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The relation between transit availability and automobile ownership: the case of Los Angeles County

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Introduction

The primary objective of this research is to examine the relationship between transit availability and automobile ownership of households, with special reference to the low-income population of Los Angeles. National data show that during the last few decades there has been a significant increase in automobile ownership among low-income households in general (Bureau of Transportation Statistics, 1990; Millar, Morrison, and Vyas, 1986). In fact, among all income groups, the increase in auto ownership has been the highest for the lowest income group (Millar, Morrison, and Vyas, 1986). Since low-income households have traditionally constituted a large segment of the transit market, the recent increases in their automobile ownership make one wonder whether, or to what extent, mass transit continues to serve the travel needs of these households.

The 1990 Nationwide Personal Transportation Survey reveals that approximately 61 percent of the households earning an annual income of less than

$10,000 had at least one vehicle at their disposal in 1983 (Bureau of Transportation Statistics, 1990). By 1990, however, this proportion increased to more than 65 percent, indicating a rapid increase in vehicle ownership among the poor during the intervening period.

Since a majority of the carless households in the country are poor, the changes in the proportion of carless households also indicate to some extent the changes in automobile ownership among the low-income households (Bureau of Transportation Statistics, 1990; Lave and Crepeau, 1994). The number of carless households in the country decreased from 11.4 million in 1960 to 10.6 million in 1990 in spite of a significant increase in the total number of households during this period (Pisarski, 1996). In terms of percentage change, the proportion of carless households decreased from 21 percent in 1960 to 11.5 percent in 1990. When New York City was excluded, the proportion of carless households in the country amounted to only about 9 percent (Lave and Crepeau, 1994). The proportion of carless households in certain urban areas is even smaller. For example, in Los Angeles County, the study area for this research, less than 5 percent of the households are currently carless.[1]

For empirical analysis, this research uses household-level data from the 1991 travel survey conducted by the Southern California Association Governments (SCAG). In addition to the household-level data from the 1991 travel survey, census tract-level data from various other sources have been used. The study area is restricted to Los Angeles County. The county was chosen as the study area because of several reasons. *First*, since the poverty population in the county is very large, transit policies are likely to affect a large number of the low-income households. The extent of poverty in the county is apparent from the fact that approximately 1.3 million of its inhabitants, or 15 percent of the total population, live below the poverty level. According to Wolch

(1998), about one in four of the county's residents received some form of welfare benefits in 1995. *Second*, mobility problems of low-income and minority populations in Los Angeles have historically attracted a lot of attention even at the national level, as evident from the federally organized reverse-commuting projects of the 1960s (Meyer and Gomez-Ibanez, 1981). *Third*, the economy of the region has been performing rather poorly in the 1990s (Lee, 1997). Since it is the poor who are most affected at times of economic distress (O'Sullivan, 1996), there is an increasing need to address the mobility problems of the region's low-income households, especially of the workers from these households. *Fourth*, there is a growing concern that mass transit in Los Angeles is becoming increasingly inequitable and detrimental to the travel needs of the low-income population (Rubin and Moore, 1996, 1997). *Finally*, there have been serious concerns in the recent past about environmental justice issues in the county in regards to provision of transportation infrastructure and services (Bullard and Johnson, 1997; Taylor et al., 1995). These issues led to litigation against the largest transit provider of the region.

Probit and logit analyses with instrumental variables were undertaken for empirical estimation of the model examining the relationship between transit availability and automobile ownership. The basic conclusion from the analyses is that automobile ownership is relatively low in areas with high transit level of service. However, the results indicate that the probability of automobile ownership decreases only slightly with increases in transit services. The analysis also shows that the low-income households in the study area have a low propensity to own automobiles, implying that transit availability may still have considerable importance fulfilling these households' mobility needs.

Income and Travel Mode

Household income is closely related to automobile ownership. For example, the 1990 Nationwide Personal Transportation Survey shows that the average number of automobiles for households with less that $10,000 annual income is merely 1.0, whereas the average for households with income $40,000 or over is 2.3 (Hu and Young, 1993, Table 3.18). One can also observe that 91 percent of the trips made by households with $40,000 or more annual income are made by automobile, whereas only 70 percent of the trips made by households with less than $10,000 are made by this mode (ibid., Table 4.33). The lower proportion of trips by automobile for the low-income households is matched by a higher proportion of trips by transit.

