ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

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MINORITY AND POOR HOUSEHOLDS: PATTERNS OF TRAVEL AND TRANSPORTATION FUEL USE

by

M. Millar, R. Morrison, and A. Vyas

Energy and Environmental Systems Division
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FOREWORD

In 1979, the U.S. Congress created the Office of Minority Economic Impact (OMEI) within the U.S. Department of Energy (DOE) out of concern for the effects of energy shortages and rising prices on minority citizens, particularly those with low incomes. The legislation [42 U.S.C., Sec. 7141 (c)] defines a minority group as one consisting of black, Oriental, American Indian, Eskimo, or Aleut citizens, or Puerto Rican or other Spanish-speaking citizens of Spanish descent. This law requires OMEI, among other things, to conduct research to (1) determine the average energy consumption and use patterns of minority groups relative to other population groups and (2) evaluate the percentage of disposable income spent on energy by minority groups relative to other population groups.

As part of its compliance with this mandate, OMEI commissioned Argonne National Laboratory (ANL) to conduct a multiyear research program to determine energy consumption and expenditures by minority groups. The ANL program consists of three tasks:

- Assemble a data base and develop the tools to assess the effects of government energy policies and programs on minority groups.
- Assess the effects of government programs on minorities and identify options for modifying those programs (e.g., through policy, regulatory, or legislative changes) to alleviate possible hardships for minority groups.
- Provide market research assistance to energy-related businesses owned by members of minority groups.

This report is one of a series produced by ANL in the performance of these tasks. It is directed at transportation and energy researchers, as well as policy analysts and other investigators outside those fields who share an interest in the characteristics and behavior of minority and poor households. Because of this broad audience, this report presumes little prior knowledge of transportation or energy analysis.

Further information on the overall OMEI research program can be obtained from Georgia Johnson, the research project officer for the DOE Office of Minority Economic Impact, or from Argonne National Laboratory. Information on this report may be obtained directly from the authors.

ACKNOWLEDGMENTS

Several individuals were instrumental in this project and truly deserve our thanks. First and foremost is Georgia Johnson of the U.S. Department of Energy's Office of Minority Economic Impact, who sponsored the research. Her continued support and valuable assistance throughout the project are especially appreciated. For their many helpful comments and suggestions during data analysis and in the presentation and discussion of findings, we thank principal investigator James Throgmorton and director of model development David Poyer of the Argonne research program. For their assistance in summarizing relevant information from several of the data sets analyzed in this project, we thank John Anderson and Lester Conley. We are grateful to Martin Wachs of the UCLA School of Architecture and Urban Planning, Claire McKnight of the University of Illinois at Chicago Urban Transportation Center, William O'Hare of the Joint Center for Political Studies, and Yehuda Gur of the Transportation Research Institute at the Israel Institute of Technology (Technion). Their timely and thorough reviews of the draft document and many helpful comments are truly appreciated. Finally, we thank LaVerne Schneberger, Louise Kickels, Barbara Salbego, and Barbara Rogowski for their diligence and patience in preparing the manuscript, Linda Haley and Mary Jo Koelbl for producing the figures, and Charles Malefyt for editing the final document.

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ABSTRACT

This report documents the travel behavior and transportation fuel use of minority and poor households in the U.S., using information from numerous national-level sources. The resulting data base reveals distinctive patterns of household vehicle availability and use, travel, and fuel use and enables us to relate observed differences between population groups to differences in their demographic characteristics and in the attributes of their household vehicles. When income and residence location are controlled, black (and to a lesser extent, Hispanic and poor) households have fewer vehicles regularly available than do comparable white or nonpoor households; moreover, these vehicles are older and larger and thus have significantly lower fuel economy. The net result is that average black, Hispanic, and poor households travel fewer miles per year but use more fuel than do average white and nonpoor households. Certain other findings -- notably, that of significant racial differences in vehicle availability and use by low-income households -- challenge the conventional wisdom that such racial variations arise solely because of differences in income and residence location. Results of the study suggest important differences -- primarily in the yearly fluctuation of income -- between black and white low-income households even when residence location is controlled. These variables are not captured by cross-sectional data sets (either the national surveys used in our analysis or the local data sets that are widely used for urban transportation planning).

SUMMARY

This report describes results from an ongoing research program conducted by Argonne National Laboratory for the U.S. Department of Energy's Office of Minority Economic Impact (OMEI). In keeping with OMEI's mandate, the program is directed toward (1) determining the energy consumption and expenditure patterns of minority population groups relative to other population groups, (2) assessing the impacts on minorities of existing or proposed government energy policies and programs, and (3) identifying options for modifying those policies and programs to alleviate anticipated hardships, particularly on low-income individuals.

Primarily expository in nature, this report describes the travel characteristics and transportation fuel consumption patterns of minority households, as defined by race or ethnicity, and -- controlling for income, residence location, and, in some cases, age of household head -- compares these characteristics and patterns with those of otherwise equivalent nonminority households. Significant differences between minority and nonminority households (based on standard statistical tests) are identified and interpreted.

Three primary data sources were used: the 1977 Nationwide Personal Transportation Study (NPTS), the 1979-81 Transportation Panel (TP) of the Residential Energy Consumption Survey (RECS), and the 1980 Annual Housing Survey (AHS). Secondary sources incorporated through published reports included the 1970 and 1980 Censuses of Population, the 1972-73, 1980-81, and 1982-83 Consumer Expenditure Surveys, the 1983 Residential Transportation Energy Consumption Survey (RTECS), and the 1969 NPTS.

Data for households (the basic unit of travel demand and energy use) were analyzed for five population categories. Surveyed households were assigned to these categories based on respondents' self-reporting of their family income and the racial or ethnic origin of the householder. These groups are black, Hispanic, white, poor, and nonpoor. A further discussion of the criteria used to define each group is included in the Introduction.

VEHICLE AVAILABILITY

Vehicles per Household

Research has repeatedly shown that the number of vehicles regularly available to a household (known as *vehicle availability*) is related to that household's size, composition, income, and residence location. Because disproportionate shares of minority households reside in the central cities of standard metropolitan statistical areas (SMSAs) and have low incomes, they may be expected as a group to have below-average vehicle availability. This should partly be offset by minority households' lower proportion of elderly householders (*elderly* is defined as age 60 or above). As shown in Fig. S.1, however, even when income, residence location, and age of householder are controlled, there are large differences in vehicle availability between white and minority households (as well as between poor and nonpoor). These differences are highlighted by a comparison of vehicle-availability distributions for each of the population groups (Fig. S.2): 32.9% of black households and 22.7% of Hispanic households were without vehicles in 1980 (compared with only 10.1% of white households). White zero-vehicle households were also significantly more likely to be elderly than were their black or Hispanic counterparts (64% vs. 35% and 30%, respectively). Because the elderly tend to live in smaller households with fewer licensed drivers and to make fewer work trips, differences in age structure between white and minority households may obscure other important differences in travel patterns and fuel use. Thus, certain of the comparisons presented in this report are limited to nonelderly households.

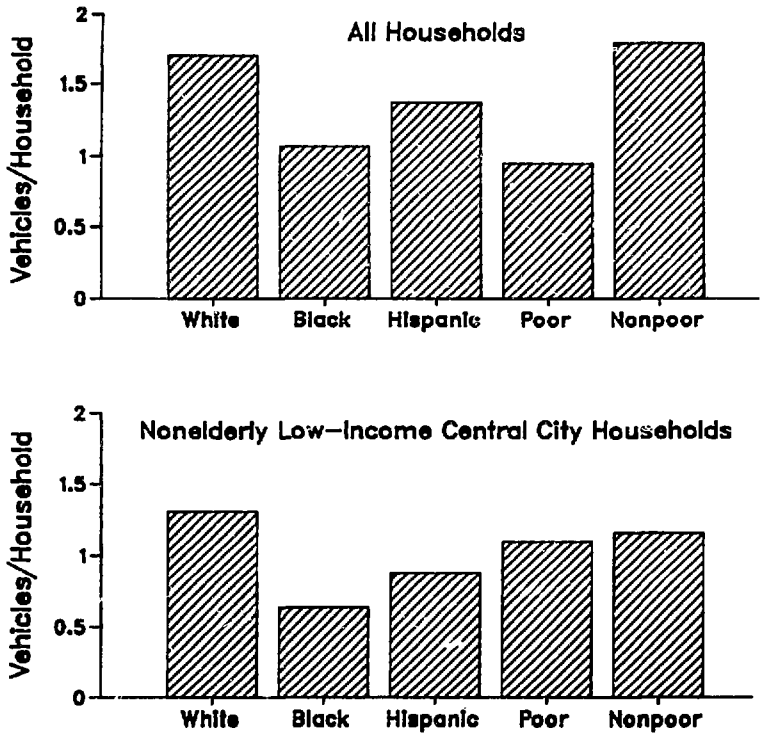

FIGURE S.1 Vehicle Availability of All Households and Nonelderly Low-Income Central City Households, by Population Group, 1980

While the distinctive demographic characteristics of minority and poor households explain some of the variation in their vehicle availabilities, one must look further to explain the remaining differences. Most of the minorities' reduced vehicle availability occurs in lower-income households regardless of residence location. Some of it may be attributable to local variations in the spatial distributions of low-income white and minority households, as well as to the relative accessibilities of their neighborhoods to public transportation. Similarly, relative densities may vary between predominantly white and minority neighborhoods, and this may influence the supply of off-street parking and other factors that make private-vehicle ownership more or less desirable.* However, none of these factors explain why the differences tend to lessen and ultimately disappear as income rises.

Our analysis suggests that racial variations in vehicle availability among low-income households may reflect differences in long-run average incomes. The growing body of research using a decade of longitudinal data from the University of Michigan's

*Even the broad categories of central city and suburb span a diversity of travel and residential densities that may vary between white and minority household groups.

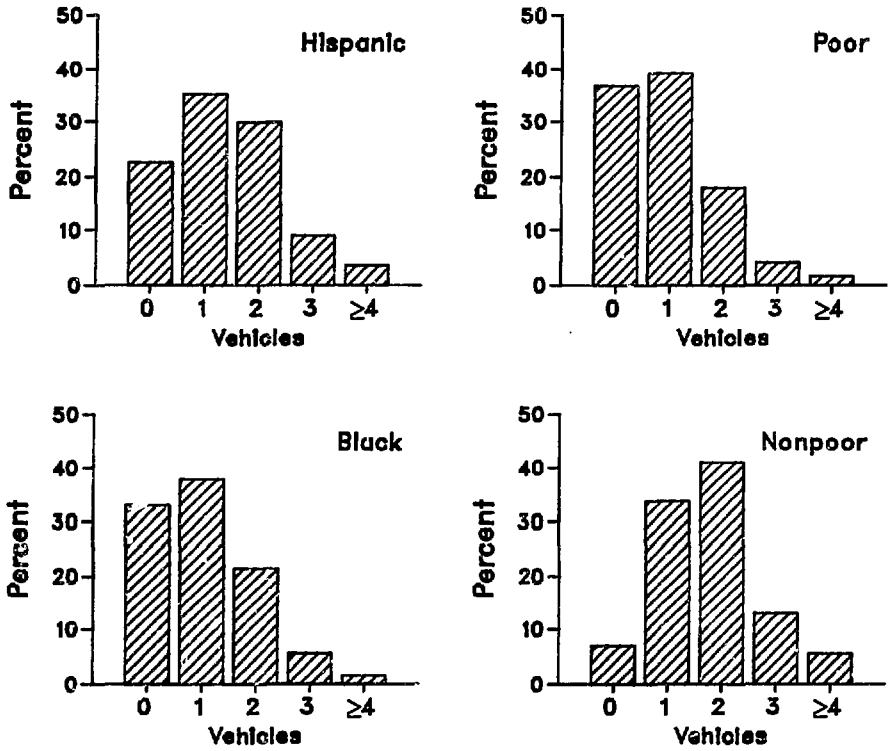

FIGURE S.2 Numbers of Vehicles Available in Each Household, by Population Group, 1980

Panel Study of Income Dynamics (PSID) strongly supports this hypothesis. The PSID data reveal large movements of generally middle-class households into and out of the low-income bracket, creating a more heterogeneous category than is apparent in cross-sectional data sets. Compared with the "persistently poor," who are heavily concentrated in two overlapping groups -- black and female-headed households -- these "temporarily poor" households are not very different from the U.S. population as a whole. Thus, they may be expected to have more accumulated wealth (including vehicles) and greater access to capital than the persistently poor and to retain a lifestyle more in keeping with their long-run average incomes. It is not possible to control for long-run income in analyzing cross-sectional data that by definition obscure income dynamics. Thus, our two groups -- low-income blacks and low-income whites -- may not be strictly comparable.

Vehicle Characteristics

The vehicles available to minority and poor households tend to be somewhat older and substantially less fuel-efficient than those available to white households. As Fig. S.3 shows, white households in 1983 were more likely to have four- or six-cylinder models

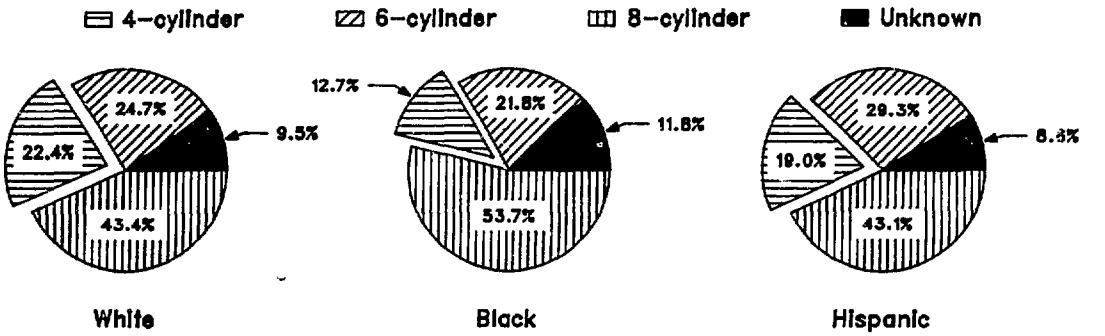

FIGURE S.3 Engine Size Distribution of Vehicles in White, Black, and Hispanic Households, 1983

than were black or Hispanic households. Their resulting automotive fuel economy was 2.2 miles per gallon (mpg) greater than that of black households and 1.5 mpg greater than that of Hispanic households. Truck fuel economy was about the same. Because white and Hispanic households tend to have relatively more trucks (which have relatively lower fuel economy) than do black households, the average fuel economy of all vehicles available to minorities is somewhat closer to that of whites (differing by 1.5 to 1.6 mpg in 1983).

The efficiency gap between vehicles in black and white households appears to have developed since the late 1970s. Fuel economy in white households rose by 4.7% between the 1979 and 1981 summer driving seasons; in both black and poor households it dropped by a comparable margin.

Vehicle Use

Household use of vehicles (i.e., annual miles/vehicle) tends to vary with household income, residence location, age of householder, and number of vehicles available to the household. Because of depressed vehicle-ownership rates, one would expect minority households to have somewhat higher vehicle use, on average, than white households when income and residence location are controlled. This is true for Hispanics, but not for blacks. Among low-income households in central cities of SMSAs, vehicles in black households were driven less than two-thirds as far as vehicles in white households in 1977 (4097 vs. 6819 miles), as shown in Fig. S.4. Presumably, the lower use in black households reflects a series of factors, including local conditions that reduce the attractiveness of driving (e.g., scarce parking, traffic congestion); the combination of older, less-reliable vehicles and less credit and savings available for expensive repairs; and a greater prevalence of informal travel arrangements (i.e., friends borrowing vehicles), the mileage from which is not reflected in the data.

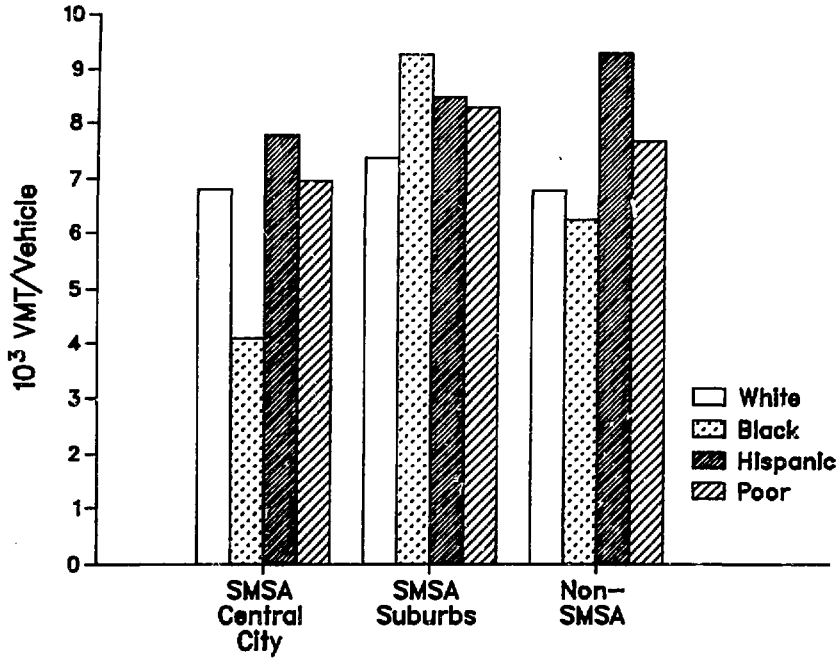

FIGURE S.4 Average Annual Vehicle-Miles of Travel (VMT) per Vehicle for Low-Income Households, by Residence Location and Population Group, 1977

HOUSEHOLD TRAVEL

Vehicle-Miles per Household

Black, Hispanic, and poor households travel substantially fewer miles than the national average. While much of the difference is due to income, residence location, and lower vehicle availability, a statistically significant difference remains when the data are summarized for low-income single-vehicle households in central cities. Again, these differences are attributed to older, less reliable vehicles and less ability to pay for expensive repairs; local conditions (e.g., parking cost and availability, traffic congestion, transit accessibility) that raise the cost or otherwise reduce the attractiveness of private-vehicle use; and greater vehicle loaning.

Travel to Work

The attributes of work trips with the greatest relevance to minorities' overall travel and fuel use are (1) length and spatial characteristics, (2) mode split (i.e., the distribution of trips across available travel modes), and (3) average load factor or private-vehicle occupancy. When income and residence location are controlled, blacks

(particularly those residing in SMSAs) have significantly longer work trips (in terms of mean travel times) than do whites. Among central city residents, only at the highest income level does the mean travel time of black workers approximately equal that of white workers.

About half of the variation is explained by differences in mode split. In 1980, the overwhelming majority of white workers (>72%) drove alone and only 5% used public transportation for their work trips. Most minority workers also drove alone (55% of blacks and 60% of Hispanics), but as a group they were far more dependent on public transportation (nearly 19% of black and 13% of Hispanic workers). An additional 25% of minority workers used carpools or vanpools, compared with 21% of white workers.

When the data are controlled for residence location and the comparison is limited to those households with vehicles regularly available, the magnitude of mode-split differences among the three groups is reduced. However, minority workers are still significantly more likely to rely on ridesharing and public transportation. Among black workers, ridesharing appears to substitute for public transportation as SMSA size declines. Remaining differences in travel times reflect a series of factors -- including differences in the spatial characteristics of commuter flows and vehicle-ownership distributions -- as well as such local variables as accessibility and level of service of both transit and highway systems.

FUEL USE AND EXPENDITURES

Household Fuel Use

In 1980, the average black household used approximately 84 gallons of motor fuel per month (almost all of it gasoline). By 1983, fuel use had risen 17% to a monthly average of 98 gallons, compared with 92 gallons for white households. This increase even exceeds the percentage drop in real gasoline price, providing additional evidence that vehicle fuel economy in black households improved relatively little over this period (even discounting growth in the average number of vehicles per black household).

Household Fuel Expenditures

In 1983, the average white household spent $1307 on motor fuel. Average black and Hispanic households spent somewhat more -- $1398 and $1418, respectively. These differences reflect the generally lower fuel economy of vehicles in minority households and would be considerably greater if vehicle availability were comparable to that of white households.

In response to the two oil price shocks between 1972 and 1980, motor fuel expenses of the average U.S. household rose from 4.3% to 6.9% of total expenditures and from 22.9% to 34.3% of transportation expenditures. Since 1980, moderating fuel prices have reduced these shares in all population groups, but the decline has been particularly marked in higher-income households. The data suggest that more-affluent households

reduced their fuel expenditures largely through vehicle replacement. By 1982, many of the vehicles in higher-income households were the relatively more expensive and more fuel-efficient models introduced since the late 1970s. If these downsized vehicles are assumed to be as durable as earlier models, the fuel expenditures of lower-income households (a disproportionate share of whom are black or Hispanic) may only now be beginning to be affected by the fuel economy improvements of the past decade.

CONCLUSIONS

Our major finding -- that significant racial variations exist in vehicle availability and use by low-income central city households -- challenges the conventional wisdom that once income and residence location are controlled, vehicle availability and travel behavior should be constant across population groups. We conclude that because long-run income and residence location cannot be fully controlled, extreme care must be taken in interpreting this finding.

Cross-sectional data sets do not capture the dynamics of income. Thus, they cannot identify the persistently poor, who tend to be concentrated among such demographic subgroups as black and female-headed households. Because capital goods and the resources needed to keep them in efficient working order are usually acquired in relatively prosperous years, households for whom prosperity is rare or nonexistent may be expected to have depressed rates of vehicle ownership and utilization, and their vehicles may be expected to be older and less reliable than those of seemingly comparable, but only temporarily poor, households. Long-run average income is the variable that is of interest, but it is not captured in most data sets, including those generally used in local and national transportation planning.

Data problems also inhibit adequate control for residence location. "Central city" is a statistical term based on jurisdictional boundaries that do not always reflect differences in density or community character. Thus, some central city households may live in relatively low-density, suburban-type communities and some households outside the central city may live in high-density, heavily built-up areas. On the national level, it is impossible to say whether the amount and degree of mismatching between statistical designations and community character are equal for white and minority households.

Among households with vehicles, we find that the average black household travels fewer miles yet consumes more fuel than the average white household. This may be seen in Fig. S.5 -- which illustrates the distributions of vehicles, private-vehicle-miles, and gasoline consumption -- of white, black, and Hispanic households in 1983.* Much of the minorities' disproportionate fuel use reflects their older, larger, and less-fuel-efficient vehicles. Recent gains in the efficiency of new vehicles, most of which are purchased by nonpoor households, have not yet benefited many minority and poor households. In fact, there is an increasing gap in fuel economy between white and black households. This suggests that fuel efficiency is either (1) not as important in the

*Because Hispanics may be of any race, the shares add to more than 100%.

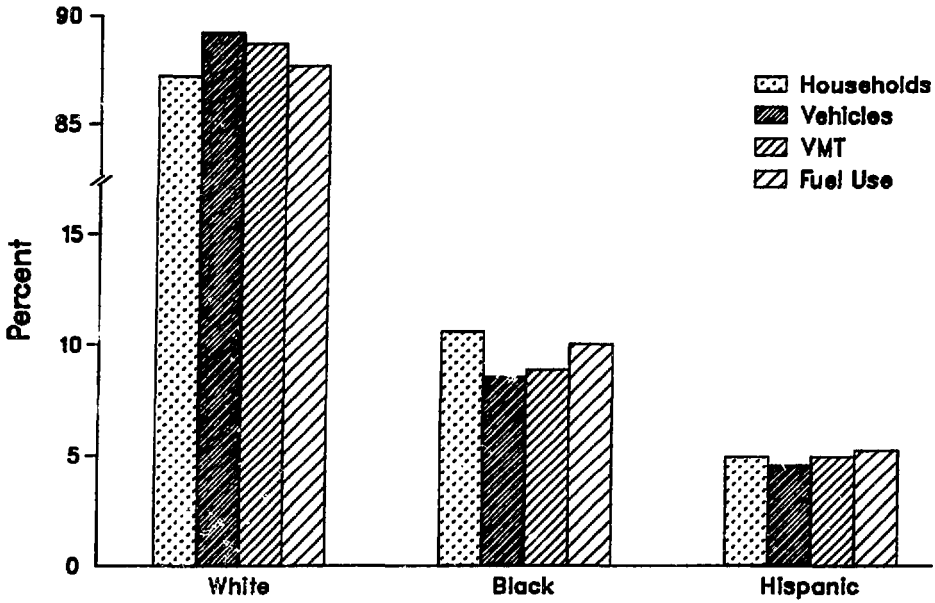

FIGURE S.5 Distributions of Households, Vehicles, Vehicle-Miles of Travel (VMT), and Fuel Use, by Population Group, 1983

vehicle-purchase decisions of black households as in those of the general population (because the average black household is larger, vehicle spaciousness may be particularly important) or (2) so subordinated to first cost that the depressed market for used large cars in recent years may have made these vehicles particularly attractive to black households.*

*The affordable stock of large used cars in the late 1970s and early 1980s was primarily of early 1970s vintage. Thus, in recent years the fuel economy of the product mix available at the lower end of the market has been among the lowest in history.

1 INTRODUCTION

1.1 PURPOSE

As part of the effort to expand the base of knowledge on energy consumption patterns of minority population groups, and to develop a series of analytical tools for measuring the effects of federal policies and programs on those patterns, staff of Argonne National Laboratory (ANL) have published several reports for the U.S. Department of Energy's Office of Minority Economic Impact (OMEI). These reports documented characteristics of residential energy demand and expenditures by minority and poor households.[1-3] Because motor fuel (i.e., fuel purchased for household vehicles) accounts for more than half the energy expenditures of the average U.S. household,[4] a complementary analysis of transportation energy demand and expenditures by minority and poor households was undertaken. That analysis is the subject of this report.

1.2 SCOPE

This report is primarily expository in nature, describing the travel characteristics and transportation energy consumption patterns of minority households -- as defined by race, ethnicity, and income -- and comparing them with otherwise equivalent nonminority households. As in earlier ANL reports for OMEI, the characteristics of poor and nonpoor (as well as minority and nonminority) households are highlighted where permitted by available data. This breakdown provides both a benchmark for comparing data on minorities and a separate category that reflects OMEI's continuing interest in low-income households. Significant differences between minority and nonminority (and between poor and nonpoor) households, based on standard statistical tests, are identified and interpreted in the text.

The report contains six sections. The first is an overview of the issues and the methodological approach, data sources, and analytical techniques used. Section 2 describes key demographic characteristics that influence travel demand and fuel use by minority households and contrasts these characteristics with those of nonminority households. Section 3 addresses the numbers and types of private vehicles available to minority and nonminority households, and Sec. 4 discusses minorities' travel behavior, with particular emphasis on their work trips. In Sec. 5, fuel consumption and expenditures for private vehicle operation are described and trends are noted. Finally, Sec. 6 highlights the implications of major similarities and differences in minority and nonminority travel behavior and fuel use, and it also raises several relevant policy issues.

Throughout the report, data on households -- the basic unit of travel demand and energy use -- are displayed for four to six different population groups, depending on the source. Survey data based on limited sampling are reported for white, black, poor, nonpoor, and, if the number of observations indicates statistical reliability, Hispanic households. As defined in earlier ANL reports for OMEI, poor households are defined as having incomes of less than 125% of the poverty threshold determined by the federal government. That threshold varies with family size and is updated annually to reflect

changes in consumer purchasing power. Because surveys generally report income categorically, the assignment of survey records to poor or nonpoor status used the federal definition for the year of interest, rounded to the nearest income breakpoint.

Data for poor and nonpoor sum to national totals. For survey data processed at ANL, the white, black, and Hispanic categories are mutually exclusive so that, with the addition of an "other" category, they too would sum to national totals. Thus, there may be small differences between survey results using our racial/ethnic definitions and those from other summaries. In the ANL tabulations, "Hispanic" excludes black Hispanics but includes Hispanics of all other races, "white" excludes Hispanics and all other races not separately identified, and "black" includes Hispanic and non-Hispanic blacks.

Census data are reported for four separate racial groups: white, black, American Indian (including Eskimo and Aleut), and Asian and Pacific Islander; data are also reported for a separate Spanish-origin (Hispanic) group that may be of any race. Because the Hispanic category is overlaid on the racial categories, data for the four racial groups sum to national totals. Published census data on poverty status are not consistent with either the "Poor-125%" definition or our focus on households, and hence are not reported here.

1.3 APPROACH

The analytical approach consisted of a literature review and a survey analysis. Selected aspects of minority travel behavior and motor fuel use reported in prior studies by O'Hare, the Joint Center for Political Studies, and the National Urban League were reviewed, as were similar studies of low-income households by Newman and Day and by Cooper et al.[5-9] This review indicated that while certain aspects of the subject have been examined in earlier work, these investigations have been either tangential to the main purpose of the work or limited to a discrete subset of travel behavior (generally the work trips). No comprehensive analysis of overall travel behavior and fuel use by minority and poor households was identified in the literature. Given OMEI's mandate to assess the impacts of federal energy policies and programs on minority groups, as well as such general social concerns as equity and the distributional effects of energy policies, such an effort is clearly in order.

