Changing Effects of Automobile Ownership on Household Travel Patterns

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This study sets forth the hypothesis that the effects of automobile ownership on household trip generation and automobile utilization are diminishing in the United States. The reasoning behind this statement is that, as motorization progressed and automobile ownership became widespread in the United States, the strong association between a household's propensity to travel and its automobile ownership, which existed in earlier stages of motorization, diminished. Therefore trip making of households can no longer be effectively explained by their level of automobile ownership. This study extends previous work of the authors in which automobile ownership effects were found to be decreasing for nuclear-family households. The relationships between household automobile ownership and a number of travel pattern indicators are examined in this study for all households contained in the 1963 and 1974 origin-destination survey results from Rochester, New York. Statistical analyses of the trip records indicate that the ability of automobile ownership to explain variations in the travel indicators has diminished over time and automobile ownership is no longer a key descriptor of household trip making. The cross-classification scheme based on household size and automobile ownership is also shown to have lost its effectiveness in household trip generation analysis. A more extensive categorization of household composition, however, has retained its explanatory power for the total number of trips generated by a household.

The models used in forecasting future travel demand rely heavily on a set of socioeconomic variables that is associated with people's propensity to travel. Among such variables is the number of automobiles owned by or available to the household *(1–4)*. Almost every model of residential trip generation or modal split developed since the 1950s has included a variable that represents automobile availability.

A frequently used procedure for household trip generation analysis classifies households according to the number of persons and the number of automobiles available and then evaluates a mean trip rate for each of the household subgroups *(5, 6)*. Frequently, other variables such as income or housing type are used in place of household size *(2, 7)*, or in some cases more than one variable (e.g., income and a descriptor of household structure) are used in addition to automobile ownership *(8)*. Implicit in the application of these classification procedures to forecasting household trip generation is the assumption that the trip rate observed for each subgroup of a cross-sectional survey sample remains unchanged over time. Automobile ownership is thus considered to be a household attribute that has the most salient, and temporally invariant, impact on the travel behavior of a household.

Automobile ownership and use, however, were changing dramatically during the time the currently used demand forecasting procedures were being formulated. The spread of automobile ownership and utilization, or motorization, in the United States, which had been taking place since the early part of this century, increased rapidly after World War II (Figure 1). In 1950, 41 percent of households did not have automobiles available, and in 1980 this percentage was only 13 percent. The percentage of households owning two or more cars increased from 7 to 52 percent during the same time period *(9, 10)*. Currently, approximately 85 percent of the adult population of the United States is licensed to drive. However, the rate of increase in the average number of automobiles per household, shown in Figure 2, is decreasing; the average number of automobiles per household increased by only 0.1 between 1975 and 1980. It may be that motorization in the United States is entering a final phase.

The dramatic increase in automobile ownership was accompanied by substantial changes in the characteristics of automobile owners. Although only a limited number of high-income households were able to afford an automobile in the early stages of motorization, the current ranks of automobile-owning households

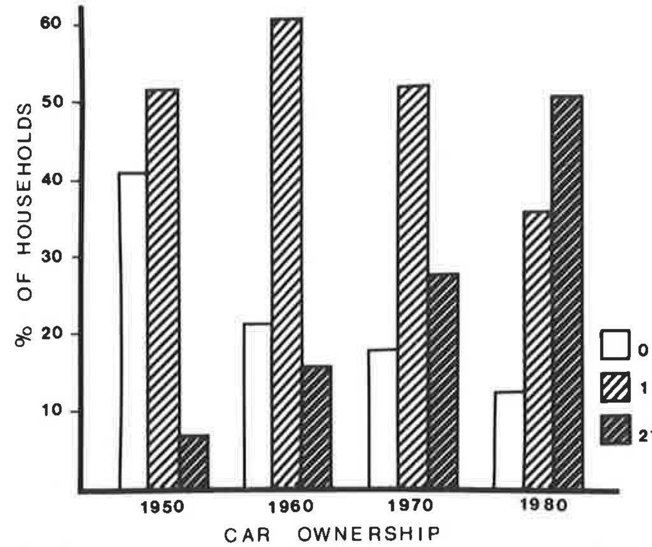

FIGURE 1 Automobile ownership in the United States: 1950–1980.