A similar relationship between income and mode can be observed in Los Angeles county also. Table 1 shows a cross-tabulation of household income and automobile ownership. It is evident from this cross-tabulation that the proportion of low-income households decreases drastically as the number of automobiles per household increases, indicating the possibility of a direct or positive relationship between income and automobile ownership. Table 2 shows the relationship between income and mode use. It is evident from the table that individuals from high-income households in the county have a far greater propensity to make trips by automobile than individuals from lower income households. The data also shows that individuals from lower-income households are more likely to use public transit than individuals from higher income households.

Table 1. Percent Distribution of Households by Household Income and Automobile Ownership in Los Angeles County (N= 5,626 Households)

Annual Household	**Percentage Households with**

Income (in $ '000)	0 Auto	1 Auto	2 Autos	3 Autos	4 or More Autos
Less than 7.5	28.67	43.01	17.83	5.59	4.90
7.5-15	18.23	54.51	19.74	5.08	2.44
15-20	7.94	47.89	32.01	7.94	4.22
20-30	3.62	48.94	34.08	9.11	4.24
30-40	2.03	34.82	48.54	10.29	4.32
40-50	0.83	26.14	52.01	15.08	5.95
50-75	0.46	13.00	56.92	20.15	9.47
75-100	1.04	9.88	53.38	21.14	14.56
100-150	0.31	5.96	50.78	26.02	16.93
150 or more	0.00	4.96	47.11	23.14	24.79
All Households	4.87	29.91	43.65	14.01	7.55

Source: Estimated from the SCAG travel survey,1991.

Table 2. Percent Distribution of Trips by Mode and Household Income of Trip Maker in Los Angeles County (N= 35,591 trips)

Annual Household Income ($)	Mode Used	
	Automobile	Local Bus
0-15,000	7.61	39.97
15,000-30,000	16.84	29.83
30,000-50,000	27.80	20.07
50,000-75,000	24.02	6.70
75,000-100,000	12.96	0.90
100,000 or more	10.77	2.53
Total	100.00	100.00

Source: Estimated from the SCAG travel survey, 1991.

The Increasing Rate of Automobile Ownership

Automobile ownership is an important factor determining individuals' mobility and accessibility because this mode is the fastest of all popular urban transportation modes. It is in fact quite common for researchers to heavily emphasize automobile ownership or use as one of the most important factors determining accessibility levels (Koening, 1980; Morris, Dumble, and Wigan, 1979). In addition to being the fastest

mode, an automobile also provides a level of comfort and convenience unparalleled by other modes of urban transportation.

One of the indicators of mobility of an individual or a group is the amount of travel undertaken (Hanson 1995; Bureau of Transportation Statistics, 1997). The faster speed of an automobile provides a greater mobility than other modes. Data from Los Angeles (Table 3) show that workers from households with larger number of automobiles on an average make longer commuting trips. These longer trips are indicative of a greater level of mobility. Due to its ability to provide a greater level of mobility, the automobile is attractive to all individuals, including the poor.

Table 3. Commuting Distance of Workers Belonging to Households with Different Automobile-Ownership Rates in Los Angeles County

Household Automobile Ownership Rate	Average Commuting Distance (Miles)
No Automobile	5.30
One Automobile	7.14
Two Automobiles	10.97
Three or More Automobiles	11.14

Source: Estimated from the SCAG travel survey, 1991.

The increase in automobile ownership among low-income households may be due to several reasons. One reason could be the externalities arising from the extensive use of automobiles by higher-income and middle-income households. Automobile ownership and activity decentralization have aided each other for decades, leading to a dispersed activity location pattern that causes a serious accessibility problem for those without an automobile. It is likely that many of the low-income households have sought a solution to this problem by acquiring an automobile. To understand the relationship of

auto use among low-income households vis-à-vis auto use by higher-income households and activity location pattern, one has to undertake an analysis with temporal data. This study, being conducted with cross-sectional data for a one time period, is unable to examine this relationship.

Another reason for the increase in automobile ownership among low-income households may be the decreasing real cost of automobile ownership and operation during the last few decades. National data indicate that the consumer price index for motor vehicles and parts has increased significantly slower than the price index for commodities as a whole, indicating a decline in the real cost of auto ownership (US Department of Commerce, 1997).[2] At the same time, the consumer price index for gasoline and oil has remained constant since the early 1980s, again indicating a favorable condition for consumers of these products.

