Psychological and Socioeconomic Correlates of Automobile Size

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Since Americans use 25 percent of all energy consumed in the United States for automotive travel, a primary place to conserve energy appears to be through increased fuel efficiency of the automobile fleet. Achievement of national energy conservation goals through this approach depends on both advances in fuel economy technology and changes in consumer purchase patterns. Knowledge of which psychological and socioeconomic variables correlate with the purchase of fuel-efficient vehicles will make it possible to market vehicles that have optimal attribute mixes to the groups that will be most receptive to promotions for fuel-efficient vehicles. Information on psychological and socioeconomic correlates of automobile buying patterns can also be used to generate and assess forecasts of sales in response to motor vehicle options. This paper focuses on a select set of psychological and socioeconomic correlates of automobile size. Several interesting correlates of automobile size were found. Analysis of the relationship between consumer awareness of fuel-efficiency ratings and size of vehicle purchased reveals that buyers of small automobiles acquainted themselves with the fuel-efficiency ratings, but no evidence suggested that awareness of the ratings caused consumers to purchase fuel-efficient vehicles. Multivehicle households have a smaller average automobile size than single-vehicle households. If this relationship continues and the number of multiautomobile households increases, sales of small-sized automobiles can be expected to increase. Other size correlates were found with respect to consumer evaluation of the relative importance of vehicle attributes, household income, and region of the country.

Americans use 25 percent of all energy consumed in the United States for automotive travel; therefore, a primary place to conserve energy appears to be through increasing the fuel efficiency of the U.S. automobile fleet (1). In accordance with these considerations, the Energy Policy and Conservation Act of 1975 has designated mandatory fuel economy standards for motor vehicles sold within the United States (Public Law 91-163). Manufacturer achievement of the corporate average fuel economy standards depends both on advances in fuel economy technology and on consumer purchase patterns. Ensuring that motor vehicle sales patterns are compatible with national energy conservation goals requires more extensive and better-organized information on consumer attitudes and behavior toward fuel-efficient vehicles.

An understanding of consumer motor vehicle ownership correlates is potentially very useful to the achievement of energy conservation goals. Knowledge of which psychological and socioeconomic variables correlate with the purchase of fuel-efficient vehicles will make it possible to market vehicles with optimal attribute mixes to the target groups that are most likely to be receptive. Information on psychological and socioeconomic correlates of automobile buying patterns is also useful in generating and assessing forecasts of sales in response to motor vehicle options offered to consumers. Since correlations do not necessarily imply causal relationships, it is important to identify causal patterns when appropriate data are available. When such data are not available, caveats should be included in the interpretation of automobile size correlates.

This paper focuses on a selected set of psychological and socioeconomic correlates of automobile size. Three data sets are examined to both confirm findings across data sets and to extend the range of relationships that could be examined. Both correlational and causal analysis methods are used to identify quantitative relationships that characterize consumer motor vehicle buying patterns.

STUDY DESIGN

Data Sets

Each of the three data sets, although initially compiled to address somewhat different issues concerning automobile purchase, use, and ownership, contains information on automobile size. Depending on data availability, various correlational and causal relationships between automobile size and psychological and socioeconomic factors are tested.

The Abt data set was gathered by Abt Associates (2). The data were initially collected to assess the impact of the Federal Energy Administration (FEA) - U.S. Environmental Protection Agency (EPA) fuel economy information program on new automobile purchases. This program was developed to provide information for the consumer on motor vehicle fuel economy in the form of both fuel efficiency labels affixed to the windows of new automobiles and light trucks and the publication of an annual fuel-economy guide for new automobile buyers.

A telephone survey was conducted among a national sample of new (1976) automobile buyers. The sample was obtained from the registration lists of R. L. Polk and Company and was stratified by automobile size. A total of 796 interviews was completed and the following information obtained:

1. Make and model of new 1976 vehicle purchased,
2. Make and model of vehicle replaced,
3. Make and model of other vehicles considered during the purchase period,
4. Reasons for purchasing the particular vehicle,
5. Fuel economy of new vehicle,
6. Importance of various vehicle attributes,
7. Vehicle usage patterns,
8. Gasoline-buying habits,
9. Awareness of and attitudes toward the gasoline-economy label,
10. Awareness of and attitudes toward the 1976 fuel-economy guide for new automobile buyers, and
11. Demographics, including age, education, income, and household size.

