COMPARISON OF EFFECTIVENESS OF VARIOUS MEASURES OF SOCIOECONOMIC STATUS IN MODELS OF TRANSPORTATION BEHAVIOR

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Socioeconomic status is often theorized to be associated with variables measuring transportation behavior, and, income is the most frequently used measure of socioeconomic status in most transportation studies. However, sociologists have long hypothesized that other measures of socioeconomic status, e.g., education or occupation, are more appropriate describers of individuals or households in certain situations. The purpose of this paper is to decide on empirical grounds whether income is more appropriate than some of the other indicators of socioeconomic status in transportation modeling contexts. Data were from a stratified probability sample of 223 households in the Santa Monica-west Los Angeles, California, area. Income of the household, education of the respondent, and occupations of the household head and the respondent were the indicators of socioeconomic status. Classes of variables measuring transportation behavior (dependent variables) were trip frequencies and indicators of modal selection. Dependent variables were used in models that included the indicators of socioeconomic status as independent variables and in simple two-variable relationships involving these indicators. Regression analysis, correlation analysis, logit analysis, and simple tests of the significance of differences in means showed that at least one of the other indicators was more strongly associated with the dependent variables in almost all cases.

•THE major purpose of this paper is to compare the strengths of the relationships between several measures of socioeconomic status and variables measuring transportation behavior. In particular, the relationships involving income, a variable often included in transportation models, will be compared to those involving other measures of socioeconomic status, e.g., education and occupation. Such comparisons will indicate whether these other measures should be included in future transportation studies in place of, or in addition to, the income variable.

MODELS OF TRANSPORTATION BEHAVIOR

Models of individual (or household) travel behavior include, as the dependent variable, a measure of transportation behavior such as frequency of travel or choice of mode. In addition, the independent variables can be divided into the following classes (not all classes are necessarily present in a given model): (a) variables that describe the available transportation systems, (b) variables that describe the individuals (or households), and (c) variables that are the results of interactions among variables in the first two classes. Travel time is an example of variables in the first class, age is an example from the second, and attitudes toward modes are examples of variables from the third.

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The variables in the second class, which includes measures of socioeconomic status, play a role somewhat different from that of the other variables. Whereas variables in the other classes often have a definite behavioral interpretation, (e.g., such variables might represent the decision process involved in the choice of modes), the variables in the second class have no such interpretation. Consequently, when large samples are available, such variables are sometimes used to stratify the sample into homogeneous groups before the models are calibrated. This strategy is used in place of calibrating a single unstratified model that contains the variables in the second class as additional linear terms. That is, the strategy of stratification is based on the assumption that the behavioral determinants of travel are somewhat different for various strata. Stopher and Lavender (13) have found that stratification did, indeed, offer a closer fitting model in the case of modal-choice models. However, whether stratification is used or not, a variable in the second class must be rather strongly associated with the dependent variable if it is to be a useful addition to the model in question.

PREVIOUS USE OF SOCIOECONOMIC STATUS

A review of the literature indicates that income has been the measure of socioeconomic status most often used in transportation studies (8, 9, 10, 11, 12, 13, 15). In a few cases, education has been used in addition to income (4, 7).

The income variable is often included under strictly economic assumptions. For example, Lave (8) included income in his model of mode choice under the assumption that, as income increases, a person's value of time also increases. A second example is the use of income in models of household trip generation (10, 15). In these studies, the variable is an indicator of the household resources available for travel.

However, sociologists have long recognized that there are other status indicators on which people in society, or a subset thereof, differ. Among these are education, occupation, prestige, and interpersonal interactions (3, 5). Often these alternative measures are used in empirical sociological applications under the assumption that the noneconomic indicators are more appropriate than income for describing individuals or families. Relying on similar sociological arguments, Aldana et al. (1) chose an occupational indicator rather than income as their measure of socioeconomic status. They asserted that socioeconomic status in a sociological, rather than strictly economical, sense was the more appropriate describer of households with respect to travel demand.

Rather than relying on a priori theoretical arguments, one may select the indicators of socioeconomic status that are most strongly associated with the dependent variable in question. The empirical section of this paper is concerned with this method of selection; that is, the same data base will be used to test relationships between the alternative measures of socioeconomic status and measures of transportation behavior.