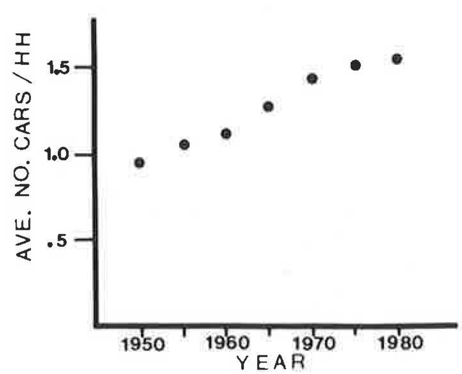

FIGURE 2 Increase in automobiles per household in the United States: 1950–1980.

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include many low-income households and households without workers. Automobile ownership by itself is no longer considered a reflection of a household's economic capability *(11)*. Because nearly 90 percent of all U.S. households own automobiles, these households are almost as heterogeneous as the entire household population and cannot be classified as a special subgroup.

In light of this expansion of automobile ownership and the changes in the characteristics of automobile-owning households, it is questionable if automobile ownership still has the same discriminating effect on travel behavior as it did earlier. Although automobile ownership has almost always automatically been chosen as a predictor of travel behavior, this practice may have been effective only in the earlier stages of motorization. At any particular time automobile ownership could be associated with trip making, but this effect may have been changing along with the changes in motorization.

In an earlier effort (*12*, p. 250), these questions were investigated using 1963 and 1974 origin-destination survey results from Rochester, New York. Analysis indicated that, between 1963 and 1974,

> more smaller, younger, and less affluent households joined the multi-car household category. No-car households in 1974 became more homogeneous in their characteristics; they were typically single-person households with no licensed drivers, no workers, low income, and consisted of older individuals. Typical one-car households also became smaller, older, and had one or no worker in 1974.

Further analysis in the same study focused on nuclear-family households (i.e., households consisting of an adult male-female couple and any children living with them). The effects of automobile ownership and several other household descriptors on a set of travel pattern indicators were explored. The set of indicators consisted of the total number of trips made by a household; the numbers of automobile trips, driver trips, and passenger trips; the numbers of trips made for purposes of work, to serve passengers, for social-recreation, and for maintenance activities; the number of trips made jointly by several household members for nonwork activities; the number of trip chains; and the mean automobile occupancy. The total time spent by the household for travel as well as the total driver time and total passenger time were also included in the set of travel pattern indicators. Statistical examination of these household travel pattern indicators offered strong empirical evidence that automobile-ownership effects had changed between 1963 and 1974. Although automobile ownership remained a "significant" predictor in 1974, its power to explain behavioral variations had substantially decreased. The same study found that the stage in the household's life cycle, a variable that clearly describes household composition in the case of nuclear households, was strongly associated with many of the indicators in 1963 and retained that strong association in 1974.

This study is an extension of the earlier study. It is an attempt to establish whether the finding of diminishing automobile-ownership effects, found for nuclear-family households, can be generalized to the entire household population and to other subgroups of households. The number of persons in a household, a simple classifier of household composition, is frequently used together with automobile ownership for trip generation analysis. Accordingly, another focus of this study is on the stability and usefulness of the household size–automobile ownership classification scheme for trip generation analysis.

SAMPLE

The statistical analysis of this study uses 1963 and 1974 origin-destination survey data from Rochester, New York, the same data sets used in a previous study *(12)*. Detailed description of the data sets can be found elsewhere *(13, 14)*, and the screening criteria used to eliminate incomplete or inconsistent household records are also discussed elsewhere *(15–17)*. The profiles of automobile-ownership subgroups obtained from the data sets are given in Kitamura and Kostyniuk *(12)*.

Table 1 gives the 1963 and 1974 households used in this study classified by the number of adults in the household, the age of children if present, age of head-of-household if no children are present, and automobile ownership. Table 2 gives the distribution of the various household types found in the data sets. It can be seen that the fraction of single-person households remained stable at approximately 14 percent between the two dates. The percentage of single-parent households, which are defined here as households with one adult and one or more children less than 15 years old, also remained stable at around 3 percent of the sample. Households with two adults with and without children make up two-thirds of

TABLE 1 1963 AND 1974 SAMPLE HOUSEHOLDS BY NUMBER OF ADULTS, LIFE CYCLE, AND AUTOMOBILE OWNERSHIP

Year	No. of Adults	No. of Auto-mobiles	Life-Cycle Stage[a] 1	2	3	4	5	Total
1963	1	0	69	53	40	16	487	665
		≥1	119	38	47	31	295	530
	2	0	61	98	51	21	295	526
		≥1	352	1,282	1,071	291	1,179	4,175
	≥3	0	14	20	20	8	47	109
		≥1	71	148	263	184	419	1,085
Total			686	1,639	1,492	551	2,722	7,090
1974	1	1	34	12	20	8	194	268
		≥2	8	1	3	4	3	19
	2	1	62	89	71	18	236	476
		≥2	79	139	199	46	138	601
	≥3	1	2	3	13	5	26	49
		≥2	15	16	55	37	71	194
Total			200	260	361	118	668	1,607