The Peskin data set was developed as a part of a study, sponsored by the Federal Highway Administration (FHWA) to assess the impact of the 1974 gasoline shortage on urban travel behavior (3). A small-scale home interview survey was conducted among households in the northern suburbs of Chicago. Households that had a high level of automobile ownership were chosen because it was assumed that such a sample would be affected most by gasoline price increases and decreased availability. A total of 425 households on 24 blocks was contacted. The response rate was 27 percent; interviews were completed with 159 households. The interview questionnaire was designed to collect

information on travel behavior during the energy crisis, at the time of the interview (1975), and in the future. Respondents were asked to anticipate their responses to price and availability scenarios. Demographic data, including number of automobiles, their make and model, age and sex of household members, dwelling-unit type, and household income, were also obtained. As would be expected among a sample of households that have a high level of automobile ownership, the mean household income was also high ($22 500). Every household sampled owned at least one automobile, and 72 percent owned two or more.

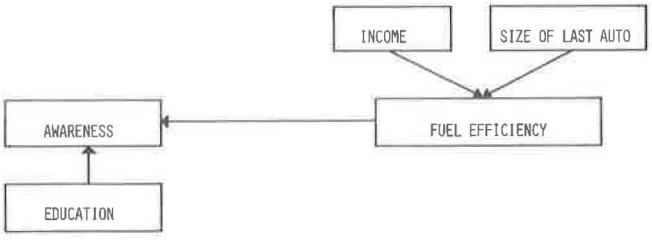
The third data set, ICPSR, was obtained from the Interuniversity Consortium for Political and Social Research. It contains data from a series of studies sponsored by FEA to examine consumers' attitudes, knowledge, and behavior regarding energy conservation (4). Data were gathered through telephone surveys of a national sample of the United States population 18 years of age and older. Information was collected from independent samples (waves) of respondents every two weeks beginning in July 1974. A total of 23 426 households was interviewed in 42 waves; each wave stressed a somewhat different issue (e.g., attitudes regarding the seriousness of the energy shortage, its probable causes, and duration). This data set also contained socioeconomic variables, such as education, income, number of automobiles per household, type of dwelling unit,and region of country, that could be correlated with an automobile size or average household automobile size.

Each of the above data sets is subject to limitations based on the initial issue being addressed. The data were insufficient in most cases to test more sophisticated causal automobile-size models; however, several salient correlates of automobile size were identified.

Analysis Methods

A variety of analytical procedures are available to the researcher for the quantitative assessment of correlational or causal relationships. Two-stage least squares is particularly useful in the development of causal models of behavior. Two-stage least squares enables the researcher to estimate systems of simultaneous equations where the same variable may be dependent in one equation and independent in another. This methodology may be used to test interdependence between variables (for example, consumer attitudes and behavior). Estimation is dependent on the presence of exogenous variables (i.e., those completely determined outside of the system under consideration) in the equations. Socioeconomic data are often a useful source of exogenous variables. The technique first involves estimation of the endogenous (interdependent) variables in terms of the predetermined or exogenous variables. Then the original endogenous variables are replaced by the estimated endogenous variables and ordinary least squares is applied. This methodology is particularly useful when experimenting with causal models of behavior (5, 6).

Figure 1. Flowgraph of interrelationship between awareness of fuel economy and size of vehicle purchased.



RESULTS

Psychological Correlates

It has been hypothesized that expanding consumer awareness of fuel-efficiency ratings can increase the purchases of smaller vehicles. A prior evaluation of the FEA-EPA fuel-economy information program found that higher awareness levels of fuel-efficiency labels and guides were positively correlated with greater fuel-conserving behavior (i.e., the purchase of smaller vehicles) (2). This result was interpreted as supporting the hypothesis. Subsequently, the relationships between consumer awareness of fuel economy and automobile size were reanalyzed by using two-stage least squares to test for the mutual dependence of awareness and size of vehicle purchased, as well as for different exogenous variable inputs. Figure 1 shows all links between variables that are significant at the 0.05 level. Note that the link from awareness to size of vehicle purchased was not determined to be statistically significant as originally hypothesized. Application of the two-stage least-squares causal model identifies the direction of the link between size and awareness. This analysis found that size was a significant explanatory variable in determining level of awareness; in other words, owners of smaller, more fuel-efficient vehicles tend to be more aware of the fuel-efficiency label and guide.

