaxed entry requirements which led to increased competition among motor carriers and reduced rates. A possible effect of the Act, then, is an increase in the number of trucks on the highway network (which reflects increased ease of entry) along with higher driving intensity (in

Motor Company found that dependability and vehicle safety were the first and second most important attributes, respectively, to automobile consumers (Automotive News, December 1, 1986). Responding to this, Ford has recently launched an advertising campaign that promotes its continuing effort to produce safer automobiles. Although Ford unsuccessfully tried this approach thirty years ago, the company believes that it is now appealing to an emerging consumer constituency concerned with vehicle safety.

On another front, Ralph Nader recently criticized the Reagan Administration for failing to advance highway safety in this country (Automotive News, December 22, 1986). The heart of Nader's complaint is his accusation that the federal government has spent a disproportionately small amount of resources on passive relative to active occupant restraint systems. To support this argument, Nader cited a recent survey by Newsweek Magazine of 15,475 new car buyers that showed eighty seven percent of those responding believed air bags should be standard equipment in all new automobiles. Interestingly, this appears to be at odds with new car purchase activities. Recent statistics released by Ford indicates that consumers are not hurrying to purchase air bags on the 1987 Tempo/Topaz models. In the first 5 months of the 1987 model year, Ford had sold only 749 air-bag equipped Tempo/Topaz models during a period in which more than 100,000 non-air-bag equipped Tempo/Topaz models were sold. Among the reasons cited is the $815 cost, potential dealer liability in servicing and replacing the unit, and the fact that the air bag option requires automatic transmission.

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order to make up for lost earnings due to lower rates). If either effect is true, it would reduce the level of safety on our nation's highways.

Ford's recent experience with air bags leads one to examine the relationship between vehicle safety and new car purchase decisions. Given the extent to which vehicle safety is currently mandated by the federal government, the lackluster sales of air bags indicates that, for many consumers, the marginal benefit of an air bag is less than its marginal cost. Alternatively, if, in a completely unregulated environment, one believes that new vehicles would have fewer safety attributes, then the value to the consumer of an air bag would be higher and lead to increased sales. The implication is that federal safety regulations, in raising the level of new car safety, decrease the value of additional safety enhancements.

This leads to the following question, which is the focus of the present study: what is the effect of vehicle safety upon new car purchase activities?

As alluded to above, there has been considerable attention in the literature devoted to the effects of vehicle safety regulation. Lave and Weber (1970), Arnould and Grabowski (1981), Graham et al. (1981) and Crandall et al. (1985) estimate benefit-cost ratios associated with alternative safety regulations. Peltzman (1975) argued that drivers exhibit compensatory behavior with the result that the beneficial effects of safety regulation are offset by greater risk taking. This has led to an on-going debate on the extent to which risk compensating behavior occurs (Robertson, 1977, 1981; Orr, 1982; McKenna, 1982; Wilde 1982, 1984; Crandall and Graham, 1984; O'Neill et al., 1984; Graham and Garber, 1984; Lund and Zador, 1983; and McCarthy, 1986).

In contrast, there has been relatively little research devoted to the demand for safety by new car buyers. Considerable strides have been made in modelling vehicle demands, as evidenced in the research of Lave and Train (1979), Manski and Sherman (1980), Hocherman et al. (1983), Winston and Mannering (1983), Mannering and Mahmassani (1985), Berkovec (1985), and Train (1986). Yet only Winston and Mannering (1983) specifically address the issue of consumer safety and new vehicle purchase behavior. Using ex-post collision rates and the probability of being involved in a severe accident (given that an injury causing accident has occurred) to reflect vehicle safety, the authors found vehicle safety to be an important attribute. Then, estimating the effect on collision costs and personal injury rates resulting from various safety regulations, the authors used the results to calculate relevant benefit-cost ratios.

Consumer Demand for New Vehicles

In economic theories of consumer behavior, individuals are generally assumed to be wealth or economic welfare maximizers. This implies that individuals will increase the extent of some action or continue to consume a commodity up to the point at which the marginal benefit of one more unit equals the marginal cost of obtaining one more unit. If the marginal benefit from consuming an additional good is greater than its marginal cost, the individual will increase his/her consumption. Similarly, we would expect to see an individual decrease his/her consumption of a good if the marginal cost of one more unit exceeded the marginal benefit.

Equalizing marginal costs and benefits typically characterizes individual consumption of a good which can be altered in small amounts. For example, suppose the price of gasoline increases, all else held constant. Since, at the new price, marginal benefit of an additional gallon is less than marginal cost (at the new higher price), the individual will decrease his/her consumption of gasoline. Commodities such as gasoline whose consumption increases or decreases with an altered economic environment are referred to as divisible commodities.

If the good in question is discrete rather than divisible, then it is not possible to increase or decrease the consumption of the good in response to a change in existing economic circumstances. Rather, the consumer will simply switch from one good to another. In the case of discrete commodities, an individual has a set of alternatives available to him/her and will select that alternative which provides the greatest level of economic welfare. Suppose, for example, that an individual is in the market for a new car and that, all else held constant (including the prices of other new vehicles) the price of a particular make/model vehicle increases 10%. Since the individual has not yet purchased a car he will not respond by consuming a little less of the vehicle. The increase in price will, however, decrease the probability that the consumer purchase this particular make/model. For discrete commodities, then, changing economic circumstances or other factors which affect the expected benefit derived from the good will alter the probability of selecting this good.

To be more explicit, assume that individual n is in the market for a new car and has J_n mutually exclusive and exhaustive make/model alternatives available. Each available make/model alternative provides the individual with some level of economic welfare, $U_{in}(x_{in},t_n)$ $i \varepsilon J_n$. Note that the benefit which individual n derives from alternative i depends upon two sets of variables, x_{in} and t_n.

x_{in} is a set of variables which characterizes vehicle i. Included in this set is not only the capital and operating cost of the vehicle but myriad other factors including acceleration, vehicle comfort, styling, transactions costs, and passenger/cargo space, which influence an individual's choice of one over another vehicle. Of especial importance to this study is a set of attributes included in x_{in} which reflect the safety features of a vehicle. All else held constant, an increase in the safety features of a given make/model would increase the level of economic welfare associated with this vehicle thereby increasing the frequency with which the vehicle is purchased. Alternatively, if a given make/model sold on the market was known to have a safety defect, this would lower the expected benefit from purchasing the vehicle and result in a reduced demand for the make/model.