The literature review suggested several salient issues appropriate for inclusion in this effort. Issues with particular relevance to minority and poor households include blacks' disproportionate reliance on public transportation, substantially longer work trip times and greater commuter burden (i.e., commuting hours per hour worked), and low-income households' apparently heavier fuel expenditure burdens.[6,7,9,10] In addition to these, the question of energy conservation and its effect on minority and poor households is both relevant and appropriate to this effort. However, because that issue is the subject of a separate study sponsored by OMEI, it is considered only tangentially here.[11]

1.4 DATA SOURCES

The major data sources used in our analysis were the 1977 Nationwide Personal Transportation Study (NPTS), the 1979-81 Transportation Panel (TP) of the Residential Energy Consumption Survey (RECS), and the 1980 Annual Housing Survey (AHS).[12-15] Additional sources, incorporated through published reports, included the 1970 and 1980 Censuses of Population; the 1969 NPTS; the 1972-73, 1980-81, and 1982-83 Consumer Expenditure Survey; and the 1983 Residential Transportation Energy Consumption Survey (RTECS).[16-20]

Where more than one source provides the same data of interest to this study, we cite the more credible source (i.e., that with more observations). In some cases -- where confidence is relatively equivalent between sources and the more recent one provides some indication of trends, or where the older source provides somewhat greater detail -- we report both. In general, however, our analysis was not intended to present and contrast particular data sets, but rather to aggregate and summarize the salient findings of those sources that provided data on minorities' transportation and energy use patterns. This focus permitted considerable discretion in selecting both the specific variables of interest and the pertinent data bases.

Several data bases used in prior ANL studies for MI were not used here. Specifically, the four RECS conducted in 1978-79, 1979-80, 1980-81, and 1981-82 were excluded because their meager transportation-related data were clearly inferior to other available data from much larger surveys. The 1983 RTECS[4] was used only at the end of our analysis when the published document was released. The corresponding data tape was unavailable during our analysis.

Appendix A describes characteristics, strengths, and limitations of the major data bases used in this analysis.

1.5 LIMITATIONS OF THE ANALYSIS

While survey analysis is clearly the most appropriate analytical method for this effort, it does have inherent limitations. Sampling error can easily overwhelm small-sample data, obscuring significant differences in patterns of transportation activity and energy use between population groups. In this analysis, the issue of sampling error has been most critical with respect to (1) examination of relatively small subsets of a sample and (2) use of expanded totals for particular population groups developed without reference to those groups' importance to the total population.

Because none of the data sources used in this analysis oversampled any racial or ethnic group, even our numerically largest category of interest -- black households -- represents less than 10% of the observations of any survey. When cross-classified by several key variables, even a fairly large survey such as NPTS yields fewer than 100 observations per cell for many of the cross-classifications. Because standard errors decline roughly with the square root of the number of observations, relatively large differences between population groups presented in this report are not always statistically significant. Moreover, other comparisons that are potentially interesting

and useful from a policy perspective are not even attempted due to sparse observations. The TP survey is particularly difficult in this regard. With only 40 to 80 black households sampled in any one month, sampling error precluded any cross-classification whatsoever.

With the exception of AHS, none of the data sources used in this report included a racial or ethnic parameter in developing their expansion factors. Without such a control, even the expanded totals for particular population groups (e.g., total vehicle-miles of travel [VMT] by black households) contain substantial error. Post-stratifying, or recomputing expansion factors to match an externally generated distribution of characteristics for particular population groups, is a possible solution to this problem. This technique was considered for the TP data set but was rejected because (1) the original RECS half-sample data (note that the households surveyed for the TP were subsampled from three earlier RECS surveys) could not be obtained and (2) the considerable effort needed to generate fully compatible external distributions for all three RECS surveys could not be justified in light of other difficulties with the TP data set (see following discussion), which would not be improved. As an alternative to post-stratifying, most survey data are reported in terms of rates -- vehicles per household, miles per vehicle, etc. -- which substantially reduces expansion error. Totals for variables of interest (e.g., total gallons of motor fuel consumed by black households) can then be computed as the product of the rates and externally generated population control totals. These external controls were obtained from the 1980 AHS.

Another difficulty that substantially limits analysis of the TP data set is the inability to estimate a household's annual mileage, fuel consumption, or fuel expenditures on the basis of monthly observations. While aggregate totals can be computed as the weighted sum of 12 consecutive monthly rates (weighted by appropriate population control totals), the result is likely to contain considerable sampling error that, because of the sampling design, is extremely difficult to calculate. Despite increased observations, standard errors are not necessarily reduced by annualizing. Households were included in the panel for an average of 2.6 months (2.7 for black households). Thus, the number of unique annual observations is not the sum of monthly observations, and the effective TP sample was only 6570 unique households (432 unique black households) in a total of 17,050 monthly observations (992 total monthly black observations). Household behavior from one month to the next is highly correlated -- a reflection of lifestyle patterns that tend to be quite stable over time. Depending on which households were sampled in any month, multiple observations of relatively high- or low-VMT households could theoretically produce greater variance in an annual estimate than in a monthly estimate, despite the obviously larger number of observations in the former.

Because of the nonuniqueness of TP observations across different months, little effort has been devoted to annualizing that data. Only one set of annual totals -- vehicles, VMT, gallons of fuel used, and expenditures -- has been estimated (see Sec. 6). These were generated to indicate distributional effects, not precise figures, and are interpreted accordingly. The more appropriate uses of the TP data -- to estimate monthly averages of miles per household, gallons per household, and miles per gallon -- are described in the following sections of this report. Due to relatively low monthly sampling rates for black and poor households, the influence of extreme values on these data has been reduced by data smoothing rather than by removal of outliers. The selected technique, Fourier smoothing, is described in Appendix B.

In sum, this analysis was constrained by the following data limitations:

- Without benefit of oversampling, sampling rates were often too low to yield statistically stable results. Small differences between population groups often could not be distinguished from random error.

- For the TP data set, the combination of low sampling rates and lack of control for multiple (and thus intercorrelated) observations of the same household also resulted in high month-to-month variations in subgroup means. To avoid eliminating outliers from an already limited sample, the data were smoothed.

- Specific variables in several of the data sets -- most notably, household income on the TP and location within or outside a standard metropolitan statistical area (SMSA)* on the AHS (see Appendix A) -- are not consistently defined and, hence, the analysis required the use of a number of approximations. Approximated data probably increase the survey error.

- The three surveys span only three years, too short a time for meaningful longitudinal analysis.

- The NPTS and TP do not include a racial/ethnic variable in developing their expansion factors. Thus, expanded totals for population groups of interest may be in error. Use of rates and an external population distribution that is cross-classified by race/ethnicity substantially reduces this problem.

The NPTS, TP, and AHS data bases cannot depict fine details of travel patterns (particularly those that reflect local conditions), and limited sampling constrains further probing for underlying factors that differentiate minorities' travel behavior. Nonetheless, these data bases do provide the raw material for a reasonably complete sketch of minorities' travel behavior and energy use. That sketch reveals several statistically significant differences, some attributable to variations in demographic characteristics, others at least partly inexplicable at this stage of analysis. Further detail would require the use of local data bases that would increase comprehensiveness but reduce our ability to generalize to national patterns and trends.

*An SMSA is defined by the U.S. Office of Management and Budget as "An area that consists of a central city and its contiguous areas and that constitutes an integrated economic and social unit." Its boundaries are usually defined in terms of entire counties.

2 DEMOGRAPHIC FACTORS THAT AFFECT TRAVEL DEMAND AND FUEL USE

2.1 OVERVIEW

Fuel consumed by households for personal travel is a function of the number and length of trips made, the share of those trips via household vehicles, and the fuel efficiency of those vehicles. Demographic factors influence each of these variables -- either directly or through intervening variables such as vehicle availability -- and to a large extent explain many of the apparent differences in fuel consumption among population groups. Because of this powerful influence, which is documented in the extensive body of transportation research, the following discussion reviews some of the key relationships between demographic factors and travel demand. The factors that influence the numbers and types of vehicles available to households and the fuel efficiency of those vehicles are discussed in Sec. 3.

2.1.1 Tripmaking

Research at both the national and local level has consistently shown that household tripmaking is related to such factors as household size, stage in the family life cycle, income, activity patterns, and residence location.[12,21-23] These factors are typically measured by various readily observed household characteristics such as number of persons, workers and licensed drivers per household, age of household head (also called householder), income, and SMSA vs. non-SMSA residence location. Because differences in population density or other indicators of either traffic congestion or transit availability tend to disappear at the regional level, regional location (e.g., Northeast vs. South census regions) is not a significant factor in household travel demand.

Table 1 shows the trip rates (i.e., trips/household/day) associated with extreme values of each of the household characteristics most closely related to travel demand. Relative to the average tripmaking rate for all households (4.0 vehicle-trips/day), households at the tails of these distributions have trip rates ranging from 3% to nearly 300% of average.[12] While vehicle availability is not a demographic characteristic, it is included in Table 1 because it is such a powerful indicator of vehicle-trip rates. Only workers per household is comparable. Although many of these characteristics are highly correlated (e.g., low income and no workers) -- which in turn reduces their cumulative explanation power -- the over- or underrepresentation of certain population groups in these extreme categories strongly affects the overall tripmaking rates of those groups.

2.1.2 Trip Lengths

To a certain extent, extremely high or low average trip lengths can either mitigate or exacerbate the effect of extremely high or low average trip rates. While trip lengths tend to vary with population density, trip purpose, and, to some extent, income, the variation is not so pronounced as with trip rates.[12] Work trips represent approximately 30% of the vehicle-trips of the average household but 38% of the VMT

TABLE 1 Daily Vehicle-Trips per Household, by Extreme Values of Demographic Characteristics

Household Characteristic	Value	Trip Rate (trips per household per day)	Ratio to Average Trip Rate[a]
Household Size	1	1.5	0.38
	≥5	6.1	1.53
Age of Householder	35-44	5.1	1.27
	≥60	1.8	0.45
Income (1977 $)	<7,500	1.7	0.42
	≥25,000	6.6	1.65
Vehicles Available	0	0.1	0.03
	≥4	8.3	2.08
Workers per Household	0	1.5	0.38
	≥4	11.9	2.98
Drivers per Household	0	1.1	0.28
	≥3	8.0	2.00
Residence Location	SMSA Central City	3.4	0.85
	SMSA Suburbs	4.4	1.10

[a]4.0 vehicle-trips/household/day; excludes transit trips (5.56 total trips/household/weekday).

Source: Ref. 12.

because of their relatively longer length (9.2 mi for work trips vs. 8.3 for all trips). Thus, households with more workers tend to have not only above-average levels of tripmaking, but also relatively high VMT per household, all else being equal.

The relationship between average trip length and income is more complex. Work trip lengths increase from 7.0 mi for workers with family incomes under $5,000 (in 1977 dollars) to 11.5 mi for those with family incomes of $25,000 to $35,000, then decrease to 9.6 mi for workers with family incomes over $50,000. This is attributable to the inverse relationship between housing and commuting costs with increasing distance from the central city.[24] For other trip purposes (shopping, visiting friends and relatives, etc.), higher-income households do not have substantially longer trips than those of lower-income households.

2.1.3 Mode Shares

Nearly 84% of all individual trips are made in private vehicles. This share varies with income (which is strongly correlated with vehicle ownership), residence, location, and trip purpose. As shown in Table 2, just under 70% of all trips by members of low-income households are by private auto or truck.[12] For very high-income households, the comparable figure is above 90%. For central cities, where most public transportation services are concentrated, the private-vehicle share of person-trips is somewhat lower (78.9%) than average and the walking and transit shares are somewhat higher than average (13% and 5%, respectively).

TABLE 2 Modal Distribution of Person-Trips, by Household Income, Residence Location, and Travel Mode, 1977 (%)

Household Characteristic	Private Vehicle[a]	Public Transportation	Walk	School Bus	Other
All Person-Trips[b]	83.7	2.6	9.3	2.9	1.5
All Work Trips	90.5	4.5	-	NA[c]	5.0[d]
Household Income (1977 $)					
<5,000	69.9	4.6	21.0	2.0	1.6
5,000-9,999	80.5	3.4	11.4	3.0	1.7
10,000-14,999	85.5	2.4	8.4	2.4	1.3
15,000-24,999	86.7	1.8	6.8	3.2	1.5
25,000-34,999	86.5	2.0	7.0	3.2	1.3
35,000-49,999	88.3	2.0	6.1	2.1	1.5
≥50,000	90.7	1.1	4.7	1.5	2.0
Residence Location					
SMSA Central City	78.9	5.0	13.0	1.6	1.5
SMSA Suburbs	85.2	2.0	8.1	3.2	1.5
Non-SMSA	87.0	0.8	7.1	3.8	1.3

[a]Includes autos, vans, pickups, and other private trucks.

[b]A "person-trip" is the travel by an individual between a single origin and a single destination. Person-trips = household trips x persons/trip.

[c]NA = data not available.

[d]Includes walking.

Source: Ref. 12.

Work trips are nearly twice as likely (4.5% vs. 2.3%) as other trips to be via public transportation, e.g., bus, rail rapid transit, streetcar, commuter rail. While lower-income workers are somewhat more likely to use public transportation, the stronger relationship is with vehicle availability. Likewise, the propensity to carpool declines with increasing numbers of vehicles per household.[12]

2.1.4 Vehicle Fuel Efficiency

In the past several years, as new vehicles have become increasingly more fuel-efficient, vehicle age has become a reasonably good indicator of relative technical efficiency or miles per gallon (mpg). Average vehicle age declines with increasing income -- from 8.2 yr for lower-income households to 5.4 yr for higher-income households.[12]

Fuel efficiency per passenger-trip is a function of both the technical efficiency of the vehicle (see Sec. 3) and the number of persons (or occupants) per trip. Vehicle occupancy varies with household size, income, and number of vehicles per household. At only 1.3 passengers per vehicle, work trips have the lowest average occupancy and are, therefore, a prime target for efficiency improvement.[12] All other trip purposes have average occupancies of approximately 2.2 persons per vehicle.[12] If work trips had comparable occupancies, total vehicle travel could be reduced by 22%.*

Table 3 shows the range of average vehicle occupancy, by household income and size, vehicle availability, and trip purpose. While the relationships are as expected (e.g., vehicle occupancy falls with increasing income), trip purpose appears to be a stronger determinant of vehicle occupancy than are demographic factors.

2.2 DEMOGRAPHIC CHARACTERISTICS OF MINORITY AND POOR HOUSEHOLDS

2.2.1 Minority and White Households

Minority households tend to have distinctive demographic characteristics that explain much of their travel behavior. Table 4 indicates that disproportionate shares of black and Hispanic households reside in central cities, have significantly lower incomes, and have no licensed drivers. All of these factors contribute to below-average vehicle travel (see Table 1). In contrast, white households are far more evenly distributed by residence location and by income; they are also much more likely to have two or more licensed drivers.

The median income of black households is the lowest of all the racial/ethnic groups reported in Table 4. At $10,943, it was only 62% as high as that of white

*This calculation illustrates the magnitude of potential efficiency improvements. However, given firmly established lifestyles and preferences, it is doubtful that any significant improvement in work-trip vehicle occupancies can be achieved.

households in 1980. Nearly half of all black households had incomes under $10,000, and more than one-third had no employed members in that year. Black households were also the most urbanized of the racial/ethnic groups, with nearly two-thirds residing in central cities (compared to only one-third of white households). While the 1970 and 1980 censuses chronicled the increasing suburbanization of the black population, in 1980 less than 20% of black households lived in the suburbs of SMSAs. The combination of low income and residential concentration in central cities (which tend to have reasonably good public transportation) may account for the substantially lower rate of licensed drivers per black household.

The Hispanic household size distribution had the highest mean (3.5 persons, vs. 2.7 for white households) and largest standard deviation of all the population groups.* While the median household income of Hispanics was higher than that of blacks or of Native Americans (which comprise American Indians, Eskimos, and Aleuts), at $13,505 it was still only 76% as high as that of whites.

After blacks, Native Americans had the highest share of households in the under-$10,000 income range and the lowest median income ($12,256). Their household size distribution was similar to that of Hispanics, i.e., far fewer single-person households and substantially more households with five or more persons. Although 46% of all Native American households were outside SMSAs, the share located in central cities (31%) was nearly equivalent to that of white households.

*Hispanics and whites are not mutually exclusive in census data.

TABLE 3 Average Vehicle Occupancy, by Household Income and Size, Vehicle Availability, and Trip Purpose, 1977

Household Characteristic	Average Vehicle Occupancy[a] (persons/ vehicle)
Household Income (1977 $)	
<5,000	1.91
5,000-9999	1.88
10,000-14,999	1.93
15,000-24,999	1.86
25,000-34,999	1.89
35,000-49,999	1.70
≥50,000	1.64
Household Size (persons)	
1	1.46
2	1.69
3	1.78
4	1.99
≥5	2.22
Vehicles per Household	
0	1.99
1	1.91
2	1.90
3	1.82
≥4	1.76
Trip Purpose	
To Work	1.30
Work-Related	1.39
Family and Personal Business[b]	2.02
Civic, Educational, Religious	1.95
Social and Recreational[c]	2.44
Other	2.20
All Households	1.87

[a]The number of private-vehicle passengers plus drivers divided by the number of drivers making trips.

[b]Includes shopping and medical-dental trips.

[c]Includes visiting friends, pleasure driving, and vacations.

Source: Ref. 12.

TABLE 4 Distribution of Households by Key Travel-Related Characteristics of Racial/Ethnic Groups (%)

Household Characteristic	White	Black	Hispanic	Native American[a]	Asian and Pacific Islander	All Households
Household Income (1980 $)[b]						
<10,000	26.8	46.5	36.9	41.3	24.4	29.1
10,000-19,999	29.5	28.7	32.6	30.8	25.7	29.5
20,000-34,999	29.5	18.7	23.2	21.0	29.8	28.2
≥35,000	14.2	6.0	7.4	6.9	20.1	13.2
Residence Location[c]						
SMSA Central City	33.0	63.8	55.8	31.2	52.1	37.6
SMSA Suburbs	40.4	19.2	32.3	22.9	39.8	37.7
Non-SMSA	26.6	17.0	11.9	45.9	8.1	24.7
Household Size (persons)[b]						
1	22.8	23.8	14.7	18.6	18.4	22.6
2	32.7	23.0	20.8	23.1	22.2	31.2
3	17.2	17.7	19.0	17.9	18.0	17.4
4	15.4	14.7	18.6	16.7	18.9	15.4
5	7.5	9.4	12.5	10.9	11.3	7.9
≥6	4.4	11.4	14.4	12.8	11.2	5.5
Mean	2.7	3.1	3.5	3.3	3.3	2.8
Licensed Drivers[d]						
0	15.1	33.7	27.8	-	-	17.6
1	29.0	35.1	30.6	-	-	29.7
2	44.4	25.4	34.1	-	-	42.0
≥3	11.5	5.7	7.5	-	-	10.7
Mean	1.6	1.0	1.2	-	-	1.5
Workers[d]						
0	28.1	34.1	27.3	-	-	28.5
1	45.6	42.8	44.6	-	-	45.3
≥2	26.4	23.1	28.1	-	-	26.2
Mean	1.0	0.9	1.1	-	-	1.0
Age of Householder (yr)						
<60	71.2	77.1	85.8	83.0	84.5	72.4
≥60	28.8	22.9	14.2	17.0	15.5	27.6
All Households	82.9	10.4	5.0	0.5	1.2	100.0

[a]Includes American Indians, Eskimos, and Aleuts.

[b]1980 Census data. Source: Ref. 17.

[c]1980 Census data. Source: Ref. 18. Population shares are based on 1980 SMSA definitions.

[d]1977 survey data. Source: Ref. 12. Significance testing was limited to survey data.

In 1980, relatively few Native American, Hispanic, or Asian households (only 14 to 17%, vs. nearly 29% of white households) were headed by persons 60 or more years old. The significantly lower propensity of elderly Native Americans, Hispanics, and Asians to maintain separate households presumably reflects a mixture of cultural and economic factors beyond the scope of this study. The implication, however, is that the standard classification of households by age of householder may be too coarse to capture much of the differential travel patterns of elderly persons in these population groups. Nevertheless, such classification is still useful in controlling for the presence of working-age household members, which in turn influences vehicle availability and use.

More than 20% of Asian households had incomes of $35,000 or more and, as a group, Asians had the highest median incomes (nearly $20,000). Asian households were also the most heavily urbanized -- 92% resided in SMSAs and slightly more than half resided in central cities. Like those of Native American and Hispanics, the size distribution of Asian households was noticeably flattened.

While income distributions of white, black, and Hispanic households varied greatly, the distributions of workers per household were not statistically different. This indicates that blacks and Hispanics work either fewer hours or in occupations with much lower average wages than do white workers.

2.2.2 Poor and Nonpoor Households

Table 5 displays demographic data for poor and nonpoor households. As with blacks and Hispanics, the poor also have marked tendencies to reside in central cities and have fewer than average licensed drivers per household. These tendencies have persisted through time -- in the 1973 data cited by Ref. 5 and in the 1977 data reported here. While poor and nonpoor households are not significantly different in terms of their average sizes, their size distributions are dramatically different. The distribution for poor households is much flatter, i.e., 38.5% of poor households have only one person (vs. 17% of nonpoor households), and 15% of poor households have six or more members (vs. 4.2% of nonpoor households). Not surprisingly, the number of workers per poor household is only half the national average (0.5 vs. 1.0). Further, the share of poor households outside SMSAs is one-third greater than that of nonpoor households, and nearly 45% of all poor households are headed by persons 60 or more years old (compared with 29% for white households and substantially less for all other population groups).

As was seen in Table 4, not all of the demographic characteristics of minority households are associated with relatively low travel demand. The average size of black, Hispanic, and poor households is significantly larger than that of white households, with much of the difference due to the larger proportions of households with five or more members. Additionally, for Hispanics, Native Americans, and Asians, the proportion of one-person households is only half that of the other groups. In total, however, the travel-inducing effect of larger household size is unlikely to offset the travel-reducing effects of low incomes, central city residence, and fewer licensed drivers per household (see Table 1), particularly if these larger households contain many children.

TABLE 5 Distribution of Poor and Nonpoor Households by Key Travel-Related Characteristics, 1977 (%)

Household Characteristic	Poor	Nonpoor	All Households
Household Income[a] ($)			
<10,000	89.0	16	31.7
10,000-19,000	11.0	36.4	31.1
20,000-29,999	NA[b]	31.2	24.8
≥30,000	NA	15.7	12.5
Residence Location			
SMSA Central City	37.4[c]	34.2	34.9
SMSA Suburbs	21.9[c]	35.1	32.4
Non-SMSA	40.7[c]	30.7	32.7
Household Size			
1	38.5[c]	17.0	21.5
2	19.5[c]	33.4	30.5
3	6.5[c]	20.1	17.3
4	11.2[c]	17.5	16.2
5	9.3	7.8	8.1
≥6	15.0	4.2	6.5
Mean	2.9	2.8	2.8
Licensed Drivers			
0	38.8[c]	12.1	17.6
1	35.1[c]	28.3	29.7
2	20.0[c]	47.7	42.0
≥3	6.2	11.9	10.7
Mean	1.0[c]	1.6	1.5
Workers			
0	59.6[c]	20.4	28.5
1	29.4[c]	49.4	45.3
≤2	11.0[c]	30.2	26.2
Mean	0.5[c]	1.1	1.0
Age of Householder (yr)			
<60	55.6[c]	77.0	72.5
≥60	44.4[c]	23.0	27.5

[a]Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[b]NA = Not applicable.

[c]Significantly different from nonpoor households.

Source: Ref. 12.

2.2.3 Poor Elderly and Nonpoor Elderly Households

The extremely large share of poor households that are also elderly (45%) has important implications for that group's travel demands. According to survey data collected in southern California, the poor elderly are much less likely to have driver's licenses than are the nonpoor elderly, particularly if they are also Mexican-American (Fig. 1).[25] The poor elderly are also much more likely to have no cars (Fig. 2) and to rely on public transportation (Fig. 3).[25] (Survey results are reported for Mexican-Americans rather than Hispanics, although the two may have been synonymous in southern California in 1975, when the survey was conducted.) The percentage of nonpoor elderly whose primary means of transportation is either "Drive Self" or "Family" is approximately equal to the percentage of all person-trips by private vehicle (83.7%, as shown in Table 2). This suggests that preferences for particular travel modes are relatively stable across age groups. However, for poor elderly the sum of "Family" and "Drive Self" ranges from only 55% for whites and Mexican-Americans to 61% for blacks. These private-vehicle shares are far below the averages shown for different income and location categories in Table 2 and suggest that the elderly poor, regardless of

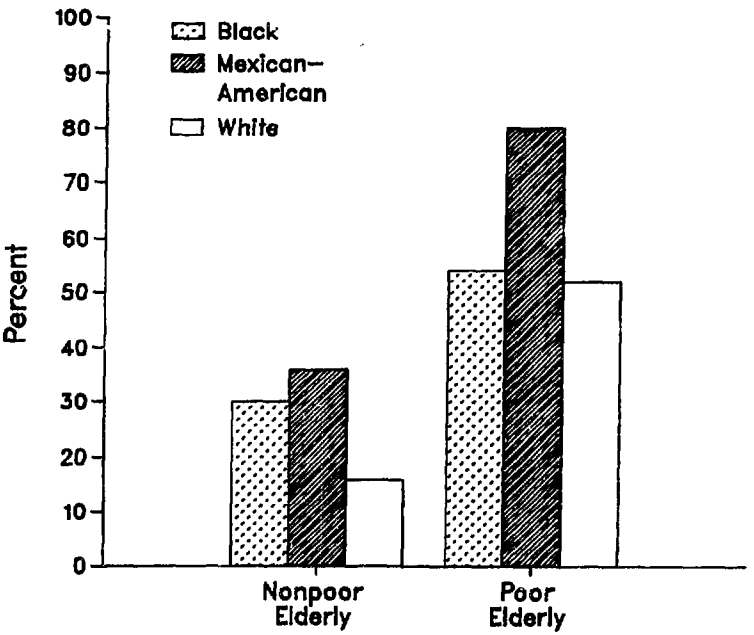

FIGURE 1 Percentages of Poor and Nonpoor Elderly in Southern California Sample without Driver's Licenses, by Ethnicity, 1975

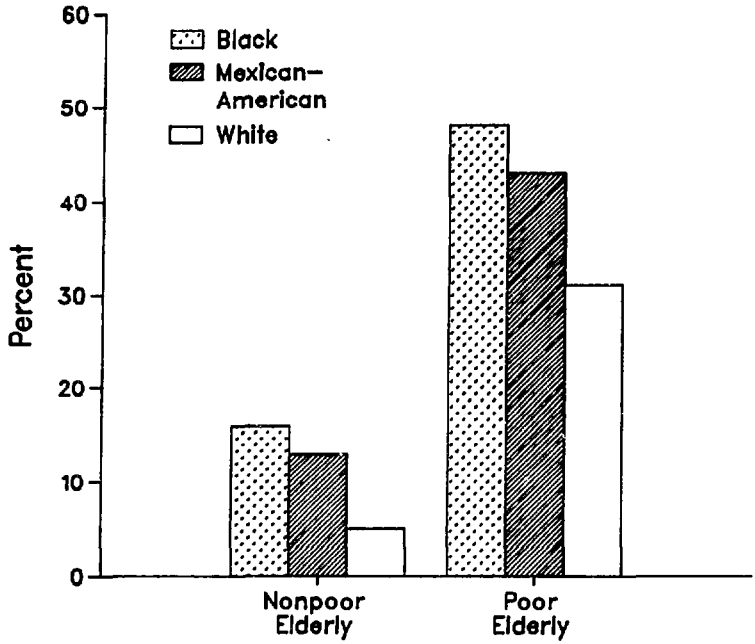

FIGURE 2 Percentages of Poor and Nonpoor Elderly in Southern California Sample without Cars, by Ethnicity, 1975

minority status, are more dependent on public transportation and are thus more likely to be disproportionately affected by policies and programs that influence the cost or quality of public transportation.*

*This policy implication is likely to weaken in the long run. Many of the elderly poor never possessed driver's licenses. Because most of the next generation of the elderly (i.e. those currently middle-aged) do drive, the future proportion of elderly persons licensed to drive should more closely approximate the proportion of nonelderly persons licensed to drive.[26]

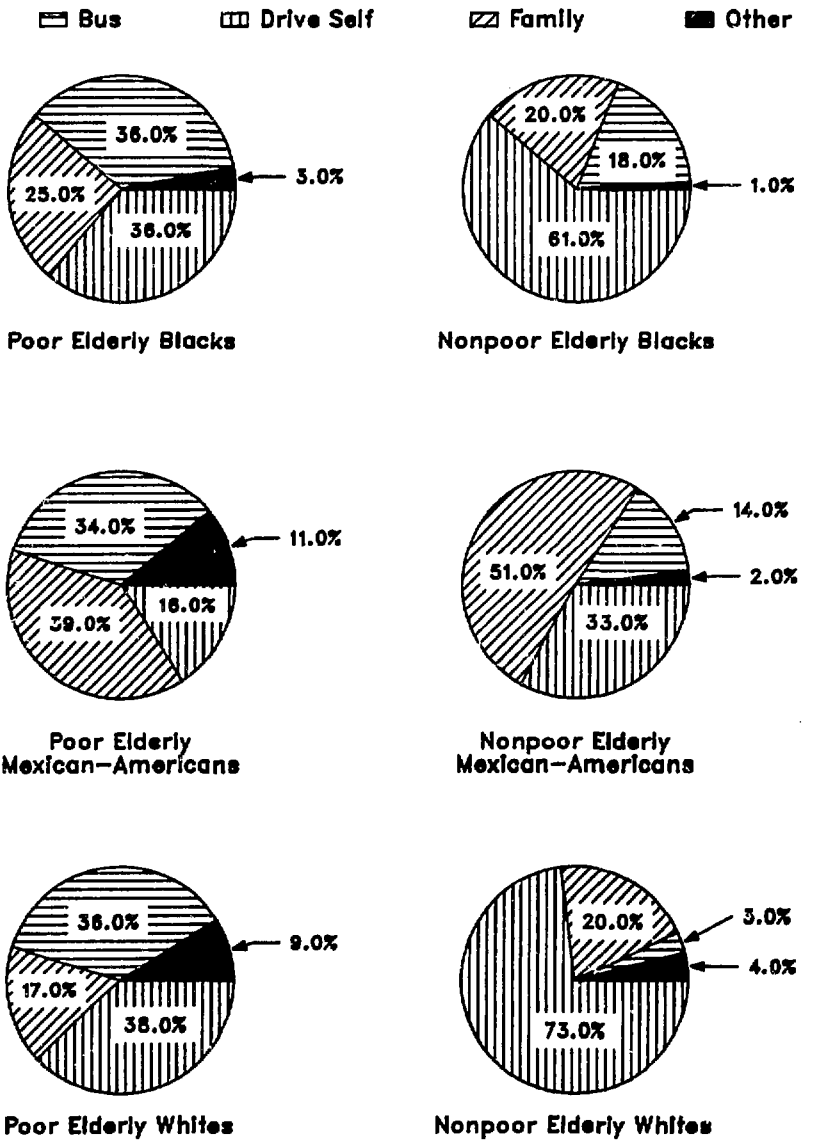

FIGURE 3 Primary Means of Transportation for Poor and Nonpoor Elderly in Southern California Sample, by Ethnicity, 1975

3 CHARACTERISTICS OF MINORITY HOUSEHOLD VEHICLES

The number and type of private vehicles available to households* have an important bearing on the quantity and modal distribution of household travel demand and, ultimately, fuel use. As shown in Table 1, households with no vehicles generate extremely little vehicular travel, while multivehicle households make more than twice the average number of daily trips. Because vehicle availability, like travel demand, is closely tied to demographic factors, a brief description of those factors precedes the discussion of the number, types, and relevant characteristics of private vehicles owned by or regularly available to minority households.