The Abt data set also contained information on consumers' beliefs about the importance of various vehicle attributes in the decision to purchase a new automobile or light truck. The attributes were factor-analyzed, and the following clusters were identified:

Factor 1—Roomy interior, good warranty, superior safety features, reliable dealer, high resale value, and good service network;
Factor 2—High styling, fast acceleration, high performance;
Factor 3—Small exterior, good fuel economy, low price, had not bought this model before; and
Factor 4—Reliable model and manufacturer, ease of handling, good dependability.

The factors may be labeled value and service (factor 1), sportiness and performance (factor 2), economy and size (factor 3), and mechanical attributes (factor 4).

These factors were then used as discriminating variables to distinguish between automobile-size groups and to highlight differences in characteristics of the groups. All four factors were entered into the discriminant analysis. Two discriminant dimensions were statistically significant. The standardized coefficients of the first discriminant function indicated that factor 3 plays a predominant role in distinguishing between automobile-size groups. The second discriminant function identified factor 2 as a salient variable in differentiating between size groups.

The centroids or points about which the size groups tend to cluster are plotted in Figure 2. Dimension I may be interpreted as an economy consideration, and dimension II is essentially a sportiness consideration. Since the standardized coefficients of both factor 3 and factor 2 are negative, the more negative the centroid, the greater the importance of the factor to that size group. Thus, subcompact owners value economy more than do owners of the other size groups. Dimension II

proved to be significant in differentiating owners of light trucks from the remainder of the sample. Purchasers of light trucks do not value sportiness and are only moderately concerned about economy. They are, however, more concerned about economy than are owners of standard or luxury automobiles. Figure 2 is particularly useful for making comparisons between groups.

Socioeconomic Correlates

It may also be hypothesized that certain socioeconomic variables influence automobile-size ownership and purchases. In Figure 1, for example, the link between income and automobile size is shown to be statistically significant. The sign of the estimated coefficient of income implies that people who have high incomes tend to buy larger automobiles. The coefficient for the size of the automobile replaced was also significant at the 0.05 level in determining the size of the new automobile purchased. Based on the sign of the coefficient, the implication is that the larger the size of the automobile being replaced, the larger the new vehicle will be. Consumers tend to replace automobiles with comparably sized vehicles.

Analysis of the Peskin data set uncovered some interesting socioeconomic correlates of automobile size. A cross-classification table of size and number of automobiles in households was formed by using an average automobile-size index (7). The automobile-size variable was recoded so that, as size increased, the value of the variable also went up. The following five size categories were used:

1 = U.S. subcompact, foreign subcompact, and sports automobile;
2 = U.S. compact and foreign compact automobile;
3 = intermediate automobile;
4 = luxury and full-size automobile; and
9 = other (i.e., light trucks and vans).

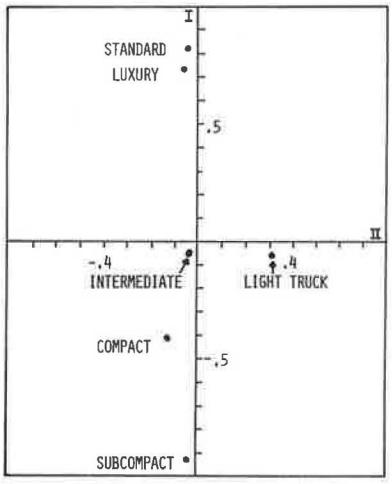


Figure 2. Plot of centroids of size groups in reduced space from discriminant analysis.

The average automobile-size index was then computed as the sum of the size variables divided by the number of automobiles for each household. A value greater than 4 for the average automobile-size index would imply that at least one of the household vehicles is a light truck. The index was divided into four categories: low (values 1-1.5 inclusive), medium (greater than 1.5 to 3), high (greater than 3 to 4) and other (greater than 4). This index was necessary so that each household would fall into only one cell of the classification table (i.e., two-automobile households would not be counted twice).

The cross-tabulation is given in Table 1. The chi-square value is significant at the 0.05 level, which implies that a systematic relationship exists between number of automobiles and average automobile size. More than 50 percent of the households surveyed were two-automobile families. The figures reveal that one-automobile households usually own a large automobile, and, in general, as the number of automobiles increases, the average automobile-size index tends to decline. For example, the cross-tabulation reveals that, for households that have a high automobile-size index, the row percentages decrease as the number of automobiles increases. Conversely, for households that have a medium automobile-size index, the row percentages increase as number of automobiles increases.