The second set of variables which affects the expected benefit from consuming make/model i includes all characteristics of individual n relevant to his/her vehicle choice decision. These include such factors as household size, household income, preferences for imported versus domestic vehicles, and life cycle stage.

If make/model i provides individual n with the highest level of economic welfare, then

(1) $U_{in}(x_{in},t_n) > U_{jn}(x_{jn},t_n) \quad i,j \in J_n;\ i \neq j$

Although each individual knows with certainty which make/model maximizes his/her level of economic welfare, this is not true for the analyst. x_{in} and t_n include observable and non-observable characteristics. For example, new vehicles can be described by observable characteristics including size (length and width), color, and trunk space. Other attributes, such as styling and dependability, may be more difficult to observe (and measure). Similarly, household income, household size, and age are observable socio-economic characteristics of an individual that may influence new car purchase behavior. Individual tastes and preferences for new vehicles, on the other hand, are not observable.

Since the researcher cannot observe all of the relevant factors which characterize the available alternatives and the individual, individual n's purchase of make/model i occurs with some probability. This is seen more clearly by defining $U_{in}(x_{in},t_n)$ as

(2) $U_{in}(x_{in},t_n) = V(z_{in},s_n,\beta) + \eta_{in}$

where z_{in} is a set of observable attributes of alternative i, s_n is a set of observable socio-economic characteristics of individual n, and β is a set of parameters to be estimated. Thus, $V(z_{in},s_n,\beta)$ is that portion of individual n's utility which is observable to the analyst and is known up to a set of unknown parameters β. η_{in} is that part of individual n's utility which is unobservable to the analyst and which varies across decision makers. Thus, it is possible for two individuals to have identical values for $V(z_{in},s_n,\beta)$ yet make different make/model choices. Similarly, for a group of individuals, the presence of the unobserved term η_{in} means that the researcher would observe each alternative being selected by some proportion of the group.

If a researcher observed a sample of individuals all of whom faced identical choice sets and all of whom had identical values for $V(z_{in},s_n,\beta)$, then the probability of individual n choosing alternative i would converge, as the sample size became very large, to the proportion of individuals observed to select alternative i.

From the researcher's perspective, the probability that individual n will select alternative i equals the probability that individual's n's utility from alternative i will exceed the utility from alternative j (j≠i) (since not all the components of x_{in} and t_n are observable). That is, P_{in} is

$$P_{in} = Pr(U_{in}(x_{in},t_n) > U_{jn}(x_{jn},t_n))$$

$$\Rightarrow \quad P_{in} = Pr(V(z_{in},s_n,\beta) + \eta_{in} > V(z_{jn},s_n,\beta) + \eta_{jn}) \quad i,j \in J_n;\ i \neq j$$

$$(3) \quad \Rightarrow \quad P_{in} = Pr(\eta_{jn} - \eta_{in} < V(z_{in},s_n,\beta) - V(z_{jn},s_n,\beta)) \quad i,j \in J_n;\ i \neq j$$

If, for all $i \in J_n$, η_{in} is assumed to be distributed Weibull, then the probability that individual n selects alternative i can be expressed as

$$(4) \qquad P_{in} = \frac{e^{V_{in}}}{\sum_{j \in J_n} e^{V_{jn}}} \qquad i \in J_n;\ i \neq j$$

where $V_{in} = V(z_{in}, s_n, \beta)$. Known as the multinomial logit (MNL) model,[5] equation (4) represents consumer demand for new vehicles.

Note that the model of vehicle demand developed above is a compensatory model. That is, individuals will trade-off one characteristic for another. As an example, consider head restraints which can either be integral or adjustable. A recent federal study estimates that integral and adjustable head restraints reduce neck injuries by 17% and 10% respectively.[6] The fact that adjustable head restraints are not kept in an extended position accounts for the discrepancy. Suppose that, all else held constant, vehicles with an integral restraint cost a consumer $100 more than those with adjustable restraints. By buying a vehicle with an adjustable restraint, a consumer is revealing that the $100 saved by buying the lower price vehicle is compensating him/her for the higher level of risk incurred (reflected in the increased probability of a neck injury).

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[5]There are several excellent references for the multinomial logit model in particular and, more generally, qualitative choice models. A seminal paper in this literature is McFadden (1974). A survey of qualitative response models is found in Amemiya (1981). Various topics concerned with the analysis and application of discrete data models are given in Manski and McFadden (1981) and Maddala (1983). Hensher and Johnson (1981), Ben-Akiva and Lerman (1985), and Train (1986) focus upon the multinomial logit model and extensions.

[6]Department of Transportation, NHTSA, An Evaluation of Head Restraints: Federal Motor Vehicle Standard 202, DOT HS-806-108 (DOT, 1982), p. 10.

Vehicle Safety and New Vehicle Demands

As developed above, the safety attributes of a vehicle constitute a subset of variables in x_{in} which determines (along with t_n) the level of economic welfare associated with alternative i. Several points can be made with regard to the safety attributes offered on new vehicles. First, many vehicle safety attributes are explicitly safety related. All of the federal motor vehicle safety standards for automobiles fall into this category. Each standard was mandated with the explicit intent of improving accident avoidance and/or crash protection and survivability characteristics of new vehicles. Since all new cars sold in this country must meet these standards, many of these safety attributes will not be relevant to one's choice of vehicle. Returning to the previous example, the presence of head restraints has enhanced occupant protection by reducing the number and extent of neck injuries. But since all new vehicles must have these, the presence of a head restraint in any particular vehicle will in general have no effect on the probability of choosing that vehicle.

There are two qualifications to the above conclusion. Suppose the number of neck injuries sustained in a particular make/model was disproportionately high and found to be the result of a defect in the headrest. Relative to all other new vehicles, this make/model has become less safe and, all else held constant, we would expect to see a decrease in the demand for this make/model of vehicle.[7] A

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[7] In fact, the recent experience of Audi illustrates this. An analysis of vehicle accidents indicated that the Audi 5000 experienced a "sudden acceleration" problem which, according to the Center for Auto Safety, has been responsible for 750 accidents in which 250 people were injured and 6 killed. Since there is a federal mandate covering accelerator control systems, the accelerator control system on the Audi 5000 would not be expected to have an

second qualification is that some safety features may affect the probability of choice due to non-safety characteristics. Two models of cars, for example, with equally effective head restraints may be identical except for the style of restraint. At the margin, the style of restraint may affect the probability of choosing one over another vehicle.