Although the consumer price indices indicate that the ownership and maintenance costs of automobile have remained fairy low over the years, when one contrasts these costs with the household income of the poor, the costs may appear rather high. In 1991, the American Automobile Association (1991) estimated the annualized cost of an average compact automobile at $3,526. The Federal Highway Administration (1991) estimated the average annual cost of an intermediate-size automobile at $3,560 for the same year. In contrast, the income threshold for a four-member poverty household was only $13,359 in 1990 (Jennings, 1994). These figures indicate that in order to own an automobile, a four-member household in poverty would have to spend at least a quarter of its income. This may be quite burdensome for poor households. A 1993 Consumer Expenditure Survey by the Bureau of Labor Statistics (1996) indicates that the lowest-income quintile of households spends about 33 percent of their after-tax income on transportation while an average household spends only about 17 percent.

This also indicates that transportation costs impose a greater burden on the household budgets of the poor than the population at large.

Yet another reason for the increase in automobile ownership among low-income households may be the declining quality of transit services. In urban areas like Los Angeles, where mass transit has been accused of being apathetic to the travel needs of the poor, the high rate of automobile ownership among the low-income households may well be the result of inappropriate transit service provision.

Mass Transit for the Poor

The mode that receives the greatest attention as an alternative to the automobile is mass transit. This is in spite of the fact that mass transit carries only about 1.8 percent of all person trips and 5.3 percent of all commuting trips in urban areas of the country (Vincent et al., 1994). Although mass transit had historically been a self-sufficient industry, it has been heavily dependent on government subsidies since the 1960s. With declining fare box revenue and increasing reliance on subsidization, the welfare role of transit seems to have become more important since then.

Since a large section of transit riders belong to low-income and minority households, in certain quarters transit's primary objective is considered to be provision of welfare. According to the American Public Transit Association (1995), one of the major objectives of mass transit is to provide mobility to the transportation disadvantaged, of which the poor constitute the largest segment (Meyer and Gomez-Ibanez, 1981). Needless to say, one of the reasons for subsidization of transit is the expectation that it continues to perform this welfare function.

When society's expectations are growing about transit's role as a provider of welfare, there is also an increasing concern that much of the transit services are being

allocated in a manner that is detrimental, or at least apathetic, to the travel needs of the poor. For example, even though it has been pointed out that transit's most profitable routes are mainly in central cities, where low-income and minority households predominantly live (Cervero, 1990), there has been a growing tendency in the recent past to extend transit routes to suburban areas (Wachs, 1989). In addition, recent years have also seen substantial investments on rail transit projects, even though bus riders on an average have lower incomes than rail riders (Wachs, 1989; Pickrell, 1992; Rubin and Moore, 1996, 1997). The prevailing criticisms about transit's failure to perform its welfare functions provide an impetus to this study.

Location of Low-Income Households

Location of households may be an important consideration when estimating accessibility level of any particular group. The reason is that, all else being equal, if the location of homes is close to location of an activity, there is likely to exist a high accessibility for the population group in question for that particular activity. For example, when the location of a group of households is closer to jobs than another group of households, the former group is likely to have a higher job accessibility level than the latter.

In almost all metropolitan areas of the US, poverty is concentrated mainly in the central cities. The poor have concentrated in central cities for a variety of reasons, including availability of low-skilled jobs in nearby areas, their low wages, discrimination in the suburban housing market, and availability of smaller and low-quality housing units in central areas (Clark and Whiteman, 1981; Kain, 1968). Los Angeles is no exception in regards to concentration of poverty in central locations. In this county, the census tracts with extreme poverty concentration are located around the

downtown and along the Interstate-110 corridor in South-Central Los Angeles. Figure 1 shows the concentration of poverty in census tracts of Los Angeles County. The figure also shows a fair amount of poverty concentration in the City of Long Beach, a large regional center with port facilities.

Variations in Automobile Ownership Rate

A comparison of locational distribution of the poverty population with the locational distribution of automobile ownership rates provides an insight into the mobility of the low-income households in Los Angeles. Figure 2 shows the automobile ownership rates per individual 18 years or older in census tracts of Los Angeles county. It is evident that generally the tracts with central location have the lowest automobile ownership rates, while the suburban tracts have higher rates. Comparison of Figure 2 with Figure 1 shows that automobile ownership is generally the lowest in the areas with high poverty concentration, indicating a potential negative relationship between income and automobile ownership.

