Factors Affecting Automobile Ownership and Use

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Factors affecting automobile ownership, effects of the availability of company cars on automobile ownership and travel behavior, and effects of short-term household evolution on automobile ownership were explored using data from two low-density, outer-ring growing suburbs and two high-density, inner-ring stable suburbs. Major findings are summarized. The average number of automobiles per household in the sample was 2.02. The average share of trips by automobile (versus transit) was 84.6 percent for work trips and practically 100 percent for nonwork trips. Life-cycle stage is a major determinant of automobile ownership; its effect is highly nonlinear. Changes in life-cycle stage alone may cause automobile ownership to increase (or decrease) substantially. Also, aging of children tends to increase automobile ownership. The number of persons eligible to drive and the number of workers affect automobile ownership positively, whereas the use of transit is associated with reductions in automobile ownership. Location of residence or workplace, or both, and residence relocation into outer-ring, low-density suburbs affect automobile ownership positively, whereas workplace locations in the central city affect automobile ownership negatively because of the availability of high-quality commuter rail service. The availability of company cars increases automobile ownership by 9 percent. The travel characteristics of those with company cars are affected significantly by the availability of an essentially free vehicle. There is some evidence that the increasing availability of company cars may increase daily vehicle miles of travel and, consequently, worsen traffic congestion.

The analyses in this paper are based on a sample of 1,420 respondents to a 1989 survey of Chicago suburbs. The following analyses are presented: (a) a static analysis to identify factors that currently affect or explain household automobile ownership; (b) an exploration of the effects of company car availability on automobile ownership and travel; and (c) a dynamic analysis of the effects of short-term household evolution on household automobile ownership.

The data include extensive demographic and socioeconomic information about households as well as detailed information on the automobile fleet available to each household. The data also include limited retrospective information on these variables for 2 years before the time of the survey (i.e., 1987); these were gathered to address issues of short-term dynamics of household automobile ownership. In addition, a weekday travel diary was completed by almost each respondent (typically an adult household member).

Four suburbs were included in the survey: two outer-ring, low-density growing suburbs (Naperville and Schaumburg) and two inner-ring, high-density (i.e., 9,700 residents per mi^2) stable suburbs (Park Ridge and Wilmette). Low density is defined as 4,600 residents per square mile, and high density as 9,700 residents per square mile. This classification of suburbs and the survey selection were taken from earlier findings (*1–4*).

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OVERVIEW OF SAMPLE

Compared with nationwide averages, the sample (Table 1) contains marginally older people [i.e., United States average was 31.4 in 1984 (*5*) and is expected to be 34.1 in 1989 (*6*)] and larger households [i.e., the 1985 nationwide average was 2.75 and dropping (*5*)]. The households in the sample earn a much higher income than the nationwide average, which was about $30,000 in 1989. (All dollar figures in this paper reflect 1989 conditions.)

Younger, larger, and less-affluent households reside in outer-ring, low-density growing suburbs. More outer-ring suburban households have children living at home. Outer-ring suburban households have more workers, and their automobile ownership is higher in terms of number and worth of automobiles owned than inner-ring suburban households. The differences in all the characteristics between outer- and inner-ring suburbs are significant at the 95 percent level (Table 1).

Automobile ownership is high and steadily increasing for all four suburbs surveyed; the percentage of households owning two or more automobiles was 62.2 percent in 1980 (census), 72.2 percent in 1987 (retrospective part of survey), and 75.1 percent in 1989.

Most household vehicles reported are passenger cars (83.3 percent), whereas 11.0 percent are station wagons or passenger vans, and 5.7 percent are cargo vans or pickup trucks. The U.S. manufacturers have the lion's share (71.5 percent); Japanese brand-name automobiles come next (18.7 percent) and European automobiles follow (9.2 percent). The average age of vehicles owned is low (4.4 years) compared with the nationwide average [6.9 years in 1983 and climbing (*4,5*)].