3.1 DEMOGRAPHIC FACTORS THAT AFFECT NUMBER AND CHARACTERISTICS OF HOUSEHOLD VEHICLES

3.1.1 Demographic Factors and Vehicle Availability

Research has repeatedly shown that vehicle availability is associated with household size and composition (e.g., the number of adults or workers per household, and age of householder), income, and residence location. Clearly, many of these factors are intercorrelated, some are synergistic (e.g., central city location and elderly householder), and others are mutually exclusive (e.g., multiworker households with only one adult). Table 6 shows the influence of several of these factors -- both individually and in conjunction with residence location -- on the average number of vehicles available to households. Not surprisingly, the combination of low income and central city location -- particularly common among black and Hispanic households -- is associated with the lowest rate of vehicle availability. Conversely, the combination of three or more workers and suburban location -- most typical among white households -- is associated with the highest rate of vehicle availability. The average number of licensed drivers per household is also a particularly strong determinant of average vehicle availability, with the number of vehicles per household tending to level off at a point approaching the number of licensed drivers.[27]

3.1.2 Demographic Factors and Vehicle Type

The share of household vehicles represented by light trucks (generally vans and pickups) also appears to vary with demographic characteristics. Light trucks are most prevalent in rural households and in households with lower-middle incomes and/or two or more vehicles. Table 7 illustrates the effect of income in single- and multivehicle households. Income is clearly important -- the percentage of light trucks in single-

*Availability, not ownership, is the relevant characteristic of interest to travel demand and energy use. A household need not own a vehicle for it to be regularly available.

TABLE 6 Vehicle Availability, by Household Demographic Characteristics

Household Characteristic	Vehicles per Household Location[a]			
	SMSA Central City[b]	SMSA Suburbs	Non-SMSA	All Locations
Household Income (1980 $)[b]				
<10,000	0.65	1.09	1.14	0.95
10,000-19,999	1.24	1.58	1.80	1.55
20,000-34,999	1.77	2.06	2.26	2.05
≥35,000	2.20	2.51	2.70	2.47
All Incomes	1.23	1.78	1.75	1.61
Age of Householder (yr)[c]				
<60	1.31	1.94	1.92	1.78
≥60	0.83	1.29	1.26	1.17
Workers[d]				
0	1.33	1.40	1.40	1.38
1	1.61	1.82	1.88	1.77
2	2.03	2.20	2.28	2.17
≥3	2.84	3.30	3.06	3.09

[a]Unless otherwise indicated, denominator includes households with and without vehicles.

[b]1980 data. Source: Ref. 28.

[c]All households. Availability rates for central city households may be somewhat underestimated because households in central cities of mid-sized SMSAs are excluded from this calculation. Based on a comparison with 1977 data from Ref. 12, the underestimate is <10%.

[d]1977 data for households with vehicles only. Source: Ref. 12.

vehicle households drops from 8.5% to less than 2% and the percentage in multivehicle households declines from nearly 27% to less than 14% as income rises from under $7500 to over $50,000 per year. However, a more important factor in the incidence of light trucks appears to be primary vs. secondary vehicle function. Even at the highest income levels, light trucks are three to four times as likely to be in multivehicle households. (As discussed below, minority households are much less likely to own two or more vehicles and much less likely to own light trucks. Presumably these two patterns are related.) Only in low-density rural areas does the share of light trucks in single-vehicle households (15.8%) approach that of multivehicle households. Here too, however, light trucks are more than twice as prevalent in multivehicle households.

TABLE 7 Distribution of Vehicle Types within Single- and Multivehicle Households, by Income, 1977 (%)

Household Vehicle Ownership and Income (1980 $)[a]	Autos[b]	Trucks[b]	Percentage of Total Vehicles[c]
Single-Vehicle Households			
<7,500	91.5	8.5	4.9
7,500-12,999	93.5	6.5	6.8
13,000-19,999	92.8	7.2	5.4
20,000-34,999	94.2	5.8	3.7
35,000-49,999	94.1	5.9	0.7
≥50,000	98.4	1.6	0.3
Subtotal	93.1	6.9	21.8
Multivehicle Households			
<7,500	73.3	26.7	4.1
7,500-12,999	73.7	26.3	10.7
13,000-19,999	77.2	22.8	17.0
20,000-34,999	79.8	20.2	28.4
35,000-49,999	82.8	17.2	11.1
≥50,000	86.4	13.6	6.9
Subtotal	79.0	21.0	78.2

[a]Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[b]Percentage of all vehicles in households within income range that are autos (or trucks).

[c]Distribution of total household vehicles by vehicle availability and income range of household.

Source: Ref. 12.

Of all vehicles owned by or regularly available to households, some 82% were passenger autos and 18% were light trucks in 1977.[12] Data for 1980 suggest that these shares may have changed slightly -- to 80.4% autos and 19.6% light trucks[28] -- but that the general patterns of vehicle preference by income and location have remained relatively stable.

3.1.3 Demographic Factors and Vehicle Characteristics

Household income is related not only to auto and light truck shares but also to several vehicle attributes that influence fuel economy, including vehicle age, engine size, and percentage of vehicles with air conditioning. Not surprisingly, these attributes are also related to the value of the vehicle. As shown in Table 8, lower-income households in 1977 tended to have vehicles nearly two years older than average, fewer than average of which had air conditioning. Because more powerful engines and optional equipment increased vehicle weights in the early 1970s,[29] the combination of a largely pre-1970 vehicle fleet and relatively less air conditioning resulted in somewhat lower average curb weight.

In 1969, the mean age of autos in the lowest-income households was also about two years greater than that of the entire fleet (7.0 vs. 5.1 years).[30] If this relationship still holds, the average vehicle age in the lowest-income households would now be well over nine years (because the 1984 fleet averaged 7.5 years); fuel economy would be no better than 15.8 mpg, the average for all model-year 1975 autos sold in the U.S.[31] This compares with about 17.5 mpg for all passenger autos on the road in 1984.[32]

TABLE 8 Characteristics of Autos, by Household Income, 1977[a]

Household Income (1977 $)	Average Age (yr)	Average Curb Wt. (lb)	Average No. of Cylinders	With Air Conditioning (%)
<5,000	8.38	3469	7.06	49.5
5,000-9,999	7.23	3572	7.00	52.6
10,000-14,999	6.54	3630	6.97	54.9
15,000-24,999	6.04	3639	6.95	58.1
25,000-34,999	5.56	3728	6.87	62.7
35,000-49,999	4.56	3835	6.87	75.2
≥50,000	5.32	3796	7.15	65.3
All Households	6.40	3640	6.97	56.9

[a]Only automobiles or station wagons owned or available on a regular basis.

Source: Ref. 14.

3.2 VEHICLE AVAILABILITY IN MINORITY AND POOR HOUSEHOLDS

3.2.1 Vehicles per Household

In 1980, the 129.5 million light-duty vehicles on U.S. roads translated into an average of 1.6 vehicles per household (1.3 autos and 0.3 light trucks or vans). The ratio of autos per household was essentially unchanged since 1977, while light trucks and vans per household had risen substantially. Among black, Hispanic, and poor households, vehicle availability rates were significantly lower than these averages. As shown in Fig. 4, 32.9% of black households and 22.7% of Hispanic households were without vehicles in 1980, compared to only 10.1% of white households. Combined with the far smaller proportion of black and Hispanic households with three or more vehicles (7.0% and 12.3%, respectively, vs. 17% for white households), the average number of vehicles per household was only 1.1 for blacks and 1.4 for Hispanics (vs. 1.7 for whites -- see Table 9). The distribution of vehicles per household was even more skewed among the poor, 36.9% of whom had no vehicles, where the average number of vehicles per household was less than 1.0.

Zero-Vehicle Households. Zero-vehicle households are a relevant subgroup for our analysis -- not only because they represent a significant share of the minority population and are likely to experience difficulty in meeting their travel needs, but also because their dramatically lower travel reduces many of the gross averages (e.g., vehicle-miles/household, gasoline expenditures/household, etc.) for minority and poor households. Thus, certain of the summaries reported here exclude zero-vehicle households.

Table 10 focuses on the characteristics that set zero-vehicle households apart from other households. Among all population groups, they are far more likely to reside in central cities and have lower incomes and elderly householders.[12,33] Table 11 shows the percentages of zero-vehicle vs. total households that resided in SMSA central cities and had low incomes in 1977. These percentages more or less reflect the conventional wisdom that households with no vehicles lack the financial resources to buy and maintain them, choose not to have them because they already have access to sufficient transportation alternatives (e.g., urban public transportation), or both.* What is not so readily dismissed is the marked difference in age distributions of total vs. zero-vehicle households. Among whites, nearly two-thirds of zero-vehicle households have elderly householders (vs. 28.5% of all white households). Among blacks and Hispanics, the same general relationship holds, but it is much weaker (i.e., for both groups, approximately one-third of zero-vehicle households have elderly householders, compared with 26% of all black households and 15% of all Hispanic households).

*Residence in central cities near public transportation may be either a result or cause of low vehicle ownership. The direction of causality cannot be inferred from the data.

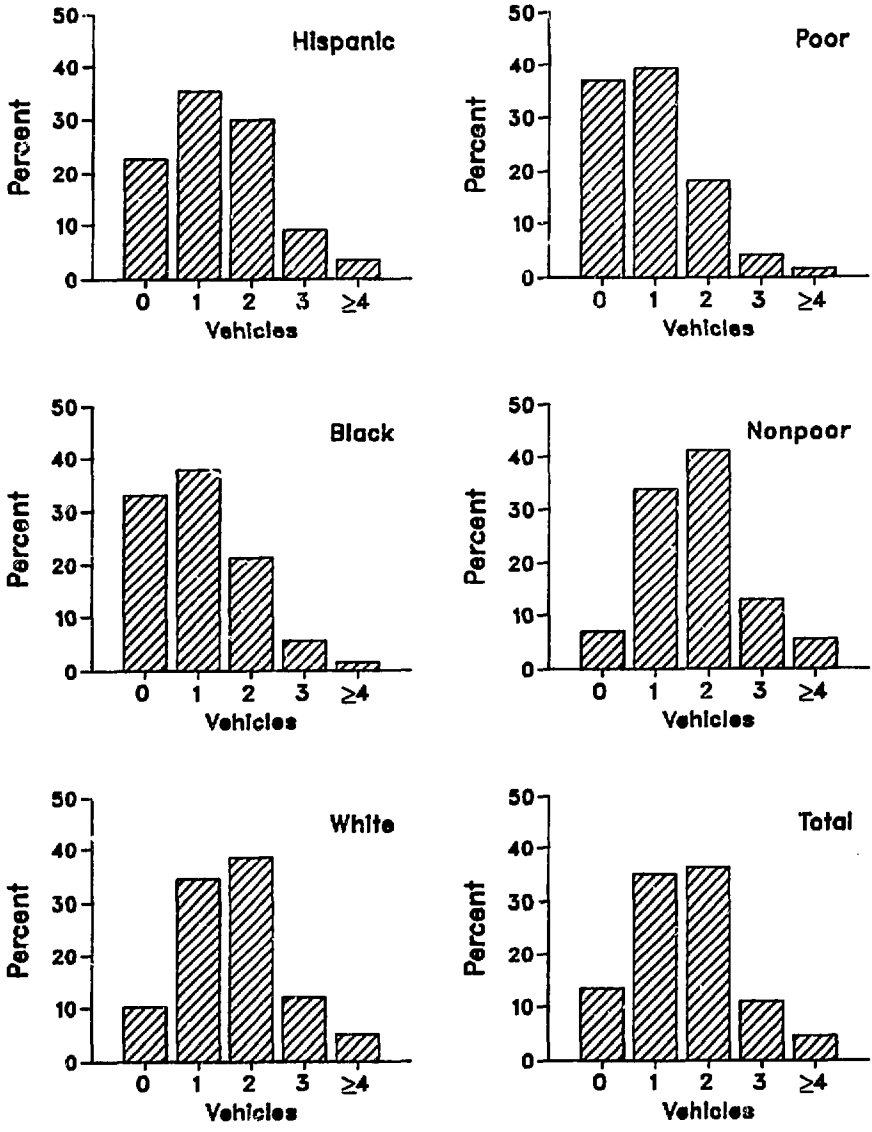

FIGURE 4 Number of Vehicles Available in Each Household, by Population Group, 1980

TABLE 9 Total Vehicles and Vehicles per Household, by Vehicle Type, for Each Population Group, 1980

Vehicle Type	White	Black	Hispanic	Poor	Nonpoor	All Households
Total Vehicles (10^6)	112.88	9.01	5.63	16.18	113.34	129.52
Autos	89.95	7.91	4.46	12.81	91.26	104.08
Trucks or Vans	22.93	1.10	1.17	3.37	22.07	25.44
Vehicles per Household	1.70	1.07	1.37	0.95	1.79	1.61
Autos	1.36	0.93	1.09	0.75	1.44	1.30
Trucks or Vans	0.35	0.13	0.28	0.20	0.35	0.32

Source: Ref. 28.

No doubt the overrepresentation of the elderly in zero-vehicle households is related to such factors as income and location, as well as to physical disabilities that limit driving ability and to the historically lower rate of drivers among older population cohorts (even when they were younger). Nonetheless, zero-vehicle white households are significantly more likely to be elderly than are their black or Hispanic counterparts. Because the elderly are more likely to live in smaller households with fewer licensed drivers and to have a far lower frequency of work trips, these differences in age structure may obscure other important differences in travel patterns and energy use between white and minority zero-vehicle households. Thus, elderly households have been omitted from certain of the comparisons in this report.

Table 12 compares the average number of vehicles per nonelderly household for each of the population groups. With elderly households omitted, average availability jumps 12% for white households but only 6% and 4%, respectively, for black and Hispanic households. Availability varies systematically with income and location for all population groups. Residence outside a central city generally increases vehicle availability by 40-60% for lower-income households and 10-30% for higher-income households in all population groups. In the lowest income group, blacks have only about half the average number of vehicles available to whites (even when residence location is controlled; in higher income groups, blacks' vehicle availability rises to 75-90% of the white rate. Similarly, when location is controlled, Hispanics' vehicle availability rises from 60-80% of whites in the lowest income group to a rate virtually identical to that of whites in upper income ranges.

TABLE 10 Distribution of Zero-Vehicle Households, by Income, Residence Location, and Householder Age, 1977 (standard errors shown in parentheses)

Household Characteristic	White	Black	Hispanic	Poor	Nonpoor	All Households
Household Income (1980 $)[a]						
<10,000	5821.7	2196.9	681.8	7337.5	2523.0	8860.5
	(87.4)	(50.6)	(32.4)	(25.9)	(86.0)	(105.3)
10,000-19,999	1385.2	366.1	183.8	142.4	1815.8	1958.2
	(77.3)	(43.6)	(29.0)	(25.9)	(80.4)	(91.4)
20,000-29,999	392.6	116.1	41.2	NA[b]	549.9	549.9
	(45.6)	(26.4)	(14.8)		(51.9)	(46.3)
≥30,000	132.1	42.8	10.6	NA	198.6	198.6
	(26.3)	(15.0)	(8.2)		(30.0)	(28.9)
Residence Location						
SMSA Central City	3617.4	1743.8	687.7	3067.0	3085.8	6152.8
	(105.2)	(61.5)	(32.3)	(97.2)	(81.4)	(128.4)
SMSA Suburbs	1817.0	408.2	134.5	1356.7	1041.8	2398.6
	(88.2)	(45.5)	(25.5)	(77.8)	(68.2)	(99.5)
Non-SMSA	2297.2	569.9	95.1	2056.1	959.7	3015.9
	(94.3)	(52.5)	(22.7)	(89.4)	(65.6)	(109.9)
Age of Householder (yr)						
<60	2773.2	1777.5	642.5	2655.7	2668.4	5324.1
	(98.2)	(61.0)	(33.2)	(94.0)	(85.0)	(127.2)
≥60	4958.5	944.4	274.8	3824.2	2419.0	6243.1
	(98.2)	(61.0)	(33.2)	(94.0)	(85.0)	(127.2)
All Households without Vehicles	7731.7	2721.9	917.3	6479.8	5087.4	11567.2
	(24.7)	(34.8)	(18.1)	(59.0)	(13.7)	(40.5)
Row Percent	66.8	23.5	7.9	56.0	44.0	100.0

[a]Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of $0-7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[b]NA = Not applicable.

Source: Ref. 12.

TABLE 11 Percentages of Zero-Vehicle Households and Total Households with Central City Residence and Low Income, by Population Group, 1977

Population Group	Central City Residence[a]		Income under $10,000 (1980 $)	
	% of Households[b]	% of Zero-Vehicle Households[c]	% of Households[b]	% of Zero-Vehicle Households[c]
White	30.8	46.8	28.5	75.3
Black	58.5	64.1	52.3	80.7
Hispanic	56.2	75.0	43.7	74.3
Poor	37.4	47.3	89.0	97.8
Nonpoor	34.2	60.7	16.7	49.6
Total	34.9	53.2	31.7	76.6

[a]Central city residence applies to SMSAs defined as of 1970 and is therefore not consistent with percentages based on 1980 Census data reported in Table 4.

[b]Percentage of all white, Hispanic, etc., households in central cities (or with incomes under $10,000).

[c]Percentage of all white, Hispanic, etc. zero-vehicle households in central cities (or with incomes under $10,000).

Source: Ref. 12.

Differences in Vehicle Availability among Low-Income Households. Most of the minority deficit in vehicle availability is in lower-income households, regardless of residence location. Some of the deficit may be attributable to local variations in the residential distributions of low-income minority households and the accessibility of those neighborhoods to public transportation. Similarly, relative densities may vary between predominantly white and minority neighborhoods, and this may influence the supply of off-street parking and other factors that make private-vehicle ownership more or less desirable. However, none of these factors explain why differences tend to lessen and ultimately disappear as income rises.

How do low-income minority households differ from low-income white households? Three possibilities were investigated:

- Household composition: if minority households tend to have fewer adults -- or more specifically, fewer licensed drivers -- their vehicle availabilities could be expected to be lower than those of white

TABLE 12 Average Number of Vehicles per Nonelderly Household, by Residence Location and Income for Each Population Group, 1980[a] (standard errors shown in parentheses)

Household Location and Income (1980 $)	White	Black	Hispanic	Poor	Nonpoor	All Households
SMSA Central City						
<10,000	0.90 (0.81)	0.50 (0.47)	0.53 (0.49)	0.63 (0.58)	0.83 (0.76)	0.70 (0.64)
10,000-19,999	1.28 (1.10)	1.04 (0.97)	1.15 (0.99)	1.14 (1.00)	1.20 (1.05)	1.20 (1.05)
20,000-34,999	1.79 (1.51)	1.59 (1.42)	1.74 (1.46)	NA[b]	1.73 (1.48	1.73 (1.48)
≥35,000	2.22 (1.94)	2.01 (1.79)	c	NA	2.20 (1.92)	2.20 (1.92)
SMSA Suburbs						
<10,000	1.42 (1.20)	0.73 (0.66)	1.18 (0.91)	1.36 (1.13)	1.23 (1.06)	1.32 (1.10)
10,000-19,999	1.64 (1.35)	1.32 (1.19)	1.47 (1.23)	1.75 (1.41)	1.59 (1.32)	1.59 (1.32)
20,000-34,999	2.10 (1.71)	1.81 (1.62)	2.11 (1.65)	NA	2.08 (1.70)	2.08 (1.70)
≥35,000	2.53 (2.18)	2.25 (1.99)	2.66 (2.23)	NA	2.52 (2.17)	2.52 (2.17)
Non-SMSA						
<10,000	1.42 (1.05)	0.78 (0.68)	1.12 (0.85)	1.27 (0.93)	1.33 (1.06)	1.29 (0.97)
10,000-19,999	1.83 (1.31)	1.60 (1.25)	1.75 (1.30)	1.93 (1.30)	1.79 (1.31)	1.80 (1.31)
20,000-34,999	2.25 (1.64)	2.02 (1.72)	2.27 (1.53)	NA	2.24 (1.64)	2.24 (1.64)
≥35,000	2.74 (2.11)	2.08 (1.74)	2.54 (2.03)	NA	2.71 (2.10)	2.71 (2.10)
All Households	1.91 (1.51)	1.13 (1.00)	1.43 (1.13)	1.15 (0.90)	1.91 (1.53)	1.78 (1.42)

[a]Includes zero-vehicle households.

[b]NA = Not applicable.

[c]Not reported because of a large variance in the observed data.

Source: Ref. 28.

households. As shown in Fig. 5, however, there are systematic differences in the average number of vehicles per licensed driver, when income and residential location are controlled. This suggests that household composition is probably not a key factor.

- Average income: if low-income white, black, and Hispanic households have systematically different average incomes, it may not be possible to control for income using the broad category of <$10,000. With 1980 data from Ref. 28, mean incomes were calculated for each of our four income categories (<$10,000, $10,000-19,999, $20,000-34,999, and >$35,000) and compared across population groups. With the exception of the highest income group, all differences were within normal sampling error. Hence, this possibility was rejected as highly unlikely.

- Long-run average income: according to this related hypothesis, fluctuations in income (i.e., "income dynamics") may temporarily place some generally middle-class households in the low-income category, thereby making that category much less homogeneous than others. Compared with the "persistently poor," who have extended periods of low annual income, these "temporarily poor" households may be expected to have more accumulated wealth (including vehicles) and greater access to capital, and to retain a lifestyle more in keeping with their long-run average income. The growing body of research using longitudinal data from the University of Michigan's ongoing Panel Study of Income Dynamics (PSID) strongly supports this hypothesis. Only 11% of the PSID sample had a total cash income below 125% of the federally defined poverty threshold in 1978, but nearly one-third fell below that level in at least one of the 10 preceding years.[34] While the temporarily poor do not appear to be very different from the population as a whole, the persistently poor are heavily concentrated in two overlapping groups -- black and female-headed households.[34-36] Although only 28% of all persons temporarily poor in 1978 lived in families headed by a woman and only 19% lived in black households, 61% of the persistently poor were in female-headed households and 62% were in black households.[34] As a result of these racial distinctions between the temporarily and persistently poor, the mean duration of a poverty spell ranged from 3.4 years for whites to 6.5 years for blacks.[35]

Cross-sectional data sets that report income for only a single point in time (generally the year prior to the survey) cannot capture important distinctions in long-run income, particularly at the lower end of the range. Thus, we suspect that our two groups -- low-income blacks and low-income whites -- may not be strictly comparable.

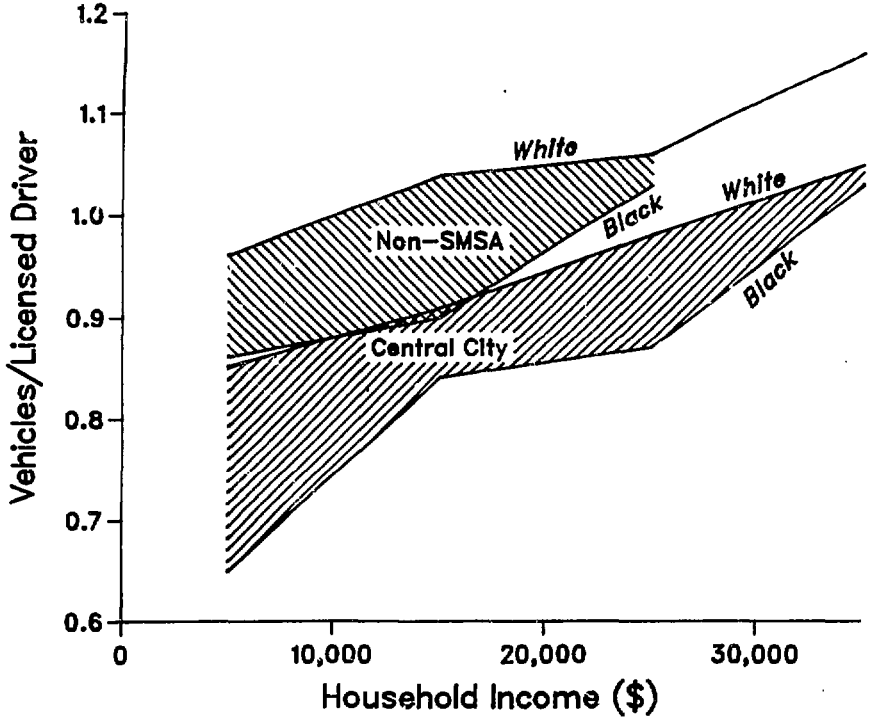

FIGURE 5 Vehicles per Licensed Driver in Nonelderly Black and White Households, by Income Category and Residence Location, 1977

3.2.2 Trends in Vehicle Availability

Before the late 1970s, virtually all household vehicles were automobiles, and most surveys of personal travel failed to obtain data on the numbers or use of other private vehicles, primarily light trucks. Thus, a discussion of trends in vehicle availability is limited to changes over time in the proportions of households with 0, 1, and 2+ autos and in average rates of auto availability. These, as well as the relationship between changes in household income and auto availability distributions, still have important policy implications, however.

Figure 6 shows that from 1969 to 1977, zero-auto households declined from more than 63% to about 50% of low-income households and from about 25% to 21% of lower-middle-income households. At the same time, single-auto households rose from about 33% to more than 40% of low-income households, while declining slightly among lower-middle and upper-income households. For the latter two groups, the share of households with two or more autos rose from 13% to 20% and from 71% to 73%, respectively. Collectively as a result of these shifts, autos per household rose from 1.16 in 1969 to 1.30 in 1977.[30]

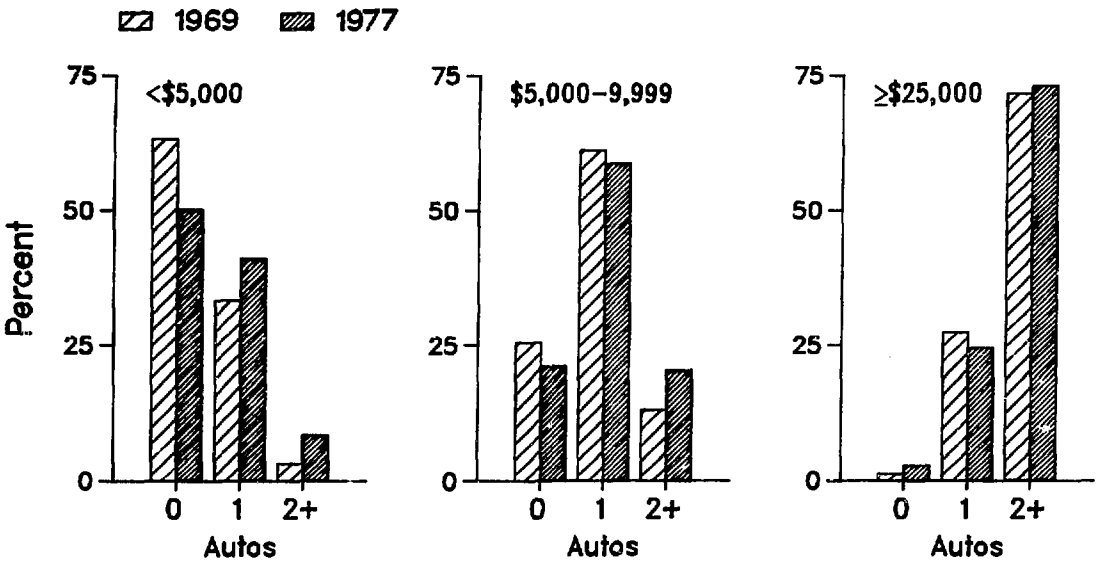

FIGURE 6 Trends in Percentages of Households with Zero, One, and Two or More Autos, by Selected Income Groups (1977 dollars)

While changes in autos per household tell part of the story, a more important measure is the change in the share of total autos in households of different income levels. Based on the 1969 and 1977 distributions of households and autos by income and counts of total autos and households, the shares of total households and total autos were calculated for five income groups. Not surprisingly, most of the growth between 1969 and 1977 -- in both share of households and share of auto -- was in the upper-middle- and upper-income groups. Over the nine-year period, groups for which auto shares rose faster (or declined slower) than household shares had a net increase in auto availability, while those for which auto shares rose slower (or declined faster) than household shares suffered a net loss in availability. Beyond small fluctuations that may be due to sampling variability, Fig. 7 shows that the lowest income group experienced the largest net gain in auto availability, followed by the lower-middle and the highest income groups. The middle income group experienced the largest net loss, part of which may be due to the continuing shift from autos to light trucks, particularly among lower- and middle-income multivehicle households. Another factor may be changes in the size and composition of middle-income households as the children of the "baby boom" generation moved out on their own; this may also explain the increase in the share of households in the lowest income group.