RESEARCH DESIGN

The data necessary to test the relationships between socioeconomic status and transportation behavior were gathered in November and December 1973 as part of a larger study on transportation attitudes and behavior (14). A stratified probability sample of 223 households in the Santa Monica-west Los Angeles, California, area was selected. One member from each household was interviewed. The size of the sample was based on the fact that, on any variable in a study using a random sample of this size, the probability of the mean response being within 6.5 percent of the true mean for the entire population is 95 percent.

There are four possible measures of socioeconomic status available from the questionnaire used. Household income was measured on a seven-point scale. The highest grade level completed by the respondent was recorded as the education variable, and both the occupation of the household head and the respondent's occupation (if different) were recorded. These were measured on a seven-point occupational scale developed by Hollingshead (2). The precise categories used for each variable are given in Table 1.

The variables measuring transportation behavior (dependent variables) can be divided into two classes: (a) those measuring monthly frequencies of travel (trip generation) and (b) those indicating modal selection for particular trips. The variables in the first class are stratified by the purposes of shopping, visiting, and entertainment-recreation. In addition, frequencies of travel for any of the preceding three purposes were used. For each strata of trip purpose, the total frequency of trips as well as the vehicular frequency was available. Vehicular frequency is generally the measure of trip generation used in studies based on origin-destination data. It is a measure that excludes trips by bicycle and walking.

The second class includes variables indicating the usual modes selected for the work trip and the most frequent nonwork trip. Although other modes were used, in the results that follow only the car and bus modes are considered. In addition, whether an individual used the bus at all for any reason in the month (actually, four weeks) preceding the interview was recorded.

The entire sample was not available for the relationships to be tested here. First, the seven respondents who failed to answer the income question were excluded from further analyses. Second, based on the nature of the dependent variable, a different number of respondents were used to test the relationships involving the various dependent variables. For example, many respondents either did not take a work trip or used neither the car nor the bus. Similarly, some respondents had to be excluded from tests of relationships involving the measures of travel frequencies because of inconsistencies in their answers to the relevant questions.

Relationships Involving Socioeconomic Status and Variables Measuring Travel Frequencies

Disaggregate models of travel frequencies, i.e., trip-generation models, have generally used the household as the unit of analysis (6, 15). In these applications, it is assumed that the household, rather than the individual, is the basic decision-making unit with respect to travel; however, there are models of travel frequencies that use the individual as the basic unit, e.g., Lansing's model of long-distance travel (7). Therefore, the issue of which unit of analysis is more appropriate in disaggregate models of trip generation has not been definitively resolved. In the present case, the individual is the basic unit because the sample contained only one respondent per household.

The models to be tested here are analogous to the models of household trip generation. In such models, there are variables indicating household needs for travel (number of persons per household) and variables indicating household resources available for travel (number of cars per household, income). In the current applications, because the individual is the basic unit, the variable indicating the number of persons is not necessary. The measure of automobile availability will be the ratio of the number of automobiles in the respondent's household to the number of licensed drivers. That is, the automobile resources available to the individual are a share of those available to the entire household. The other measures of socioeconomic status will be tested in addition to the income variable. The sex of the respondent and an age variable are also included in the model. (Sex is recorded as males = 1 and females = 2. Age is measured on a seven-point scale with the following categories: 18 to 24 = 1, 25 to 34 = 2, 35 to 44 = 3, 45 to 54 = 4, 55 to 64 = 5, 65 to 74 = 6, and 75 and over = 7.) The basic model is represented symbolically as

$$Y = CONSTANT + a_1AGE + a_2SEX + a_3C/DL + a_4SES \qquad (1)$$

where Y is one of the variables (dependent) measuring monthly trip frequencies

Table 1. Variable scales used to measure indicators of socioeconomic status.

Scale Value	Category	Scale Value	Category
Income		Occupation	
1	<$4,000	1	Higher executives of larger concerns, proprietors, and major professionals
2	$4,000 to $7,999	2	Business managers, proprietors of medium-sized businesses, and lesser professionals
3	$8,000 to $11,999	3	Administrative personnel, owners of small businesses, and minor professionals
4	$12,000 to $14,999	4	Clerical and sales workers, technicians, and owners of little businesses
5	$15,000 to $24,999	5	Skilled manual workers
6	$25,000 to $50,000	6	Machine operators and semiskilled manual workers
7	>$50,000	7	Unskilled manual workers

Note: The highest grade level completed by the respondent is the education variable.

Table 2. Results of multiple regression analysis for total frequency.