Automobile ownership increased roughly by 1.5 percent a year from 1987 to 1989—a high rate given that automobile ownership in the sampled suburbs is already high. Part of the reason is that the period between 1987 and 1989 was marked by extraordinary financial incentives from domestic and foreign manufacturers. Since then, new car sales have decreased substantially. Another part of the reason is that about half of the sample contains people who either reside in or relocated from inner-ring suburbs, the central city, or other areas outside the Chicago metropolitan area to outer-ring, lower-density suburbs; such locations have a strong positive asso-

TABLE 1 Characteristics of Suburbs

Characteristics	OUTER RING	INNER RING	ALL
Population Age	31.7	37.8	34.5
Household (HH) Size	2.9	2.8	2.85
Number of Workers	1.7	1.5	1.6
% of HHs with Children	54.3	49.2	52.0
Average HH Income	59,500	67,200	63,000
Automobiles per HH	2.07	1.96	2.02
Median Worth of HH Autos	13,000	12,000	12,700

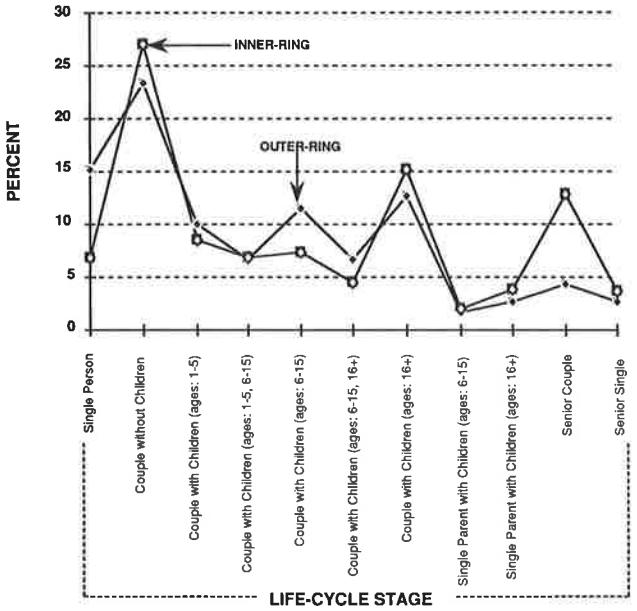

FIGURE 1 Life-cycle stage distributions in outer- and inner-ring suburbs.

ciation with increases in automobile ownership, as discussed later in detail.

The life-cycle stage of a household describes its position in the cycle of life. The life-cycle stage distributions are substantially different between outer- and inner-ring suburbs, as Figure 1 indicates. In Figure 1, several children-age categories for the Single Parent with Children life-cycle stage are not present because of lack of data.

STATIC ANALYSES OF AUTOMOBILE OWNERSHIP

In the static analyses section, descriptive and variance and regression analyses are used to identify associations between potential causal factors and automobile ownership. The last part of this section presents a detailed analysis on the associations and effects of company cars on automobile ownership.

Factors Affecting Automobile Ownership

The number of automobiles and its variants (i.e., automobiles per driver and total worth of household automobiles) are analyzed extensively. These three variables include owned and leased cars and company cars available to the household.

The independent variables used are defined as follows:

- LC STAGE 11 is the original list of life-cycle stages (Figure 1);
- LC STAGE 4 is an aggregate list of life-cycle stages compiled from the original list of 11 stages as follows:
  - –Early (Stages 1 and 2),
  - –Child-development (Stages 3, 4, 5, and 8),
  - –Child-independent (Stages 6, 7, and 9), and
  - –Senior (Stages 10 and 11).
- WORK FULL is the number of full-time workers in the household;
- HHSIZE is the household size (range, 1 to 6);
- DRIVERS is the number of household members eligible to drive (i.e., at the age of 16 or older) irrespective of the extent that the privilege is exercised;
- INCOME CAT represents total household income categories specified as follows:
  - –Less than $32,500,
  - –At least $32,500 but less than $57,500,
  - –At least $57,500 but less than $100,000, and
  - –$100,000 or more.
- TRANSIT represents the use of public transportation (1 if at least one trip in the 1-weekday travel diary was made by mass transit, and 0 otherwise);
- DENSITY represents the type of community in which the household resides (1 = low-density, outer-ring, and 0 = high-density, inner-ring);
- SUBURBS is the number of household workers who work in a suburb other than the one in which they reside (range = 0 to 4);
- SAME is the number of household workers who work in the suburb in which they reside (range = 0 to 2);
- CITY is the number of household workers who work in the non–central business district (CBD) central city of Chicago (range = 0 to 3);
- CBD is the number of household workers who work in Chicago's CBD (range = 0 to 2).