[a]Life-cycle stages are defined in terms of the age of the household head if there is no child and in terms of the age of the youngest child, if there is one, as Stage 1: no child, age of head < 45 years, Stage 2: age of the youngest child < 5 years, Stage 3: age of the youngest child between 5 and 14 years, Stage 4: age of the youngest child ≥ 15 years, and Stage 5: no child, age of head ≥ 45 years.

TABLE 2 PERCENTAGE DISTRIBUTION OF THE 1963 AND 1974 SAMPLES BY HOUSEHOLD COMPOSITION

Household Type	1963	1974
One-adult households		
Single-person households	13.7	14.8
Single-parent households	3.2	3.0
Two-adult households		
Nuclear-family households		
With working adults[a]	53.6	53.7
Without working adults	9.3	9.1
Two adults of the same sex	3.3	4.3
Households with three or more adults		
Households with no child	7.8	7.1
Households with children	9.1	8.0
Total	100.0	100.0

[a]The households examined in Kitamura and Kostyniuk *(12)*.

TABLE 3 1963 AND 1974 SAMPLE HOUSEHOLD TRIP RATES BY AUTOMOBILE OWNERSHIP, HOUSEHOLD SIZE, AND NUMBER OF WORKERS

	Trip Rate			Sample Size		Percentage to Year Total	
	1963	1974	*t*	1963	1974	1963	1974
All households	7.91	8.01	0.49	7,193	1,666	100.0	100.0
Zero-automobile households	2.00	1.05	-4.38	1,314	110	18.3	6.6
One-automobile households	7.98	6.06	-8.54	4,296	713	59.7	42.8
Multiple-automobile households	12.65	10.57	-6.32	1,583	843	22.0	50.6
One-person households	1.98	2.26	1.66	960	242	13.3	14.5
Two-person households	5.18	5.57	2.02	2,001	557	27.8	33.4
Three-person households	8.07	8.05	-0.06	1,235	299	17.2	17.9
Four-person households and larger	11.58	12.83	3.35	2,997	568	41.7	34.1
Zero-worker households	2.04	3.04	4.57	1,264	344	17.6	21.1
One-worker households	8.33	7.62	-2.74	3,818	622	53.2	38.1
Multiworker households	10.72	11.02	0.91	2,098	665	29.2	40.8

both samples. The previous study *(12)* examined the composition of this group and found that nuclear families with workers constituted 54 percent of the sample in both 1963 and 1974. Approximately 9 percent of the sample is nuclear families without working adults, and 3.3 percent of the 1963 sample and 4.3 percent of the 1974 sample are households consisting of two adults of the same sex. Other non-nuclear-family households with three or more adults with and without children make up the remainder of both samples. It appears that there was little change in the distribution of household types in Rochester between 1963 and 1974. This is an important point because any changes in travel patterns in the samples found between the two years cannot be attributed to changes in the distribution of household types.

Samplewide statistics show practically identical household trip rates for the two years (Table 3). However, the trip rate decreased substantially in 1974 for all automobile-ownership subgroups, which indicates that single-car and multicar households in 1974 included more households with lower propensity to travel than in 1963 and also that no-car households in 1974, which comprise only 6.6 percent of the sample households, had extremely low mobility. The trip rates tabulated by household size, on the other hand, indicate that the household trip rate increased in 1974, especially among two-person households and households with four or more people. This tabulation suggests that the number of trips per person in 1974 was at the same level as in 1963, whereas the number of trips per automobile appears to have declined sharply in 1974.