		AGE		SEX		C/DL		INC		EDU		OC1		OC2				
Trip Purpose	Constant	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	RC	S		S.E.	R	R^2	r_{SES}
Shopping	11.23	-0.27	0.43	+0.49	1.52	+2.44	1.79	-0.14	0.45							0.11	0.01	-0.01
(N = 205)	8.23	-0.18	0.45	+0.50	1.52	+2.22	1.78			+0.17	0.22					0.12	0.01	0.08
	10.37	-0.32	0.44	+0.46	1.52	+2.41	1.78					+0.18	0.41			0.11	0.01	0.01
	10.02	-0.41	0.44	+0.02	1.57	+2.40	1.77							.49	0.41	0.14	0.02	0.06
Visiting	20.46	-1.30^a	0.41	-2.44	1.41	-0.09	1.77	-0.83^b	0.41							0.29	0.08	-0.13
(N = 211)	23.17	-1.54^a	0.44	-2.37	1.42	-0.50	1.76			-0.32	0.21					0.27	0.07	-0.02
	17.51	-1.40^a	0.42	-2.43	1.43	-0.68	1.76					+0.28	0.52			0.26	0.07	-0.01
	17.40	-1.46^a	0.42	-2.84	1.47	-0.71	1.75							+0.50	0.38	0.27	0.07	-0.00
Entertainment-recreation	13.73	-1.27^a	0.29	-2.40^b	1.02	-0.23	1.23	+0.53	0.59							0.36	0.13	0.12
	8.92	-1.00^a	0.30	-2.47^b	1.00	-0.26	1.21			+0.42	0.15					0.39	0.15	0.27^c
(N = 213)	17.18	-1.10^a	0.30	-2.32^b	1.01	-0.09	1.21					-0.69^b	0.27			0.38	0.14	0.24^c
	16.19	-1.13^a	0.30	-2.01^b	1.04	+0.05	1.22							-0.50	0.27	0.36	0.13	-0.22^c
Shopping, visiting, or	44.82	-2.53^a	0.74	-4.69	2.63	+0.04	3.20	+0.07	0.77							0.29	0.08	0.01
entertainment-	37.21	-2.19^a	0.78	-4.72	2.61	-0.30	3.16			+0.51	0.38					0.30	0.09	0.17^d
recreation	46.31	-2.39^a	0.76	-4.49	2.63	-0.01	3.15					-0.56	0.71			0.29	0.08	-0.13
(N = 197)	44.51	-2.62^a	0.76	-5.09	2.73	+0.10	3.16							+0.36	0.70	0.29	0.08	-0.07

Note: RC is the regression coefficient, R is the multiple correlation coefficient, R^2 is the squared multiple correlation coefficient, r_{SES} is the simple correlation between the dependent variable and the indicator of socioeconomic status, and S.E. is the standard error.

[a]Significant at $p < 0.01$. [b]Significant at $p < 0.05$. [c]Significant at $p < 0.01$ (two-tail test). [d]Significant at $p < 0.05$ (two-tail test).

Table 3. Results of multiple regression analysis for vehicular frequency.

		AGE		SEX		C/DL		INC		EDU		OC1		OC2				
Trip Purpose	Constant	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	RC	S.E.	R	R^2	r_{SES}
Shopping	3.09	-0.21	0.35	+1.85	1.24	+4.41^a	1.46	+0.20	0.36							0.23	0.05	0.06
(N = 205)	2.76	-0.16	0.37	+1.81	1.24	+4.48^a	1.45			+0.06	0.18					0.23	0.05	0.06
	3.48	-0.21	0.36	+1.79	1.24	+4.45^a	1.45					+0.08	0.34			0.23	0.05	-0.00
	2.94	-0.31	0.36	+1.37	1.28	+4.56^a	1.44							+0.46	0.33	0.25	0.06	0.08
Visiting	13.86	-0.85^b	0.36	-2.13	1.24	+2.01	1.56	-0.56	0.36							0.26	0.07	-0.08
(N = 211)	15.69	-1.00^a	0.38	-2.08	1.25	+1.74	1.54			-0.21	0.19					0.25	0.06	-0.00
	11.93	-0.91^b	0.37	-2.12	1.25	+1.61	1.54					+0.17	0.34			0.24	0.06	-0.02
	12.07	-0.92^b	0.37	-2.25	1.29	+1.58	1.54							+0.17	0.34	0.24	0.06	-0.05
Entertainment-recreation	8.87	-0.96^a	0.23	-1.12	0.80	+1.93^b	0.97	+0.19	0.23							0.36	0.13	0.07
	5.76	-0.80^a	0.24	-1.14	0.80	+1.85	0.96			+0.24^b	0.12					0.38	0.14	0.23^c
(N = 213)	10.58	-0.86^a	0.23	-1.05	0.80	+1.94^b	0.96					-0.42^b	0.22			0.37	0.14	-0.20^c
	10.03	-0.87^a	0.24	-0.83	0.82	+2.02^b	0.96							-0.34	0.22	0.37	0.13	-0.20^c
Shopping, visiting, or	25.49	-1.87^a	0.68	-1.40	2.41	+7.08^b	2.94	+0.10	0.71							0.29	0.09	0.04
entertainment-	22.64	-1.73^b	0.72	-1.43	2.41	+6.99^b	2.91			+0.20	0.35					0.29	0.09	0.13
recreation	26.76	-1.76^b	0.70	-1.25	2.42	+7.07^b	2.90					-0.43	0.65			0.29	0.09	-0.11
(N = 197)	25.50	-1.92^a	0.70	-1.62	2.51	+7.15^b	2.90							+0.19	0.65	0.29	0.09	-0.07