Variations in Transit Availability

A GIS-based transit availability index was developed to measure transit availability of census tracts in Los Angeles County.[3] The transit availability index for the census tracts was obtained by using route density and frequency of services on each route. In order to account for walking trips to transit stations/stops outside the census tract of residence, the boundary of each tract was increased by 0.6 miles on all sides for

estimating the index. Transit routes within this extended area was considered accessible to individuals within the census tract. The index was estimated as follows:

$$\left(\sum_{r=1}^{m} L_r F_r \right) \div A_i$$

Where L is the length (miles) of a transit route r within the extended area of the census tract i, F is the hourly service frequency on route r within that area in AM peak period, m is the number of routes within the extended census tract, and A_i is the extended area of the tract (square miles). For the estimation of this index, route maps and frequency of services were collected from all the major transit providers in the county, including Los Angeles County Metropolitan Transportation Authority, Santa Monica Municipal Bus Lines, Culver City Municipal Bus Lines, Long Beach Public Transportation Company, Foothill Transit, City of Torrance Transit System, City of Gardena Municipal Bus Lines, Montebello Municipal Bus Lines, Norwalk Transit System, and City of Commerce Municipal Bus Lines.

In spite of the recent tendency towards suburbanization of transit services, in Los Angeles County transit continues to be provided predominantly in central city areas. This is evident from Figure 3, where availability of transit services in census tracts within Los Angeles County is shown. It is evident that transit availability is significantly higher in the City of Los Angeles than the suburban jurisdictions. Transit availability is particularly high in the east-west corridor along Interstate-10 as well as the Interstate-110 corridor south of downtown Los Angeles. The transit availability index shown in Figure 3 can be compared with the location of low-income populations within the county, as shown in Figure 1. This comparison shows that transit availability index is fairly high in most areas with high concentration of low-income populations. The Interstate-10 corridor west of downtown seems to be the only exception, where

transit availability is high without having a high concentration of low-income populations. A comparison of Figure 3 with Figure 2 indicates that transit availability is fairly high in most areas with low automobile-ownership rates. However, transit availability is also fairly high in some areas with reasonably high automobile-ownership rates, such as the areas along the western half of the Interstate-10 corridor.

The Relationship Between Transit Availability and Automobile Ownership

The foregoing discussion provides an insight into the locational distribution of low-income households, as well as locational variations in automobile ownership rates and transit availability. Although the information provided above gives a general picture of the relationship between transit availability and automobile ownership, it does not provide any objective measure of this relationship. The following analysis is meant to obtain an understanding of the relationship in an objective manner.

The analysis begins with a statement of the conceptual relationship between transit availability and automobile ownership. This statement is followed by a brief review of literature addressing similar issues. Subsequently the relationship between the two variables is empirically estimated using data from Los Angeles County. Finally, the implications of the empirical estimation are discussed.

The Conceptual Model

The hypothesis to be tested here is that household automobile ownership varies according to availability of mass transit in areas where the households locate. Thus, the number of automobiles owned by households is the dependent variable while the

availability of mass transit in the residence zones is the key policy variable. Since automobile ownership is likely to depend not only on transit availability, but also on several other variables, these other variables are to be included as controls. These control variables pertain either to the households or the zones. The household characteristics considered for the purpose of testing this hypothesis were household income, dwelling type, number of licensed drivers, number of workers, and household size. The control variables for locational characteristics included job density and dwelling density of census tracts. It is expected that household income, household size, number of workers in household, number of licensed drivers in household, and residence in single family dwellings will have a positive relationship with automobile ownership. It is expected that job density and dwelling density in residence zones will have a negative relationship with automobile ownership of households. Finally, it is expected that automobile ownership will have a negative relationship with transit availability.

Previous Studies on Auto Ownership

There are numerous examples in the existing literature where researchers have estimated automobile ownership of households in terms of household characteristics and zonal characteristics (Golob and Van Wissen, 1989; Golob, 1990; Golob, 1996; Train, 1980; Lerman and Ben-Akiva, 1976; Burns et al., 1976).

In terms of methodologies, most studies use some form of logit or probit models for estimating automobile ownership. Although there has been a reasonable consistency in using probit and logit models to estimate auto ownership, there is no consistency in

the selection of independent variables in the various models. While Golob and Van Wissen (1989) use only income as an independent variable, other studies, such as Train (1980), Lerman and Ben-Akiva (1976), and Golob (1996) use several independent variables in their models. Characteristics of households and zones have been used as independent variables in these studies. Models have included income, household size, and number of licensed drivers as household characteristics. For zonal characteristics, models have considered density of activities, transit accessibility, and certain dummy variables indicating whether a household is located in an urban area or a rural area, or whether household is located near CBD or far from CBD. Aside from these household and zonal characteristics, variables such as housing type and tenure status of dwellings have been used as independent variables in some of the models.