Regardless of its cause, the growth in auto availability among households in the lowest income group is clearly a positive development with important implications for minority households, most of which also have low incomes. If the trend continues, it suggests that policies with impacts on vehicle availability and use will increasingly affect low-income households even though such households now have below-average rates of vehicle availability. It also suggests that lower-income households will be one of the

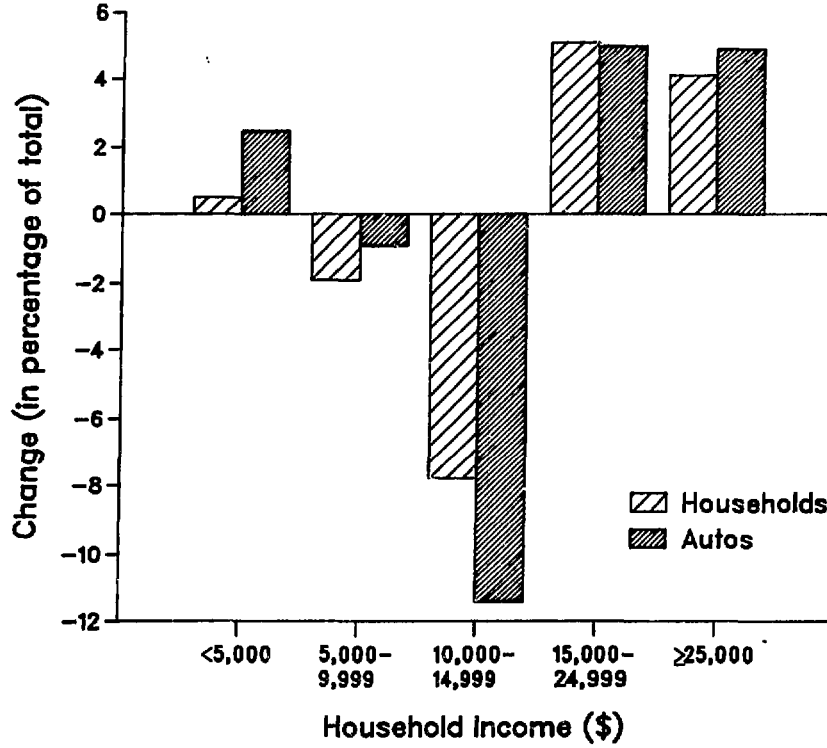

FIGURE 7 Change in Distributions of Total Households and Total Autos, by Income Group 1969-77 (1977 dollars)

largest sources of growth in the future vehicle fleet,* and given the high price of newer vehicles, their demand may keep older vehicles in the fleet longer than in the past. This, in turn, will affect the average age and fuel economy (see following discussion) of vehicles in low-income households.

3.3 CHARACTERISTICS OF VEHICLES AVAILABLE TO MINORITY AND POOR HOUSEHOLDS

3.3.1 Vehicle Types

Table 13 presents vehicle availability rates by type (i.e., autos per household and light trucks or vans per household) for nonelderly households. Again, the aggregate rates

*Preliminary data from the 1983 Nationwide Personal Transportation Study confirm that a disproportionate share of the 1977-83 growth in the vehicle population occurred in lower-income households.[37]

TABLE 13 Vehicle Availability Rates for Nonelderly Households, by Residence Location, Income, and Vehicle Type for Each Population Group, 1980

Household Location and Income (1980 $)	White		Black		Hispanic		Poor		Nonpoor		All Households	
	Autos	Trucks	Autos	Trucks	Autos	Trucks	Autos	Trucks	Autos	Trucks	Autos	Trucks
SMSA Central City												
<10,000	0.81	0.08	0.4.	0.03	0.49	0.04	0.58	0.05	0.76	0.07	0.64	0.06
10,000-19,999	1.10	0.18	0.97	0.08	0.99	0.17	1.00	0.15	1.05	0.15	1.05	0.15
20,000-34,999	1.51	0.28	1.42	0.16	1.46	0.28	NA[a]	NA	1.48	0.25	1.48	0.25
≥35,000	1.94	0.28	1.79	0.22	b	b	NA	NA	1.92	0.28	1.92	0.28
SMSA Suburbs												
<10,000	1.20	0.23	0.66	0.08	0.91	0.27	1.13	0.23	1.06	0.17	1.10	0.21
10,000-19,999	1.35	0.29	1.19	0.12	1.23	0.25	1.41	0.34	1.32	0.27	1.32	0.27
20,000-34,999	1.71	0.39	1.62	0.19	1.65	0.46	NA	NA	1.70	0.38	1.70	0.38
≥35,000	2.18	0.36	1.99	0.35	2.23	0.43	NA	NA	2.17	0.35	2.17	0.35
Non-SMSA												
<10,000	1.05	0.37	0.68	0.10	0.85	0.27	0.93	0.34	1.06	0.27	0.97	0.31
10,000-19,999	1.31	0.51	1.25	0.35	1.30	0.46	1.30	0.63	1.31	0.49	1.31	0.50
20,000-34,999	1.64	0.61	1.72	0.29	1.53	0.74	NA	NA	1.64	0.60	1.64	0.60
≥35,000	2.11	0.63	1.74	0.34	b	b	NA	NA	2.10	0.62	2.10	0.62
All Households	1.36	0.35	0.93	0.13	1.09	0.28	0.75	0.20	1.44	0.35	1.30	0.32

[a]NA = Not available.

[b]Not reported because of a large variance in the observed data.

Source: Ref. 28.

for each of the population groups are substantially different -- 1.36 autos and 0.35 trucks per white household vs. 0.93 autos and 0.13 trucks per black household and 1.09 autos and 0.28 trucks per Hispanic household. Further, when income and residence location are controlled, the magnitude of these differences again drops among all but the lowest-income households.

The availability deficit among Hispanics and especially among blacks is reduced somewhat when the comparison is limited to autos. However, most of the convergence is in upper-income households, where the deficit in vehicle availability is already substantially lower. Among black and Hispanic households with incomes under $10,000, auto availability is still only 55-65% and 60-80%, respectively, of that of white households. The magnitude of this difference is beyond sampling error and again suggests either fundamental differences in income dynamics between low-income white and minority households or more subtle geographic and household composition variables that affect vehicle availability.

Beyond the clear deficit in vehicles per household, black and Hispanic households also differ from white households in the shares of household vehicles represented by autos and light trucks. As shown in Table 13 and Fig. 8, blacks are much less likely to have light trucks than are either whites or Hispanics, even when income and residential location are controlled. Because light trucks are roughly three times as prevalent in multivehicle households (see Table 7), some of the difference may be attributed to blacks' overrepresentation in single-vehicle households. However, when controlled for vehicle availability, the shares of trucks in black single- and multivehicle households still tend to be significantly lower than those of white households for most income and location categories. The shares of trucks in Hispanic households are not substantially lower than those of white households and in non-SMSA locations may actually exceed the latter.

Historically, light trucks have tended to be more popular in rural areas and in western states.[38] While this may explain some of the variation in aggregate light truck availability among whites, blacks, and Hispanics, one can speculate that as a result of the regional distribution of black households a portion of their truck preferences is shifted toward autos. Thus, these households should have above-average rates of auto availability. Apparently, the factors that contribute to deficits in auto availability among black households (discussed above) more than compensate for this effect.

3.3.2 Vehicle Age

As shown in Table 14, the average vehicle in black and Hispanic households is substantially older than the average vehicle in white households. When income is controlled, this age discrepancy widens for the lowest-income households but disappears for households with incomes above $20,000. The discrepancy does not appear to be related to the age of the householder. Rather, it appears that the lower economic mobility of low-income Hispanic and especially black households not only reduces their vehicle availability but -- for those with vehicles -- also limits purchases to older, lower-valued units and extends the holding period before vehicle replacement.

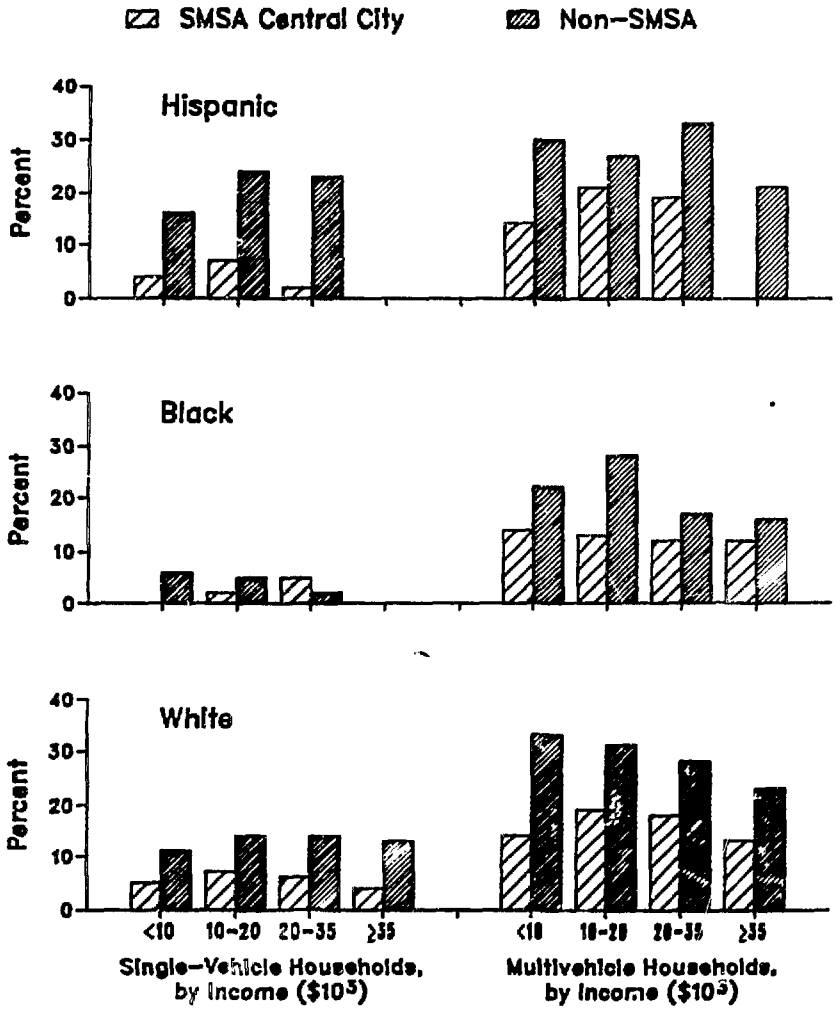

FIGURE 8 Shares of Light Trucks in Vehicles Available to White, Black, and Hispanic Single- and Multivehicle Nonelderly Households

Similar findings were obtained from 1973 data reported by Newman and Day.[8] In that year, 69% of the autos in poor households were five or more years old, compared with only 37% of the autos in nonpoor households. In 1977, the proportion of vehicles five or more years old was 78% in poor households,* compared to only 19% in nonpoor households.[12]

*In the analysis of 1973 data, "poor" is roughly equivalent to or below the poverty level; in the analysis of 1977 data, "poor" is defined as at or below 125% of the poverty level.

TABLE 14 Average Age of Household Vehicles, by Household Income and Householder Age for Each Population Group, 1977 (standard errors shown in parentheses)

Household Characteristic	White	Black	Hispanic	Poor	Nonpoor	All Households
Household Income (1980 $)[a]						
<10,000	8.1 (0.08)	8.9 (0.21)	8.8 (0.36)	8.7 (0.10)	7.7 (0.10)	8.2 (0.07)
Nonelderly	7.8 (0.06)	8.7 (0.18)	8.9 (0.27)	8.3 (0.18)	7.6 (0.06)	8.0 (0.06)
Elderly	8.4 (0.12)	9.1 (0.30)	b	9.4 (0.17)	7.8 (0.15)	8.5 (0.11)
10,000-19,999	6.8 (0.05)	6.8 (0.17)	7.4 (0.27)	7.6 (0.17)	6.7 (0.05)	6.8 (0.05)
Nonelderly	6.9 (0.06)	6.6 (0.18)	7.3 (0.27)	7.5 (0.18)	6.7 (0.06)	6.8 (0.06)
Elderly	6.7 (0.12)	8.1 (0.49)	b	b	6.8 (0.12)	6.9 (0.12)
20,000-29,999	6.2 (0.05)	5.9 (0.20)	6.1 (0.28)	NA[c]	6.1 (0.05)	6.1 (0.05)
Nonelderly	6.2 (0.05)	5.7 (0.20)	6.1 (0.29)		6.1 (0.05)	6.1 (0.05)
Elderly	6.2 (0.15)	b	b		6.3 (0.15)	6.3 (0.15)
≥30,000	5.4 (0.06)	5.5 (0.30)	b	NA	5.4 (0.06)	5.4 (0.06)
Nonelderly	5.4 (0.07)	5.5 (0.31)	b		5.4 (0.06)	5.4 (0.06)
Elderly	5.5 (0.18)	b	b		5.5 (0.18)	5.5 (0.18)
All Households	6.5 (0.03)	7.1 (0.11)	7.2 (0.17)	8.5 (0.08)	6.3 (0.03)	6.6 (0.03)
Nonelderly	6.4 (0.03)	6.7 (0.12)	7.1 (0.17)	8.1 (0.10)	6.2 (0.03)	6.4 (0.03)
Elderly	7.2 (0.07)	8.5 (0.24)	8.3 (0.65)	9.4 (0.16)	6.8 (0.07)	7.3 (0.07)

[a]Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[b]Not reported because of a large variance in the observed data.

[c]NA = Not applicable.

Source: Ref. 12.

3.3.3 Vehicle Fuel Economy

The fuel economy of new vehicles has nearly doubled since the early 1970s, spurred by the two oil shortages and federally mandated fuel economy standards. This dramatic improvement has reversed the relationship between vehicle age and fuel economy. In the early 1970s, older vehicles were less likely to be equipped with fuel-guzzling high-output engines and such options as air conditioning. Hence, fuel economy was directly related to vehicle age, and lower-income households tended to have somewhat more fuel-efficient vehicles (see Table 8). By the end of the decade, however, newer models formed a larger share of the vehicles in more affluent households. Fuel economy became inversely related to vehicle age, and relatively affluent households tended to have more fuel-efficient vehicles.

In terms of relationships between poor and nonpoor and between black and white population groups, the greater incidence of relatively newer vehicles in more affluent households has created a gap in fuel economy. This gap may be seen in Table 15 for the summer driving season and in Figs. 9 and 10 for the 28 months from June 1979 through September 1981.*

While small deficits in fuel economy (on the order of 1.4 to 1.5 mpg for black households and somewhat less for poor households) may not be statistically significant, given the relatively small sample sizes for the monthly data,‡ known relationships between household income and average vehicle age suggest that a disparity in fuel economy should persist as long as the fuel economy of new vehicles (a disproportionate share of which are purchased by affluent households) rises faster than that of the entire fleet. Our ability to see this effect, even in as short a period as 28 months, enhances the credibility of the TP data set.§

The apparent drop in the average summer fuel economy of vehicles in black and poor households (Table 15) at a time when fuel prices were rising is the most interesting finding from our examination of fuel economy relationships and trends. It suggests that fuel economy is either (1) a less important criterion in the vehicle-purchase decisions of these households (compared to the general population) or (2) so subordinated to first cost that the depressed market for used large cars in the late 1970s may have made these vehicles particularly attractive to black and poor households. A related possibility is

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*Monthly data have been smoothed; see Appendix B for a discussion of the smoothing technique.

‡Although standard errors cannot be estimated from the smoothed data, those from the unsmoothed data indicate that most differences would not be statistically significant at confidence levels of 95% or more.

§Based on more recent sales data, one can speculate that the reverse may now be occurring -- i.e., the fuel economy of the entire fleet may be rising faster than that of new vehicles. Hence, fuel-economy differences between vehicles in white and black, and poor and nonpoor, households may be declining.

TABLE 15 Summer Fuel Economy for Vehicles in Each Population Group, 1979-81

Economy Factor and Population Group	1979	1980	1981	Change (%)
Fuel Economy[a] (mpg)				
White	14.8	15.3	15.7	6.1
Black	14.3	13.9	13.6	-4.9
Poor	14.3	14.6	13.8	-3.5
Nonpoor	14.9	15.3	15.6	4.7
All Households	14.8	15.3	15.5	4.7
Fuel Economy Ratios				
Black/White	0.97	0.91	0.86	-
Poor/Nonpoor	0.96	0.95	0.88	-

[a]Harmonic mean fuel economy in mpg for June-September of year shown.

Source: Ref. 37.

that these households are somewhat larger than the norm (see Tables 4 and 5) and therefore would purchase somewhat larger vehicles. Further, since the affordable stock of large used cars in the late 1970s was primarily of early 1970s vintage, the fuel economy of vehicles available to these households was among the lowest in history.

As disturbing as the downward trend in the summer fuel economy of vehicles available to black households is the rate at which this drop occurred. As shown in Table 15, the rate of decline exceeded the rate of increase in fuel economy of all household vehicles. While 1983 data suggest that the fuel economy of vehicles in black households may have stabilized at a level close to that shown in Table 15, indications are that black households' adjustment to the fuel price increases of 1979-80 may have been exacerbated by the low fuel economy of both their existing vehicles and the fleet of affordable replacement vehicles then on the market.

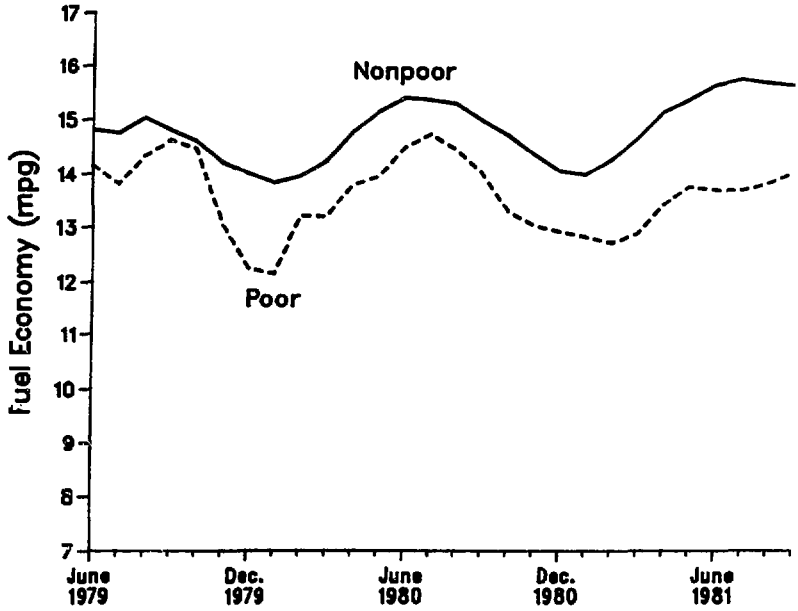

FIGURE 9 Fuel Economy of Vehicles in White, Black, and Poor Households, June 1979-September 1981

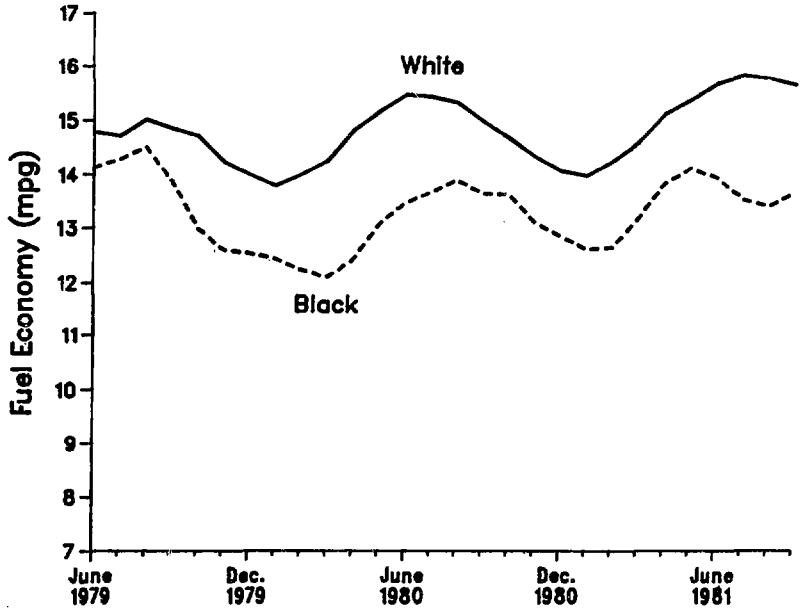

FIGURE 10 Average Annual Miles per Vehicle for Low-Income Households, by Residence Location and Population Group, 1977

3.4 VEHICLE USE IN MINORITY AND POOR HOUSEHOLDS

Vehicle use (expressed as annual miles per vehicle) is related to household income, location, and composition, as well as to several vehicle attributes -- primarily age -- and the number of vehicles available to meet an individual household's travel needs. All else being equal, households with fewer vehicles may be expected to use each of them more intensively than households with many vehicles.*

Among households with at least one vehicle, 1977 use ranged from 7613 miles in poor households to 9276 miles in nonpoor households (Table 16). This difference is statistically significant at the 0.001 level. Poor households also had systematically lower use than nonpoor households for all residence locations. Vehicle use in Hispanic households did not differ significantly from that in white households either in the aggregate or when income and location were controlled. Among black households, vehicle use did not differ significantly in the aggregate, but when location and income were controlled, differences began to emerge. Across all incomes, black households in central cities drove their vehicles only 82% as far in a year as did white households (7235 vs. 8807 mi); across all locations, low-income black households had a similar deficit (5700 vs. 6953 mi).

Figure 11 shows that the difference was most marked among low-income households in central cities, where blacks averaged only 4097 miles per vehicle compared with 6819 for whites. This disparity (statistically significant at the 0.001 level) cannot be readily explained, but may be due to fewer work trips in private vehicles,‡ local variations in the density of travel opportunities (i.e., the ability to satisfy travel demands in shorter vs. longer trips), characteristics of available travel modes, or "cultural" effects. If, for example, low-income black households are more likely to live in neighborhoods with traffic congestion on local streets, scarce parking, and relatively convenient transit services, they may make greater use of public transportation and thus drive less than comparable white households. Alternatively, there may be a greater incidence of vehicle loaning (to friends or relatives) among low-income central city blacks.§ Or, because the average vehicle in low-income black households is relatively older, and thus presumably less reliable, it may be driven less than the average vehicle in low-income white households. Further, one may argue that the lower economic mobility of low-income black households makes savings or credit less likely. Thus, expensive repairs may be deferred until absolutely necessary and, when breakdowns do occur, the vehicle may be out of service longer (i.e., until the household can pay for repairs). Available data cannot "prove" any of these explanations. While the literature supports their plausibility, it is still not clear why the disparity is limited to central city households.

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*However, the reverse may also be true; households with many vehicles may have many licensed drivers who use each vehicle as intensively as do single-vehicle households.

‡Recall that a relatively large proportion of black households have zero workers and a smaller proportion have two or more workers, and that work trips accounted for 38% of the miles traveled by the average household in 1977.

§The method used to calculate miles per vehicle includes only trips made by household members in household vehicles. If vehicle loaning is more prevalent among blacks, this could result in a substantial underestimate of vehicle utilization.

TABLE 16 Average Annual Miles per Vehicle for Each Population Group, by Income, Residence Location, and Householder Age, 1977 (standard errors shown in parentheses)

Household Category	White	Black	Hispanic	Poor	Nonpoor	All Households
Household Income (1980 $)[b]						
<10,000	6953	5700	8423	7157	6680	6923
	(229)	(374)	(793)	(260)	(300)	(206)
10,000-19,999	8824	8965	9792	9207	8865	8894
	(267)	(711)	(1004)	(792)	(272)	(256)
20,000-29,999	9972	9063	8962	NA[c]	9882	9882
	(316)	(964)	(1309)		(313)	(302)
≥30,000	10086	10879	d	NA	10055	10055
	(406)	(1771)			(416)	(393)
Residence Location						
SMSA Central City	8807	7235	8430	6964	8819	8609
	(269)	(421)	(697)	(361)	(265)	(239)
SMSA Suburbs	9808	12084	8494	8282	9983	9858
	(285)	(1024)	(1025)	(5320)	(291)	(275)
Non-SMSA	8718	7150	10173	7675	8880	8684
	(257)	(659)	(1829)	378)	(279)	(246)
Age of Householder (yr)						
<60	9774	8907	9006	8790	9798	9696
	(202)	(429)	(537)	(345)	(202)	(197)
≥60	6390	5310	6816	4681	6696	6327
	(206)	(581)	(1351)	(354)	(224)	(199)
All Households	9142	8234	8808	7613	9276	9082
	(201)	(367)	(556)	(260)	(206)	(193)

[a]The aggregate difference between white and black households is not statistically significant. In other data sources (see Refs. 4 and 13), vehicle use appears to be higher in black households, but again differences are not statistically significant.

[b]Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[c]NA = Not applicable.

[d]Not reported because of a large variance in the observed data.

Source: Ref. 12.

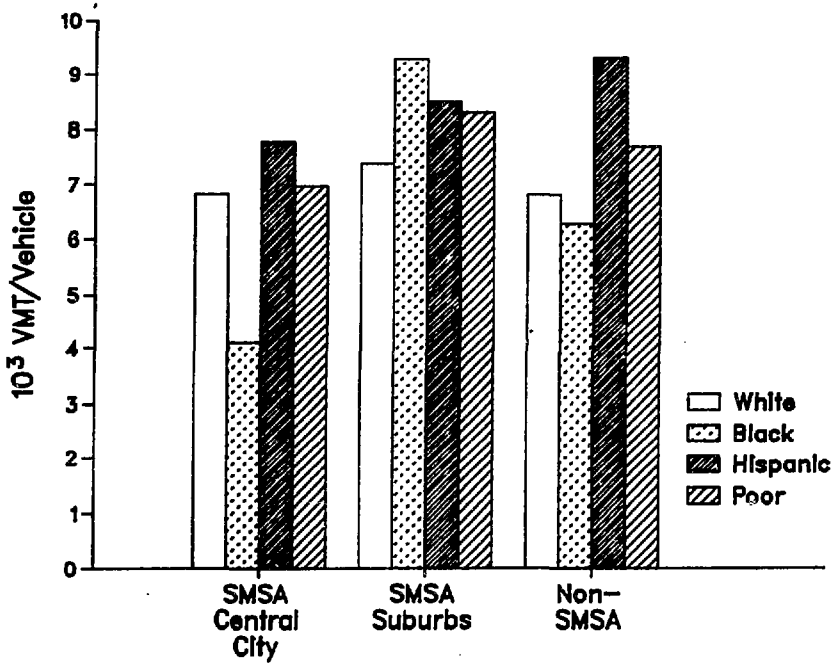

FIGURE 11 Average Annual Vehicle-Miles of Travel (VMT) per Vehicle for Low-Income Households, by Residence Location and Population Group, 1977

4 TRAVEL BEHAVIOR OF MINORITY AND POOR HOUSEHOLDS

As discussed in Sec. 2, the volume of travel by minority and poor households is related to the demographic characteristics of the households and their members. In addition to the number and characteristics of available vehicles, the key aspects that influence a household's transportation fuel use are (1) total miles driven in household vehicles and (2) characteristics of particular types of trips that account for major portions of household travel. Of all trip types or purposes, work trips are the largest single component of household travel. Thus, the work trip characteristics of minority and poor households are particularly relevant.

The following discussion focuses on rates of travel in household vehicles, i.e., annual and monthly vehicle-miles of travel (VMT), as well as such characteristics of work trips as average length, mode split, spatial characteristics of commuter flows, and private-vehicle occupancy.

4.1 TOTAL HOUSEHOLD TRAVEL

4.1.1 Vehicle-Miles per Household

In 1977, the average household traveled 13,281 miles in vehicles owned by or regularly available to its members. White households traveled 6% more than average, while black and Hispanic households traveled 43% and 25% less, respectively. Poor households had the lowest travel rate, 53% below average. When both income and residential location are controlled (see Table 17), these gaps narrowed somewhat -- particularly with rising income -- although standard errors are large.

Households with Vehicles. Because a disproportionate share of minority households do not have vehicles, it is useful to restrict travel comparisons to only those households with vehicles (see Table 18). Several trends are apparent:

- For all population groups, central city households tend to have the lowest VMT per household. The VMT of suburban households is relatively comparable to that of non-SMSA households.

- Within each of the location categories, household VMT increases with increasing income, but at a decreasing rate.

- All but one of the differences between black or Hispanic households and white households that are noted in Table 17 fail to hold up when the comparison is limited to only those households with vehicles. The notable exception is the highly significant difference (0.001 level) between VMTs of white and black low-income central city households.