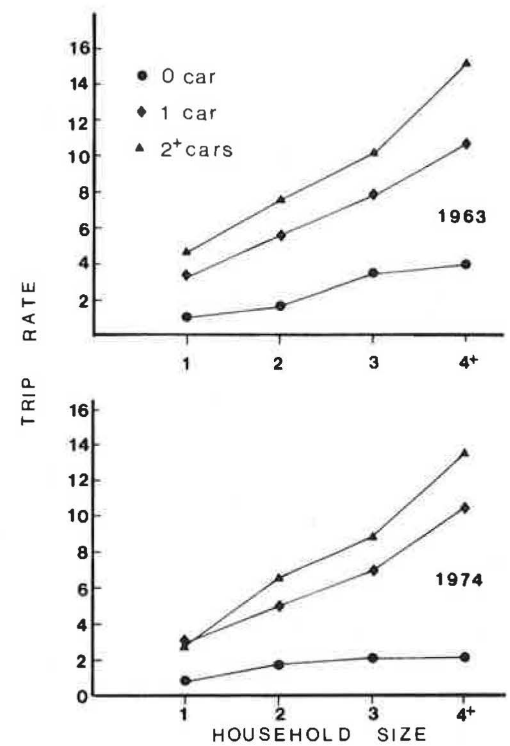

FIGURE 3 1963 and 1974 sample trip rates by household size and automobile ownership.

EFFECTIVENESS OF CROSS-CLASSIFICATION BY AUTOMOBILE OWNERSHIP AND HOUSEHOLD SIZE

The sample trip rates of household subgroups defined by the number of automobiles available and household size (Figure 3) exhibit similar patterns in 1963 and 1974. However, the trip rates of multicar households are not as distinctly high in 1974 as in 1963. In 1974 the separation between single-car households and multicar households is not as clear as in 1963.

Table 4 gives statistical support of this decreasing distinction between automobile-ownership subgroups. Analysis of variance (ANOVA) was conducted using categories of automobile ownership and household size on the following travel indicators: number of trips; number of driver trips, passenger trips, and automobile trips; travel time expenditure; and total driver time. The results indicate that the magnitude of automobile-ownership main effects decreased in 1974 for all of the travel indicators examined here. The reduction is especially noticeable for number of automobile trips and total driver trip time. For example, the automobile-ownership main effect explains 6.98 percent of the total variation in number of automobile trips in the 1963 sample. This percentage decreases to 1.11 percent in the 1974 sample. More dramatic reduction in variance explanation can be found for total driver trip time, a surrogate of household vehicle miles traveled (VMT), for which the variance explanation by the automobile-ownership main effect decreases from 10.09 to 0.98 percent. On the other hand, the difference in variance explanation between the two years is not as salient for number of trips and travel time expenditure (4.97 to 1.09 percent and 1.88 to 0.80 percent, respectively). It can be immediately inferred from the ANOVA results that household auto-

TABLE 4 ANALYSIS OF VARIANCE OF AUTOMOBILE OWNERSHIP AND HOUSEHOLD SIZE EFFECTS ON HOUSEHOLD TRIP PATTERNS

	Effect (degrees of freedom)			
	C (2)	H (3)	CH (6)	Error
No. of trips				
1963	**4.97**	**6.13**	**1.32**	87.58
1974	**1.09**	**1.16**	**0.53**	97.22
No. of driver trips				
1963	**11.86**	1.79	0.97	85.37
1974	**2.50**	0.76	0.60	96.14
No. of passenger trips				
1963	0.67	**4.14**	**0.94**	94.25
1974	0.16	0.73	0.26	98.85
No. of automobile trips				
1963	6.98	**3.91**	**1.31**	87.81
1974	**1.11**	**1.04**	**0.42**	97.44
Travel time expenditure				
1963	**1.88**	3.24	**0.52**	94.36
1974	**0.80**	0.38	0.27	98.55
Total driver trip time				
1963	**10.09**	**0.64**	0.43	88.84
1974	**0.98**	0.14	0.21	98.68

Note: Expressed as percentage of the total variation. A bold-faced value indicates that the effect is significant at $\alpha = 0.001$. C refers to automobile-ownership main effect, H to household main effect, and CH to automobile-ownership-household-size interaction effect. The 1963 sample size is 7,193 and 1974 sample size is 1,666. The categories used are 0 automobile, 1 automobile, and 2 or more automobiles and household sizes of 1 person, 2 persons, 3 persons, and 4 or more persons. It was necessary to group larger households in the 4-or-more-person category because there were no households with 5 or more people without automobiles in the 1974 sample. All rows total 100.

mobile ownership offers little explanation of automobile utilization in the 1974 sample.

The ANOVA results given in Table 4 show that the variance explanation by the household-size main effect has also decreased in 1974. Furthermore, the two-way classification scheme based on automobile ownership and household size does not appear as effective in 1974 as in 1963. The large increases in the percentage of the error variance given in Table 3 imply that the variance explained by these two factors has substantially decreased in the 1974 sample. For example, automobile ownership and household size explained 12.42 percent of the total variation in number of trips in the 1963 sample and only 2.78 percent in 1974. This analysis leads to the conjecture that the frequently practiced procedure of trip generation analysis that cross-classifies households according to automobile ownership and household size may not be as effective as it is generally believed to be.