Among the aforementioned studies, the two that were specifically interested in identifying the relationship between transit availability/accessibility and automobile ownership were Train (1980) and Lerman and Ben-Akiva (1976). Although Train included the transit variable as one of the independent variables in his model, Lerman and Ben-Akiva refrained from including the variable in spite of conceptual consideration. One of the potential flaws in Train's model was that he did not consider the possibility of an endogeneity problem between transit accessibility and auto ownership.

Empirical Estimation of the Model

Empirical estimation of the model was undertaken with data for Los Angeles County. One of the potential problems in estimating the conceptual model was that of

endogeneity or simultaneity between transit availability and auto ownership. Although it is crucial for the study to determine auto ownership of households on the basis of transit availability in the areas of their residence, the relationship between the two variables is not uni-directional. That is, while auto ownership of households may be affected by transit availability in their residence zones, transit availability in different zones may be affected by the auto-ownership rates of households within the zones. In other words, while households' auto ownership decisions may be affected by zonal transit availability, transit agencies may provide services on the basis of auto ownership rates of residents. This bi-directional relationship between transit availability and automobile ownership may cause an endogeneity problem in the model. An endogeneity problem results in biased and inconsistent estimation of a model. To overcome the potential endogeneity problem, the instrumental variables method was used for estimation of automobile ownership. The instrumental variables method produces estimates that are biased but consistent. The theoretical underpinnings for simultaneous categorical models of the type adopted here are to be found in Amemiya, 1978; Rivers and Vuong, 1988; Heckman, 1978; Maddala and Lee, 1976; Lee, Maddala and Trost, 1980.

Considering that transit agencies are likely to provide services on the basis of certain zonal characteristics, in the first step of this modeling exercise, transit availability of zones was predicted by a regression model. The independent variables used in this model are listed in Table 4. The parameter estimates and the test statistics are provided in Table 5. The regression model in Table 5 provided the predicted values

of transit availability index for census tracts. These constitute the instrumental variable for the subsequent probit and logit models.

Table 4. Description of Variables Used for Estimating Transit Availability in Census Tracts

CBD	Dummy variable indicating whether the census tract is in CBD, yes=1, no=0
POVERTY	Percent population below poverty in census tract
NWHITE	Proportion of nonwhite persons in tract
JOBDENS	Density of jobs per square mile in census tract
DWDENS	Density of dwellings per square mile in census tract
MEDAGEST	Median age of structures in census tract

Source: 1990 Census of Population and GIS map for census tracts.

Table 5. Regression Model Estimating Transit Availability in Census Tracts

Variable	Mean	Std. Devn.	Parameter Estimate		Stdzd. Parameter Estimate	Std. Error	Hetero-consist. Std. Error	Variance Inflation Factor
Intercept	18.77	33.91	- 23.3345	***	0.0000	2.04	1.79	0.00
CBD	0.01	0.11	105.9222	***	0.3261	6.13	42.54	1.28
POVERTY	0.14	0.12	21.5270	***	0.0749	6.78	7.00	2.01
NWHITE	0.41	0.27	11.1502	***	0.0886	2.81	2.54	1.79
JOBDENS	4696.00	10043.00	0.0008	***	0.2181	0.00	0.00	1.36
DWDENS	3758.00	3302.00	0.0039	***	0.3822	0.00	0.00	1.19
MEDAGEST	32.52	49.37	0.4733	***	0.1353	0.06	0.06	1.05
R^2	0.549							
Adj-R^2	0.547							
F-Stat	329.63							
Prob>F	0.0001							
N	1635							

*** Significant at 1% level.

The description of the variables used in the models estimating auto ownership of households is provided in Table 6. The empirical relationships obtained through the probit model are provided in Table 7.