Analysis of variance indicated that the number of household members eligible to drive had by far the largest effect on automobile ownership; it overshadowed the contribution of most other variables. Excluding this variable from specifications revealed that (a) life-cycle stage has the highest contribution in the amount of variance explained (12 percent), (b)

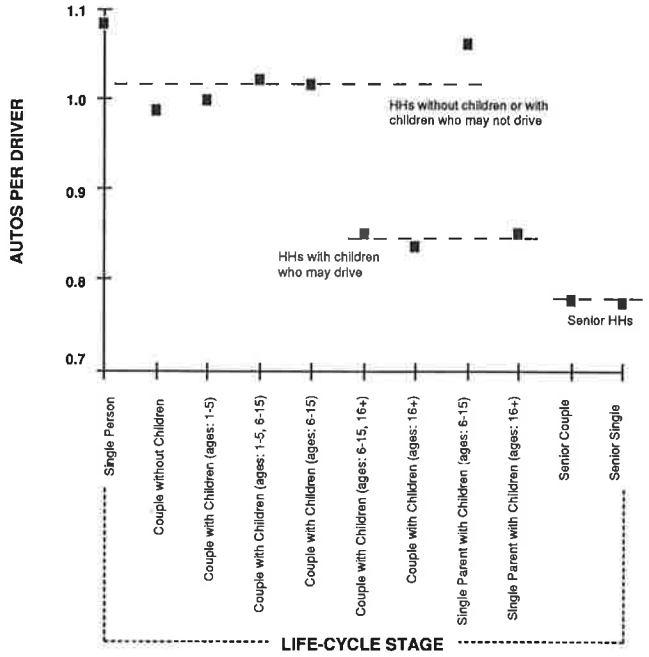

FIGURE 2 Distribution of ratio of automobiles per driver across life-cycle stages.

aggregate life-cycle stage (4 stages) does not work as well as the original 11-stage classification (5 percent), (c) residence location and location of work are important and significant contributors (DENSITY, 6 percent; all workplace variables combined, 11 percent), (d) public transportation use has a large and significant effect (9 percent), and (e) size (4 percent), number of full-time employed workers (7 percent), and household income (3 percent) all have a significant effect on household automobile ownership (*4*).

Of all workplace variables, SUBURBS has by far the largest contribution in the portion of variance explained, which signifies the need for more automobiles if the workplace is in a suburb, since currently public transportation service is limited among Chicago suburbs.

The most powerful explanatory factors—life-cycle stage, drivers, and income—are discussed further. Figure 2 shows that automobile availability is low (i.e., approximately 0.85 automobile per driver) at life-cycle stages describing families with children eligible to drive (i.e., child-independent stages 6, 7, and 9); it takes a relatively stable value around 1.0 automobile per driver over stages describing either families with children who cannot drive (i.e., child-dependent stages 4, 5, and 8) or early-stage households (HHs) (i.e., Stages 1, 2, and 3); and it reaches a minimum around 0.77 automobile per driver at very advanced life-cycle stages (i.e., senior couples or singles).

The trend of automobile availability across life-cycle stages suggests a maturing over time with respect to automobile acquisition, that is, households in advanced stages (i.e., 6 to 11) seem to be better at rationing and using their automobile fleet by assigning roughly 0.90 automobile per driver, whereas in early stages there is a tendency to own more automobiles than appear to be necessary (i.e., in several stages more than one automobile is available per driver). At advanced stages, with more drivers in the household, families may come up against income constraints that prevent them from maintaining the automobile-per-driver levels achieved in earlier stages.

The number of drivers and income are important variables that partially explain household decisions concerning automobile ownership. Table 2 presents the level of automobile ownership by household income categories and number of drivers. Income per person is used instead of household income not only because household size is implicitly accounted for, but also because this is a more objective representation of a household's financial ability given that total income must cover the needs of a variable number of persons (e.g., a two-person household earning $50,000/year can afford higher expenditures than a four-person household earning the same income). Among other things, the former household is financially better equipped to buy an automobile and to participate in activities, which in turn increases mobility needs.

The results in Table 2 indicate that the number of drivers (i.e., people who can fulfill their transportation needs by driving) is a much stronger force driving automobile ownership than income, which has a positive but marginal effect on automobile ownership. Economics of scale are clearly identifiable: households with one or two drivers own roughly one or two automobiles, respectively, and households with three or more drivers own roughly 20 percent fewer automobiles than the respective number of drivers.