FURTHER EXAMINATION OF DIMINISHING AUTOMOBILE-OWNERSHIP EFFECTS

The apparent decrease in automobile-ownership effects found in the two-way cross-classification analysis of the previous section is reexamined in this section. The intent is to base the conclusion on a more robust statistical basis by conducting further analysis in less restrictive contexts using different statistical models. Two methods used in this section are the log-linear model of classification table analysis *(18)* and analysis of variance with a covariate. In the analysis of this section households are characterized by number of adults, number of workers, life-cycle stage, and automobile ownership.

One of the advantages of the log-linear model of classification table analysis is its liberal cell sample-size requirements, which are crucial when a multidimensional table defined by strongly correlated factors is analyzed. The model is applied to five-way tables formed by categories of automobile ownership (C), number of adults (A), number of workers (W), life-cycle stage (L), and a travel pattern indicator (T). The magnitude of the association between a household attribute and travel indicator can be evaluated by examining the magnitude of the interaction terms involving the two factors. For example, the automobile ownership effect on travel patterns is represented by the interaction term of automobile ownership and the travel indicator, denoted by CT.

This analysis was conducted for three travel indicators: the total number of household trips, the number of driver trips, and the total travel time expenditure. Table 5 gives the magnitude of interaction terms as chi-square statistics divided by the degrees of freedom (to account for the difference in degrees of freedom among interaction effects). The data in the table show a ratio obtained by dividing the chi-square measure for the interaction effect involving each household attribute by the value of the chi-square measure of the interaction involving the number of adults (AT). This ratio is developed so that the 1963 and 1974 samples of different sizes can be compared.

TABLE 5 RELATIVE MAGNITUDE OF THE ASSOCIATION OF HOUSEHOLD ATTRIBUTES AND TRAVEL INDICATORS

	AT	WT	LT	CT
No. of trips				
1963				
χ^2/DOF	10.11	60.07	34.63	81.51
Ratio	1.00	5.94	3.42	8.06
1974				
χ^2/DOF	3.20	8.41	10.89	9.84
Ratio	1.00	2.63	3.40	3.07
Total travel time expenditure				
1963				
χ^2/DOF	9.50	62.30	25.05	51.29
Ratio	1.00	6.56	2.64	5.40
1974				
χ^2/DOF	3.35	4.51	8.67	9.48
Ratio	1.00	1.34	2.59	2.83
No. of driver trips				
1963				
χ^2/DOF	7.94	31.46	18.27	383.10
Ratio	1.00	3.96	2.30	48.24
1974				
χ^2/DOF	2.59	12.30	3.96	25.73
Ratio	1.00	4.76	1.53	9.95

Note: The magnitude of the association between a household attribute and travel pattern indicator is expressed by a chi-square value divided by the degrees of freedom (χ^2/DOF). A refers to the number of adults, W to the number of workers, L to life-cycle stage, and T to travel indicator; AT represents the interaction between A and T and so forth. The relative magnitude of these effects is shown in the table as the ratio to that of AT. The categories used are 1, 2, and 3 or more for number of adults; and 0, 1, and 2 or more for number of automobiles and number of workers. The five life-cycle stages are as defined in Table 1. The effects are all significant at $\alpha = 0.0001$.

The declining relative effect of automobile ownership (CT) in 1974 is evident from Table 5. For example, the automobile-ownership effect on number of trips (CT) in 1963 is more than 8 times larger than that of number of adults (AT). This ratio reduces to 3.07 in the 1974 sample. Although the automobile-ownership interaction term (CT) is always significant (at $\alpha = 0.01$ percent), its relative effects have decreased in 1974 for all three travel pattern indicators examined in Table 5; it is no longer a predominant factor for number of trips or travel time expenditure.

Analysis of variance (ANOVA) is next applied to the same multidimensional classification table. Two modifications to the table were necessary because of sample-size requirements. First, the number of workers became a covariate, rather than a classifier (it is assumed that the covariate has an identical slope for all household subgroups). Second, automobile ownership had to be represented by the following two categories: no-car households and households with one or more cars for the 1963 sample, and households with zero or one car and multicar households for the 1974 sample because of the small number of no-car households in the 1974 sample. The first change appears to have resulted in an overrepresentation of the effects of number of workers, and the second change may possibly have caused an underrepresentation of automobile-ownership effects.