Table 6. Description of Variables Used for Estimating Automobile Ownership of Households

I15	Dummy variable, if income below $15,000 then 1, else 0
I15-20	Dummy variable, if income between $15,000-20,000 then 1, else 0
I30-40	Dummy variable, if income between $30,000-40,000 then 1, else 0
I40-50	Dummy variable, if income between $40,000-50,000 then 1, else 0
I50-75	Dummy variable, if income between $50,000-75,000 then 1, else 0
I75-100	Dummy variable, if income between $75,000-100,000 then 1, else 0
I100-150	Dummy variable, if income between $100,000-150,000 then 1, else 0
I150PLUS	Dummy variable, if income $150,000 or more then 1, else 0
SFAMILY	Dummy variable, if single family then 1, else 0
DRIVERS	Number of licenses drivers in household
OWNER	Dummy variable, if lives in owned dwelling then 1, else 0
WORKERS	Number of workers in household
HHSIZE	Household size
TRANSIT	Predicted value of transit availability obtained from regression model in Table 5
DWDENS	Density of dwellings per sq. mile in tract
JOBDENS	Density of jobs per sq. mile in tract

Under the simple circumstances of the model, a probit and a logit model are likely to provide similar outcome. As Ghareib (1996) points out, logit is a superior model than probit from an analytical standpoint, although probit has a deeper theoretical basis. A logit model is also recommended over probit for the purpose of prediction

(ibid.). To maintain a balance between theory and predictability, both a probit and a logit model were used for examining the relationship between transit availability and auto ownership. An additional advantage of the logit model is that it produces the odds ratios for different explanatory variables. These ratios are simple and easy to understand.

Table 7. Probit Model Estimating Auto Ownership of Households (Dependent Variable: Number of Autos=0, 1, or 2 or more)

Variable	Mean	Std. Devn.	Parameter Estimate	χ^2	
I15	0.14	0.35	- 0.3985	38.11	***
I15-20	0.07	0.25	- 0.1128	2.15	
I30-40	0.14	0.35	0.2263	11.46	***
I40-50	0.13	0.33	0.3937	29.46	***
I50-75	0.19	0.39	0.7192	98.70	***
I75-100	0.10	0.30	0.7887	67.99	***
I100-150	0.06	0.23	1.0194	56.66	***
I150PLUS	0.02	0.14	1.1931	25.86	***
SFAMILY	0.62	0.49	0.3388	54.55	***
DRIVERS	1.67	0.83	0.8603	568.23	***
OWNER	0.49	0.50	0.1988	17.45	***
WORKERS	1.20	0.89	0.0147	0.23	
HHSIZE	2.86	1.53	0.1589	124.88	***
TRANSIT	11.89	29.71	- 0.0027	5.14	**
DWDENS	3129.66	3199.40	- 0.0000	2.69	
JOBDENS	4225.66	10961.00	0.0000	0.12	
Intercept for 2 Autos			0.1705	4.66	**
Intercept for 1 Auto			- 1.9858	-	
Prob>χ^2 = 0.0000					
Total households= 5505 (0-car households=260, 1-car households=1644, and 2 or more car households=3601)					

** Significant at 5% level *** Significant at 1% level

It can be observed from Table 7 that almost all the independent variables relating to households are highly significant with expected signs. The only exception is the number of workers in households, a variable found to have an insignificant relationship with auto ownership. A positive relationship exists between income and automobile ownership. The empirical relationship between the two indicates the influence of income on automobile ownership. The empirical estimates also indicate that households in single family homes, households with a larger number of licensed drivers, households living in owner-occupied homes, or households of larger size have a greater likelihood of auto ownership. Among the variables representing zonal characteristics, transit availability is the only variable that has a significant relationship with automobile ownership. As expected, this variable has a negative relationship with automobile ownership. The relationship indicates that households having greater access to transit have greater automobile ownership rate.

Another way to look at the relationship between transit availability and automobile ownership is through the odds ratios of the variables. The computer software used for this research allows calculation of the odds ratios of automobile ownership through a logit procedure. Table 8 provides these odds ratios together with other relevant test statistics.

The parameter estimates and test statistics from the logit model are consistent with those from the probit model. The last column of Table 8 provides the odds ratios of auto ownership. An odds ratio lower than one indicates a lower likelihood of automobile ownership while an odds ratio greater than one indicates a higher likelihood of automobile ownership. The odds ratios for automobile ownership increases with increases income. The ratios are greater than one for households in single family homes and households in owner-occupied dwellings. The ratio for household size is also

greater that one, indicating a positive relationship between household size and auto ownership. The odds ratio for the transit variable is only slightly smaller than one, indicating that although transit availability has a significant negative relationship with automobile ownership, the likelihood of auto ownership of households will decrease only slightly with increases in transit availability in their residence zones. This may be interpreted as good news and bad news for the transit industry. While it is good news that transit continues to have a significant negative relationship with automobile ownership even in a dispersed area like Los Angeles, it is bad news that significant improvements in transit services will be required for bringing forth even a moderate decrease in automobile ownership.