The ICPSR data set analysis also supported a correlation between average household automobile size and number of automobiles. A series of regressions were conducted by using average automobile size as the dependent variable and various combinations of independent variables. The value of an F-statistic indicated whether the regression formulation was significantly different from zero at the 0.05 level. If the F-test showed statistical significance, t-tests were used to assess the significance of individual coefficients. Several formulations were examined but the following one resulted in all coefficients being statistically significant and having signs that were readily interpretable:

$$\text{Average automobile size} = f(\text{education, region of interview, number of automobiles}) \quad (1)$$

where $R^2 = 0.075$ and $F = 2.945$ (10, 360 degrees of freedom).

It is particularly important to note the sign of the estimated coefficients. Both education and number of automobiles were found to be inversely related to average automobile size, which implies that, as the number of automobiles increases, average automobile

Table 1. Cross-tabulation of number of automobiles by automobile-size index.

Number of Automobiles	Automobile-Size Index: Low		Medium		High		Other		Row Count	Percent
	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
One	1	2.3	11	25.0	32	72.7	0	0	44	27.8
Two	5	5.7	40	45.5	42	47.7	1	1.1	88	55.7
Three +	0	0	12	46.2	7	26.9	7	26.9	26	16.5
Total	6	3.8	63	39.9	81	51.3	8	5.1	158	100.0

Notes: Raw chi-squared = 42.084 26 with six degrees of freedom.
Cramer's V = 0.364 94.
Contingency coefficient = 0.458 62.

size decreases. Similarly, as education increases, average automobile size decreases. The coefficients of the dummy variables used to code possible responses to region are not to be directly interpreted. Since they were significant at the 0.05 level, an association between average automobile size and region of the country is confirmed.

To further clarify the implication of the regression findings, three cross-tabulations of automobile size with number of automobiles, education, and region were calculated. The distribution of automobile sizes by number of automobiles in household is given in the table below.

Number of Automobiles	Subcompact or Compact Automobile (%)	Other-Sized Automobile (%)
One-automobile households	24	76
Two-automobile households	30	70
Three-automobile households	32	68

Note that, as the number of automobiles owned by a household increases, the percentage of subcompacts and compacts also increases. The percentage of larger sizes displays a concomitant decrease. The table below gives the distribution of automobile size by education of the respondent.

Education	Subcompact or Compact Automobile (%)	Other-Sized Automobile (%)
8th grade or less	19	81
Some high school	24	76
High school graduate	27	73
Some college or college graduate	34	66

A greater proportion of the more-educated respondents owned subcompacts or compacts than did the less-educated individuals. The results of segmentation by region of the country are illustrated in the table below.

Region	Subcompact or Compact Automobile (%)	Other-Sized Automobile (%)
New England	45	55
Middle Atlantic	30	70
East North Central	30	70
West North Central	32	68
South Atlantic	23	77
East South Central	24	76
West South Central	23	77
Mountain states	18	82
Pacific states	32	68

The highest percentage of subcompact and compact automobiles was found in New England, and the lowest percentage was found in the Mountain states. The southern regions also had lower percentages of small automobiles than did other areas of the country.

SUMMARY AND CONCLUSIONS

This study presents a preliminary examination of the psychological and socioeconomic correlates of vehicle size. Consumer awareness of fuel-economy ratings was found to be positively correlated with vehicle size, but this does not imply that increased awareness will necessarily lead to the purchase of smaller automobiles. A causal model of behavior found that awareness level was a function of size of automobile purchased and not vice versa.

Consumers tend to group certain vehicle attributes together. These were identified as value and service, sportiness and performance, economy and size, and mechanical attributes. Economy-size considerations were determined to be the most significant in differentiating between vehicle size classes. The importance placed on sportiness and performance distinguished owners of light trucks as a distinct group from buyers of passenger automobiles.

Income and size of the automobile being replaced are correlated with the size of new automobile purchased. Higher-income households tend to purchase larger vehicles and consumers generally replace automobiles with comparably sized vehicles. Average automobile size and number of automobiles are inversely related (i.e., as the number of automobiles per household increases, the average automobile size declines). Average automobile size is also correlated with education and region of the country. In general, as education increases, average automobile size decreases. Average automobile size differs between regions of the country.