This ANOVA was conducted on the following set of travel indicators: number of trips, driver trips, passenger trips, automobile trips, trip chains, trips for work, social-recreational trips, maintenance trips, and trips to serve passengers as well as travel time expenditure. The results of this ANOVA, given in Table 6, indicate the same decline in variance explanation by household automobile ownership. The decline is especially noticeable for number of driver trips, number of car trips, and total driver–trip time expenditure—the same result found in the simpler analysis of Table 4. Although the analysis here is limited by the binary categorization of automobile ownership, the consistency found between the data in Tables 4 and 6 supports the conclusion of diminishing effects of automobile ownership on travel.

Only a few of the ANOVA tables of Table 6 exhibit appreciable differences in the total variance explained between 1963 and 1974. For some travel pattern indicators (e.g., total number of trips), the variance explanation increases (and the error variance decreases) for the 1974 sample. This forms a marked contrast to the result shown in Table 4, where the ANOVA based on cross-classification by household size and automobile ownership indicated that the percent of variance explained by these two factors sharply decreased in 1974 for all indicators examined. The data in Table 6 thus offer additional support of the conjecture that the cross-classification of households according to automobile ownership and household size may not be as effective a tool for trip generation analysis as it has been believed to be.

The same analysis of variance is repeated for the subgroup of households that are in later stages of life cycle, namely, those households whose heads are at least 45 years old and where no children are present. This particular subgroup is studied here partly because its internal sample distribution allows the application of the three-category representation of automobile ownership (no-car, single-car, multicar). An analysis of variance of this group of households can therefore be used to confirm the diminishing automobile-ownership effects found in Table 6. Analyzing this group is also useful because its lower automobile-ownership rate as indicated in the previous analysis (*12* and Table 1) may imply different automobile-ownership effects for this group. The results are given in Table 7 in the same format as in Table 6, except that life-cycle stage is no longer a classifier. The ANOVA tables in general confirm the earlier results with the automobile-ownership main effect dropping dramatically between the two years for all twelve of the indicators. The conjecture of diminishing automobile-ownership effects holds true for households of later life-cyle stages as well as for nuclear-family households *(12)* and all households examined collectively.

TABLE 6 ANALYSIS OF VARIANCE OF LIFE CYCLE, NUMBER OF ADULTS, AND AUTOMOBILE OWNERSHIP EFFECTS ON HOUSEHOLD TRAVEL PATTERNS

	Effect (degrees of freedom)								
	L (4)	A (2)	C (1)	LA (8)	LC (4)	AC (2)	LAC (8)	W (1)	Error
No. of trips									
1963	**1.91**	**0.29**	**3.14**	0.03	**0.34**	**0.16**	0.05	**2.48**	91.59
1974	**4.68**	0.13	0.36	0.25	0.39	0.04	0.63	**3.94**	89.59
No. of driver trips									
1963	**0.34**	0.05	**8.60**	0.04	**0.66**	**0.35**	0.03	**1.87**	88.05
1974	**1.02**	0.13	**0.81**	0.34	0.25	0.12	0.41	**5.49**	91.43
No. of passenger trips									
1963	**1.42**	**0.17**	**0.39**	0.06	0.11	0.09	0.09	**0.47**	97.20
1974	**3.46**	0.22	0.01	0.43	0.30	**0.74**	1.17	**0.62**	93.05
No. of automobile trips									
1963	**1.04**	**0.12**	**4.64**	0.03	**0.45**	**0.36**	0.07	**1.49**	91.79
1974	**2.50**	0.12	**0.39**	0.27	0.36	0.04	0.68	**4.16**	91.48
Travel time expenditure									
1963	**1.22**	**0.33**	**0.72**	0.06	0.04	0.05	0.06	**2.43**	95.11
1974	**1.44**	0.04	0.40	0.21	0.52	0.02	0.29	**1.02**	96.06
Total driver trip time									
1963	0.11	0.07	**6.17**	0.02	**0.30**	**0.39**	0.04	**1.67**	91.22
1974	0.30	0.05	**0.42**	0.24	0.43	0.09	0.21	**1.10**	97.16
No. of trip chains									
1963	**2.56**	**0.56**	**3.24**	0.03	**0.41**	**0.17**	0.07	**2.35**	90.61
1974	**5.05**	0.43	**0.39**	0.19	0.29	0.02	0.45	**3.87**	89.30
No. of work trips									
1963	0.04	0.00	0.27	0.05	0.01	0.03	0.04	**25.18**	74.37
1974	0.16	**0.44**	0.15	0.67	0.28	0.21	0.37	**23.09**	74.64
No. of joint nonwork trips									
1963	**0.80**	**0.13**	**1.03**	0.07	**0.20**	0.08	0.04	**0.15**	97.51
1974	**1.81**	**0.63**	0.02	0.66	0.28	**0.69**	1.12	0.21	94.57
No. of maintenance trips									
1963	**0.60**	**0.25**	**1.61**	0.03	0.12	**0.14**	0.09	**0.20**	96.95
1974	**1.75**	**0.67**	0.03	**1.42**	0.34	0.23	0.88	0.21	94.46
No. of social-recreational trips									
1963	**1.00**	0.08	**0.69**	0.09	0.06	0.03	0.04	0.01	98.00
1974	0.65	0.19	0.00	0.58	0.48	0.04	1.03	0.04	96.98
No. of serve-passenger trips									
1963	0.18	0.01	**1.43**	0.04	**0.25**	0.09	0.03	**0.76**	97.21
1974	0.50	0.37	0.00	0.82	0.15	0.03	0.22	**0.91**	96.99