TABLE 17 Household Travel, by Residence Location and Income for Each Population Group, 1977[a] (VMT per household; standard errors shown in parentheses)

Location and Income[b]	White	Black	Hispanic	Poor	Nonpoor	All Households
SMSA Central City						
<10,000	4927 (304)	1830 (477)	3975 (744)	3565 (312)	4749 (374)	4043 (247)
10,000-19,999	9957 (483)	8009 (875)	8575 (1271)	11027 (1573)	9534 (430)	9636 (420)
20,000-29,999	16626 (680)	12219 (1393)	14696 (2324)	NA[c]	15956 (615)	15956 (615)
≥30,000	20552 (894)	18410 (2847)	d	NA	20275 (842)	20275 (842)
SMSA Suburbs						
<10,000	6653 (414)	4683 (877)	7274 (1758)	5825 (460)	7298 (583)	6516 (373)
10,000-19,999	14104 (580)	18675 (2103)	16701 (3000)	16447 (2144)	14349 (570)	14466 (559)
20,000-29,999	20394 (622)	14596 (2751)	12880 (2903)	NA	20028 (606)	20028 (606)
≥30,000	23727 (743)	d	d	NA	23520 (606)	23520 (724)
Non-SMSA						
<10,000	6992 (343)	4459 (647)	8688 (1803)	6303 (367)	7415 (497)	6750 (308)
10,000-19,999	15342 (567)	11048 (1858)	d	17973 (1577)	14910 (442)	15199
20,000-29,999	20111 (684)	d	d	NA	20096 (674)	20096 (674)
≥30,000	23653 (573)	d	d	NA	23517 (563)	23517 (563)
All Households	14119 (308)	7683 (371)	9920 (638)	6279 (273)	15107 (341)	13281 (285)

[a]Total vehicle-miles traveled in household vehicles divided by total households (including zero-vehicle households).

[b]Income in 1980 dollars. Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[c]NA = Not applicable.

[d]Not reported because of a large variance in the observed data.

Source: Ref. 12.

TABLE 18 Annual Travel by Households with Vehicles, by Income and Residence Location for Each Population Group, 1977 (VMT per household; standard errors shown in parentheses)

Location and Income[a]	White	Black	Hispanic	Poor	Nonpoor	All Households
SMSA Central City						
<10,000	8605 (594)	4635 (744)	9254 (1757)	8172 (666)	7613 (782)	7897 (474)
10,000-19,999	11496 (558)	10356 (1172)	11467 (1587)	13126 (1886)	11302 (557)	11426 (500)
20,000-29,999	17532 (700)	14131 (1622)	15837 (2441)	NA[b]	17014 (644)	17014 (644)
≥30,000	21203 (907)	21863 (3030)	c	NA	21229 (863)	21229 (863)
SMSA Suburbs						
<10,000	9540 (638)	10347 (2169)	c	10428 (916)	9254 (897)	9776 (602)
10,000-19,999	14744 (602)	21475[d] (2277)	17641 (2481)	17448 (2244)	15081 (641)	15211 (581)
20,000-29,999	20685 (625)	15148 (2815)	13849 (3090)	NA	20356 (610)	20356 (610)
≥30,000	23881 (744)	c	c	NA	23704 (726)	23704 (726)
Non-SMSA:						
<10,000	9362 (485)	8397 (1310)	11639 (2436)	9879 (627)	8856 (755)	9399 (456)
10,000-19,999	15900 (581)	11806 (1971)	19102 (3283)	18659 (1621)	15469 (619)	15770 (562)
20,000-29,999	20283 (686)	c	c	NA	20301 (677)	20301 (677)
≥30,000	23949 (1003)	c	c	NA	23880 (944)	23880 (944)
All Households with Vehicles	16070 (347)	12018 (601)	13645 (866)	10727 (434)	16508 (354)	15682 (334)

[a]Income in 1980 dollars. Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because income is reported within a particular range rather than as a specific figure, all conversions are approximate.

[b]NA = Not applicable.

[c]Not reported because of a large variance in the observed data.

Source: Ref. 12.

- When vehicle availability is controlled, the greater VMT of black vs. white suburban households with lower-middle incomes becomes statistically significant.

Differences in Travel among Low-Income Households. Our investigations of vehicle availability and use (see Secs. 3.2 and 3.4) revealed similar differences among low-income households; these were attributed principally to variations in economic mobility and local area accessibility on the one hand, and to differences in the average age of vehicles on the other. Quite likely, these same factors contribute to lower household travel.

Two other explanations for observed differences in the travel of white vs. black in low-income central city households with one or more vehicles were investigated to the extent that the data would permit:

- **Household Composition.** The number of licensed drivers per household, an indicator of household composition, was examined in Sec. 3.2.1 as a possible explanation of racial differences in vehicle availability. As shown in Fig. 5, low-income black households in central cities have fewer vehicles per licensed driver than their white counterparts. Because this difference is in the wrong direction to explain the lower VMT per household, it suggests that household composition is probably not the determining factor.

- **Vehicle Availability.** Further disaggregation of VMT per household is shown in Table 19 for low-income white, black, and Hispanic households in central cities. The comparison is limited to nonelderly households with one vehicle. Despite relatively large standard errors, the difference between black and white households remains statistically significant.

This difference between black and white households is attributed to many of the same factors believed responsible for racial variations in vehicle availability -- i.e., reduced economic mobility among black households, and local conditions that reduce the attractiveness of private-vehicle use. Other equally important factors include the older, less reliable vehicles in black households, and the possibility that blacks make greater use of borrowed vehicles when their own vehicles are out of service or are used primarily for work travel and thus unavailable to household members during the day.

4.1.2 Monthly Travel

Monthly data from the RECS Transportation Panel (TP) are too sparse to permit such detailed analysis. However, the same general trends may be seen in the broad univariate categories displayed in Figs. 12-14.[13] Within normal seasonal fluctuations, Fig. 12 shows that VMT gaps -- between black and white, and between poor and nonpoor, households -- persists throughout the entire survey period, although there is some evidence to suggest a slight narrowing trend between poor and nonpoor households.

TABLE 19 Annual Travel by Nonelderly Low-Income Households with One Vehicle, by Population Group, 1977 (VMT per household; standard errors shown in parentheses)

Households	White	Black	Hispanic	All Households
All Single-Vehicle Nonelderly Households with Incomes <$10,000[a]	10720 (837)	7392 (780)	10096 (1582)	10223 (657)
All Such Households in:				
SMSA Central City	11716 (2219)	5587 (675)	8179 (1641)	9869 (1463)
SMSA Suburbs	11411 (1185)	11253 (2546)	11138 (1973)	11339 (1002)
Non-SMSA	9533 (963)	7700 (1491)	[b]	9776 (863)

[a]1980 dollars. Income ranges from the 1977 survey were modified to aid comparison with ranges reported for 1980. The ranges shown correspond to 1977 incomes of 0-$7499, $7500-14,999, $15,000-24,999, and ≥$25,000. Because all sources report income within a particular range rather than as a specific figure, all conversions are approximate.

[b]Not reported because of a large variance in the observed data.

Source: Ref. 12.

Similar (but unsmoothed) univariate plots of monthly VMT by residence location and household income are shown in Figs. 13 and 14. Again, lower VMT is shown to be related to central city residence and low income.

Figure 15 presents an unsmoothed plot of monthly household VMT calculated from TP data, along with a comparable plot of total VMT published by the U.S. Department of Transportation's Federal Highway Administration (FHWA).[39] The fairly constant spread between the two data series and the fairly consistent month-to-month variation (with occasional lags in peaks and valleys) lend credibility to the overall TP data set. However, for particular subsets of the 28-month time series, the "fit" to the generally accepted FHWA control totals varies somewhat.

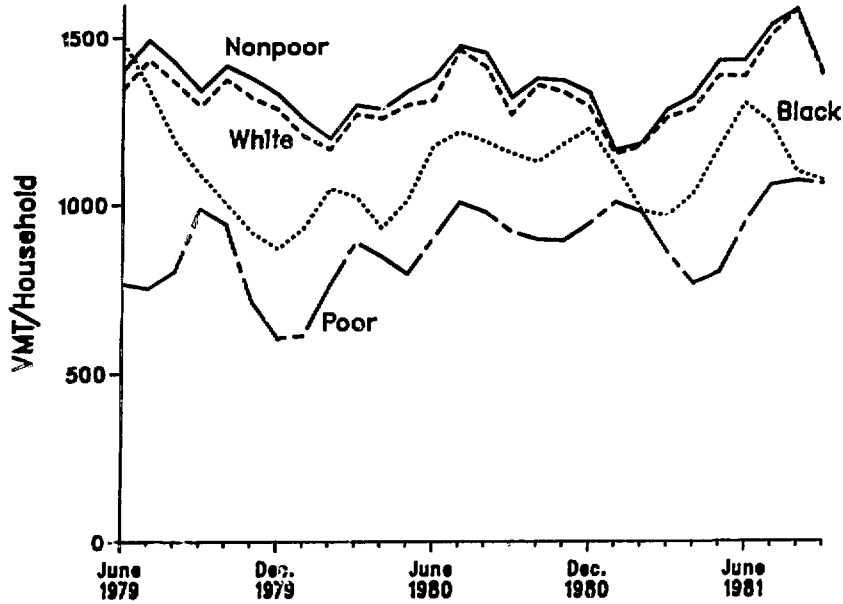

FIGURE 12 Monthly VMT per Household, by Population Group, June 1979-Sept. 1981

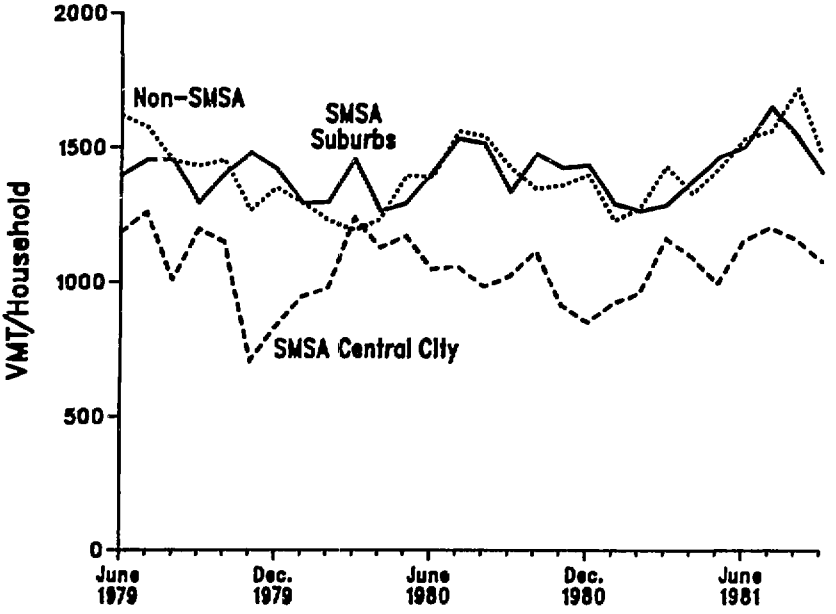

FIGURE 13 Monthly VMT per Household, by Household Residence Location, June 1979-Sept. 1981

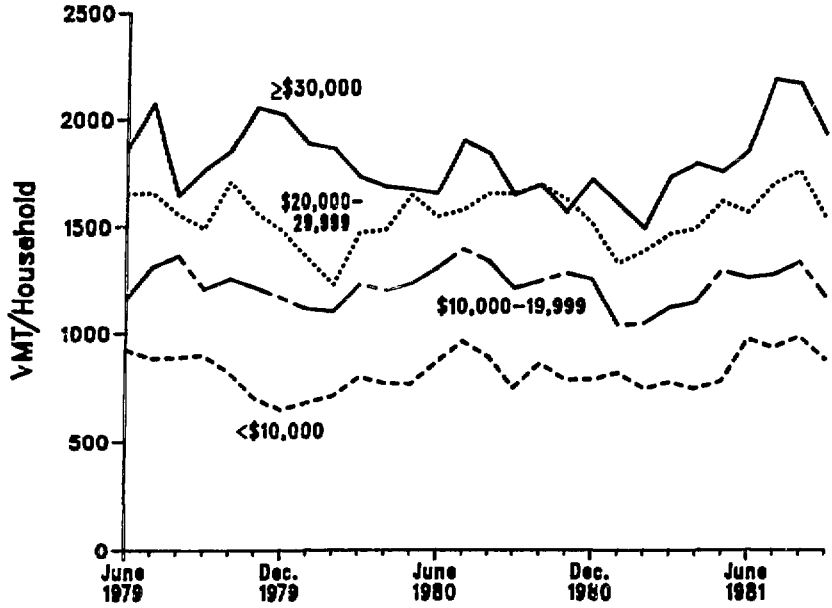

FIGURE 14 Monthly VMT per Household, by Household Income Category, June 1979-Sept. 1981

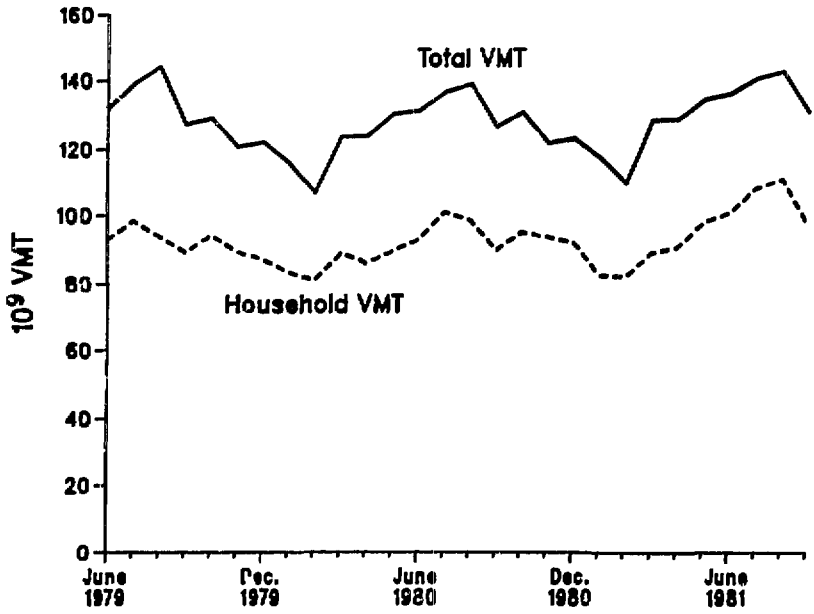

FIGURE 15 Estimates of Total and Household VMT, June 1979-Sept. 1981

4.2 TRAVEL TO WORK

In 1983, work trips (including home-to-work and other work-related trips) accounted for 34% of all household VMT.[40] That share ranged from 25% for households with incomes below $10,000 to 36% or more for those with incomes above $20,000. That same range was evident in 1969 and 1977.[12,30] Between 1969 and 1983, the most notable trends in work travel were declines in average trip length, from 10.2 miles to 8.8 miles, and in public transportation use, from 7.2% to 4.4% of all trips. Population and employment shifts, together with the often poor quality of public transportation between low-density suburban residences and workplaces, are responsible for both of these changes.

The work trip attributes most relevant to minorities' overall travel patterns and energy use are the length and spatial characteristics of the trip, the distribution of trips across available travel modes (known as the mode split), and the load factor (or occupancy) in private-vehicle trips. Even when residence location is controlled, minorities' work travel tends to exhibit distinctive patterns for many of these attributes.

4.2.1 Trip Length

Trip length may be characterized by either distance or duration. While both are valuable descriptors of travel patterns, respondent-reported distance is often subject to considerable error (particularly when the trip is via public transportation), and thus duration tends to be a more reliable measure.

Duration, or mean travel time, varies somewhat with income and residence location, but other factors -- including mode split, spatial distribution of commuter flows, and size of the metropolitan area -- are at least as important. As shown in Table 20, suburban work trips tend to be somewhat longer than average, and non-SMSA work trips tend to be somewhat shorter. All else equal, work trips also tend to lengthen with increasing income. However, the variation between whites and blacks (and to a lesser extent between whites and Hispanics) is considerably greater than the variations due to income or location. According to data from both the 1977 NPTS and the 1980 Census, blacks have significantly longer work trips than whites. When income and residence location are controlled (see Fig. 16), the difference persists, particularly for urban workers. Among central city residents, only at the highest income level is the mean trip length of black workers approximately equal to that of white workers.

Similar findings were obtained by O'Hare in his analysis of the 1975 and 1979 Annual Housing Surveys, by Newman and Day in their work with the 1973 Survey of Lifestyles and Energy Use, and by Goodman and Berkman in their analysis of the Spring 1972 wave of the Panel Study of Income Dynamics.[5,8,10] Goodman and Berkman used employment and work-trip data on householders residing in SMSAs to compute annual "commuter burdens" of black and white workers. Controlling for SMSA size and distance of residence from the urban center, Goodman and Berkman found that the average black spends 25% more time commuting per hour worked than does the average white (i.e., 0.102 vs. 0.082 hr). About half of this difference is attributed to racial variations in

TABLE 20 Mean Work Trip Length, by Residence Location and Household Income Category for Workers in Each Population Group, 1980

Worker Characteristic[a]	White	Black	Hispanic	Native American[b]	Asian and Pacific Islander	Poor[c]	Nonpoor[c]	All Workers
Workers Residing in:[d]								
SMSA Central City	20.8	28.2	24.7	21.9	24.3	22.4	22.4	22.4
SMSA Suburbs	22.6	25.0	22.7	23.0	25.2	20.5	23.0	22.8
Non-SMSA	18.3	21.3	18.2	20.2	15.7	20.4	21.9	21.7
Household Income (1980 $)								
<10,000	15	22	19	-	-	17	17	17
10,000-19,999	17	23	19	-	-	19	18	18
20,000-29,999	18	25	20	-	-	NA[e]	19	19
≥30,000	18	21	19	-	-	NA	19	19
All Workers (mean minutes)	21.1	26.2	23.2	21.6	24.1	20.5	21.9	21.7
All Workers[f] (mean miles)	8.6	9.0	8.5	-	-	7.2	8.8	8.6

[a]Excludes persons who work at home. Standard errors of 1980 Census estimates (Ref. 18) are extremely small, hence even very small differences are statistically significant. Standard errors are not yet available for Ref. 29.

[b]Includes American Indians, Eskimos, and Aleuts.

[c]"Poor" travel time estimates based on ratio of poor to all workers from Ref. 29; "nonpoor" estimates computed from "poor" and Ref. 18 values.

[d]1980 SMSA definitions and boundaries.

[e]NA = Not applicable.

[f]Because respondent-reported distance estimates are typically less reliable than time estimates, and because little variation is apparent in the aggregate totals, they are not shown by income and location.

Source: Trip time by residence location: Refs. 18 and 29; trip time by income: Ref. 19, trip distance: Ref. 29.

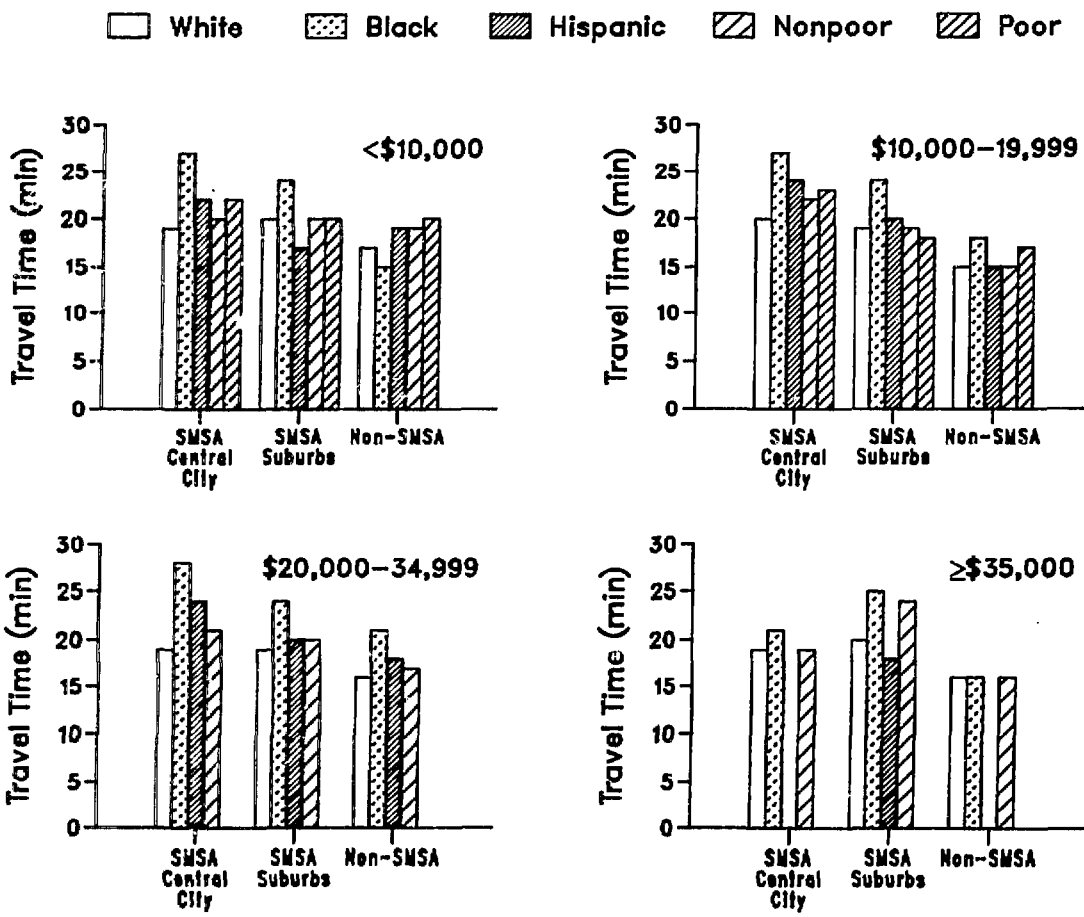

FIGURE 16 Mean Work Trip Travel Times, by Residence Location and Household Income Category for Each Population Group, 1980

mode split (see Sec. 4.2.3). The remainder may be related to housing market segregation, which restricts blacks' ability to adjust their housing location to their place of employment; the data could neither confirm nor deny this hypothesis.

Commuting burdens (expressed as commuting hours/hours worked) were found to be particularly acute for heads of low- and moderate-income black households. As shown in Fig. 17, the commuting burden was 2.5 times greater for heads of the lowest-income black households than for their white counterparts (0.134 vs. 0.053). This ratio declines with increasing income because work trips tend to lengthen with income among whites, but not among blacks.

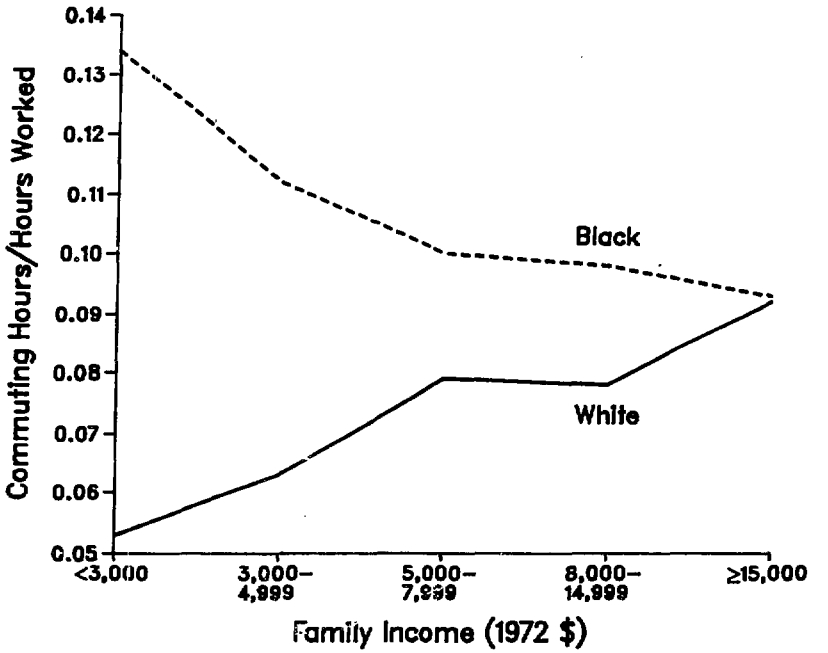

FIGURE 17 Commuting Burden for Black and White Household Heads, by Income, 1972

4.2.2 Spatial Characteristics

Commuter Flows. According to the 1980 census, the bulk of commuter movement in urbanized areas is within central cities (37.2%) and within suburbs (35.3%).* Contrary to conventional wisdom, these flows easily exceed that from suburb to central city (18.7%).[6]

When examined by population group, commuter flows differ dramatically. According to the 1970 and 1980 censuses, (Fig 18), blacks and Hispanics are far more likely than whites to live and work in central cities (58.6% and 48.6% vs. 33.5% in 1980). Conversely, whites are twice as likely as blacks to live and work in the suburbs (38.3% vs. 17.3%) and to live in the suburbs and work in a central city (20.2% vs. 10.3%). For Hispanics, the comparable percentages are 27.6% living and working in the suburbs and 13.4% living in the suburbs and working in a central city.

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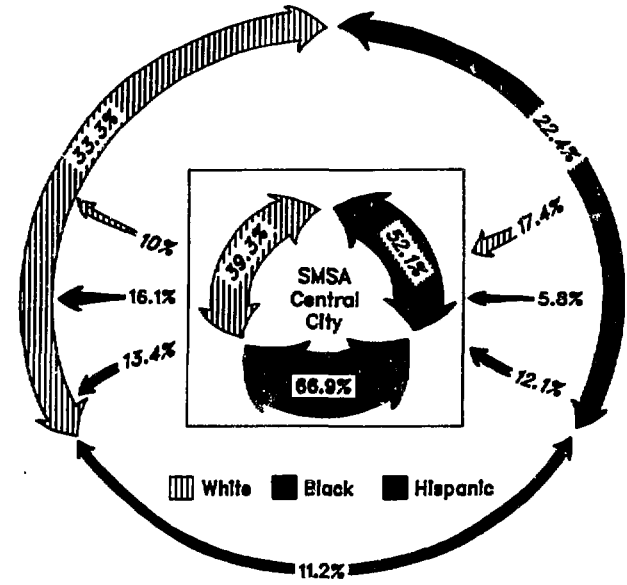
*All information on the spatial characteristics of work trips was obtained from Ref. 6. Because that source summarizes census data for urbanized areas, this discussion applies specifically to those areas, although observed patterns may also apply to SMSAs. Among larger SMSAs (those with a population of 250,000 or more), the within-suburb flow accounts for the largest share of all work trips, as well as the fastest-growing movement (having risen from 30.5% of all work trips in 1960 to 36.3% in 1970 and 41.9% in 1980).[41]



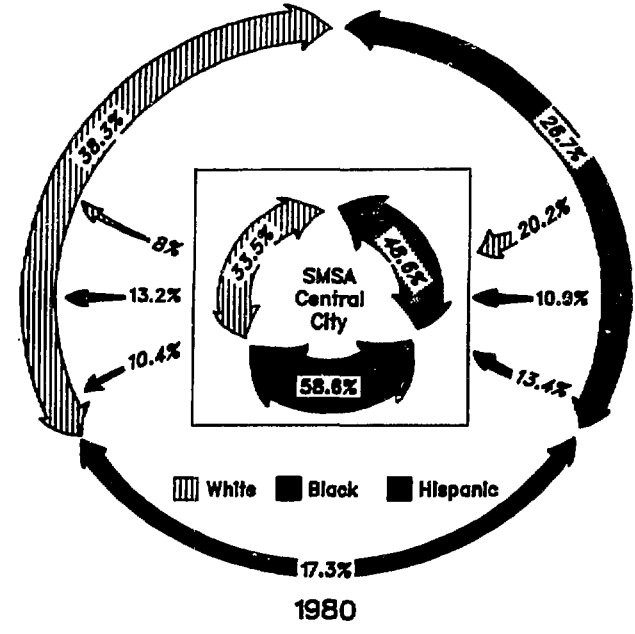


FIGURE 18 Distribution of Work Trips in Urbanized Areas, by Commuter-Flow Direction and Population Group, 1970 and 1980

Historically, the evidence suggests that housing discrimination forces minority workers into a disproportionate amount of reverse commuting -- living in a central city and working in the suburbs. In 1970, while only 10% of white workers reverse-commuted, more than 16% of black workers and 13% of Hispanic workers did so. By 1980, these shares had declined for all three groups (to 8% of white workers vs. 13% of black workers and 10% of Hispanic workers). Nonetheless, the relative likelihood of reverse-commuting had remained virtually unchanged -- i.e., black workers were still 60-65% more likely, and Hispanics 30-35% more likely, than whites to reverse-commute.

Such differences in commuter flows may account for some of the above-discussed differences in average work trip times. Table 21 displays average 1980 travel times by commuter flow for white, black, and Hispanic workers in all urbanized areas and in the 25 largest urbanized areas.* Compared with a 45% longer trip when averaged across all commuter flows (27.1 vs. 21.5 minutes), black-white differences within particular flows range from as little as 1% to as much as 44% for workers living in a central city and working outside the central business district (CBD). Similar patterns are shown for Hispanic workers. The 27% difference in Hispanic vs. white travel time declines to a 2-15% difference for most movements. Again, the key exception is the central city-to-non-CBD flow, where Hispanic workers continue to have substantially longer trips.

Size of the urbanized area is a key variable in explaining differential travel times and, as a result, commuting burden. When the above comparison is limited to the 25 largest urbanized areas, black and Hispanic travel times are much closer to those for whites. Indeed, in these large urbanized areas, much of the overall white-Hispanic differential disappears because Hispanic workers have somewhat shorter than average trips from inner suburbs to central city workplaces, and other movements are not so much longer as to greatly affect the mean. While the overall white-black differential remains significant, it disappears for suburb-to-central city and central city-to-CBD trips and grows for reverse-commutes and non-CBD central city movements.