In addition to characteristics that are explicitly tied to a vehicle's safety are those that have indirect implications for crash avoidance and/or occupant protection. Rather than a primary consideration, in this case safety effects may be a secondary factor. For example, many consumers purchase option packages which improve the overall handling of a vehicle. Although the primary consideration is to have a car that is "fun to drive", the superior handling capabilities of the vehicle also enhances crash avoidance capabilities.

A final point to note in this discussion is that a given safety feature may not have the same effect on vehicle choice behavior for two individuals. Assume, as is generally done, that the demand for safety increases with the level of income. Then one would expect that, all else held constant, higher income individuals will attach a higher value to a marginal unit of safety than an individual whose income was less.

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effect on the probability of buying the vehicle. After the acceleration problem was announced, Audi's accelerator control system would be expected to alter the probability of buying the vehicle, all else held constant. This in fact occurred. After the announcement, there was a significant drop in sales.

In sum, vehicle safety has various effects on new car purchase behavior. For many attributes, particularly those regulated by the federal government, the attribute will not affect choice behavior unless a safety related defect is identified. Second, some safety attributes have non-safety considerations which, at the margin, will influence choice of vehicle. Third, there are some vehicle characteristics that are not explicitly related to safety but do have secondary implications for accident avoidance and occupant protection. Moreover, the extent to which safety concerns affect an individual's choice will depend upon various socio-economic characteristics of the individual.

Data

Data for this analysis came from two primary sources. In July 1985, J.D. Powers and Associates conducted a nationwide survey of new 1985 vehicle buyers who had taken delivery in February/March 1985. A total of 68,825 surveys were mailed and 30,306 returned yielding a 45% overall response rate.[8] For each of 143 1985 vehicle models, a stratified random sample was used in order to obtain approximately 200 usable observations per model. The survey obtained information on multiple facets of new vehicle purchase decisions, including a description of the new vehicle purchased, purchasing and financing arrangements, source of sales by make and market segment of vehicle, owner loyalty, and socio-economic characteristics of the principal purchaser and household.

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[8]The population for the sample was new private use sales vehicle registration records compiled by R.L. Polk and Company (for all included states except New York) and Advanced Information Marketing (for the state of New York).

A second source of information was the Automobile Club of Southern California. Since 1984, the Automobile Club has a Target Car program in which it evaluates currently manufactured four passenger vehicles on 11 design characteristics, including (but not exclusive to) crashworthiness potential, handling, fuel economy, luggage capacity, and size.[9] Cost information for each vehicle was also collected.

Since it is not possible to evaluate every new vehicle each year, the Automobile Club selects a subset of new vehicles. The basic criteria for including a vehicle in a given year's testing program are: four passenger vehicle; significant new design; vehicle not tested in the previous year; enclosed cargo/luggage area; and similar vehicles not tested. Specifically excluded from the testing programs were sports cars (e.g. Porsche) and "sporty" cars (e.g. Ford Mustang, Chrysler Laser). In 1984, 1985, and 1986 the Automobile Club evaluated 57, 71, and 59 automobiles, respectively. Ideally, only vehicles evaluated in 1985 should be included in the analysis. However, if this is done, numerous makes and models would be excluded from the analysis. If a vehicle was evaluated in both 1985 and 1986, the 1985 information was used since it can be reasonably assumed that a significant design change occurred in 1986. However, if a vehicle was <u>not</u> evaluated in 1985 but was evaluated in 1986, then the 1986 specifications were assigned to the 1985 make/model.[10] In effect, it was assumed

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[9] The other design characteristics are ride quality, entry and exit, acceleration, interior noise, interior size, and turning circle.

[10] Also, Ford, Chrysler, and General Motors have "sister" cars, that is, automobiles that are structurally similar. For example, Tempo and Topaz for Ford, Reliant and Aries for Chrysler, and Toronado, Riviera, and Eldorado for General Motors are, respectively, in the same family line. In the event that a given make/model was not tested by the Automobile Club but a "sister" car was

that a vehicle was tested in 1986 because it was not included in the 1985 evaluation or a similar model was not tested. The gain in the number of make/models included in the analysis was believed to offset any potential misspecification .f the vehicle was included because of a new design or enclosed cargo/luggage area. In addition, for this analysis, those makes and models evaluated in 1984 but not in 1985 were excluded because some measurement criteria were changed. For example, in 1984 one measure of acceleration was the number of seconds to increase speed from 0 to 50 miles per hour whereas in 1985 and 1986 it was measured from 0 to 60. Through this procedure, 68 out of a possible 143 makes and models were included in the analysis.

In order to develop a usable data set, it was necessary to relate the specific make/model information collected from the Automobile Club to the data collected by J.D. Powers and Associates. For the set of 68 makes and models evaluated by the Automobile Club, an eight digit id number was defined to reflect make/model, body style, engine type (gasoline, turbo gas, diesel, and turbo diesel), number of cylinders, and transmission type (automatic, 4 speed, and 5 speed). The objective of such specificity was to identify as closely as possible the relevant attributes of each vehicle purchased. Similarly, for each household in the J.D. Powers data set, a comparable eight digit id number was assigned to the newly acquired vehicle. Any household which did not have a vehicle id number that was found on the Automobile Club set was eliminated. The original data set was reduced by 30% due to missing values on a number of impor-

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evaluated, the specifications for the sister car were used.

tant variables (e.g. household income and household size). Subsequently, by eliminating those observations who purchased vehicles not evaluated by the AAA Target Program, the usable data set was further reduced to 4,902 observations.

Recall that stratified random sampling was conducted in the original survey to insure a sufficient number of responses for each make and model. In order to have a sample of observations representative of the new car population, observations in the usable data set of 4,902 observations needed to be appropriately weighted. Taking the 68 makes and models in the usable data set as the base population, observations in this data set were weighted so that each of the 68 models were represented in the data set in the same proportion as reflected by annual registration figures. For this data set, Table 1 profiles new car purchase decisions.