The reason that income has only a marginal effect on household automobile ownership may be that for this relatively high income sample, the ability to buy automobiles is less important than the need to use them. Therefore, if there is little need for additional automobiles, it is not likely that an additional automobile will be bought, regardless of the fact that there may be no income constraint. This is supported by the presence in the data set of affluent single-person households

TABLE 2 Automobiles by Household Income per Person and Drivers

	INCOME PER HOUSEHOLD PERSON ($ thousands)			
DRIVERS	INC<10	10≤INC<20	20≤INC<30	30≤INC
1	0.89 (28)	0.93 (29)	@	1.09 (144)
2	1.83 (83)	1.92 (300)	1.93 (303)	2.01 (168)
3	@	2.63 (97)	2.61 (33)	2.63 (57)
4+	@	3.18 (66)	3.58 (47)	@

NOTES: (#) = number of households;
@ = insufficient number of observations (0-9).
Figures are from 1989 calculations.

TABLE 3 Worth of Automobiles by Household Income per Person and Drivers (in Thousands of Dollars)

	INCOME PER HOUSEHOLD PERSON ($ thousands)			
DRIVERS	INC<10	10≤INC<20	20≤INC<30	30≤INC
1	4.4 (28)	4.9 (29)	@	8.1 (144)
2	10.9 (83)	12.6 (300)	14.8 (303)	17.6 (168)
3	@	16.6 (97)	23.2 (33)	21.7 (57)
4+	@	18.6 (66)	23.1 (47)	@

NOTES: (#) = number of households;
@ = insufficient number of observations (0-9).
Figures are from 1989 calculations.

and double-income–no-kids households with upper-bracket incomes and relatively low automobile ownership.

Another perspective on the role of income is revealed in Table 3, in which the worth of household automobiles is tabulated with respect to household income per person and number of drivers. It is obvious that larger-income households spend a substantially larger amount of money on automobiles than do lower-income households.

An interesting example of resource allocation is furnished by the second column of Tables 2 and 3 (income per person between $10,000 and $20,000). One-driver households (mostly households having a single person, a senior single person, or a single parent with young children) have no one to share expenses (i.e., rent or mortgage, home equipment). As a result, less capital is left for automobile acquisition: the average worth of each automobile owned is $5,300. Larger households with two or more drivers are able to realize economies of scale. As a result, more capital becomes available for automobiles: the average worth of each automobile owned is $6,500.

The aforementioned interpretations deal with behavior that accounts for the transportation utility of automobile ownership; the value of automobiles owned as well as the potentially confounding role of prestige involved in automobile ownership remain unaccounted for. These issues have been explored previously (*7*).

Automobile Ownership Models

The next step of the analysis was modeling of household automobile ownership. The specifications include all factors that could help in understanding more about the process affecting household automobile ownership decisions.

The model displayed in Table 4 offers a good fit with the data (R^2 = .54) that improves substantially (R^2 = .67) after segmentation across the categories involving the age of the head of the household.

The inclusion of the life-cycle stage variable in the specification is bound to fail because the numerical values assigned to various life-cycle stages do not correspond in any way to the natural meaning of the life-cycle stage concept and its effect on household automobile ownership. The use of dummy variables to represent life-cycle stages resulted in an inferior model fit with a large number of insignificant parameter estimates (see also *Dynamic Analysis of Automobile Ownership*).

The best results for nonsegmented models were obtained by including CHILD DEP, a dummy variable that represents households in child-dependent stages (i.e., stages in which children exist and are all younger than 16 years of age); and SENIOR, a dummy variable that represents senior households in which at least one member is 65 years or older. Another variable used in the model is HHINC$, which is the total household income in thousand dollars.

TABLE 4 Explanatory Household Automobile Ownership Model: Best-Fit Estimation and Best-Fit Segmentation

Model Segment	A L L	Age of Head of Household Categories 35<	35-49	50-64	65+
Dependent	NUMBER OF HOUSEHOLD AUTOMOBILES				
R-squared	0.54	0.67			
Cases	1372	207	520	92	153
Constant	0.23	0.07*	0.68	0.94	0.49
DRIVERS	0.58	0.89	0.51	0.45	0.53
DENSITY	0.14	0.24	0.13	-	-
TRANSIT	-0.28	-0.20	-0.24	-	-
WORK FULL	0.11	-	0.15	-	-
SUBURBS	0.11	-	-	0.24	0.26
CHILD DEP	0.11	-	-	-	n/a
SENIOR	-0.13	n/a	n/a	n/a	n/a
HHINC$	0.004	-	-	-	-

Note: all parameters significant at 95%, except (*)=not sign.
(all estimations with 1989 data)

All factors displayed in the model have a significant impact on household automobile ownership. The number of drivers has the largest positive effect, and use of public transportation has the largest negative effect on automobile ownership. Residence locations in a low-density, outer-ring suburb as well as the number of workers who are employed in the suburbs (with little public transportation for suburb-to-suburb commutes) increase household automobile ownership. All variables except TRANSIT and SENIORS have a positive effect on automobile ownership.