Trends in Employment Locations. Although the literature abounds with discussions of geographic shifts in job opportunities, the actual data are limited. Indirect evidence based on population shifts suggests that relatively more employment growth is occurring in central cities of smaller urbanized areas and in the suburban portions of large metropolitan areas than in large central cities.[24,43,44] This out-migration of jobs is reflected in the work trip flows reported in Table 22. Between 1970 and 1980, the number of work trips destined for suburban job sites grew by 6.8 million, compared to an increase of 6.0 million work trips destined for central city job sites. Thus, 53% of the

*As defined by the Transportation Research Board of the National Research Council, an urbanized area is "A city (or twin cities) that has a population of 50,000 or more (central city) and surrounding incorporated and unincorporated areas that meet certain criteria of population size or density." Compare with the definition of SMSA in Sec. 1.5.

TABLE 21 Mean Commuting Time, by Residence and Workplace Location, of White, Black, and Hispanic Workers Living in Urbanized Areas, 1980 (in minutes; percentage of white worker averages shown in parentheses)

Worker Residence and Workplace Location	All Urbanized Areas				25 Largest Urbanized Areas			
	White	Black	Hispanic	All Workers	White	Black	Hispanic	All Workers
Living in Central City and Working in CBD[a]	23.8 (100)	29.1 (122)	27.3 (115)	24.9 (112)[b]	33.1 (100)	34.7 (105)	33.6 (102)	33.4 (131)[b]
Living in Central City and Working in Central City outside CBD	18.5 (100)	26.7 (144)	22.9 (124)	20.0 (90)[b]	23.8 (100)	31.5 (132)	26.8 (113)	25.5 (100)[b]
Living in Central City and Working in Suburbs	25.2 (100)	31.8 (126)	28.6 (113)	26.4 (119)[b]	28.1 (100)	35.9 (128)	30.2 (107)	29.9 (118)[b]
Living in Suburbs and Working in CBD	34.9 (100)	35.1 (101)	35.7 (102)	35.1 (158)[b]	42.3 (100)	39.7 (94)	39.1 (92)	42.1 (166)[b]
Living in Suburbs and Working outside CBD	26.9 (100)	29.9 (111)	28.0 (104)	27.2 (123)[b]	32.8 (100)	34.3 (105)	30.8 (94)	33.0 (130)[b]
Living in Suburbs and Working in Suburbs	18.7 (100)	21.4 (114)	19.8 (106)	18.8 (85)[b]	19.3 (100)	22.7 (118)	20.1 (104)	19.5 (77)[b]
Average, All Commuter Flows	21.5 (100)	27.1 (145)	23.8 (127)	22.2 (100)[b]	24.5 (100)	31.0 (127)	25.9 (106)	25.4 (100)[b]

[a]CBD = central business district.

[b]Percentage of grand average for all workers, all flows.

Source: 1980 Census Public-Use Microdata One Percent File C, as reported by Ref. 6.

TABLE 22 Trends in Commuter Flows for White, Black, and Hispanic Workers, 1970-80

Workers, Residence, and Workplace[a]	1970			1980			Change, 1970-1980 (%)		
	White	Black	Hispanic	White	Black	Hispanic	White	Black	Hispanic[b]
Living in Central City (%)	49.4	82.9	65.6	41.6	71.8	59.0	-15.8	-13.4	-10.1
Working in CBD	5.9	8.6	7.0	5.1	8.4	5.5	-13.6	-2.3	-21.4
Working in Central City outside CBD	33.6	58.4	45.3	28.5	50.3	43.2	-15.2	-13.9	-4.6
Working outside Central City	9.9	16.0	13.3	7.9	13.1	10.3	-20.2	-18.1	-22.6
Living in Suburbs (%)	50.6	17.1	34.4	58.4	28.2	41.0	15.4	64.9	19.2
Working in CBD	2.9	0.7	1.6	3.6	1.7	1.8	24.1	142.9	12.5
Working in Central City outside CBD	14.3	5.1	10.4	16.3	9.0	11.5	14.0	76.5	10.6
Working outside Central City	33.5	11.4	22.5	38.6	17.4	27.7	15.2	52.6	23.1
Total Workers (10^6)[c]	37.5	4.4	2.0	46.9	6.2	3.8[b]	25.2	38.9	86.1

[a]Urbanized areas only. Includes work-at-home and walking trips.

[b]Because the definition of "Hispanic" differed in the 1970 and 1980 censuses, apparent trends in this group should be interpreted cautiously.

[c]Excludes workers whose workplaces were not reported.

Source: 1970 and 1980 Census public-use microdata files, as reported by Ref. 6.

net growth in urbanized area employment appears to have been in the suburbs. However, because additional urbanized areas were designated in 1980, some of this growth may not have been truly "new" jobs.

Among minorities, only 40% of net employment growth was in the suburbs, but external flows -- by commuters who live and work in the suburbs -- more than doubled.* Further, within-central-city trips, traditionally the heaviest flow among minority workers, grew relatively slowly. These trends suggest that minorities' future commuting patterns may differ from historical and current patterns. Specifically:

- While external flows are now a lesser share of minorities' work trips, they are growing rapidly and in time may approach those of whites.
- By the same logic, the within-central-city flow may account for a far smaller share of minorities' future work trips.
- With an increasing share of minority employment moving to the suburbs, one would expect minorities' reliance on public transportation to decline.
- If minorities rely increasingly on private transportation to get to work, one would also expect their average vehicle availability to rise.

4.2.3 Modal Characteristics

Mode Split. Black, white, and Hispanic workers exhibit distinctive mode split patterns. As shown in Table 23, blacks and Hispanics are far less likely to drive to work alone, regardless of their residence location or household income. Conversely, the use of public transportation is, in the aggregate, more than three times greater among blacks (and 2.5 times greater among Hispanics) than among whites. Even when residence location is controlled, blacks are still 2.3 to 3 times more likely than whites to use public transportation for their work trips (i.e., 27.3% vs. 12.0%, 9.8% vs. 3.9%, and 2.5% vs. 0.8% for black and white workers residing in central city, suburban, and non-SMSA locations, respectively). Likewise, the difference in public transportation use by white and Hispanic (as well as poor and nonpoor) workers declines somewhat when residence location is controlled (to 1.4 to 1.8 times that of white workers), but still remains significant. While income is related to mode split, further disaggregation by household income fails to reduce the disparity between white and minority mode shares.

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*The overall increase in work trips among urbanized area residents was 25.4% for whites and 39.4% and 86.8% for blacks and Hispanics, respectively.[6] Because the definition of "Hispanic" differed in the 1970 and 1980 censuses, large increases in any characteristics of that population are highly suspect.

TABLE 23 Work Trip Mode Shares, by Residence Location and Income for Each Population Group, 1980 (%)

Workers and Modes[a]	White	Black	Hispanic	All Households
Workers Residing in				
SMSA Central City				
Drive Alone	67.2	51.3	53.6	63.2
Shared Ride	18.7	20.4	23.0	19.3
Public Transportation	12.0	27.3	21.6	15.6
SMSA Suburbs				
Drive Alone	74.0	63.0	66.4	73.1
Shared Ride	20.5	25.9	26.0	21.0
Public Transportation	3.9	9.8	5.4[b]	4.3
Non-SMSA				
Drive Alone	73.4	55.2	65.2	71.9
Shared Ride	23.8	40.3	30.8	25.2
Public Transportation	0.8	2.5	1.4[b]	0.9
Worker Household Incomes (1980 $)				
<10,000				
Drive Alone	69.6	45.3	53.2	63.6
Shared Ride	19.4	27.3	24.8	21.3
Public Transportation	7.7	26.0	20.1	12.3
10,000-19,999				
Drive Alone	72.7	56.0	56.9	69.1
Shared Ride	19.4	24.5	29.1	20.8
Public Transportation	5.3	18.5	12.2	7.8
20,000-29,999				
Drive Alone	72.9	61.4	65.4	71.3
Shared Ride	20.7	22.0	24.6	21.1
Public Transportation	4.2	15.7	8.4	5.6
≥30,000				
Drive Alone	75.2	67.3	64.7	74.2
Shared Ride	17.6	18.4	30.6	18.2
Public Transportation	5.4	13.2	4.2	5.9
All Workers				
Drive Alone	72.1	55.0	60.0	69.9
Shared Ride	20.8	25.1	25.0	21.4
Public Transportation	5.2	18.6	13.0	6.9
Other	1.9	1.3	2.0	1.8

[a]Excludes work-at-home and walking trips.

[b]Standard error of the estimate. For all except extremely small subsets of the population, standard errors from the 1980 Census are on the order of 0.1 or less. Only public transportation work trips of non-central-city Hispanics have somewhat larger standard errors (i.e., ≈0.4).

Source: Refs. 18 and 28.

Carpools are also much more prevalent among black and Hispanic workers than among white workers with similar residence locations. As shown in Table 24, black workers appear to substitute carpooling for public transportation as SMSA size declines.

Vehicle availability is a key variable in mode choice. As shown in Table 24, the propensity of minority workers to rely on public transportation is reduced when the comparison is limited to those households with vehicles regularly available. However, the remaining differences are still highly significant and cannot be explained with available data. Presumably, a series of factors that include differences in commuter flows and vehicle availability combine to produce the distinctive mode-split patterns of black, white, and Hispanic workers.

Trends in Mode Split. Direction of flow is particularly relevant to both current and future mode-split patterns. As shown in Table 25, for all but the suburb-to-CBD and central-city-to-CBD flows, black workers in urbanized areas were two to four times as likely as white workers to commute via public transportation in 1980 (Hispanic workers were 1.7 to 2.5 times as likely). In fact, minority workers' relatively greater propensity to use public transportation to get to work (greater compared to that of white workers) grew for most flows between 1970 and 1980. Overall, black workers in urbanized areas were 2.7 times as likely as whites to commute by public transportation in 1970. By 1980, that probability had grown to 2.9. For Hispanics, the comparable ratios were 1.4 in 1970 and 2.0 in 1980. These increases in relative propensity occurred because of the relatively greater drop in public transport mode share among white workers.

When examined by direction of flow (Fig. 19), several other trends in public transportation work trips are apparent. In urbanized areas, nearly two-thirds of the work trips via public transportation are within central cities. While whites still account for the bulk of these movements, their share declined from 66.9% in 1970 to 58.4% in 1980. Thus, minorities (who represent less than one-quarter of the households residing in central cities) now account for more than 40% of the central city work trips on public transportation. The next-largest flow, from suburb to central city, grew from 13.7% of public transportation work trips in 1970 to 22.5% in 1980 and was the only movement to experience a net gain in absolute ridership. That flow is overwhelmingly white (86.4%), but here too, the white share declined between 1970 and 1980. The suburb-to-suburb flow represents only 8.1% of public transportation work trips (vs. 35.3% of total work trips) and it also is dominated by white workers; this was the only movement in which the white share rose between 1970 and 1980.

While only 274,000 workers use public transportation to commute from central city residences to suburban job sites, the smallest of the public transportation flows has the heaviest minority ridership (51.1%). Between 1970 and 1980, this flow declined from 7.8% to 5.1% of public transportation work trips. However, the minority share rose during this period. Reverse-commuting, despite its small volume, is important from the standpoint of both efficiency and equity. Efficient management of transportation resources suggests that public transportation systems aim for a better balance between inbound and outbound (as well as between peak and off-peak) movements. Historically, public transportation has concentrated on serving the central-city-to-CBD and suburb-to-CBD markets, which account for only 5% and 4%, respectively, of all work trips.

TABLE 24 Work Trip Mode Shares, by SMSA Size and Vehicle Availability for Each Population Group, 1980 (%)

SMSA Size and Travel Mode[a]	Households with Vehicles			All Households		
	White	Black	Hispanic	White	Black	Hispanic
Large SMSA - Central City						
Drive Alone	68.1	61.0	56.4	61.7	48.5	43.7
Shared Ride	16.3	18.6	26.1	15.6	16.6	23.2
Public Transportation	13.3	19.3	16.8	20.2	34.0	32.2
Other	2.3	b	b	2.5	b	b
Large SMSA - Other						
Drive Alone	74.0	70.4	65.2	73.2	65.3	62.5
Shared Ride	18.5	18.7	29.2	18.5	19.8	29.9
Public Transportation	5.5	10.1	4.0	6.2	14.3	6.1
Other	2.0	b	b	2.1	b	b
Medium SMSA						
Drive Alone	77.3	70.8	68.7	76.1	63.8	65.3
Shared Ride	18.4	22.6	26.9	18.6	23.5	27.2
Public Transportation	2.2	6.2	b	3.0	12.1	b
Other	2.1	b	b	2.3	b	b
Small SMSA - Central City						
Drive Alone	78.6	62.1	74.0	77.4	56.4	70.8
Shared Ride	17.1	26.9	25.4	17.2	28.3	26.7
Public Transportation	1.6	b	b	2.2	12.4	b
Other	2.8	b	b	3.2	b	b
Small SMSA - Other						
Drive Alone	79.1	74.1	82.0	78.8	67.7	80.4
Shared Ride	18.5	23.3	14.3	18.5	28.6	16.1
Public Transportation	b	b	b	b	b	b
Other	2.0	b	b	1.7	b	b
Non-SMSA						
Drive Alone	75.0	61.0	69.4	74.3	55.1	66.8
Shared Ride	22.2	36.6	27.8	22.6	40.7	30.1
Public Transportation	0.6	b	b	0.7	2.5	b
Other	2.2	b	b	2.3	b	b

[a]Excludes work-at-home and walking trips.

[b]Not reported because of a large variance in observed data.

Source: Ref. 28.

TABLE 25 Work Trips via Public Transportation, by Commuter Flow for White, Black, and Hispanic Workers, 1970 and 1980

Workers, Residence, and Workplace[a]	1970			1980			Change, 1970-1980 (%)		
	White	Black	Hispanic	White	Black	Hispanic	White	Black	Hispanic[b]
Living in Central City (%)	17.9	36.8	22.9	12.0	27.2	21.6	-33.0	-26.1	-5.7
Working in CBD	43.9	59.0	52.6	30.5	44.1	44.9	30.5	-25.3	-14.6
Working in Central City outside CBD	13.9	33.8	21.9	9.5	25.8	21.6	-31.7	-23.7	-1.4
Working outside Central City	7.4	22.2	11.0	3.6	13.1	9.0	-51.4	-41.0	-18.2
Living in Suburbs (%)	7.1	15.9	5.9	5.2	11.5	6.7	-26.8	-27.7	13.6
Working in CBD	32.7	39.0	27.9	32.2	32.3	32.5	-1.5	-17.2	16.5
Working in Central City outside CBD	7.3	15.6	7.6	6.5	12.9	8.0	-11.0	-17.3	5.3
Working outside Central City	4.1	12.3	3.6	1.7	7.5	4.5	-58.5	-39.0	25.0
Total Workers (10^6)	12.3	33.3	17.1	7.9	22.8	15.4	-35.8	-31.5	-9.9

[a]Urbanized areas only. Includes work-at-home and walking trips and workers whose workplaces were not reported.

[b]Because the definition of "Hispanic" differed in the 1970 and 1980 censuses, apparent trends in this group should be interpreted cautiously.

Source: 1970 and 1980 Census public-use microdata files, as reported by Ref. 6.

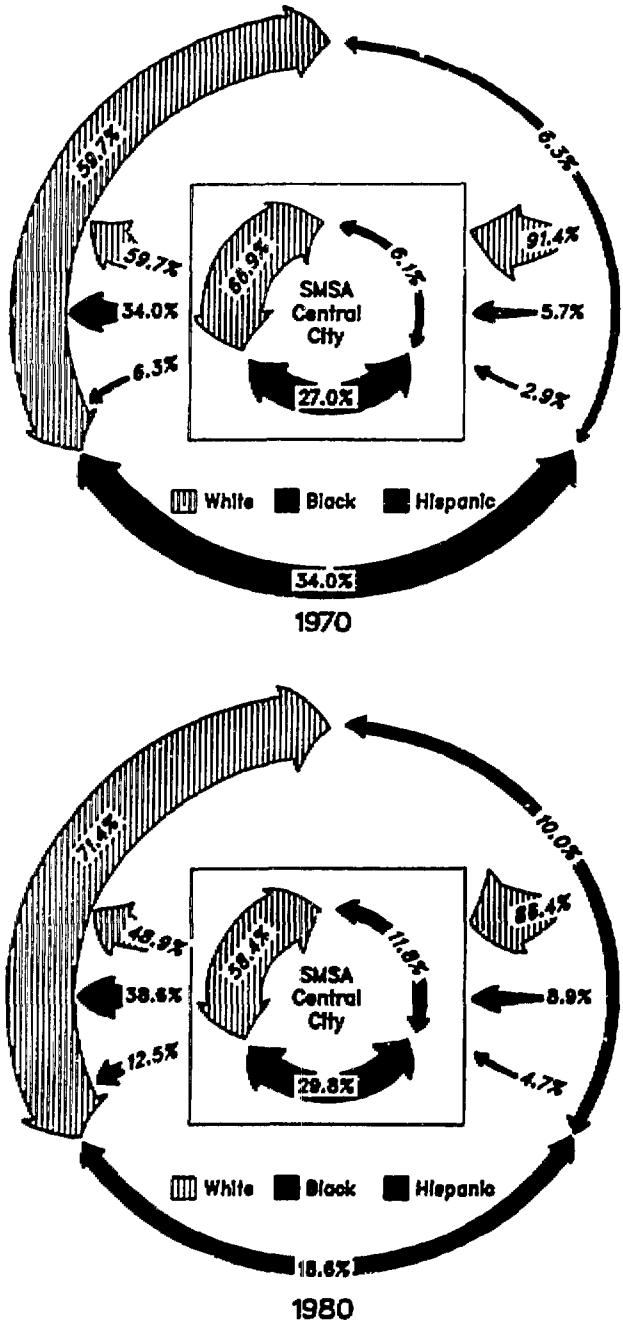

FIGURE 19 Distribution of Public Transportation Work Trips, by Commuter-Flow Direction and Population Group, 1970 and 1980

Particular emphasis has been placed on luring the latter -- largely white -- riders to heavily subsidized services. By contrast, few resources have been directed toward within-suburb or reverse-commute markets (39% and 8% of all work trips).* Given the dispersed nature of these trips (particularly within-suburb), it may be financially infeasible to greatly improve service. However, public policy should recognize that reverse service has been particularly poor and, generally speaking, ridership has been limited to those with no other transportation alternative. These "captive riders" are disproportionately minorities, older workers, women, and the working poor.[6] Few would deny that these riders need some basic level of transit service. All too often, however, that need goes unmet. For example, it is widely recognized that most of the new jobs for which black central city workers are qualified are in the suburbs and that the lack of adequate reverse transit service is a major obstacle to blacks' economic progress.[43,44] In the absence of a fundamental reorientation of the traditional concept of radial transit services, public transportation is hard pressed to respond to these changing spatial demands.

Modal Travel Time. As mentioned earlier, some of the variation in average work trip travel times between white and minority workers may be attributed to differences in mode split (generally speaking, public transportation travel times are double those for solo drivers). When SMSA size, residence location within an SMSA, and mode choice are controlled -- and when the comparison is restricted to only those households with one or more vehicles available -- mean travel times of black and Hispanic workers more closely approach those of white workers (Table 26).‡ The remaining differences -- travel times on the order of 10-20% longer for black vs. white workers -- cannot be explained with available data.

A further obvious distinction between the work trips of minority and white workers is the consistently different pattern in public transportation travel times by persons in households with vehicles compared to those in households without vehicles (Table 27). White workers in zero-vehicle households have consistently shorter public transportation work trips than do white workers in households with vehicles available. Presumably, this reflects a locational preference for housing and employment near transit services. By contrast, black workers in zero-vehicle households tend to have longer travel times than black workers in households with vehicles; the reason for this is not clear. Perhaps public transportation is somewhat less accessible in those neighborhoods where zero-vehicle black households are concentrated; perhaps workers in

*An additional 29% of all work trips are between central city residences and non-CBD central city job sites. The quality of transit serving these trips tends to be highly location-specific.

‡Major exceptions are the substantially longer travel times of black workers in non-SMSA and large-SMSA locations who commute by "other" means. Because "other" may include varying proportions of walking, bicycling, working at home, etc., it is unclear whether these differences are real or spurious.

TABLE 26 Mean Work Trip Travel Time, by Residence Location and Travel Mode for White, Black, and Hispanic Workers in Households with Vehicles Available, 1980 (minutes)

Worker Residence and Travel Mode	White	Black	Hispanic
Large SMSA - Central City	22	28	25
Drive Alone	20	24	22
Shared Ride	24	26	23
Public Transportation	40	42	43
Other[a]	10	14	9
Large SMSA - Other	22	25	21
Drive Alone	21	22	20
Shared Ride	26	27	22
Public Transportation	48	46	45
Other[a]	9	10	11
Medium SMSA	18	19	22
Drive Alone	18	18	21
Shared Ride	22	23	24
Public Transportation	34	23	b
Other[a]	8	b	b
Small SMSA - Central City	15	18	16
Drive Alone	14	17	17
Shared Ride	19	18	13
Public Transportation	b	b	b
Other[a]	8	b	b
Small SMSA - Other	17	21	15
Drive Alone	17	20	16
Shared Ride	23	26	b
Public Transportation	b	b	b
Other[a]	6	b	b
Non-SMSA	17	20	16
Drive Alone	16	18	14
Shared Ride	26	26	23
Public Transportation	49	b	b
Other[a]	5	8	6
All workers, All Locations	19	24	21

[a]Includes work-at-home and walking trips.

[b]Not reported because of a large variance in observed data.

TABLE 27 Mean Travel Time for Public Transportation Work Trips, by Residence Location and Vehicle Availability for White, Black, and Hispanic Workers, 1980 (minutes)

Households and Locations	White	Black	Hispanic
Households without Vehicles			
Large SMSA - Central City	37	42	42
Large SMSA - Other	38	50	a
Medium SMSA	29	37	a
Households with Vehicles			
Large SMSA - Central City	40	42	43
Large SMSA - Other	48	46	45
Medium SMSA	34	23	a

[a]Not reported because of a large variance in observed data.

Source: Ref. 28.

those neighborhoods travel further (on average) to their jobs or under traffic conditions that substantially reduce their average travel speeds; or perhaps these longer work trips are a result of constraints on residence and workplace location decisions.

Vehicle Types. The 1980 Census provides a further breakdown of private-vehicle work trips by vehicle type for each population group (see Table 28). In all locations, Native Americans are most likely to commute by truck. In descending order of truck use, Hispanics are the next most likely, followed by whites, blacks, and Asians. Truck and van commuting also is most prevalent outside SMSAs, where these vehicles account for one-quarter of all private-vehicle work trips. Among rural Hispanics and Native Americans, trucks serve an even higher proportion (about 30%) of all work trips. Presumably, this greater propensity to commute by truck reflects the concentration of Hispanics and Native Americans in western states, where light trucks are more prevalent.

Among all four minority groups, ridesharing is consistently higher than among white workers, both in the aggregate (24-27%, vs. 21% for all work trips) and for each locational subset. The highest ridesharing percentage, more than 40%, is among black workers residing outside SMSAs. As stated earlier, ridesharing appears to substitute for public transportation among black workers in rural areas.

TABLE 28 Distribution of Work Trips by Residence Location and Private-Vehicle Type for Each Population Group, 1980 (%)

Residence Location and Vehicle Type[a]	White	Black	Hispanic	Native American[b]	Asian and Pacific Islander	All Households
Residence Location						
SMSA Central City						
Drive Alone	67.2	51.3	53.6	60.4	51.8	63.2
Auto	59.1	47.7	46.2	50.6	48.7	56.1
Truck or Van	8.1	3.5	7.5	9.8	3.1[c]	7.1
Shared Ride	18.7	20.4	23.0	23.2	22.5	19.3
Auto	16.3	18.7	19.7	19.3	21.0	17.1
Truck or Van	2.3	1.7	3.2	4.0	1.5	2.2
SMSA Suburbs						
Drive Alone	74.0	63.0	66.4	67.8	64.8	73.1
Auto	63.0	57.5	56.1	52.8	60.6	62.5
Truck or Van	11.0	5.5	10.3	15.0	4.2	10.6
Shared Ride	20.5	25.9	26.0	25.7	25.7	21.0
Auto	17.3	22.9	21.7	19.8	23.9	17.9
Truck or Van	3.1	3.0	4.4	5.9	1.8	3.2
Non-SMSA						
Drive Alone	73.4	55.2	65.2	63.3	68.6	71.9
Auto	54.2	46.3	46.8	42.8	58.8	53.5
Truck or Van	19.2	8.9	18.4	20.5	9.8	18.4
Shared Ride	23.8	40.3	30.8	31.4	27.0	25.2
Auto	17.7	32.3	21.2	20.5	22.6	18.9
Truck or Van	6.0	8.0	9.6	10.9	4.4	6.3
All Workers						
Drive Alone	72.1	55.0	60.0	64.2	59.0	69.9
Auto	60.0	50.1	50.2	48.3	54.9	58.6
Truck or Van	12.2	4.9	9.8	15.8	4.1	11.3
Shared Ride	20.8	25.1	25.0	27.3	24.3	21.4
Auto	17.2	22.0	20.6	19.9	22.5	17.8
Truck or Van	3.6	3.1	4.4	7.3	1.8	3.6

[a]Excludes work-at-home and walking trips. Because modes other than private vehicles are not shown, shares do not sum to 100%.

[b]Including American Indians, Eskimos, and Aleuts.

[c]Standard error of this estimate is approximately 0.2. All other standard errors are <0.2.

Source: Ref. 18.

TABLE 29 Average Private-Vehicle Occupancy during Work Trips, by Residence Location for Each Population Group, 1977 (passengers and driver per car)

Residence Location	White	Black	Hispanic	Poor	Nonpoor	All Households
SMSA Central City	1.21	1.31	1.44	1.38	1.22	1.24
SMSA Suburbs	1.26	1.45	1.30	1.47	1.26	1.27
Non-SMSA	1.27	1.69	1.51	1.42	1.29	1.31
Average Occupancy, All Work Trips	1.25	1.44	1.41	1.42	1.26	1.27

Sources: Ref. 12.

The relatively greater ridesharing among black and Hispanic workers is also reflected in the average occupancies of their private-vehicle work trips. As shown in Table 29, the private-vehicle work trips of black workers have about 15% higher occupancy rates than those of white workers. Again, the difference is especially marked (>33%) for workers residing outside SMSAs.

5 FUEL USE AND EXPENDITURE PATTERNS OF MINORITY AND POOR HOUSEHOLDS

Fuel use and expenditures by minority and poor households are functions of both the distinctive travel patterns and vehicle attributes of these households (see Secs. 3 and 4) and retail fuel prices. The following discussion focuses first on fuel price, fuel use per household and vehicle, and vehicle fuel economy (see also Sec. 3.3.3); then on fuel expenditures; and finally on expenditure trends, with policy implications for minority households.

5.1 FUEL PRICE

Retail fuel prices tend to vary not only by grade and type (e.g., premium gasoline vs. regular vs. diesel fuel), but also by brand affiliation and service level of the retailer (i.e., full vs. self-serve), distance and method of distribution from fuel terminals to service stations, and, to a certain extent, by the level of local taxes. However, in national surveys such as that of the Transportation Panel (TP), many of these variations are obscured by relatively low sampling rates and lack of geographic detail, which prevent controlling for many of these influences. Thus, average prices computed from fuel purchases recorded in the TP file tend to show little variation.

Figure 20 illustrates average retail prices of gasoline (in current and constant 1980 dollars) by quarter, from January 1979 to December 1983. Developed by the Bureau

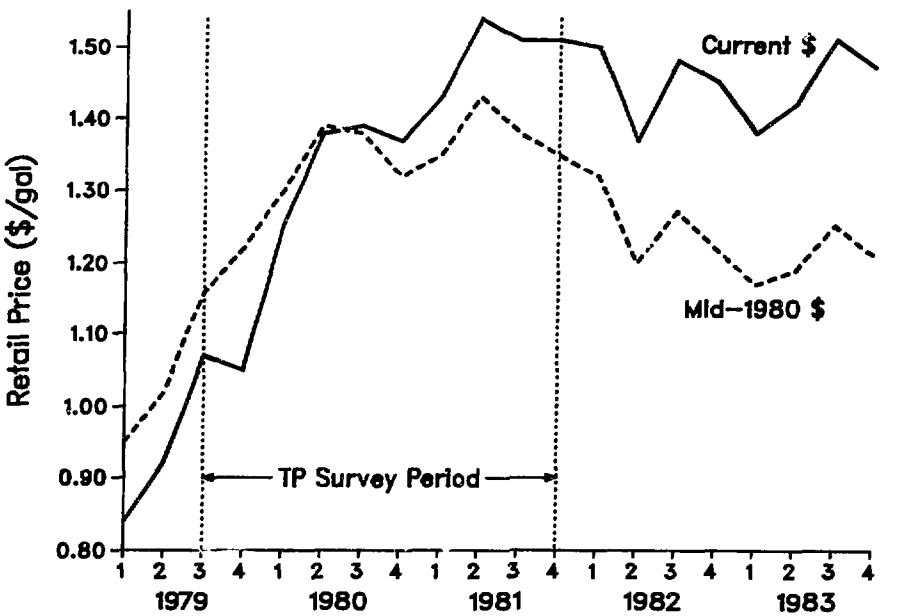

FIGURE 20 Average Sales-Weighted Retail Price of Unleaded Regular Gasoline to Urban Consumers, 1979-1983

of Labor Statistics (BLS), these prices are based on a sampling of 2600 service stations in 85 urban areas.[45] They correspond to the sales-weighted average price of unleaded regular gasoline (including taxes) during the first month of each quarter. The 28 months for which the TP collected fuel-purchase logs are also highlighted in the figure.