There are several interesting observations which can be made from Table 1. First, with the exception of households with 4 or more vehicles, a similar proportion of households with 1, 2, or 3 vehicles purchase domestic, European, and Japanese cars. With respect to households with 4 or more vehicles, a slightly larger proportion of households purchase non-American vehicles. The origin of new vehicle purchased does vary, however, by age. In particular, young car buyers purchase relatively more Japanese cars than do buyers who are twenty-five and older. Similarly, individuals over the age of forty-five buy relatively less Japanese cars than their younger counterparts. Complementing this result, observe that households with less than $20,000 buy relatively more Japanese cars (10.54%) while those who earn between $40,000 and $60,000 purchase relatively more American cars (37.83%) and people earning more than $60,000 favor European

Table 1

New Car Purchase Profile of Usable Data Set

	Domestic	European	Japanese
Number of Vehicles			
1	24.41	22.03	27.90
2	52.35	51.17	45.05
3	16.30	16.28	18.01
4	6.94	10.53	9.04
Age of Owner			
Under 24	6.95	5.55	1[illegible].86
25-44	52.29	63.74	62.14
Over 45	34.73	30.72	23.0[illegible]
Household Income			
Under $20,000	7.82	5.83	10.54
$20,000-$39,999	39.29	24.42	41.70
$40,000-$60,000	37.83	31.86	26.30
Over $60,000	15.05	37.90	21.86

Owner Education			
Did Not Graduate High School	6.73	1.54	1.70
Graduated High School	23.65	15.69	13.69
Attended College	62.97	79.53	80.85
Trade/Technical School	6.65	3.24	3.75
Household Size			
1	8.47	16.55	14.67
2	33.23	41.35	31.89
3	22.34	16.50	24.43
$\geq$ 4	35.96	25.61	29.02
Brand Loyalty			
New Make	72.82	82.34	83.05
Same make as Previous Car	27.18	17.66	16.95

cars (37.90%). Given that the median 1985 purchase price of American, European, and Japanese vehicles was $11,161, $17,000, and $10,755 respectively, it is likely that these findings reflect an income effect. Education offers perhaps the most striking deliniation between those who buy American cars and those who buy foreign manufactured automobiles. A larger percentage of American car buyers did not attend college than did foreign car buyers by a much greater difference than exists in any other category. This is consistent with a hypothesis by Lave and Bradley (1980) that more educated individuals tend to be pro-environmentalist and anti-establishment, both of which imply, all else held constant, an increase in the probability of purchasing an imported vehicle. With respect to family size, it is noted in Table 1 that a larger percentage of American cars are bought by larger families relative to Japanese or European cars. This reflects the fact that U.S. manufactured vehicles, on average, are larger which better accomodates the needs of larger households. This is not true, however, for two member households where there is a demonstrated preference for European vehicles. Last, with respect to brand loyalty, consumers exhibit much stronger ties to U.S. manufactured vehicles than do buyers of non-U.S. manufactured automobiles.

Estimation Data Set

Although the weighted data set developed in the previous section and summarized in Tables 1 contained all of the relevant so 'economic and vehicle data, it was not possible to use the entire data set t estimate the model.[11] Therefore, a sample was drawn from the 4,902 usable data set. Moreover, the sample was drawn under the constraint that the sample proportion of each of the 68 make/models represented in the usable data set equalled the proportion in which each of these are represented in the population, a procedure which guarantees that the estimated parameters of the model will be consistent.[12] This sampling strategy resulted in a random sample of 726 observations. Comparing the mean values on a large number of vehicle and socio-economic characteristics revealed that the randomly drawn sample was representative of the larger set of observations.

Before estimating the model, it was necessary to define alternative choice sets for each individual in the sample. Since, as developed in the previous section, both the Automobile Club data and the J.D. Powers data contained 68 new car make/models, 14 randomly selected vehicles were drawn from the Automobile Club data set and assigned to each of the 726 observations in the estimation sample. These 14 assigned alternatives combined with an individual's chosen alternative gives each observation a choice set of 15 make/models.[13]

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[11] Given the number of explanatory variables and the number of alternatives in the model, there was a binding capacity constraint on Purdue's IBM 3083 computer.

[12] Since the original sample was stratified on the make/model of vehicle, the sample was a choice based sample. In general, estimating the parameters of a choice based sample using exogenous sample maximum likelihood will yield inconsistent estimates. However, in the special case where the sampling fraction is chosen to equal the population shares, exogenous sample maximum likelihood is appropriate. See Ben-Akiva and Lerman, Discrete Choice Analysis, p. 237.

[13] McFadden (1978) has shown that this sampling of alternatives technique satisfies an uniform conditioning property which ensures that the coefficient estimates will be efficient.

Estimation Results

An individual's new car purchase decision reflects the underlying attributes of the vehicle as well as the purchaser's socio-economic characteristics. In general, a vehicle can be summarized according to its cost, performance, comfort, safety, cargo carrying, and all other characteristics. Although most individuals may acknowledge these characteristics as relevant to one's decision making process, there is less agreement on the specific definition of each. For example, acceleration from a standstill, acceleration during passing actions, and a vehicle's maneuverability are three measures of a vehicle's performance. For each characteristic, Table 2 identifies the variable(s) which defines each characteristics and Table 3 presents the mean value and standard error for each of the variables in the estimating equation.

It is expected that both PRCSH and FLCOST will carry negative signs reflecting the fact that an increase in the cost of purchasing/operating a vehicle, all else held constant, will decrease the purchase probability of the vehicle.

In general, increasing vehicle performance is expected to increase the probability of purchasing a vehicle, although the effect of these attributes may vary by an individual's age. Three age categories are defined: young, if a respondent's age is less than 25 years; medium age, if a respondent's age is between 25 and 44 years of age; and old, if a respondent's age is greater than or equal to 45 years of age. Since ACC4060 and SLALOM are measured in seconds, each of the acceleration variables, YNG4060, MED4060, and OLD4060, and each of

Table 2

Cost Related Attributes

PRCSH	Purchase price of vehicle divided by annual household income[1]
FLCOST	Per mile fuel cost, defined as the average gasoline price in respondent's home state divided by the EPA's fuel economy for city driving

Performance Related Attributes

ACC4060	Number of seconds required to increase a vehicle's speed from 40 MPH to 60 MPH[2]
SLALOM	Number of seconds required to complete a slalom test course[3]

Comfort Related Attributes

FRLR	The sum of front and rear leg room.[4]
FRSR	The sum of front and rear shoulder room.[5]
N30	Interior noise level (in decibels) at a speed of 30 MPH.
EE	Ease with which individuals can enter and exit the vehicle. EE takes on a value from 1 to 10 where 10 is the best.[6]
DSLHT	Door sill height, in inches.