These results have a number of underlying policy implications for both automobile manufacturers and the government. For example, the original evaluation of the FEA-EPA fuel-economy information program concluded on the basis of a correlation between fuel-economy awareness and the purchase of smaller, more fuel-efficient vehicles that increasing the level of awareness of both the fuel-economy label and the fuel-efficiency guide would lead to the purchase of more fuel-efficient vehicles. Our reanalysis of the data set clarifies the relation between awareness of fuel economy and vehicle-size purchase decisions, and it shows the prior conclusions to be erroneous. Awareness was shown to be a function of size, but size was not a function of awareness. This is not to imply that awareness does not have a role in a decision to purchase an automobile or light truck. Research has indicated that there is a general lack of credibility surrounding the EPA fuel-efficiency figures (8). Consumers either do not understand or do not believe the ratings. Influencing the purchase of fuel-efficient vehicles through consumer awareness will require an improved validity for the government fuel-efficiency ratings and heightened promotional efforts that stress the consumer benefits of fuel-efficient vehicles.

Economy considerations were indeed found to be important among buyers of small automobiles. As the size of the new vehicle purchased increased, the importance of economy declined. By using discriminant analysis, buyers of light trucks may be differentiated on the basis of their attitudes toward the importance of sportiness and performance. This cluster of attributes is, on the average, much less important to purchasers of light trucks than it is to owners of passenger vehicles. A better understanding of consumer willingness to trade off attributes relating to fuel efficiency, performance, size, and costs is essential in order to promote and design fuel-efficient vehicles that will satisfy the consumer.

A negative correlation was identified between average automobile size and the number of automobiles. There is a tendency for multiple-vehicle households to have a smaller average automobile size. If the trend toward multiple-automobile households continues,

this would imply a general decline in average vehicle size per household. The fuel-conservation implications of such trends cannot be determined until automobile usage patterns of multiautomobile households are more fully examined. The relationship between household size and vehicle size should also be explored.

More extensive data sources are required in order to develop a more complete understanding of consumer attitudes and behavior toward small automobiles. Data limitations forced us to use correlational methods, with one exception. The interrelationship between consumer attitudes and behavior should be studied more fully through the use of causal models (5, 6). This would necessitate the collection of new data sets that can more properly reflect consumer socioeconomic and attitudinal effects on automobile and light truck purchases.

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**R. Dobson was with Charles River Associates when this research was performed.*

Rationale for an Alternative Mathematical Approach to Movement as Complex Human Behavior

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This paper contains arguments and data analysis for a new mathematical approach for the study of human behavior such as intraurban travel. Current disaggregate models are criticized because of their unrealistic axioms about (a) the simplicity of behavior incorporated in the concept of the dependent variable, a trip; (b) the constancy, ad hoc differentiation, or random variability of choice sets between persons; and (c) the complexity and uniformity of decision strategies and rules about how utilities for options are formed and manipulated. Arguments are advanced for more realistic approaches to movement; for inductive data analysis to specify new descriptive choice models, based on different assumptions; and hence for a consistent underlying microeconomic theory that is based on more realistic axioms for the ultimate derivation of improved analytic models of travel. The paper contains exploratory small-sample analysis to demonstrate that, by reconceiving movement as complex, hypotheses can be formulated that fit standard kinds of travel data as well as current models that have different, less realistic assumptions. Movement is thought of as (a) a sequence of events differentiated by time and space coordinates, (b) choice sets that individuals and groups find systematically limited and variant because of the spatial properties of cities, and (c) decision strategies that are simpler and more variant than currently believed because of the differences in choice sets. This paves the way for the further development of the alternative approach proposed for the study of movement as complex human behavior.

Recent well-known criticisms of disaggregate utility-theory-based models of movement come from diverse sources (1-4). The realism of a number of different assumptions has been questioned. Specifically, it has been asserted that models of spatial and other travel choices:

1. Do not provide a realistic description of the group movements that they attempt to predict, since they ignore decisions about the sequence of a household member's activities during a given decision period (5-9);
2. Assume that limited sets of the socioeconomic characteristics of individuals and characteristics of given options (such as the travel time differences to