Being at a child-dependent stage increases automobile ownership, whereas being at a senior stage decreases automobile ownership. There are many more households in child-dependent stages in outer- (36.4 percent) than in inner-ring suburbs (29.0 percent), and many more senior households in inner- (16.6 percent) than in outer-ring suburbs (6.9 percent). The significant difference in automobile ownership between outer- (i.e., 2.07 automobiles per household) and inner-ring suburbs (1.96 automobiles per household) can be partly explained by the various underlying life-cycle stage distributions in each type of community.

The model specifications in Table 4 show, however, that despite the inclusion of major socioeconomic, locational, and transportation supply variables, the DENSITY variable remains significant. The variable may account for other factors in outer- and inner-ring suburbs, such as intra-household age structure differences, underlying cultural differences, or differences in spatial arrangements of land uses and the transportation systems connecting them.

Several estimations across various population segments were explored (e.g., age of household head, life-cycle stage, household income categories and residence location). Segmentation by the age of the head resulted in a most substantial improvement in model fit (see Table 4). Some variables from the full specification were omitted from this final estimation, either because they are not applicable (n/a) or because their parameter estimate in earlier specifications was not significant.

Segmentation by age of the head of household reveals that the effect of the number of licensed drivers tends to decrease as the household ages. The effects of residence location and use of public transportation on automobile ownership are significant only for younger households. Also, the number of workers employed in the suburbs has a significant effect on automobile ownership only in older households, in which multiple workers are more common.

Company Cars

This section presents a detailed investigation of the effects of company car availability on individual and household transport behavior characteristics.

In a study conducted in the United Kingdom, Bates et al. point out that employer financing or subsidy of automobile costs has important effects on the household's decisions about automobile ownership and use (*8*). The availability of company cars increases the actual household automobile ownership through two causal chains: (a) the household disposable income is effectively increased, and (b) restrictions in the use of company-financed vehicles force households to maintain additional vehicle(s). Bates et al. also noted that company car users tend to live farther from work and that automobiles are provided predominantly according to status instead of to job performance requirements. These results may carry cultural or historical biases (1969–1975 data from the United Kingdom).

The analysis strategy matched groups of households with and without company cars in terms of the number of drivers, number of workers, number of automobiles available, and income bracket. The only difference is that the automobile ownership of the one group is equal to n owned or leased automobiles, whereas the automobile ownership of the other group is equal to $n - 1$ owned or leased automobiles plus one company car; so both groups of households have an identical number of automobiles available.

The results of this investigation are summarized in Table 5. The sample includes 67 households that had one company car available and 410 similar households that had no company

TABLE 5 Effects of Company Cars on Transportation Behavior of Individuals Who Use Them

#CARS	DRV	WRK	HH INCOME	Cases	% DRIVE ALONE TO WORK	% WORK in SUBURBS	DISTANCE by AUTO (miles)
1+C	2	1	$57,500-	12	*100.0	81.8	*48.1
2	2	1	$99,999	86	66.7	52.9	28.3
1+C	2	2	$57,500-	21	*90.5	86.4	*66.1
2	2	2	$99,999	147	82.7	81.9	37.9
1+C	2	1	$100,000	7	*100.0	71.4	N42.6
2	2	1	or more	56	69.8	44.2	37.8
1+C	2	2	$100,000	20	*100.0	70.0	@49.2
2	2	2	or more	107	75.8	58.1	35.0
2+C	3	3	$100,000	7	@100.0	71.4	@58.4
3	3	3	or more	14	69.2	64.3	36.1

NOTES: DRV=number of household drivers; WRK=number of household workers; (*)=comparison significant at 95%; (@)=comparison signif. at 85%; (N)=comparison not signif.

car available. The respondent is the primary driver of the company car in 65 of the 67 selected households that have a company car available. The actual number of households with company cars in the sample is 164 (11.5 percent of the sample), but the socioeconomic profiles are so widespread that only 67 belonged to groups of sufficiently high membership to support statistical analysis.