Safety Related Attributes

HDSTR	Head stroke, which is a measure of crashworthiness potential. It equals the horizontal distance from the windshield to the seat back measured 25 inches vertically from the front lower seat cushion.
PASBELT	Dummy variable which equals 1 if vehicle has either an airbag or a passive seat belt, 0 otherwise

SAFEST	Dummy variable which equals 1 if vehicle is identified as one of the most crashworthy vehicles in the 1985 model year, 0 otherwise.[7]
RECL	Dummy variable which equals 1 if vehicle make/model experienced a safety related recall in the previous year, 0 otherwise
MRECL	The number of manufacturer safety related recalls divided by the number of vehicle make and models produced by the firm.
EXLNG	Exterior length of vehicle, in inches.

Cargo Carrying Attributes

TRNK	Number of cubic feet of cargo volume specified in the EPA Fuel Economy guide.

Other Attributes

LYLMK	Dummy variable which equals 1 if new vehicle purchased is of the same make as the respondent's previous vehicle, 0 otherwise
AMC	Dummy variable which equals 1 if vehicle is manufactured by American Motors Corporation, 0 otherwise
CHRY	Dummy variable which equals 1 if vehicle is manufactured by Chrysler Corporation, 0 otherwise
FORD	Dummy variable which equals 1 if vehicle is manufactured by Ford Motor Company, 0 otherwise
FRGN	Dummy variable which equals 1 if vehicle is manufactured in a foreign country, 0 otherwise

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[1]The purchase price is defined as the manufacturer's base vehicle price, adjusted for engine option, transmission option, freight, and California emission system.

[2]For each vehicle evaluated, there were four separate speed tests. For this analysis, ACC4060 is a simple average of the four tests.

[3]Based upon a test developed by Motor Trend Magazine, the test course is 800 feet long and 100 feet wide. Each vehicle is tested three times on the course. SLALOM is an average of the three test scores.

(cont'd)

[4]Front leg room is measured from the accelerator pedal heel point up over the lower seat cushion to the seat back. Rear leg room is measured from the rear of the front seat back, horizontally to rear seat lower cushion, down the lower cushion to the intersection of the rear seat back and rear lower cushion.

[5]Front (rear) shoulder room is measured laterally across the width of the vehicle at a height of 18 inches vertical from the intersection of the front (rear) seat back with the lower seat cushion.

[6]The procedure was developed by the Automotive Engineering Department of AAA with the assistance of Man Factors, Inc., a human engineering research company. The primary concern of the procedure is with entry/exit into the rear seat area.

[7]See The Car Book by Jack Gillis, 1985 Edition. For each size class of vehicle, a crash test index is calculated that is based upon occupant protection, windshield retention, and fuel leakage when a vehicle is involved in a frontal crash at 35 MPH.

Table 3

Descriptive Statistics for Explanatory Variables

Variable	Mean	Standard Error
PRCSH	.3092	.0078
FLCOST	4.982	.0397
ACC4060	7.053	.0375
SLALOM	9.373	.0176
FRLR	71.040	.0974
FRSR	109.513	.2245
N30	63.811	.1317
EE	7.275	.0282
DSLHT	12.676	.0638
HDSTR	36.942	.1115
PASBELT	.0207	.0053
SAFEST	.2493	.0161
RECL	.4545	.0185
MRECL	.4855	.0128
EXLNG	184.958	.7087
TRNK	21.220	.4367
LYLMK	.2190	.0154
AMC	.0110	.0039
CHRY	.1088	.0116
FORD	.1419	.0130
FRGN	.4325	.0184

the slalom variables, YNGSL, MEDSL, and OLDSL, used in the estimating equation is expected to carry a negative sign.

Vehicles that are more comfortable are expected to increase the likelihood, all else held constant, of purchasing a vehicle. With respect to interior roominess, this will be related to the number of members in the family. For example, a vehicle with roomy front seat areas but cramped back seat space may be a deterrent to a large family but irrelevant to a one or two member family. Front/rear leg and shoulder room is defined according to family size. SFRLR and SFRSR equals FRLR and FRSR, respectively, for households with 1 or 2 members. And LFRLR and LFRSR equals FRLR and FRSR, respectively, for households with three or more members. It is expected that each of these variables will carry a positive sign. Increasing noise levels in a vehicle's interior, all else held constant, is expected to reduce a vehicle's attraction. N30, therefore, is expected to carry a negative sign. Finally, EE is expected to carry a positive sign since the ease of entry/exit raises the benefits, ceteris paribus, associated with the vehicle.

All else held constant, an individual will prefer a safer to a less safe vehicle. To the extent that consumers perceive vehicles with passive restraints to be more safe, to that extent one would expect PASBELT to have a positive sign. In addition, one would expect that HDSTR would carry a negative sign. The further one is from the windshield the less likely will there be a serious head injury in the event of a frontal crash. With respect to recalls, the effects are ambiguous. On the one hand, a vehicle with a safety recall in the previous year leads one to suspect safety related problems in the current model year inducing one to look to other models. Alternatively, a safety related defect identified in the previous year would be fixed making the particular vehicle more safe in the current year. This would increase the likelihood of purchasing the vehicle. If RECL has a positive sign, this indicates that the latter effect outweighs the former effect whereas a negative sign implies the opposite. If, however, relative to the number of makes produced, a manufacturer has a disproportionate number of safety related recalls, a consumer may lose confidence in the ability of the manufacturer to produce "safer" vehicles. It is expected, then, that MRECL will carry a negative sign. Finally, SAFEST is expected to carry a positive sign. And to test the hypothesis that a safe vehicle is more important to older than younger consumers, this variable is defined as YNGSAF and OLDSAF, respectively, if the respondent is less than 44 and greater than or equal to 45 years of age.