Average purchase prices (all fuels, all grades) based on TP data for those same 28 months are shown in Fig. 21 for four respondent subgroups. Clearly, poor and nonpoor households pay much the same price. While the 1980-81 data suggest that the average black household may pay slightly more (on the order of 2¢/gallon) than the average white household, the difference is not statistically significant.

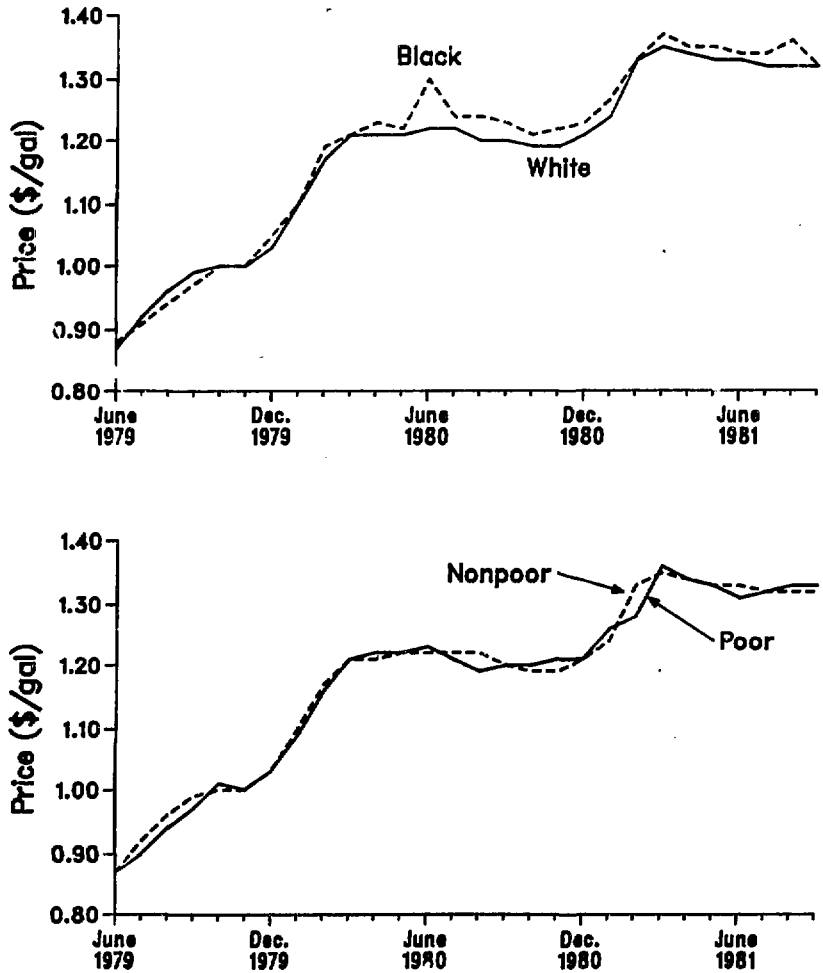

FIGURE 21 Average Price Paid for Motor Fuel by White, Black, Poor, and Nonpoor Households, June 1979-Sept. 1981

5.2 FUEL USE

5.2.1 Total Fuel Use

Estimates of monthly gasoline use by households from the TP survey, together with total gasoline sales from DOT's Federal Highway Administration (FHWA), are plotted in Fig. 22. While the general shape of the TP data is much like that of the plot of FHWA's total U.S. sales, it is not clear why the two estimates move closer over the survey period. The apparent reduction in nonhousehold fuel use may be due to either lingering effects of the 1980 recession or the relatively more rapid turnover and, hence greater fuel-economy improvement, in business (nonhousehold) vehicles.

According to the TP survey, households used 74.9 billion gallons of motor fuel in calendar year 1980, of which approximately 73 billion were gasoline. In 1983, RTECS data show households consuming 80.3 billion total gallons and 78.3 billion gallons of gasoline. The 1980-83 increase in household motor-fuel use contrasts with a decrease -- from 104.6 to 103.2 billion gallons -- in total gasoline sales.[39] Again, the apparent decline in the nonhousehold component implies either a (1) reduction in business travel, (2) shift from gasoline to diesel fuel for business use, or (3) relatively more rapid improvement in the fuel economy of nonhousehold vehicles.

Table 30 shows household use of leaded and unleaded gasoline. Of the 78.3 billion gallons consumed in 1983, slightly more than 41% contained lead. Hispanic households,

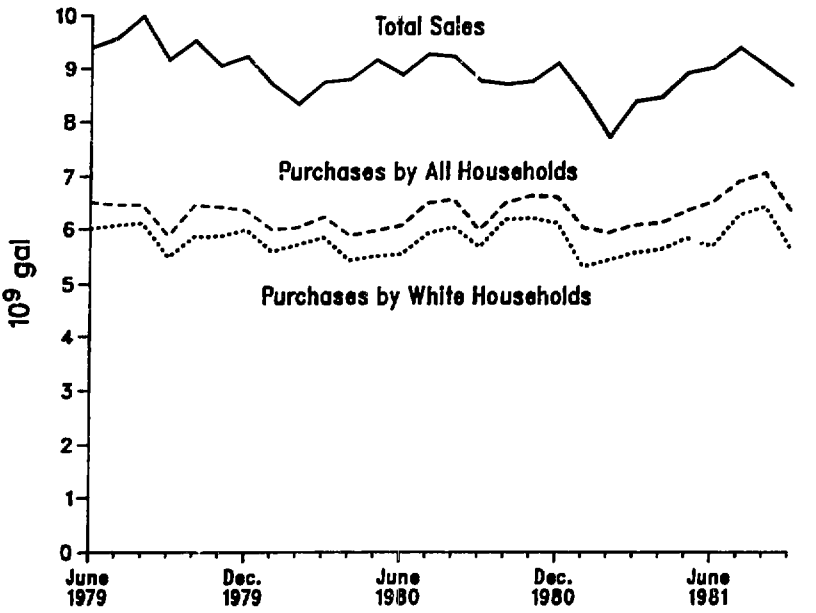

FIGURE 22 FHWA Estimates of Total U.S. Gasoline Sales vs. TP Estimates of Fuel Purchases by Households, June 1979-Sept. 1981

TABLE 30 Household Use of Leaded and Unleaded Gasoline, by Household Demographic Characteristics, 1983 (standard errors shown in parentheses)

Household Characteristic	Gasoline Consumption (billion gallons)			Leaded Share (%)
	Leaded	Unleaded	Total	
Population Group				
White	28.6 (0.92)	40.1 (1.20)	68.7 (1.51)	41.6
Black	3.1 (0.13)	4.8 (0.57)	7.9 (0.89)	39.2
Hispanic[a]	1.9 (0.35)	2.3 (0.35)	4.2 (0.57)	45.2
Residence Location				
SMSA Central City	9.3 (0.70)	12.8 (0.70)	22.1 (1.15)	42.1
SMSA Suburbs	14.0 (0.81)	22.2 (1.49)	36.2 (1.95)	38.7
Non-SMSA	9.0 (0.60)	11.1 (1.18)	20.1 (1.57)	44.8
Region				
Northeast	5.1 (0.48)	9.1 (0.33)	14.2 (0.54)	35.9
Midwest	8.1 (0.59)	11.4 (0.70)	19.5 (0.76)	41.5
South	11.5 (0.60)	16.8 (0.97)	28.3 (1.30)	40.6
West	7.4 (0.54)	8.7 (0.39)	16.1 (0.48)	46.0
Age of Householder (yr)				
<60	27.2 (0.87)	38.3 (1.15)	65.5 (1.44)	41.5
≥60	5.0 (0.41)	7.8 (0.41)	12.8 (0.60)	39.1
Household Income (1983 $)				
<5,000	1.2 (0.21)	1.0 (0.11)	2.2 (0.22)	54.5
5,000-9,999	4.2 (0.24)	4.2 (0.38)	8.4 (0.46)	50.0
10,000-14,999	4.7 (0.55)	5.0 (0.37)	9.7 (0.74)	48.5
15,000-19,999	5.2 (0.47)	5.1 (0.45)	10.3 (0.63)	50.5
20,000-24,999	3.8 (0.28)	5.4 (0.47)	9.2 (0.60)	41.3
25,000-34,999	6.4 (0.40)	11.3 (0.60)	17.7 (0.85)	36.2
≥35,000	6.7 (0.58)	14.0 (0.74)	20.7 (1.20)	32.4
All Households	32.2 (1.00)	46.1 (1.24)	78.3 (1.72)	41.1

[a]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

Source: Ref. 4.

and households outside SMSAs or in the western states, had somewhat elevated shares of leaded fuel use (roughly 45%), while households in the Northeast had somewhat lower shares (roughly 36%). Of the demographic characteristics shown in Table 30, income is clearly the best indicator of leaded-fuel use. Among households with incomes under $20,000, leaded gasoline accounted for 50% of fuel purchases; among households with incomes over $35,000, it represented only 32%.

5.2.2 Fuel Use per Household

The average vehicle-owning household consumed approximately 88 gallons of motor fuel per month (almost all of it gasoline) in 1980. Black households consumed slightly less, approximately 84 gallons, and poor households consumed considerably less, approximately 68 gallons.[13] Figures 23-25 illustrate these rates, as well as the relationships between household income, residence location, and fuel use. Figure 23 also indicates the trend toward higher fuel use by poor households during the period June 1979 to September 1981.

In calendar year 1983, black households with vehicles consumed an average of 1180 gallons, compared to 1211 gallons for Hispanic households and 1103 gallons for white households. In terms of monthly consumption, the data suggest a slight increase (<5%) in the rate for the average white household, compared to a more substantial rise (17%) in the rate for the average black household. The latter increase even exceeds the percentage drop in real gasoline price, suggesting that the fuel economy of vehicles

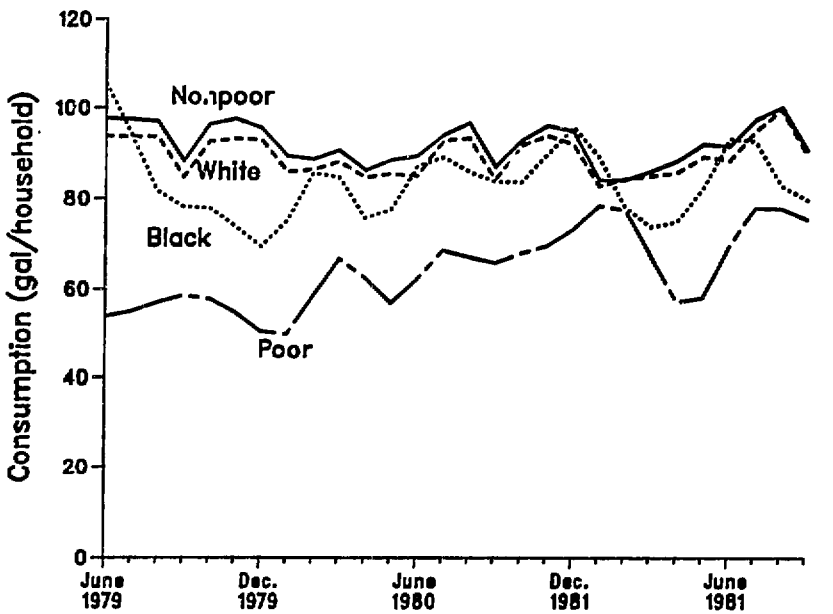

FIGURE 23 Monthly Motor Fuel Use by Black, White, Poor, and Nonpoor Households, June 1979-Sept. 1981

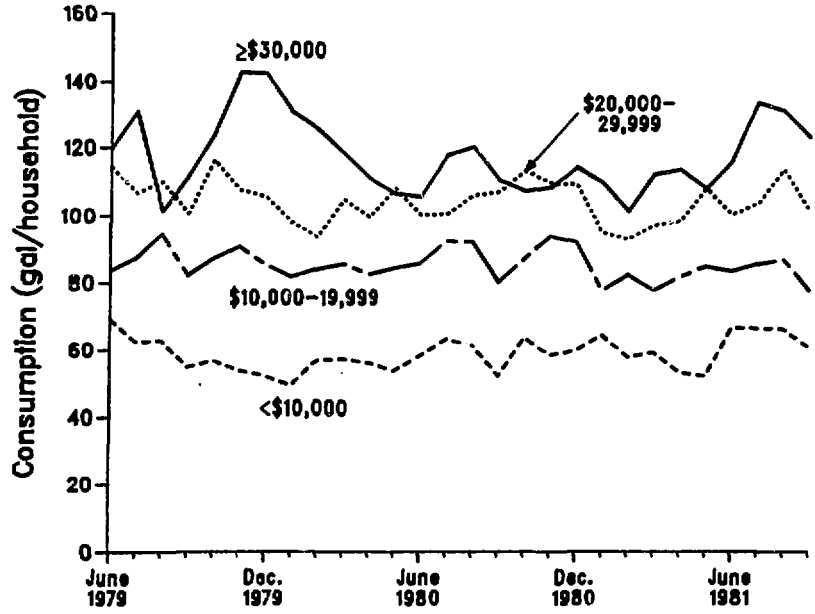

FIGURE 24 Monthly Motor Fuel Use per Household, by Household Income, June 1979-Sept. 1981

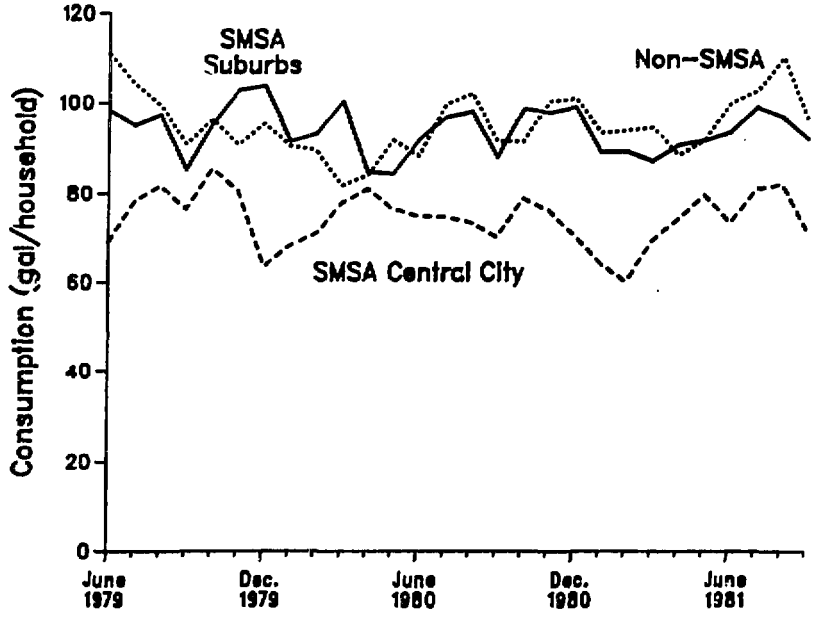

FIGURE 25 Monthly Motor Fuel Use per Household, by Household Residence Location, June 1979-Sept. 1981

in black households improved relatively little over this period, although other factors -- including employment growth and increased vehicle ownership -- may have had some effect.

Table 31 presents selected portions of the 1983 Residential Transportation Energy Consumption Survey (RTECS) published data. In addition to the highly significant difference in vehicle availability between black and white households (similar findings from 1977 NPTS and 1980 AHS are discussed in Sec. 3). The data also show significant differences in fuel use rates between (1) central city and other households, (2) lower-middle- and upper-income households, (3) elderly and nonelderly households, and (4) most significant of all, households with 1, 2, and 3 or more vehicles. The 1979-81 fuel use curves in Figs. 24 and 25 are consistent with the 1983 relationships observed in Table 31. However, the positive correlation between income and motor-fuel use breaks down when the data are disaggregated by race/Spanish origin. As shown in Table 32, fuel use by black and Hispanic households appears to fluctuate almost randomly with income. This suggests that raw RTECS data may be too sparse to permit cross-tabulations of race/Spanish origin with other variables of interest.

5.2.3 Fuel Use per Vehicle

Fuel consumption per vehicle is significantly higher in black and Hispanic households than in white households (Table 33). The difference is largely due to variations in average fuel economy. Table 33 also displays several univariate comparisons of fuel economy -- by vehicle age and number of engine cylinders for the three population groups. Based on published RTECS data for 1983, these comparisons show that not only were the vehicles in white households more fuel-efficient, they were also somewhat newer and less powerful.[4] For example, more than 60% of the 1983 fleet of vehicles in black households had eight cylinders and only 14% had four cylinders (compared to shares of 42% and 25% in white households).* Similarly, nearly one-third of the vehicles in black households were 10 or more years old in 1983, compared to only 27% of the vehicles in white households. Even if blacks' older vehicles were to achieve the average fuel economy for their vintage (which they did not), they would still be more than 30% below the average economy for vehicles less than five years old. Thus, it appears that several vehicle characteristics, including but not limited to age and engine cylinders, combined to depress the fuel economy of minorities' household vehicles.

This depressed fuel economy is still more pronounced when the comparison is limited solely to automobiles (Table 34). Because light trucks have relatively lower fuel economy and are more prevalent in white households, their inclusion in average fuel economy tends to obscure some differences. For autos alone, white households achieved more than 2 mpg (12%) better fuel economy than did black households and 1.5 mpg (9%) better than did Hispanic households in 1983.

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*Among Hispanic households, the comparable shares were 21% four-cylinder and 47% eight-cylinder.

TABLE 31 Vehicle Availability and Annual Fuel Use per Vehicle-Owning Household, by Household Demographic Characteristics, 1983 (standard errors shown in parentheses)

Household Characteristic	Households[a] (millions)	Vehicles per Household	Fuel Use (gal/household)
Population Group			
White	63.8	1.8	1103
	(0.89)	(0.02)	(20.1)
Black	6.8	1.6	1180
	(0.61)	(0.05)	(88.5)
Hispanic[b]	3.5	1.7	1211
	(0.42)	(0.06)	(55.7)
Residence Location			
SMSA Central City	22.3	1.7	989
	(0.84)	(0.03)	(36.6)
SMSA Suburbs	31.4	1.9	1177
	(1.38)	(0.02)	(22.4)
Non-SMSA	18.0	1.8	1153
	(1.21)	(0.04)	(32.3)
Household Income (1983 $)			
<5,000	3.2	1.3	724
	(0.29)	(0.06)	(50.7)
5,000-9,999	9.8	1.5	864
	(0.63)	(0.04)	(36.3)
10,000-14,999	10.5	1.5	933
	(0.60)	(0.03)	(32.7)
15,000-19,999	9.7	1.7	1087
	(0.45)	(0.03)	(53.3)
20,000-24,999	8.7	1.8	1087
	(0.50)	(0.05)	(41.3)
25,000-34,999	14.7	1.9	1236
	(0.56)	(0.02)	(28.5)
≥35,000	15.6	2.2	1380
	(0.76)	(0.04)	(40.0)
Age of Householder (yr)			
<60	54.4	1.9	1237
	(1.52)	(0.02)	(26.0)
≥60	17.8	1.6	729
	(0.80)	(0.03)	(18.2)
Household Vehicles			
1	30.6	1.0	664
	(0.92)	--	(15.3)
2	29.6	2.0	1217
	(0.92)	--	(20.7)
≥3	12.1	3.2	1988
	(0.56)	(0.03)	(49.7)
All Households	72.2	1.8	1112
	(0.65)	(0.02)	(21.1)

[a]Excludes households without regularly available vehicles.

[b]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

Source: Ref. 4.

TABLE 32 Motor-Fuel Use in White, Black, and Hispanic Households, by Household Income, 1983 (gal/yr)

Household Income (1983 $)[a]	White	Black	Hispanic[b]	All Households
<5,000	654	873	c	724
5,000-9,999	823	1,083	1,060	864
10,000-14,999	947	910	1,263	933
15,000-19,999	1,056	1,415	918	1,087
20,000-24,999	1,077	1,211	1,431	1,087
25,000-34,999	1,236	1,202	1,218	1,236
≥35,000	1,361	1,578	1,539	1,380

[a]Standard errors are not available.

[b]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

[c]Not reported because of a large variance in observed data.

Source: Ref. 4.

In addition to vehicle characteristics, residence location also influences fuel economy. As shown in Table 34 (as well as in Fig. 25), vehicles in central city households are less fuel-efficient. This may reflect either (1) a greater proportion of miles driven under congested urban conditions or (2) systematic differences in the fleet of vehicles in these households. The effect of these two factors -- technical and environmental -- on the fuel economy of vehicles in minority households will be explored in a follow-up study scheduled to begin in early 1986.

5.3 *FUEL EXPENDITURES*

5.3.1 Fuel Cost of Travel

With relatively equivalent gasoline prices, fuel cost per mile of travel is largely a function of vehicle fuel economy. In 1983, fuel economy ranged from a low of 13.3 mpg for black households to a high of 16.1 mpg for households with annual incomes over $35,000. The fuel cost of travel ranged from 8.87¢/mile (7.43¢/mile in $1980) for black households to 7.45¢/mile (6.24¢/mile in $1980) for the high-income households (see Table 34).

TABLE 33 Vehicles, Fuel Use per Vehicle, and Fuel Economy, by Model Year and Number of Engine Cylinders for White, Black, and Hispanic Households, 1985 (standard errors shown in parentheses)

Vehicle Characteristic	White			Black			Hispanic[a]			All Households		
	Total Vehicles (millions)	Gallons per Vehicle	Miles per Gallon	Total Vehicles (millions)	Gallons per Vehicle	Miles per Gallon	Total Vehicles (millions)	Gallons per Vehicle	Miles per Gallon	Total Vehicles (millions)	Gallons per Vehicle	Miles per Gallon
Model Year[c]												
1979 or Later	40.5	615	18.8	3.2	653	16.7	1.8	690	16.6	44.8	619	18.6
	(1.46)	(9.2)	(0.22)	(0.41)	(35.3)	(0.62)	(0.27)	(62.1)	(0.76)	(1.30)	(9.9)	(0.20)
1974-1978	43.2	655	13.7	4.2	752	13.0	2.3	722	13.1	48.4	663	13.7
	(1.12)	(9.2)	(0.12)	(0.46)	(39.1)	(0.42)	(0.33)	(36.1)	(0.33)	(1.06)	(8.6)	(0.12)
1973 or Earlier	31.0	542	12.9	3.4	803	11.1	1.6	804	12.3	35.2	567	12.7
	(1.21)	(11.9)	(0.12)	(0.38)	(98.0)	(0.67)	(0.33)	(61.1)	(0.48)	(1.13)	(16.4)	(0.17
Engine Cylinders[c]												
4	25.9	473	22.9	1.4	537	21.0	1.1	490	20.9	28.3	478	22.7
6	28.5	606	15.7	2.4	777	12.7	1.7	707	14.2	31.4	618	15.4
8	50.0	678	12.4	5.9	754	12.3	2.5	867	12.1	57.0	687	12.4
All Household Vehicles[b]	115.3	610	15.3	11.0	734	13.3	5.8	732	13.9	129.3	621	15.1
	(2.31)	(6.7)	(0.12)	(1.08)	(41.8)	(0.35)	(0.75)	(27.1)	(0.35)	(2.07)	(8.1)	(0.12)

[a]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

[b]All vehicles, including "other or unknown" model year and number of cylinders. Hence, breakdowns by model year and number of cylinders do not sum to total vehicles.

[c]Excludes vehicles for which number of cylinders is unknown; standard errors not available for engine cylinders.

Source: Ref. 4.

TABLE 34 Fuel Economy and Fuel Cost of Travel, by Household Demographic Characteristics, 1983[a] (standard errors shown in parentheses)

Household Characteristic[b]	Fuel Economy (mpg)			Fuel Cost (1983 ¢/mi)
	Autos	Trucks	Total	
Population Group				
White	16.2 (0.16)	13.3	15.3 (0.12)	7.71
Black	14.0 (0.35)	13.2	13.3 (0.35)	8.87
Hispanic[c]	14.7 (0.47)	13.0	13.9 (0.35)	8.42
Residence Location				
SMSA Central City	15.3	13.5	14.7 (0.15)	8.03
SMSA Suburbs	16.6	13.3	15.6 (0.19)	7.56
Non-SMSA	15.7	13.1	14.8 (0.24)	8.04
Household Income (1983 $)				
>5,000	14.1	15.6	14.2 (0.55)	8.31
5,000-9,999	14.5	12.4	13.9 (0.31)	8.49
10,000-14,999	15.3	13.3	14.7 (0.29)	8.03
15,000-19,999	15.0	12.7	14.0 (0.31)	8.36
20,000-24,999	16.2	13.0	15.3 (0.18)	7.71
25,000-34,999	16.6	13.6	15.6 (0.27)	7.56
≥35,000	17.1	13.5	16.1 (0.24)	7.45
Age of Householder (yr)				
<60	16.3	13.2	15.2 (0.15)	7.76
≥60	15.0	12.8	14.8 (0.22)	8.04
All Households	16.0 (0.16)	13.3 (0.25)	15.1 (0.12)	7.81

[a]Excludes households with no regularly available vehicles.

[b]Available only for average fuel economy of all vehicles in the household.

[c]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

Source: Ref. 4.

In 1980, the cost of travel (in 1980 ¢/mile) was roughly as follows:

White	7.89
Black	9.02
Poor	8.27
Nonpoor	7.94
Average	7.97

Thus, between 1980 and 1983, real fuel cost per mile of travel declined by roughly 2%. Based on the published data, both white and black households appear to have experienced the same percentage improvement.

5.3.2 Annual Expenditures

In 1983, U.S. households with one or more regularly available vehicles spent an average of $1319 on gasoline (Table 35). While black and Hispanic households averaged

TABLE 35 Household Gasoline Expenditures, by Household Income for White, Black, and Hispanic Households, 1983 (1983 $/household)

Household Income (1983 $)	White	Black	Hispanic[a]	All Households
<5,000	772	1,030	b	724
5,000-9,999	971	1,278	1,240	864
10,000-14,999	1,117	1,074	1,478	933
15,000-19,999	1,246	1,670	1,074	1,087
20,000-24,999	1,271	1,429	1,674	1,087
25,000-34,999	1,458	1,418	1,425	1,236
≥35,000	1,606	1,862	1,801	1,380
All Households[c]	1,307 (30.1)	1,398 (160.8)	1,418 (191.4)	1,317 (30.3)

[a]Hispanics may be of any race. Because they may also be included in either the white or black groups, population-group data do not sum to national totals.

[b]Not reported because of a large variance in observed data.

[c]Standard errors shown in parentheses (available only for total households).

Source: Ref. 4.

somewhat more -- $1398 and $1410, respectively -- the differences are not statistically significant. Likewise, although black and Hispanic households in virtually every income category exhibited higher fuel expenditures than those of white households, the variances in the data are too great to conclude that they reflect real differences in expenditure levels.

Over time, however, evidence suggests that black households tend to spend somewhat more on gasoline and respond somewhat differently to price increases than do other households. As shown in Table 36, black households consistently spent 3-7% more on gasoline in each of three survey years. Further, in response to the two price shocks between 1972 and 1980, the real fuel costs to the average white household rose 44%, compared with 51% for those of the average black household. While both dropped by a comparable margin between 1980 and 1982, the net increase over the entire 10-year period was 18% for white households and 23% for black households.

Much of this variation is attributable to the income distributions of white and black households. Between 1972 and 1980, gasoline expenditures of the highest-income households increased by only 6%, and between 1980 and 1982 they declined by more than 15%. Overall, the gasoline expenditures of these wealthier households fell by roughly 10% for the decade, while those of low-income households rose by 23%.

These patterns are best interpreted in relationship to total household expenditures and household transportation expenditures. As shown in Table 37, households in the lowest income quintile (including those without vehicles) spent an average of 14% of their budgets on transportation in 1972 and again in 1982. This contrasts with an average of about 19% for households in the highest quintile. Across all income groups, the table shows that while transportation budgets (expressed as a share of total household expenditures) fluctuate in the short run (e.g., in response to major movements in fuel prices), they are remarkably stable in the long run.

Much of that stability is achieved by trading off the individual components within the transportation budget. Lower-income households appear to balance their budgets by reducing their capital expenditures, even though vehicle replacement could reduce fuel expenses over the long run. Higher-income households have a near-opposite pattern. Among lower-income households, gasoline purchases rose from 23% of transportation expenditures in 1972 to 36% in 1980, after which they dropped to 34% in 1982. For these same households, vehicle expenses (also expressed as a share of transportation expenditures) declined steadily -- from 37% in 1972 to 31% by 1980 and to 29% by 1982. Between 1972 and 1980, higher-income households experienced a similarly sharp increase (from 21% to 31%) in the gasoline share of their transportation budgets. By 1982, however, their gasoline shares had declined to 24% while their vehicle shares had risen to historical levels of approximately 42% of transportation expenditures.

Thus, it appears that affluent households reduced their fuel expenses by purchasing more-fuel-efficient vehicles. Most lower-income buyers could not afford these newer models. If the CES data were disaggregated by race/ethnicity and summarized for only vehicle-owning households, racial variations would likely appear in the

TABLE 36 Estimated Annual Gasoline Expenditures by Households with Vehicles, 1972, 1980, and 1983 (1980 $/household)

Household Characteristic	Survey and Year of Data: CES 1972	CES 1980-81	RTECS 1983
Population Group			
White	927	1,350	1,071
Black	949	1,438	1,146
Hispanic	NA[a]	NA	1,162
Residence Location			
SMSA Central City	859	NA	957
SMSA Suburbs	987	NA	1,143
Non-SMSA	947	NA	1,126
Region			
Northeast	NA	1,374	1,028
Midwest	NA	1,316	1,077
South	NA	1,380	1,135
West	NA	1,354	1,040
Household Income[b]			
<5,000	581	606	698
5,000-9,999	749	1,028	836
10,000-14,999	960	1,090	905
15,000-19,999	1,106	1,366	1,047
>20,000	1,292	1,730	1,228
All Households	930	1,381	1,080

[a]NA = data not available.