Note: See note, Table 2.

[a]Significant at $p < 0.01$. [b]Significant at $p < 0.05$. [c]Significant at $p < 0.01$ (two-tail test).

stratified by trip purposes, AGE is the age variable, SEX is the sex variable, C/DL is the automobile availability ratio, and SES is one of the four indicators of socioeconomic status (INC is the income variable, EDU is the education variable, OC1 indicates the occupation of the household head, and OC2 indicates the occupation of the respondent).

As mentioned earlier, there are four strata of trip purposes (including the stratum of the variables measuring travel frequencies for any of the three specific purposes) and two measures of travel frequency, total and vehicular frequency, for each stratum. For each combination of trip purpose and measure of travel frequency, four versions of the basic model are tested, i.e., one version for each of the measures of socioeconomic status. The results of the multiple regression analyses are given in Tables 2 and 3.

Before the relative performances of the various indicators of socioeconomic status are discussed in detail, some general observations are in order. It is apparent from the results in Tables 2 and 3 that none of the indicators of socioeconomic status are especially good predictors of travel frequencies for the purposes of shopping and visiting. On the other hand, almost all of the indicators are significantly associated with the trip-frequencies in the entertainment-recreation stratum. A possible reason for these variations in explanatory power is that the first two purposes are relatively more basic, and hence, there may be less systematic variance to be explained. Similarly, entertainment-recreation travel is relatively more discretionary, and, therefore, there may be more systematic variance in the dependent variables.

The three independent variables other than the measures of socioeconomic status follow general patterns throughout the regression analysis. The age variable is in all cases negatively associated with the dependent variables. In all relationships, excluding those involving shopping travel, the sex variable is such that women travel less frequently. Finally, the pattern involving the automobile availability ratio is interesting. When measures of total travel frequency (Table 2) are the dependent variables, the coefficients of the automobile availability ratio are insignificant and often are in a direction contrary to intuition. On the other hand, in Table 3, the coefficients of the automobile availability ratio are much larger and often statistically significant. This finding appears to indicate that differences in vehicular travel frequencies resulting from differential automobile availability may be offset by more nonvehicular travel by those with fewer automobile resources available.

The relative performances of the various indicators of socioeconomic status will now be observed, and special attention will be focused on the income variable. Only for the visiting stratum is the income variable superior to the other indicators. Further, for the entertainment-recreation stratum and the stratum containing travel frequencies for any of the three purposes, the income variable appears to be clearly inferior to the other three indicators. This finding is especially important because overall fit of the models in these last two strata, especially the entertainment-recreation stratum, is better than the fit in the shopping and visiting strata.

An interesting finding is that, in three of the four possible combinations of trip purpose and measure of travel frequency for the last two trip purpose strata, the education variable performed the best in terms of yielding the version of the basic model that explained the most variance. In the case of vehicular travel for any of the three purposes, although the variable indicating the occupation of the head of the household yielded a model explaining slightly more variance than that involving education (the difference in multiple correlation coefficients was indiscernible when the coefficients were rounded to two decimal places), the simple, two-variable correlation between the dependent variable and the measures of socioeconomic status was highest for the relationship containing the education variable. Inasmuch as the education variable is probably easier to measure in terms of definition, operation, and interviewing than the other three indicators, this particular finding assumes added importance.