The results in Table 5 suggest that the availability of a company car causes several substantial and, in many cases, significant differences in transport behavior. To begin with, the commute to work by those with company cars is being made exclusively by automobile; in most cases it is drive alone (i.e., 100 versus 67 percent for the first group in Table 5, or 97 versus 73 percent overall—weighted average of all groups in Table 5). Also, the overwhelming majority of company car users work somewhere in the suburbs (including the suburb in which they reside). This proportion is much lower for respondents from similar households without a company car (i.e., 82 versus 53 percent for the first group in Table 5 or 78 versus 64 percent overall—average of all groups in Table 5).

The total distance traveled by automobile on the 1 weekday for which the respondent reported is in most cases significantly higher for owners of company cars than for those without company cars. This finding is largely because company car owners need to travel more for work-related purposes: company car owners travel 29.4 mi for such purposes, whereas respondents from similar households without a company car travel 11.0 mi (averages from all groups in Table 5).

The latter may be partly attributed to the substantial difference in occupations between the two groups, as the following distributions of occupations indicate:

Occupation	*Respondent with Company Car*	*Respondent Without Company Car*
Managerial/business owner	48.6	29.2
Sales	31.4	10.9
Professional/technical	12.9	45.2
Other	7.1	14.7
Total	100	100

The proportion of salespersons in the group with the availability of a company car is three times higher, and the proportion of managers or business owners is nearly two times higher than the group without the availability of a company car. Thus, company cars are seemingly more available to travel-intensive occupations. (This does not preclude use of the company car for personal trips. It is possible that a number of household trips are diverted to the company car from the owned automobiles.) In contrast to the study by Bates et al. (*8*), which noted that company cars are given mostly to high-status employees, in the United States (the Chicago suburbs to be exact) company cars seem to be available mostly for employees who need to travel extensively. Of course business owners may have the power to purchase company cars independent of their business travel needs.

The degree of substitution between company and privately owned automobiles is revealed in the following automobile ownership model (in which all parameters are significant at 95 percent):

$$\begin{aligned}\text{HH AUTOS} = {} & 0.39 + 0.27 * \text{COMPANY} \\ & + 0.10 * \text{DENSITY} + 0.13 * \text{CHILD DEP} \\ & + 0.14 * \text{WORK FULL} \\ & - 0.19 * \text{TRANSIT} + 0.10 * \text{SUBURBS} \\ & + 0.59 * \text{DRIVERS} \\ & - 0.14 * \text{SENIOR} \qquad R^2 = .53\end{aligned}$$

This model indicates that the availability of a company car increases the automobile ownership of households by 0.27 automobile, which corresponds to an average increase of about 9 percent. In other words, only 9 percent of the households maintain the regular household fleet plus the company car; the rest of them (91 percent) substitute a household-owned automobile with the company car—that is, if a company car is available, they do not buy an additional car. This means that the cost of owning and operating a second or third household automobile (the company car) is partly or entirely absorbed by a company; therefore, the annual household income effectively increases by the amount of the subsidy, thereby increasing the overall ability of the household to participate in activities and to travel.

The Internal Revenue Service requires that company cars be reported for taxation as fringe benefits. One method for estimating the contribution of a company car to a household's income is the *annual lease value method*, according to which the fair market value of the company car is assessed when given to the employee. Then an annual lease value for the first 4 years is computed; for example, a car worth $11,000 in 1990 has an annual lease value of $3,350 for the years 1990 through 1993. This value is to be added to the household's income. For the next 4 years, assuming that the same company car is available to the household, the fair market value is reassessed and the new annual lease value is estimated (*9*).

The proportion of households with the availability of a company car is 13.5 and 10.4 percent in outer- and inner-ring suburbs, respectively; the 3.1 percent difference is statistically significant at the 91 percent level. The outcome that more households with company cars were captured in outer-ring suburbs agrees with the outcome of Bates et al., who found that company car users tend to live farther from work. Furthermore, 12.7 percent of those households that relocated between 1987 and 1989 had the availability of a company car, whereas only 11.3 percent of those that did not relocate had the availability of a company car. These may be indications that companies essentially subsidize (affordable) distant housing.

DYNAMIC ANALYSIS OF AUTOMOBILE OWNERSHIP

The objective of this part of the analysis is to explore the potential causal links between changes in household characteristics (i.e., life-cycle stage, household size, number of workers and residence location) and changes in household automobile ownership between 1987 and 1989. Several limitations apply to this part of the analysis because of the restricted breadth

of the retrospective part of the questionnaire survey. Information about incomes, work locations, and use of public transportation and company-subsidized automobiles is not available for 1987; thus their changes between 1987 and 1989 cannot be estimated and analyzed. As a result, outcomes from this part of the analysis can serve only as indications of potential associations between changes in causal factors and changes in automobile ownership.