Note: Number of workers is used as a covariate in this analysis of variance. The categories used are 1 adult, 2 adults, and 3 or more adults for number of adults (A) and the five stages for life-cycle stage (L) are as defined in Table 1. Because of sample size limitations, different automobile-ownership categories are used in the two survey years: 0 automobile and 1 or more automobiles for 1963, and 0 or 1 automobile and 2 or more automobiles for 1974. The degrees of freedom for the error terms are 7,059 in 1963 and 1,576 in 1974. Interaction terms significant at $\alpha = 0.01$ are indicated by bold-faced numbers. All rows total 100.

TABLE 7 ANALYSIS OF VARIANCE OF NUMBER OF ADULTS AND AUTOMOBILE OWNERSHIP EFFECTS ON HOUSEHOLD TRAVEL PATTERNS: OLDER HOUSEHOLDS

	Effect (degrees of freedom)				
	A (2)	C (2)	AC (4)	W (1)	Error
No. of trips					
1963	**0.40**	**4.51**	**0.50**	**11.25**	83.33
1974	1.24	0.95	1.17	**5.13**	91.51
No. of driver trips					
1963	0.11	**8.79**	0.20	**6.20**	84.71
1974	0.78	**1.61**	1.05	**6.05**	90.52
No. of passenger trips					
1963	**1.54**	**1.13**	**1.34**	2.24	93.75
1974	0.80	0.03	1.36	0.30	97.51
No. of automobile trips					
1963	0.18	**6.80**	**0.71**	6.56	85.76
1974	1.17	0.96	1.33	5.15	91.39
Travel time expenditure					
1963	0.22	**2.10**	0.41	**5.94**	91.34
1974	0.46	0.68	0.71	0.39	97.76
Total driver trip time					
1963	0.07	**7.51**	0.27	2.63	89.52
1974	0.19	0.87	0.69	0.47	97.78
No. of trip chains					
1963	**1.28**	**4.43**	**0.98**	**9.73**	83.58
1974	**1.56**	**1.43**	1.53	**4.80**	90.68
No. of work trips					
1963	**0.33**	**0.88**	**0.31**	**40.83**	57.65
1974	0.25	0.04	0.04	**39.89**	59.77
No. of joint nonwork trips					
1963	**0.90**	1.45	**1.51**	**0.39**	95.75
1974	**1.72**	0.11	1.35	**2.33**	94.49
No. of maintenance trips					
1963	0.31	**2.16**	0.34	0.07	97.12
1974	0.60	0.75	0.47	**1.22**	96.95
No. of social-recreational trips					
1963	0.27	**1.65**	0.25	**0.26**	97.58
1974	0.89	0.21	1.10	**1.64**	96.16
No. of serve-passenger trips					
1963	0.13	**1.33**	0.42	**3.02**	95.10
1974	0.67	0.04	0.39	0.19	98.71

Note: This tabulation includes the household life-cycle stage 5 (head's age no less than 45 years, no children). Number of workers is used as a covariate. The categories used are 0, 1, and 2 or more for number of automobiles and 1, 2, and 3 or more for number of adults. Bold-faced numbers are significant at $\alpha = .01$. All rows total 100.

SUMMARY AND CONCLUSIONS

The earlier analysis of 1963 and 1974 nuclear-family households indicated that the effect of automobile ownership on trip rate, travel time expenditure, and activity engagement is diminishing. This study broadens this finding to include households of all types.