Relationships Involving Socioeconomic Status and Variables Indicating Modal Selection

The assumption common to many of the existing models of mode choice is that individuals trade off time savings for increased costs in their selection of modes (8, 9, 11, 12, 13).. Such models are calibrated by using statistical techniques appropriate for situations in which the dependent variable is categoric rather than continuous. The particular technique that has been used most often is multivariate logit analysis. Based on this technique, a modal-choice model in which there are two alternative modes might be

$$P(\text{Mode } 1) = e^{L(X)}/(1 + e^{L(X)}) \tag{2}$$

where

$$L(X) = \text{CONSTANT} + a_1\Delta\text{TIME} + a_2\Delta\text{COST} + \sum_{i=1}^{n} a_{i+2} I_i \tag{3}$$

where ΔTIME is the variable comparing the times of the competing modes, ΔCOST is the analogous variable involving the costs, I_i are variables describing individuals, and P(Mode 1) is the probability of selecting the first mode.

The data needed to calibrate such models must meet at least two requirements. First, data on the times and costs for all competing modes must be available. The present data base includes this information. Second, there must be a method of separating those who choose among modes from those who are captive to one of the modes, and therefore are not included in the data used to calibrate the model. In this paper, the criterion used to separate choosers from captives was whether or not the respondents perceived the existence of a mode that is an alternative to their usual mode. Unfortunately, when this criterion was applied, only 38 respondents were choosers between the car and bus for the work trip (34 car users and 4 bus users). Similarly, there were 41 choosers for the most frequent nonwork trip (33 car users and 8 bus users). The small number of bus users as well as the small overall number of choosers prevents the calibration of modal-choice models for these trips.

There are alternative tests that may shed some light on the issue of which indicator of socioeconomic status is most strongly associated with modal selection. First, for both the work trip and the most frequent nonwork trip, it is possible to observe the differences in means between the car and bus user groups based on the various indicators of socioeconomic status. In this case, the modal-use groups include both choosers and captives.

Second, inasmuch as the data indicate whether each respondent used the bus at all in the month preceding the interview, it is possible to calibrate a modified modal-choice model by using this information as the dependent variable. Because travel time and trip costs are trip specific, such information is not available for the model. However, there are other variables describing the qualities of the competing transportation systems. These are the distance of the respondent's home from the bus line (in blocks) and the automobile availability ratio. In addition, age, sex, and one of the variables indicating socioeconomic status are included in the model, which is represented as

$$P(\text{Bus Use}) = e^{L(X)}/(1 + e^{L(X)}) \tag{4}$$

where

Table 4. Differences in means between car- and bus-user groups based on indicators of socioeconomic status, work trip, and nonwork trip.

Item	INC	EDU	OC1	OC2
Work trip				
Car users (N = 107)				
Mean	3.60	14.56	3.10	3.27
Standard deviation	1.57	3.36	1.71	1.58
Bus users (N = 7)				
Mean	2.71	12.29	5.29	5.71
Standard deviation	0.95	3.40	1.70	1.25
z-statistic	2.28[a]	1.71	-3.30[b]	-4.91[b]
Nonwork trip				
Car users (N = 173)				
Mean	3.52	14.06	3.47	3.94
Standard deviation	2.11	3.55	1.82	1.92
Bus users (N = 14)				
Mean	2.36	12.29	4.86	4.79
Standard deviation	1.55	2.92	1.61	1.48
z-statistic	2.61[a]	2.14[b]	-3.08[a]	-2.02[b]

Note: The z-statistic is assumed to be normally distributed and approximates the student t-statistic for large (N >30) samples.
[a]Significant at $p < 0.05$ (two-tail test). [b]Significant at $p < 0.01$ (two-tail test).

Table 5. Linear function values from modified modal-choice model in which dependent variable is whether or not bus was used in month (N = 210).

Constant		BDIS		C/DL		SEX		AGE		INC		EDU		OC1		OC2		
LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	LC	S.E.	ρ^2
-0.77	0.92	+0.20	0.14	-1.57[a]	0.48	+0.29	0.38	-0.042	0.11	-0.006	0.11							0.33
-0.95	1.20	+0.20	0.14	-1.59[a]	0.48	+0.29	0.38	-0.036	0.12			+0.011	0.057					0.33
-1.44	0.92	+0.17	0.14	-1.46[a]	0.47	+0.24	0.39	-0.083	0.11					+0.22[b]	0.10			0.35
-1.04	0.88	+0.19	0.14	-1.54[a]	0.47	+0.17	0.40	-0.070	0.11							+0.13	0.10	0.34

Note: ρ^2 is the logarithm of the likelihood ratio divided by the logarithm function when all coefficients of the independent variables (and the constant) are zero, LC is the logarithmic coefficient, and S.E. is the standard error.
[a]Significant at $p < 0.01$. [b]Significant at $p < 0.05$.