EXLNG is a size variable which is also related to a vehicle's safety. Part of the information on crashworthiness potential measured by AAA was front crush, which equals the distance from the firewall to the front of the radiator (or front of the air conditioner condenser if equipped). But this measure is positively correlated to a vehicle's length. Assuming that, all else held constant, individuals prefer larger to smaller vehicles, this effect is reinforced by the increased safety afforded the user.[14] EXLNG, then, is expected to have a positive sign.

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[14] Preliminary estimation runs confirm this. Front crush was significant in runs without EXLNG but, overall, produced poorer fitting models than those with EXLNG.

In general, an increase in cargo carrying capacity is expected to be a desireable attribute, the importance of which varies by household size. However, since various size measures of vehicle, as reflected in exterior length and interior leg room, are included, the effect of TRNK is ambiguous. Holding length of car and interior roominess constant, for example, an increase in trunk space may come at the cost of decreasing engine size or a change in styling (e.g. convertible instead of a sedan). Notwithstanding the ambiguous sign, however, it is expected that a smaller family will place less weight on trunk size than a larger family. For this analysis, STRNK is equal to TRNK for households with 3 or fewer members and LTRNK is equal to TRNK for households with 4 or more members.

With regard to other attributes, LYLMK is included to test the hypothesis of brand loyalty. Consumers are expected to exhibit brand loyalty which implies a positive coefficient on the variable. Finally, AMC, CHRY, FORD, and FRGN are included to represent other factors that are relevant to consumers but not explicitly included in the model. Note that, by not being included, General Motors is the normalizing manufacturer.

Table 4 summarizes the estimation results from the new vehicle purchase model. With some exceptions, the results presented in Table 4 are consistent with expectations.

Capital and operating costs of new vehicles are significant deterrents of consumption activities. An increase in the purchase price of a new vehicle or in its fuel consumption costs reduces the likelihood that an individual will purchase the vehicle.

Table 4

Estimation Results - Model of New Vehicle Purchases

Independent Variable	Coefficient Estimate	Asymptotic t-statistic
PRCSH	- 4.424	- 8.22
FLCOST	- .322	- 3.26
YNG4060	.330	2.15
MED4060	.172	2.55
OLD4060	- .0497	- .58
YNGSL	- 2.252	- 4.00
MEDSL	- .721	3.37
OLDSL	.987	4.57
SFRLR	.0429	1.61
LFRLR	.0561	2.12
SFRSR	.0519	2.94
LFRSR	.0594	3.35
N30	- .129	- 5.60
EE	.203	3.04
DSLHT	.101	3.50
HDSTR	- .0576	- 3.06
PASBELT	.643	1.87
YNGSAF	.659	4.96
OLDSAF	1.030	4.26
RECL	.235	1.64
MRECL	- .121	- .53
EXLNG	.0129	2.30
STRNK	- .0305	- 5.31
LTRNK	.0049	.72
LYLMK	2.012	16.36
AMC	.138	.31
CHRY	.301	1.62
FORD	- .022	- .11
FRGN	.057	.36

Number of households: 726
Number of observations: 10,890

Log-likelihood at 0: 1966.0
Log-likelihood at convergence: 1547.9

$\chi^2 = 836.26$
$\chi^2_{.05(29)} = 17.70$

Performance, however, exhibits some perverse effects. Higher acceleration performance times are expected to lower the probability of purchase yet we find the opposite results. For both young and middle age consumers, an increase in the number of seconds to accelerate from 40 MPH to 60 MPH increases the likelihood of purchasing the vehicle.[15] It is negative for individuals 45 or older but not significant at the .05 level. In their analysis of vehicle type choice behavior, Manski and Sherman (1980) identified a similar result. Note, however, that this result is reversed for the slalom variables. In this case, lower slalom times increases the probability of purchasing a vehicle for young and middle age individuals whereas lower times are a deterrent to purchase for older individuals. Looking at the coefficient values for the acceleration and slalom time variables, it is seen that lower acceleration times become increasingly important whereas lower slalom times become increasingly unimportant as one ages. Although this doesn't explain the perverse signs, it is consistent with younger individuals wanting a vehicle that is "fun to drive" (i.e. handles well) and older individuals desiring larger, more powerful, and more comfortable (which comes at the cost of handling capabilities) vehicles. And, to emphasize a point made by Manski and Sherman, the perverse signs might indicate that, all else considered, acceleration *per se* is overrated by the automobile manufacturers.

All of the comfort variables are consistent with the stated hypotheses. Leg and shoulder room, entry/exit into the vehicle, and door sill height have

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[15] The model was also estimated using 0-60 MPH acceleration times. Similar results to those obtained in Table 4 were found.

positive signs and are significantly different from 0. In addition, interior space is more important to larger than smaller families. Lastly, increased levels of interior noise reduces the probability of purchasing a given vehicle, all else held constant.

The effect of safety upon new car purchase behavior was mixed. First, to the extent that the exterior length of the car is correlated with front crush, drivers of longer cars will, in general, have more frontal crush protection. The positive sign on EXLNG, then, is consistent with the hypothesis that, all else held constant, individuals prefer safer to less safe vehicles.[16] Second, HDSTR carries a perverse sign. Increasing the distance from the windshield to the seat back provides front seat occupants with improved protection and, all else constant, is expected to increase the probability of purchase. A further distance from the windshield, however, also decreases accessibility to the various controls on the dashboard which in turn may have an indirect effect on overall safety of the trip. If this is indeed the case, then the negative sign on HDSTR indicates that the positive effects of increasing HDSTR on passenger safety are more than offset by its negative effects on dashboard control accessibility with its concomitant implications for safe driving conditions. Fourth, as discussed above, effect of a safety related recall on purchase behavior was ambiguous

[16]The effect of EXLNG on vehicle is similar to the relationship which is oftentimes identified between vehicle weight and safety. It is generally argued that the heavier the vehicle the safer are its occupants. In earlier runs of the model, vehicle weight was included as an explanatory variable but was consistently insignificant. Given the correlation between weight and a number of the variables in Table 4, the insignificance of vehicle weight was not surprising.

whereas the proportion of manufacturer recalls were expected to decrease purchase behavior. The positive sign on RECL indicates that the quality improvement of the vehicle as a result of the recall more than offsets the direct deterrent effect of the recall. Although not significant at a .05 level, the negative sign on MRECL suggests that consumers may discriminate between manufacturers on their ability to produce safe cars. Fifth, identifying a vehicle make/model as one of the most crashworthy was strongly significant and carried its hypothesized sign. Moreover, as seen in Table 4, the importance of this attribute differs by age classification. The importance of this attribute to older buyers is 56% higher relative to the younger consumers. Last, the estimation results indicate that passive restraints are not a deterrent but rather increase the probability of vehicle purchase.