Examination of the trip rates of all of the households in the 1963 and the 1974 samples shows that, although trips per person did not change much over the 11 years between the two surveys, the trips per automobile decreased considerably, which indicates that households with lower propensity to travel were joining multicar households. Furthermore, the difference between the trip rates of one-car and multicar households, which was clear in 1963, was much less discernible in 1974. The variance explanation of automobile ownership on total driver time, which is a reasonable surrogate for vehicle miles traveled by the household, was approximately 10 percent in 1963 and decreased to only 1 percent in 1974.

Three different analyses, ANOVA using automobile ownership and household size as classifiers, a log-linear model of multidimensional classification table analysis, and a multidimensional ANOVA with a covariate, the last two of which used more extensive household composition classifications, found large decreases in the association of automobile-ownership classifications and travel pattern indicators. This was true for all of the households in the sample examined collectively and also for households in later stages of life cycle.

The analysis of this study also indicates that the effectiveness of the cross-classification analysis based on automobile ownership and household size in household trip generation analysis has decreased substantially. The variance in household trip generation explained by this cross-classification scheme decreased from 12 percent in 1963 to 3 percent in 1974. When household size was replaced with a more extensive descriptor of household composition, the variance explained by the descriptor together with automobile ownership was about 10 percent in both years. The result implies that household size is no longer an adequate descriptor of household composition, which presumably has more direct and stable association with household travel patterns.

This analysis has consistently indicated that automobile ownership and household size are not as effective classifiers in household travel demand analysis as they are generally believed to be. It is difficult to challenge such a widely practiced household trip generation procedure as the cross-classification by automobile ownership and household size. However, when this classification scheme was being developed and when automobile ownership was indeed strongly associated with travel behavior, this country was in earlier stages of motorization. If automobile-ownership effects have been changing with motorization, it is probable that trip generation procedures have been established on the basis of transient relationships. The results of this study urge a fundamental and critical review of the existing trip generation procedures.

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Availability of Information and Dynamics of Departure Time Choice: Experimental Investigation

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The effect of information availability on the dynamics of user behavior in urban commuting systems is investigated through an experimental procedure that involves real commuters interacting in a simulated traffic system under two distinct informational situations: in one only the decision maker's own performance on the previous day is available, and in the other complete information about the system's performance on the previous day is available. The results are examined from the perspective of a theoretical framework articulated previously in conjunction with the results of the first, limited-information, experiment. The focus of this paper is on the results of the complete-information experiment relative to those obtained in the first one. It is found that additional information raises users' aspiration levels and generally improves their predictive capability, but results in greater day-to-day departure time switching and longer convergence periods to a steady state, which is superior, in terms of user costs, to that attained under limited information.

The dynamics of individual choice behavior in transportation systems remain one of the least understood aspects of travel demand analysis. Of particular interest are the dynamics of trip-timing decisions, which determine the time-varying flow patterns in commuting systems and are important elements in the design and evaluation of peak-period congestion relief strategies. A major source of complexity in addressing these phenomena is the dynamic interaction between user decisions and the system's performance, which greatly diminishes the ability of conventional survey methods to generate observational data at a meaningful level of richness within practical resource constraints.

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Recently, a promising experimental approach was proposed by Mahmassani et al. *(1)*, whereby real commuters were involved during a period of 24 days in a simulated traffic system. The consequences of individual departure time decisions on a given day were evaluated by simulating traffic patterns in the system resulting from the aggregated time-varying departure functions. Given feedback from the simulation, participants would select their departure time for the next day. This approach provides a useful alternative to prohibitive large-scale, real-world experiments for studying the commuting system's overall behavior and dynamic properties as well as the behavioral mechanisms that govern the day-to-day choices of individual trip makers. In particular, it can effectively support theoretical development and model building, which could be subsequently validated, if only in part, in the field.

One of the attractive features of this approach is that it affords the analyst a high degree of control over the information available to participants, thereby allowing the investigation of the effect of availability of information on the system's dynamic properties. In the first such experiment conducted *(1, 2)*, the informational situation considered was one in which users had only their own experience to rely on. Everyday, participants were provided with their performance on the previous day, in the form of an arrival time at the work destination.

A theoretical framework for the day-to-day departure time decision-making dynamics of individual commuters was presented by Mahmassani and Chang *(2)*, along with the results of that first experiment. The principal behavioral hypothesis were subsequently verified through the calibration of individual choice models *(3, 4)*. In particular, user behavior under limited information in the commuting system was viewed as a dynamic boundedly