This objective was approached using analysis of variance and regression modeling. The following variables were used:

- *Dependent Variable*
  - DCARS: automobile ownership difference = (1989 automobiles) − (1987 automobiles).
- *Independent Variables*
  - DHHSIZE: difference in household size = (1989 size) − (1987 size);
  - DWORKFULL: difference in number of full-time employed household workers = (1989 full-time workers) − (1987 full-time workers);
  - DDRIVERS: difference in number of persons eligible to drive in the household; the variable takes integer values from −3 to 2.

Residence location changes between 1987 and 1989 are defined with three dummy variables:

- SUBURB: 1 = relocated from another suburb, 0 = no change;
- CITY: 1 = relocated from city of Chicago, 0 = no change; and
- FAR: 1 = relocated from some place outside metropolitan Chicago, 0 = no change.

DSTAGE is the change in household life-cycle stage. The effects of the change of life-cycle stage (DSTAGE variable) on automobile ownership are nonlinear; thus, a special procedure was devised to determine appropriate values. This procedure involved the estimation of a linear regression automobile ownership model in which each life-cycle stage was included as a dummy variable. The parameter estimates represent the effect of each life-cycle stage on automobile ownership. Then, these estimates were used in a dynamic model. Automobile ownership models with life-cycle-stage dummy variables were estimated with both 1987 and 1989 data. All parameters but one were significant in the 1987 model, whereas five parameters in the 1989 model were not significant. The 1987 model was used (*4*). Although its overall goodness of fit is mediocre (R^2 = .34), all parameters are significant and intuitive in sign and relevant size; therefore, the model was used with confidence.

The model includes major factors such as residence location, household size, and workers in the specification; thus, the parameters for each life-cycle stage largely express the effect of each life-cycle stage on automobile ownership. These parameters were used to create a matrix, the cells of which contain the specific effect of changing stages on automobile ownership. For example, a change from Stage 2 to Stage 3 results in a decrease of automobile ownership by 0.28 automobile. A small part of this matrix is illustrated. The 121 values contained in the full 11-×-11 matrix in Table 6 are the values for the DSTAGE variable (*4*).

The use of the DSTAGE variable relies on the assumption that the effects of life-cycle stage on automobile ownership remain the same in 1989 as in 1987. Application of the F_{CHOW} test between the 1987 and 1989 models did not reject the null hypothesis that the parameter estimates of the two models are equal (*4*); therefore, changes in tastes and needs caused by changes in culture and economy were assumed to be negligible (over the 2 years studied).

The best-fit linear regression specification for the dynamic model is presented next; all parameters are significant at 95 percent.

$$\begin{aligned} DCARS = {} & 0.087 + 0.206 * DHHSIZE + 0.139 * DWORKFULL \\ & + 0.249 * DDRIVERS + 0.378 * DSTAGE \\ & - 0.148 * SUBURB + 0.209 * CITY \\ & + 0.115 * FAR \qquad R^2 = .23,\ F = 60,\ n = 1{,}415 \end{aligned}$$

The model suggests that increases in household size and number of workers and drivers have a positive effect on household automobile ownership. The mediocre overall fit of the model may be because (a) the period covered is short, and only two time points are available; and (b) several explanatory variables could not be included because they are not known for 1987.

The parameter of the DSTAGE variable must be multiplied by the appropriate value corresponding to each particular life-cycle change (i.e., for change from Stage 1 to Stage 2 the value is 0.34) to estimate the effect on the change in automobile ownership. This effect can be positive, negative, or zero; based on the model estimate, the range of the effect of life-cycle stage change varies between −0.4 and +0.4 auto-

TABLE 6 Matrix of DSTAGE Values

CHANGE IN AUTOMOBILE OWNERSHIP		TO (1989 LIFE-CYCLE STAGE)				
		1	2	3	4	. . .
FROM (1989 LIFE-CYCLE STAGE)	1	0	0.343	0.061	-0.008	
	2	-0.343	0	-0.282	-0.352	
	3	-0.061	0.282	0	-0.070	
	4	0.009	0.352	0.069	0	
	.					
	.					
	.					

mobile, that is, in several cases it may have a powerful effect on automobile ownership.