For large families, cargo capacity carries a positive sign but is not significant at a .05 level of significance. Trunk size is important, however, to small families such that larger carrying space, all else held constant, decreases the probability of purchase. As discussed above, since interior size and exterior length are also included in the estimating equation, increased trunk size may be costly in terms of styling, engine size, or some other attribute not explicitly incorporated in the analysis. The results suggest, then, that for small families the loss of other attributes more than offsets the benefits of increasing carrying capacity.[17]

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[17] These results are consistent with recent analyses of Hocherman et al. (1983) and Train (1986). In the former analysis, the explanatory variables included a "size of vehicle" variable and luggage space. In this case, luggage space decreased the probability of purchase when the car was not used for work. In the latter case, when a vehicle size variable was not included as an explanatory variable, luggage space increased the probability of owning a particular

Consistent with other analyses, brand loyalty is found to be a highly significant determinant of purchase behavior. Also, with the exception of Chrysler vehicles, the results did not exhibit a differential preference for AMC, Ford, and foreign made vehicles to those manufactured by General Motors. There does exist, however, a preference for Chrysler vehicles, all else held constant, to GM cars.

In sum, having controlled for other factors which influence an individual's purchase decision, the results indicate that vehicle safety is important to consumers in their new car purchase decisions. All else held constant, the presence of passive occupant restraints and the crashworthiness of a vehicle are relevant considerations to a consumer's choice. In addition, as reflected by its negative coefficient, the results suggest that the direct effect on safety of head stroke may more than offset an indirect effect on dashboard accessibility. And a make's recall record in the previous year increases the likelihood that the vehicle will be purchased in the present year.

Vehicle Safety and Purchase Behavior

From the estimation results reported in Table 4, it is possible to obtain additional insights into the relationship between vehicle safety and new car purchase decisions. Table 5 reports the amount an individual would be willing to pay, in terms of vehicle purchase price, for a change in HDSTR and EXLNG

(cont'd)

type of vehicle.

Table 5

Change in Capital Cost to Compensate
for Unit Change in Attribute

HDSTR	- $603
EXLNG	$135

respectively [18]

Since an increase in HDSTR decreased the probability of purchase, the figure in Table 5 indicates hat an individual would pay up to $603 for a one inch [illegible] ase in the head stroke. As mentioned above, this does not state that an individual is willing to pay up to $603 for less safety, since a lower head stroke also means enhanced accessibility to dashboard controls. To the extent that such proximity has implications for a safer trip, the individual is exhibiting a net demand for safety.

In like manner, an individual reveals a willingness to pay up to $135 for a one inch increase in exterior length. Given that there is a positive correlation between exterior length and front crush, this reflects a willingness to pay for a safer vehicle, although from the data it is not known how much of the increase is specifically related to safety and how much to size (independent of safety) considerations.

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[18] To exemplify the metho. of calculating the figures in Table 5, let the expected benefit V of purchasing a vehicle be a linear function of the price share (P/I) and H, i.e.

$$V = \alpha(P/I) + \beta(H)$$

where P is purchase price, I is annual household income, H is head stroke, and α and β are estimated parameters from Table 4. Holding V constant, the trade-off between P and HDSTR can be expressed as:

$$\frac{\Delta P}{\Delta H} = - \frac{\beta I}{\alpha}$$

A requirement for this calculation is that neither variable be a dummy variable.

It is also possible to investigate the sensitivity of purchase decisions to changes in HDSTR and EXLNG. Table 6 identifies representative vehicles in different market segments and presents the "choice elasticity of demand" with respect to HDSTR and EXLNG, where the elasticity measure gives the percentage change in the probability of purchase resulting from a 1% change in HDSTR and EXLNG respectively.

The results in Table 6 indicate that an individual's purchase behavior is "elastic" with respect to HDSTR and EXLNG, that is, a 1% change in the attribute leads to a greater than 1% change in the probability of choice. For example, a 1% increase in exterior length increases the probability of purchasing a Ford Escort by 2.027% and an Oldsmobile Delta 88 by 2.563%. By examining the table, a general pattern for head stroke is that the more luxurious cars are more elastic. With respect to exterior length, the larger and more luxurious cars tend to have larger elasticities.

Since the other safety variables enter the estimating equation in dummy form, it is not possible to calculate either the amount an individual is willing to pay for a change in the attribute or the relevant elasticity measure. However, it is possible to examine the sensitivity of vehicle choice probabilities to alternative states of nature. Using the same representative vehicles as in Table 6, the choice probability was calculated under the following assumptions:

1. passive occupant restraint is or is not present;
2. according to crashworthiness indices, the vehicle is or is not identified as one of the safest.

Table 6

Elasticity of Choice Probability with

Respect to HDSTR and EXLNG

Market Segment	$E_{Pr,HDSTR}$	$E_{Pr,EXLNG}$
Basic Small		
Ford Escort	-1.793	2.027
Nissan Sentra	-1.779	1.912
Lower Middle		
Chevrolet Cavalier	-1.983	2.021
Honda Accord	-1.618	1.747
Upper Middle		
Chevrolet Celebrity	-1.528	1.992
Nissan Maxima	-2.123	2.253
Middle Specialty		
Buick Regal	-1.784	1.962
Ford Thunderbird	-1.778	2.000
Basic Large		
Chevrolet Caprice	-1.505	2.260
Oldsmobile Delta 88	-1.668	2.563
Luxury		
Oldsmobile 98	-1.719	2.151
Mercedes 300	-2.128	2.518
Audi 5000	-2.215	2.227

The figures in Table 7 indicate that the presence of a passive restraint increases the probability of purchasing a vehicle by 85% to 90%. For example, if the probability of purchasing a given vehicle is 5% without passive restraints, the results in Table 7 suggests that the probability would increase to 9¼%-9½%. Similarly, a vehicle which is perceived to be one of the safest, in terms of its crashworthiness, more than doubles its purchase probability.