Table 8. Multinomial Logit Model for Household Automobile Ownership. Dependent Variable: Auto-Ownership per Household (Automobiles = 0, 1, 2 or more)

Variable	Parameter Estimate	Standard Error	Wald χ^2	Pr>χ^2	Odds Ratio
I15	-0.728	0.116	39.27	0.0001	0.483
I15-20	-0.203	0.138	2.16	0.1417	0.816
I30-40	0.384	0.120	10.25	0.0014	1.468
I40-50	0.663	0.131	25.74	0.0001	1.940
I50-75	1.254	0.132	89.78	0.0001	3.505
I75-100	1.326	0.177	56.34	0.0001	3.765
I100-150	1.830	0.266	47.47	0.0001	6.235
I150PLUS	2.056	0.457	20.25	0.0001	7.812
SFAMILY	0.608	0.083	54.41	0.0001	1.837
DRIVERS	1.685	0.068	614.51	0.0001	5.391
OWNER	0.335	0.086	15.08	0.0001	1.398
WORKERS	0.023	0.056	0.17	0.6778	1.024
HHSIZE	0.314	0.027	140.26	0.0001	1.368
TRANSIT	-0.004	0.002	3.950	0.0469	0.996
DWDENS	0.000	0.000	2.89	0.0890	1.00
JOBDENS	0.000	0.000	0.02	0.8923	1.00
Intercept for 2 Autos	-3.508	0.149	557.41	0.0001	-
Intercept for 1 Auto	0.140	0.145	0.92	0.3364	-
Testing Global Null Hypothesis Beta = 0:					

Criterion	Intercept Only	Intercept and Covariates	χ^2 for Covariates
-2 Log L	8617.90	15514.12	3103.78 with 16 DF (p=0.0001)

Association of Predicted Probabilities and Observed Responses:
Gamma = 0.769
Total households= 5505 (0-car households=260, 1-car households=1644, and 2 or more car households=3601)

Note: Descriptive statistics of variables identical with Table 7.

The odds ratio for the dummy variable representing the lowest income class (below $15,000 annual income) is less than 0.5. It indicates that the likelihood of automobile ownership is extremely low for low-income households, irrespective of the increase in auto ownership among the poor. This empirical observation may have serious implications for developing transit policies. The fact that the odds ratio for the transit variable is only slightly less than one implies that auto-ownership decisions of households in general are affected by availability of transit service in their residence zones only to a very small extent. On the other hand, the extremely small odds ratio of auto ownership for the lowest-income category indicates that transit may be extremely useful for the poor because of their inability to obtain an automobile.

Conclusion

In view of the increasing automobile-ownership among low-income households, this paper examined the relationship between transit availability and household automobile-ownership rates with empirical data from Los Angeles County. One of the basic conclusions from the analysis is that household automobile-ownership rates are inversely related to transit availability in the census tracts of residence. However, the likelihood of automobile ownership decreases only minimally with increases in transit availability. Another significant conclusion from this research is that the low-income

households in the study area have very low likelihood of owning automobiles, even though there has been an increase in automobile ownership among these households nationally. Because of their low propensity for owning automobiles, it seems that mass transit continues to be an important means for providing mobility to these households.

The fact that low-income households have a low propensity to own automobiles in Los Angeles may indicate that such households have a low propensity to own automobiles in other metropolitan areas also. This is particularly likely because Los Angeles is normally considered more automobile-oriented than most other metropolitan areas of the country.

Finally, it seems that in spite of an increase in automobile ownership among low-income households, their propensity for owning automobiles continues to be low. Given this low propensity, it is possible that such households in general have continued to be highly dependent on mass transit into the 1990s. If such is the case, it would seem reasonable that transit agencies make it a top priority to provide services to low-income neighborhoods rather than making plans for general extension of services.

Notes

1. Estimated from the travel survey of the Southern California Association of Governments, 1991.

2. Spenser (1996) shows that the real cost of new cars has increased slightly over the years between 1975 and 1996. However, since new cars also have improved technology and safety features, it may be more appropriate to look at the consumer price index for all cars rather than the price of new cars alone.

3. For a survey of transit availability indices, see Henk and Hubbard (1996).

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