The estimates for the relocation variables indicate that relocation from Chicago (CITY) and from another state or abroad (FAR) have a positive effect on automobile ownership, whereas relocation from another suburb (SUBURB) has a small negative effect on automobile ownership, possibly because some people relocate to certain locations to take advantage of their better public transportation supply or to get closer to their workplace.

Although part of the effect of missing variables is likely to have been captured by the constant, their absence probably affects, to an unknown degree, the magnitudes of the estimated parameters. Thus, all outcomes in this section should be treated with caution. The results probably serve as good indications of associations between changes in causal factors and changes in automobile ownership, but they may not be used to quantify the effect of independent variables on the dependent variable.

CONCLUSIONS AND DISCUSSION OF RESULTS

This paper presented a multiperspective investigation aimed at identifying static and dynamic factors affecting suburban household automobile ownership. Key findings are summarized below, followed by a short discussion.

- The life-cycle stage, number of persons eligible to drive, and household income are the major socioeconomic factors affecting household automobile ownership.
- The location of residence in outer-ring, low-density growing suburbs, as well as the location of workplace in the suburbs, increase household automobile ownership.
- Automobile availability (i.e., automobiles per driver) is 9 percent higher in outer- than in inner-ring suburbs; this is partly because most of the population of outer-ring suburbs is in early life-cycle stages with high automobile availability, whereas most of the population in inner-ring suburbs are senior households with low automobile availability.
- Relocation from the central city (Chicago), another U.S. state, or abroad to a suburb has a strong positive effect on automobile ownership.
- Higher-income households own more expensive rather than more automobiles than lower-income households with the same number of drivers.
- Economies of scale with respect to automobile ownership are clear: smaller households (i.e., with up to two drivers) own a number of automobiles equal to the number of drivers in the household, whereas larger households (i.e., with three or more drivers) own approximately 20 percent fewer automobiles than the number of drivers.
- Availability of a company car increases the average household automobile ownership by 0.27 automobile. Most households (91 percent) substitute company cars for household-owned cars, which translates into substantial income benefits for households with the availability of a company car.

This study indicates that "traditional" demographic and socioeconomic factors continue to have close associations with household automobile ownership. In addition, life-cycle stage, location of residence and employment, public transportation use, and company car availability affect automobile ownership. These less traditional but important factors affecting automobile ownership are discussed in the following.

There are indications that changes in life-cycle stage affect automobile ownership substantially. The effect is clearly nonlinear: the change from single person to couple marginally decreases automobile ownership; the change from couple without children to couple with young children increases automobile ownership; the change from couple with young children to couple with children, some of whom are eligible to drive, increases automobile ownership substantially; and most changes to single parent or to senior households decrease automobile ownership.

Location of residence in outer-ring suburbs and location of the workplace in the suburbs have positive effects on automobile ownership characteristics (i.e., automobile ownership and availability are 5.6 and 8.9 percent higher in outer- than in inner-ring suburbs, respectively).

Use of public transportation has a negative effect on automobile ownership. The lower automobile ownership characteristics in inner-ring suburbs can be partly attributed to the fact that public transportation services are much better in these locations: not only is more service available, but transit can serve most work trip commuting destinations of inner-ring suburb workers (i.e., central city destinations).

Whether the higher automobile ownership in outer-ring suburbs is a cause or an effect, the implications of this finding for congestion in the developing suburban fringe are significant and serious. More automobiles are connected with more travel and more pressure on the limited roadway network.

The number of eligible drivers in a household was found to be the most significant factor determining household automobile ownership across most social groups. It is theorized that the causal link lies among the following three facts: (a) irrespective of age, people face certain needs and activity sets—they need a means of transportation to fulfill these needs and to participate in activities; (b) public transit diminishes as a transportation option in the suburbs, particularly in outer-ring suburbs; and (c) most members of today's households are "busy with their lives" (i.e., work, school, individual exercise, and social activities), which is partly an outcome of the individualism and freedom of expression in modern society (more so in the United States than in other western societies). Therefore, there is little time left to serve other members of the household and less homogeneity in tastes and activities, which limits opportunities to consolidate destinations and share automobile usage. Thus, it is beneficial (if not necessary) to have an automobile available for every person in the household who is eligible to drive.

Individuals who have a company car available travel much longer distances by automobile; the automobile also is their exclusive means of travel to work. There is some evidence that more of them tend to reside farther away (outer-ring, low-density suburbs) as well. Thus, the availability of company cars may be fueling congestion because high use and long commutes by automobile become affordable.

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