Other Results

Table 8 provides some insight into the sensitivity of purchase decisions to proportional changes in vehicle capital and fuel costs. These results are also presented for the representative vehicles identified in Table 6.

The measures in Table 8 indicate that new car purchase decisions are moderately sensitive to purchase price and fuel cost. As one would expect, it is seen in the table that the larger and more luxurious vehicles exhibit greater capital and fuel cost sensitivity than their smaller and less luxurious counterparts.

Summary and Conclusion

Increases in real per capita income, the deregulation of the motor carrier industry, and a recent upward trend in the number of fatalities per capita have fueled a renewed interest in vehicle safety. Although part of the focus continues to center upon the reactive effect of consumers to vehicle safety

Table 7

Sensitivity of Choice Probability to

Occupant Restraint and Crashworthiness Indices*

Market Segment	(PB - PNB) / PNB	(PSAF - PUSAF) / PUSAF
Basic Small		
Ford Escort	90.2	109.2
Nissan Sentra	89.5	101.8
Lower Middle		
Chevrolet Cavalier	90.1	104.8
Honda Accord	85.3	100.5
Upper Middle		
Chevrolet Celebrity	86.4	105.0
Nissan Maxima	90.2	105.8
Middle Specialty		
Buick Regal	85.3	123.6
Ford Thunderbird	85.8	114.4
Basic Large		
Chevrolet Caprice	84.0	104.3
Oldsmobile Delta 88	89.4	114.2
Luxury		
Oldsmobile 98	87.1	111.7
Mercedes 300	90.2	115.5
Audi 5000	90.2	103.8

* PB (PNB) is the choice probability when passive restraint is present (absent) and PSAF (PUSAF) is the choice probability when vehicle is identified (not identified) as one of the most crashworthy.

** Each of the ratios in the table is multiplied by 100 to convert the number to a percent.

Table 8

Elasticity of Choice Probability with

Respect to Purchase Price and Fuel Costs

Market Segment	$E_{Pr,PRICE}$	$E_{Pr,FLCOST}$
Basic Small		
Ford Escort	- .971	-1.176
Nissan Sentra	-1.002	- .964
Lower Middle		
Chevrolet Cavalier	- .974	-1.317
Honda Accord	- .900	-1.092
Upper Middle		
Chevrolet Celebrity	-1.018	-1.455
Nissan Maxima	-1.498	-1.706
Middle Specialty		
Buick Regal	- .995	-1.418
Ford Thunderbird	-1.043	-1.391
Basic Large		
Chevrolet Caprice	-1.073	-1.828
Oldsmobile Delta 88	-1.244	-1.898
Luxury		
Oldsmobile 98	-1.478	-1.507
Mercedes 300	-2.778	-1.544
Audi 5000	-1.649	-1.375

regulation, there is additional interest in assessing consumers' direct demand for safety. That is, do the new car purchase activities of consumers exhibit a demand for safety after controlling for all other factors relevant to the decision? Surprisingly, there has been little research in this area. As cited in the introduction, one of the few studies that addressed this issue was Winston and Mannering (1983). Their results were consistent with the hypothesis that, all else held constant, the probability of purchasing a given vehicle increases the safer the vehicle. Among the implications of this analysis, it was estimated that Ford buyers with 0% and 20% lap belt use have net benefits of $258.97 and $270.88 (in 1980 dollars) respectively from air bags. Yet, since March 1986, only 2% of the 189,000 models sold were equipped with air bags, resulting in a recent price reduction to $215.

A possible explanation for the discrepancy between the estimated net benefits and observed behavior is that Winston and Mannering included very few variables to control for the multitude of attributes that influence purchase decisions. In addition to two safety related variables, the only non-price attributes in the model were vehicle weight, vehicle horsepower, and manufacturer dummy variables. The effect of omitting relevant variables will generally lead to biased estimates of the included variables and could well explain the optimistic cost-benefit measures for air-bags.

Using data collected in a nationwide household survey and supplemented by Automobile Club of Southern California Target Car Program, a more inclusive model of new car purchase decisions was specified in the present analysis that controlled for performance, comfort, size, and vehicle cost. <u>The primary conclu-</u>

sion of the analysis is that individuals do exhibit a demand for safety. A vehicle which is rated highly on governmental crash test programs is more likely to be purchased than one which is not so rated. From a policy standpoint, this provides an argument for mandating that new car dealers post crash test indices as they are required to post mileage information. The results of this analysis indicates that such a policy would increase the number of safer vehicles sold in a given year. Moreover, the increased sales would provide a signal to motor vehicle companies to devote more resources to the production of safer cars.

In addition, head stroke and a safety related recall in the previous year are significant determinants of choice behavior. In each of these instances, the attribute captures both positive and negative safety implications which reflects the multifaceted nature of vehicle safety. In the case of head stroke, it was found that an increase in head stroke decreases the likelihood of purchase. This was thought to reflect the indirect effect that head stroke has upon accessibility to dashboard controls. On the other hand, a safety related recall increases the probability of purchase which reflects the net positive effect that a prior recall has upon the current safety provided by a vehicle.

Finally, it was found that the presence of a passive restraint increased the probability of purchase. This latter result must be tentative, however, in that only a few models offered passive restraints. In this analysis, passive restraints included vehicles with passive seats belts or air bags. Given Ford's recent air bag experience, one must wonder whether the presence of a passive seat belt will have a stronger (positive) effect on vehicle choice than the presence of an air bag.

An interesting extension of the present analysis would consider the current model year in which a larger number of vehicles are offering air bags. In addition, various models have non-skid brake systems as options. Will these increase the probability of purchase or will the additional cost be higher than its expected benefit?

A final issue which may influence individual vehicle choices and the amount of vehicle safety demanded is recent statewide legislation raising the speed limit to 65 miles per hour. If this is expected to decrease the overall safety of one's driving environment, then a possible reaction to this would be to decrease the amount of risk taking. And one way to do this is to purchase a vehicle that offers more occupant protection and/or accident avoidance capabilities.

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