Table 6. Differences in means between group that did not use bus in month and group that did.

Item	INC	EDU	OC1	OC2
Group that did not use bus (N = 168)				
Mean	3.42	13.92	3.39	3.87
Standard deviation	1.68	3.48	1.78	1.92
Group that did use bus (N = 42)				
Mean	3.21	13.64	4.29	4.50
Standard deviation	1.57	3.09	1.90	1.82
z-statistic	0.76	0.51	-2.78[a]	-1.98[b]

Note: See note, Table 4.
[a]Significant at $p < 0.01$ (two-tail test). [b]Significant at $p < 0.05$ (two-tail test).

$$L(X) = CONSTANT + a_1AGE\ a_2SEX + a_3C/DL + a_4BDIS + a_5SES \quad (5)$$

where P(Bus Use) is the probability of using the bus for any reason in the month, BDIS is the distance from the respondent's home to the closest bus line, and the other variables are as defined previously. In addition, the simple differences in means between user and nonuser groups based on the various indicators of socioeconomic status are given in Tables 4 and 6. The logit values given in Table 5 were obtained by use of the CLOGIT program written by Daniel McFadden of the University of California, Berkeley.

In two of the three situations (most frequent nonwork trip and whether or not the bus was used at all), the variable indicating the occupation of the household head was superior to the others. For the work trip, the respondent's occupation was the best variable, and the occupation of the household head was next best. Although the income indicator was superior to the education variable in all three situations, the difference in means involving income was insignificant in the situation of whether the respondent used the bus at all. Finally, it should be noted that the variable indicating the occupation of the household head was superior to the income indicator in all these situations, and the variable indicating the respondent's occupation was superior in two of the three situations.

The structure of the modified modal-choice model is interesting. Although the signs of the coefficients of the independent variables are almost always in the expected direction (the coefficient of the education variable is an exception), only the coefficient of the automobile availability ratio is significant in three of the four versions of the model. In the fourth version, which is the best one, the coefficient of the variable indicating the occupation of the household head is also significant.

The main conclusion from these exercises is that some of the other indicators of socioeconomic status were superior to the income indicator in the tests performed. This finding is consistent with the conclusion that the income indicator was generally inferior to at least one of the other indicators.

CONCLUSIONS

Before the implications of the results are discussed, it is necessary to mention some of the features of this study that might affect the generality of the results. First, specific indicators of socioeconomic status were used in the cases of the income and occupational variables. It is possible that different scales for these variables might yield different results. Second, inasmuch as the sample was relatively small, the indicators of socioeconomic status were used as additional linear terms in the models rather than as stratification criteria. It is possible that, if a stratification strategy were followed, the conclusions for the relative effectiveness of the various indicators might be different. For example, if the relationships between the indicators of socioeconomic status and the dependent variables are nonlinear, the stratification strategy might yield results different from those that are obtained by using the indicators as additional linear terms. Finally, it was not possible to test the conventional modal-choice modal. Therefore, one cannot generalize these results for this type of model with much certainty, and the results of this study must be regarded as suggestive rather than definitive.

On the other hand, the results do have implications for transportation modeling and surveys. There is some fairly strong evidence that the income variable, which has been the most frequently used indicator of socioeconomic status in previous transportation studies, is not as effective as other indicators of socioeconomic status for explaining transportation behavior.

This is even more important in view of the success in obtaining usable responses in this and previous surveys. Specifically, in the present survey, all respondents supplied the information on education and occupation variables; however, about 3 percent of the respondents refused to answer the income question. The refusal rates for income questions have been even higher in other transportation surveys. For example, it is possible to calculate the following refusal rates from three other studies: Lave (8), 7.57 percent; Lisco (9), 17.61 percent; and Stopher (12), 3.87 percent. Therefore, other indicators might be more efficient because the chances of obtaining relevant information about them might be greater than for income.

In light of the greater effectiveness of some of the other indicators of socioeconomic status in this study, it is recommended that future transportation surveys should contain such indicators in addition to or in place of the income variable to explain travel behavior. Of course, future research with different scales for these indicators [or based on a large sample so that (a) the stratification strategy can be tested and (b) conventional modal-choice models can be calibrated] would either strengthen or weaken the basis for the preceding recommendation.

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