[b]RTECS income ranges are in 1983 dollars. Thus, a small portion of RTECS households, may be classified in the next-higher bracket (1980 dollars) and their expenditures may slightly reduce the average shown for that bracket.

Source: Refs. 4, 28, 44, and 46.

TABLE 37 Household Transportation Budgets and Shares of Budgets Spent for Vehicles and Gasoline, by Income Quintile, 1972-82

Budgets and Shares	Percentage of Expenditures			% Change from 1972	
	1972	1980	1982	1980	1982
Transportation Budget[a]					
All Households[b]	18.7	20.2	19.5	7.9	4.3
Lowest 20%	14.2	16.1	14.8	13.4	4.2
Second 20%	17.6	19.9	18.6	13.1	5.5
Third 20%	19.7	21.4	20.6	8.8	4.9
Fourth 20%	19.9	21.6	20.5	8.7	3.3
Highest 20%	18.8	19.8	19.8	5.2	5.2
Ratio: Lowest to Highest	0.8	0.8	0.7	7.7	-1.1
Difference: Highest-Lowest	4.6	3.7	5.0	-	-
Gasoline Share[c]					
All Households[b]	22.9	34.3	28.6	49.8	25.1
Lowest 20%	23.1	36.4	34.9	57.7	50.9
Second 20%	24.1	37.6	33.8	55.9	40.1
Third 20%	23.8	36.6	30.8	53.4	29.1
Fourth 20%	23.5	34.3	29.3	45.9	24.8
Highest 20%	21.5	31.3	24.3	45.5	13.1
Ratio: Lowest to Highest	1.1	1.2	1.4	8.4	33.4
Difference: Highest-Lowest	-1.6	-5.1	-10.5	-	-
Vehicle Share[c]					
All Households[b]	40.2	33.7	37.3	-16.1	-7.2
Lowest 20%	36.8	30.7	28.9	-16.7	-21.5
Second 20%	37.0	30.6	31.3	-17.2	-15.4
Third 20%	39.8	31.9	36.0	-19.9	-9.5
Fourth 20%	41.0	36.1	37.1	-11.7	-9.5
Highest 20%	41.7	34.9	41.7	-16.4	-0.2
Ratio: Lowest to Highest	0.9	0.9	0.7	-0.3	-21.4
Difference: Highest-Lowest	4.9	4.2	12.7	-	-

[a]Percentage of total household expenditures.

[b]All households with full income reporting.

[c]Percentage of household transportation expenditures.

Source: Refs. 14, 44, 46.

vehicle shares of transportation expenditures for low-income households (such a summary would require analysis of the CES public use tapes, not all of which are yet available). Such variations would be consistent with our finding of racial variations in vehicle availability among low-income households and our conclusion that such variations are largely attributable to differences in income dynamics.

6 CONCLUSIONS

In many respects, this analysis raised as many questions as it provided answers. We have come a long way toward describing the travel and energy use patterns of minority and poor households. We have discovered major differences between white and minority households in vehicle attributes, travel patterns, and energy use and have identified a number of possible factors responsible for those differences. But we have not yet unearthed all the contributing factors or quantified the contributions -- individually and in combination -- of the various factors identified to date. Without this more complete understanding, we can suggest policy implications but cannot analyze them or their impacts. Clearly, policy analysis is the objective of the research process. That objective cannot be achieved, however, until a number of analytical activities have first been conducted. The following discussion focuses on potential policy implications of our findings and on the logical next steps leading to effective policy analysis.

6.1 PRESENT AND FUTURE VEHICLE-AVAILABILITY PATTERNS

Significant racial differences exist in vehicle availability among low-income households. Those differences probably reflect the more transient nature of poverty in low-income white households, with their relatively greater accumulated wealth and greater access to credit markets. The differences suggest that policies to improve the economic condition of low-income households (e.g., income maintenance and employment development) may have important transportation impacts, including dramatic growth in the number of vehicles in black households and a decline in blacks' reliance on public transportation.

There is some indirect evidence to suggest that the gap may already be narrowing and that, even in the absence of specific policies, minorities may account for a disproportionate share of the growth in the future vehicle fleet. Thus, policies with impacts on vehicle availability and use will increasingly affect minorities. Furthermore, given the high price of newer vehicles and the apparent primacy of first cost in minorities' purchase decisions (see below), demand could keep older vehicles in the fleet longer than in the past. This could lengthen the lag between the achievement of new-car fuel-economy improvements and any comparable improvement to the minority fleet, thereby deferring (if not actually reducing) minorities' benefit from such policies as the Corporate Average Fuel Economy (CAFE) standards.

Not only do minority and poor households have fewer vehicles, but their vehicle-replacement decisions may be somewhat different than those of white and nonpoor households. We believe that differences in long-run average incomes are largely responsible for variations in vehicle availability and are partly responsible for variations in vehicle-replacement decisions. A further source of variation may be differences in how vehicle attributes are evaluated by black and white households. This is discussed below in Sec. 6.3.

6.2 TRAVEL PATTERNS

Significant racial differences are seen in annual miles per household and per vehicle among low-income households residing in central cities of SMSAs. These differences may be attributed to the older, less reliable vehicles available to black households, to local conditions that raise the cost or otherwise reduce the attractiveness of private-vehicle use, or to measurement problems in the data set. If the observed differences are valid, they imply that low-income black households have considerable latent demand for travel. Thus, such policies as encouraging the accelerated turnover of the private-vehicle fleet, improving the highway accessibility of minority neighborhoods, or promoting shifts in population and employment may have unforeseen impacts on minority travel behavior.

Differences in the travel behavior of white and minority households are particularly marked for the journey to work. Hispanic and (especially) black workers have significantly longer travel times even though they travel no farther than white workers. About half the difference is due to minorities' greater reliance on public transportation. The remainder is attributed to differences in the distributions of residence-workplace locations (i.e., commuter flows), to characteristics of transportation networks serving individual SMSAs, and to housing-market segregation that restricts minorities' ability to adjust their housing location to their place of employment. Clearly, policies affecting public transportation have a disproportionate impact on minorities. Based on the spatial distribution of their commuter flows, their work trips would be well served by improvements in non-CBD-oriented transit services (e.g., between central city residences and non-CBD workplaces either within that city or in the suburbs).

Because minority workers are also more likely to rideshare, they could benefit from policies to promote the formation and operation of carpools and vanpools. Given the rapid growth of suburban employment centers, such policies could be particularly effective if targeted toward reverse-commuters.

6.3 FUEL USE AND EXPENDITURES

Based on vehicle attributes, one can infer that there was no difference in the fuel economy of vehicles in white and minority households in the past, but by 1979 a gap had appeared. By 1983, that gap had widened to 2 mpg between white and black households and was statistically significant (the 1.4-mpg gap between whites and Hispanics was not significant). As a result, fuel costs (and fuel taxes) in minority and low-income households were greater per mile of travel. Further, lower-income households balanced their budgets by reducing their share of expenditures on vehicles, while more affluent households were increasing theirs.

Admittedly, the 1979-83 period was far from typical. The average household radically altered its valuation of fuel economy in response to expensive and uncertain fuel supplies and widespread expectations of rapidly rising prices Minority households apparently were less willing or able to do so. Based on their actions over this period, fuel economy was either not as important a criterion in minorities' vehicle purchase decision or was so subordinated to first cost that the depressed market for large used cars made

those vehicles particularly attractive. More recent events suggest that the average consumer's valuation of vehicle attributes has moved closer to historical patterns. At this point, it is unclear whether that movement will increase the supply of more-fuel-efficient models in the market segment available to minority and poor consumers or will simply increase competition (and therefore price) for the models they heretofore preferred. Furthermore, if downsized, more fuel-efficient models are less durable than those that historically reached this market segment, minority and poor households may reap a far smaller share of the benefits of recent improvements to new-car fuel economy.

Future policy analyses of fuel economy should address such questions as (1) which vehicles are most likely to "trickle down" to the market segment patronized by low-income and minority consumers, (2) whether those vehicles retain the same fuel economy as when new, and (3) what measures (e.g., changes in CAFE standards, vehicle maintenance clinics, a used-car fuel economy guide, etc.) could raise the fuel efficiency of minorities' choices in that market segment.

6.4 THE NEXT STEPS

This initial analysis describes minorities' travel and energy use patterns. Differences in vehicle attributes and in household travel and fuel use are identified and attributed to demographic and other known variations between white and minority households. Aside from standard statistical tests applied to survey data, the analysis involves little hypothesis-testing or model-building. Rather, it sketches the broad transportation and energy use patterns of white, black, Hispanic, poor, and nonpoor households and identifies major differences between minority and nonminority, poor, and nonpoor groups. Policy implications are mentioned where appropriate, but are not evaluated or quantified.

This report is intended to serve as a reference for subsequent analyses. The major differences between population groups -- the numbers and attributes of vehicles available to households -- affects most of the other topics studied, including average fuel economy of vehicles in minority and poor households and annual miles traveled by these households. Further research into the factors responsible for these differences is clearly in order. Particular attention should be devoted to the:

- Effect of persistent poverty on vehicle availability and use.
- Effects on household travel (especially for work trips) and energy use of local variations in the geographic distributions of households and workplaces and in the characteristics of available public transportation.
- Dynamics of vehicle addition and replacement in minority and poor households and the implications of established habits and preferences on the fuel economy of their vehicles.

Additional attention should be devoted to quantifying household travel behavior and energy use in order to model these phenomena and predict future patterns. Of particular relevance here is the need to forecast the impact of increased vehicle availability on minority (especially black) fuel use and expenditures. Finally, analyses of alternative policies -- those identified here as well as others having the potential to affect minority and poor population groups differently from white and nonpoor groups -- should be undertaken. These policy analyses should build upon this initial sketch and the data base developed to support it.

APPENDIX A:

DATA SOURCES

A.1 NATIONWIDE PERSONAL TRANSPORTATION STUDY

This study (usually known as NPTS) provides the most recent comprehensive data set on passenger travel currently available. It was used in our analysis as the base data set for analyzing personal vehicle stock, total household travel, and work trip characteristics, with cross-classification by a number of social and economic attributes of the household.

The NPTS was a national household-based survey conducted throughout the U.S. from April 1, 1977, through March 31, 1978. Bureau of the Census sampling procedures ensured that each area of the country and time of year were statistically represented. A home interview was conducted in each of the 17,949 households sampled.

During the interview, detailed information was obtained on the household's demographic characteristics (e.g., age of members, education, income, etc.) and travel patterns, as well as on the characteristics of motor vehicles and other transport modes available to the household. The survey was conducted either on the day following the household's designated "travel day" or as soon as possible thereafter. Information was obtained for all trips made by household members during the travel day as well as for trips of 75 miles or longer in the previous 14-day period.[47]

The NPTS data set contains this raw information, along with weighting factors for expanding the estimates to national household- and person-based totals (e.g., household trips, person-trips, etc.) for several different racial and ethnic groups, as well as the requisite income and family size information for gauging poor or nonpoor status. Sampling rates were sufficiently high to provide reasonable confidence in population estimates for white, black, Hispanic, poor, and nonpoor groups. The sparse number of Asian and Native American observations raised problems of statistical stability that precluded their use in this analysis.

A.2 TRANSPORTATION PANEL OF THE RESIDENTIAL ENERGY CONSUMPTION SURVEY

The Household Transportation Panel (TP) was designed by the Department of Energy's Energy Information Administration (EIA) and conducted, under contract, by Response Analysis, Inc. The TP provides monthly estimates of fuel consumed and miles driven by household vehicles.* Data were recorded in fuel purchase logs by monthly panels of respondents who were generally asked to report for two months initially, and then to report for another two months after a four-month interval of nonparticipation.

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*"Household vehicles" includes all motor vehicles regularly used by the household except motorcycles, mopeds, large trucks, and large buses.

Each month's panel was a representative national sample selected from the 48 contiguous states and the District of Columbia.

The entire TP comprised vehicle-owning households subsampled from three national surveys -- the National Interim Energy Consumption Survey (NIECS), the RECS Household Screener Survey (Screener), and the first Residential Energy Consumption Survey (RECS1). Each month a combined sample of approximately 1000 households that used vehicles for personal transportation was drawn from these three surveys, with individual households reporting in the above-noted 2-4-2 pattern. Sample households were asked to complete monthly logs indicating, for each fuel purchase, the total cost and quantity of fuel purchased, the price per gallon, the vehicle's fuel gauge reading after purchase, the odometer reading, and the type of fuel purchased. Logs were mailed to sample households shortly before the first day of the reporting month. Follow-up telephone calls were made at the beginning of the month to verify receipt and answer any questions, at mid-month to encourage continued participation, and shortly after the end of the month to collect the data and ask several topical questions.[48-50]

The TP data set contains fuel purchase and household demographic information for the sample households (the latter as obtained from the original RECS survey), along with weighting factors for expanding the estimates to national monthly totals (e.g., gallons purchased, fuel expenditures, miles traveled, etc.). The weights account for sampling, household nonresponse, and, in some cases, partial purchase data (as determined by an edit check). Because the demographic information includes race/Spanish origin* and poverty status,‡ the expanded TP data can be used to produce national-level estimates of fuel consumption, miles traveled, and average vehicle fuel economy for white, black, poor, and nonpoor groups.

A.3 ANNUAL HOUSING SURVEY

The Annual Housing Survey (AHS) is conducted by the Bureau of the Census for the Department of Housing and Urban Development. It consists of two separate data collection efforts -- a national survey of a sample of housing units and a survey of housing units in 60 standard metropolitan statistical areas (SMSAs) that are sampled on a rotating basis (i.e., once every four years). The SMSAs are defined as they were for the

*Spanish origin is coded on approximately one-third of the records, for those households subsampled from the RECS1 survey. The small number of Hispanic observations precluded their use in this analysis.

‡An unknown amount of time-variability is associated with households defined as poor in the TP data set. Because income data were obtained one to three years before the TP survey (i.e., when the household was first interviewed for the NIECS, Screener, or RECS1 survey) household incomes may have increased or decreased in the intervening years, making some "poor" households nonpoor and some "nonpoor" households poor when their fuel purchases were recorded. This issue is further discussed in Ref. 11.

1970 Census.* The national sample varies in size from 60,000 to 82,000 housing units for the survey years 1973-81 and for 1983 and includes both a primary and supplemental (rural) component. Since 1981, the national survey has been known as the American Housing Survey and has become a biennial data collection effort.

The AHS is a home interview survey. Census interviewers visit each housing unit in the sample and obtain data on general housing characteristics and, for occupied units, on the income and demographic characteristics of the household and each member, costs incurred for various housing-related purposes, energy-related characteristics of the unit, and travel-to-work information for each worker in the household.‡ Sample observations are expanded to national totals with a three-stage ratio estimation procedure reflecting initial selection probability, response rate, and housing unit construction since 1970, and are constrained to independently derived estimates of the current housing stock according to region, location and tenure of residence, race, and sex of householder.

The 1980 AHS was conducted from mid-August through December 1980. The primary national sample consisted of 65,216 housing units. Excluding noninterviews (i.e., unoccupied units, households whose usual residence was elsewhere, and households who refused to be interviewed after repeated calls), the usable sample consisted of 58,390 household records.[14,15]

The 1980 AHS is a valuable source for such transportation-related data as household characteristics, vehicle ownership, and journey-to-work patterns for relatively small population groups. With a sample size more than three times that of NPTS (and nearly nine times that of TP), AHS permits more detailed analyses of white, black, Hispanic, poor, and nonpoor population groups. Although standard errors cannot yet be computed (the census report that documents results of the 1980 journey-to-work portion of AHS is not yet available), they should be on the order of half those estimated for NPTS (assuming comparable sampling and nonresponse errors), thereby permitting more definitive analysis of population differences. Because of differences in variable definitions between the AHS and the NPTS and TP data tapes, very little AHS data are included in this draft. A special, consistent tabulation has been requested of the Census Bureau. Certain results of that tabulation have been included in this report.

A.4 CONSUMER EXPENDITURE SURVEY

Conducted by the Bureau of the Census for the Bureau of Labor Statistics, the Consumer Expenditure Survey (CES) is an ongoing data collection effort designed to

*NPTS and TP also use the 1970 definitions of SMSAs.

‡For 1975 and 1980, journey-to-work information is available for all household members; for other survey years these data are available for only the householder.

obtain a continuous flow of information on the buying habits of American consumers.* The survey consists of two components: (1) an interview panel survey that obtains expenditure information for households from five interviews conducted every three months and (2) a diary or recordkeeping survey of households for two consecutive one-week periods.

The 1980-81 Quarterly Interview Survey of the CES was used in our analysis to compute annual motor-fuel expenditures of vehicle-owning households by population group, residential location, region, and income. That survey sampled 5000 households from 85 urban areas that are representative of the U.S. urban population. The Quarterly Interview Survey relied on recollection -- i.e., respondents were asked to recall both relatively large expenditures and fairly regular expenditures over the preceding three months.[14]

Published CES data report only aggregate averages -- e.g., motor fuel expenditures by all households with a black householder. Because motor fuel expenditures are generally confined to households with vehicles, differences in vehicle availability among particular population subgroups can obscure differences in expenditure levels. Thus, CES data were adjusted by a set of factors reflecting the share of households in each particular subgroup that had regular use of one or more vehicles. The factors were developed from 1980 AHS data.

*Before 1979, the CES was conducted approximately every 10 years. Preliminary data from the first two years (1980-81) of the new ongoing survey were published in early 1985; data from the second two years (1982-83) were published in late 1985. The microdata files were not available as of our analysis.

APPENDIX B:

DATA SMOOTHING TECHNIQUES

The Transportation Panel (TP) of the 1980 Residential Energy Consumption Survey (RECS) is both a useful and a frustrating data source for transportation analysis. It is useful because the data were collected during 1979-81, a period of rapidly rising fuel prices; it is frustrating because sample sizes were small and many variables were uncontrolled during the data collection and subsequent expansion to national totals. Because race and income were among the uncontrolled variables, sample sizes of poor and minority (mostly black) households fluctuated widely during the 28 months of data collection, and that random variation was not corrected during subsequent expansion and weighting. Thus, the national totals for black and poor households (and all other variables measured for those households) were judged unreliable for this effort.

Expressing the TP data as a household rate helps ameliorate the problems associated with small sample sizes and uncontrolled variables. Dividing the expanded total of black household vehicle-miles of travel (VMT) by the expanded total of black households effectively removes the incorrect weight applied to each household. However, the resulting rates (VMT per household) still reflect the original random variation introduced by small sample sizes and the resulting sampling biases toward high-VMT households in some months and low-VMT households in other months. These errors may be described as "sampling noise." The noise apparently masks not only the expected seasonal variation in driving patterns and gasoline purchases, but also may disguise household reactions to the sharp rise in gasoline prices. Furthermore, the noise also makes comparisons between income and population groups difficult or impossible. White or nonpoor households exhibit much less sampling noise, due simply to larger sample sizes.

Graphical analysis of the time-series data from TP for black and poor households suggests that the sampling noise is significant. The noise is a monthly disturbance of relatively high frequency, because the households were sampled monthly. By contrast, seasonal variations occur over several months and consumer reactions to higher fuel prices occur over an even longer period. The latter probably consists of two components: (1) a short-term component explained by actions such as carpooling and either reducing or linking trips and (2) a long-term component resulting from increased vehicle fuel efficiency.

Several methods were considered for reducing the high-frequency noise in the TP data. Fitting nth-degree polynomials in time was rejected because seasonal variation over the 28 months of data collection makes the choice of n arbitrary; that is, should there be four peaks in the fit curve and three valleys, or two peaks and three valleys? Curve fitting is also sensitive to outliers in the data, and many of the time series suffered from outliers.

Three-month moving averages were also tried but failed to provide enough smoothing. Moving averages yielded curves with sharp changes in direction from one month to the next -- probably not an accurate reflection of reality -- and extending the

time over which the averages were calculated (to increase the smoothing) tended to mask seasonal variations.

The smoothing technique that was eventually applied to the TP data is Fourier transformation and inversion (or smoothing). Fourier smoothing is an excellent way to remove high-frequency noise from a lower-frequency signal. It requires no assumptions about the final shape of the smoothed data, is insensitive to outliers, and can provide enormously variable degrees of smoothing. Successful use of the technique hinges on the fact that most functions may be written as the sum of series of sines and cosines with known frequencies. Equations 1 and 2 summarize the real-valued results when the discrete Fourier transform is applied to N real-valued data points, $x_0, \ldots, x_{N-1}$

$$R_k = (1/N) \sum_{j=0}^{N-1} x_j \cos(2\pi jk/N) \qquad k = 0, \ldots, N-1 \tag{1}$$

$$I_k = (-1/N) \sum_{j=0}^{N-1} x_j \sin(2\pi jk/N) \qquad k = 0, \ldots, N-1 \tag{2}$$

The transformed data points R_k and I_k may then be filtered to remove the high-frequency noise:

$$R'_k = f_k R_k \tag{3a}$$

$$I'_k = f_k I_k \tag{3b}$$

where f_k is the filter function given by:

$$f_k = 1-(k/E)^2 \qquad \text{for } k < E \tag{4}$$

$$f_k = 0 \qquad \text{for } k \geq E$$

The filter function is quadratic to avoid the sudden attenuation of frequencies in the area of E that may introduce false high frequencies in the data. The cutoff frequency E determines the degree of smoothing; small values of E will attenuate only very high frequencies in the data. Larger values of E will eliminate progressively lower-frequency components. The filtered transform values are then subjected to the inverse Fourier transform by:

$$x'_j = \sum_{k=0} \{R'_k \cos(2\pi kj/N) - I'_k \sin(2\pi kj/N)\} \tag{5}$$

for $j = 0, \ldots, N-1$

Equations 1 through 5 were implemented with a suitable algorithm and applied to TP black and poor household data only. While the smoothing technique works equally well for larger sample sizes, white and nonpoor samples were judged to be large enough to need no smoothing.

Fourier smoothing was reasonably successful in reducing what appears to be sampling noise in the data. Seasonal variations that make logical sense are still observable in the smoothed data, as are differences between groups. Differences are of the correct sign and of approximately the expected magnitude. Fourier smoothing was less successful in determining consumer response to the sharp jump in gasoline prices. While the smoothed data suggest some consumer reaction, it is not clear whether it can be isolated with confidence from the remaining errors associated with the data.

REFERENCES

1. Poyer, D., and A. Teotia, *Residential Fuel Consumption Patterns for Poor, Black, and Elderly Households: A Comparative Study, Volume 1: Data Base Development*, Argonne National Laboratory Report ANL/EES-TM-207 (Dec. 1982).

2. Poyer, D., *Residential Fuel Consumption Patterns for Poor, Black, and Elderly Households: A Comparative Study, Volume 2: Analytical Assessment*, Argonne National Laboratory Report ANL/EES-TM-236 (Aug. 1983).

3. Klein, Y., et al., *Patterns of Residential Energy Demand by Type of Household: White, Black, Hispanic, and Low and Nonlow Income Levels*, Argonne National Laboratory Report ANL/EES-TM-284 (Oct. 1984).

4. *Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983*, U.S. Dept. of Energy, Energy Information Administration, Washington, D.C., DOE/EIA-0464(83) (Jan. 1985).

5. O'Hare, W.P., *Racial Differences in the Journey to Work: Evidence from Recent Surveys*, presented at Annual Meeting of the American Statistical Assn. (Aug. 1983).

6. *Demographic Change and Worktrip Travel Trends*, Joint Center for Political Studies, prepared for U.S. Dept. of Transportation, Urban Mass Transportation Administration, Washington, D.C., UMTA-DC-09-7009-85 (Feb. 1985).

7. *Housing Fuel Consumption and Journey to Work Patterns of Minorities: Their Implications for Federal Energy Policies*, National Urban League, Inc., Washington, D.C. (June 1983).

8. Newman, D.K., and D. Day, *The American Energy Consumer*, a report to the Energy Policy Project of the Ford Foundation, Ballinger Publishing Co., Cambridge, Mass. (1975).

9. Cooper, M., et al., *Equity and Energy: Rising Energy Prices and the Living Standards of Lower Income Americans*, Westview Press, Boulder, Colo. (1983).

10. Goodman, J.L., and M. Berkman, *Racial Differences in Commuting Behavior from the Panel Study of Income Dynamics*, Review of Public Data Use (5)4:29-36 (July 1977).

11. LaBelle, S., et al., unpublished information, Argonne National Laboratory (July 1985).

12. *1977 Nationwide Personal Transportation Study*, U.S. Dept. of Transportation, Federal Highway Administration, public use tape.

13. *Residential Energy Consumption Survey Transportation Panel*, U.S. Dept. of Energy, Energy Information Administration, public use tape.

14. *Annual Housing Survey, 1980*, U.S. Dept. of Commerce, Bureau of the Census, and U.S. Dept. of Housing and Urban Development, Washington, D.C., Current Housing Reports, Series H-150-80 (March 1983).

15. *Annual Housing Survey, 1980: National Core and Supplement File, Technical Documentation*, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C. (1983).

16. *Consumer Expenditure Survey: 1980-81 Interview, Supplemental Information*, U.S. Dept. of Commerce, Bureau of Labor Statistics, Washington, D.C. (Jan. 7, 1985).

17. *1980 Census of Population, Detailed Population Characteristics*, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C., PC80-1-D1-A (March 1984).

18. *1980 Census of Population, General Population Characteristics*, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C., PC80-1-B1 (May 1983).

19. *Consumer Expenditure Survey, Interview Survey, 1972-73*, U.S. Dept. of Commerce, Bureau of Labor Statistics, Bulletin 1985, Washington, D.C. (1978).

20. *Consumer Expenditure Survey Results from 1982-83*, U.S. Dept. of Commerce, Bureau of Labor Statistics, Washington, D.C., USDL 85-402 (Sept. 27, 1985).

21. *Profile of the '80s*, U.S. Dept. of Transportation, Asst. Secretary for Policy and International Affairs, Washington, D.C., GPO 1981-341-428:1036 (Feb. 1980).

22. *Transportation Facts*, Chicago Area Transportation Study, various issues (1984-85).

23. Levinson, H.S., *Characteristics of Urban Transportation Demand*, prepared for U.S. Dept. of Transportation, Urban Mass Transportation Administration, Washington, D.C., UMTA-IT-06-0049-78-1 (April 1978).

24. Meyer, J.R., J.F. Kain, and M. Wohl, *The Urban Transportation Problem*, Harvard University Press, Cambridge, Mass. (1965).

25. Torres-Gil, F., D. Newquist, and M. Simonin, *Transportation: The Diverse Aged*, USC Research Program on Social and Cultural Contexts of Aging, prepared for National Science Foundation, Washington, D.C., NSF/RA 77-0023 (May 1976).

26. Wachs, M., et al., *Transportation for the Elderly: Changing Lifestyles, Changing Needs*, Univ. of California Press (1979).

27. *National Transportation Trends & Choices*, U.S. Dept. of Transportation, Office of Transportation Planning, Washington, D.C., PB-282 230 (Jan. 1978).

28. *1980 Annual Housing Survey*, U.S. Dept. of Housing and Urban Development, public use tape.

29. Heavenrich, R.M., J.D. Murrell, and J.P. Cheng, *Passenger Car Fuel Economy... Trends Through 1984*, SAE Intl. Congress & Exposition, Detroit, SAE 840499 (Feb. 27-Mar. 2, 1984).

30. *1969 Nationwide Personal Transportation Study*, U.S. Dept. of Transportation, Federal Highway Administration, Washington, D.C., Reports 1-10 (1972-74).

31. *Motor Vehicle Facts and Figures '85*, Motor Vehicle Manufacturer's Assn., Detroit (July 1985).

32. *Highway Statistics 1983*, U.S. Dept. of Transportation, Federal Highway Administration, Washington, D.C., HHP-41/10-84 (Oct. 1984).

33. Paaswell, R.E., and W.W. Recker, *Problems of the Carless*, Praeger Publishers, New York (1978).

34. Duncan, G.J., et al., *Years of Poverty, Years of Plenty: The Changing Economic Fortunes of American Workers and Families*, University of Michigan Institute for Social Research, Ann Arbor (1984).

35. Bane, M.J., and D.T. Ellwood, *Slipping Into and Out of Poverty: The Dynamics of Spells*, Working Paper No. 1199, National Bureau of Economic Research, Cambridge, Mass. (1983).

36. Rainwater, L., *Persistent and Transitory Poverty: A New Look*, Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University, Working Paper No. 70 (June 1981).

37. Williams, F., U.S. Dept. of Transportation, personal communication (August 1985).

38. Greene, D.L., et al., *Regional Transportation Energy Conservation Data Book*, Oak Ridge National Laboratory Report ORNL-5435 (Sept. 1978).

39. *Highway Statistics 1981*, U.S. Dept. of Transportation, Federal Highway Administration, Table MF-21, Washington, D.C. (1982).

40. *Highway Statistics 1984*, U.S. Dept. of Transportation, Federal Highway Administration, Tables NPTS 1-9, Washington, D.C. (Oct. 1985).

41. Fulton, P.N., *Changing Journey-to-Work Patterns: The Increasing Prevalence of Commuting Within the Suburbs in Metropolitan America*, presented at 65th Annual Meeting of the Transportation Research Board, Washington, D.C. (Jan. 13-16, 1985).

42. *Impact of Demographic and Migration Trends on Future Travel in Metropolitan Areas*, U.S. Dept. of Transportation, Washington, D.C., DOT-P-30-81-01 (Dec. 1980).

43. Kain, J.F., *The Distribution and Movement of Jobs and Industry*, in The Metropolitan Enigma: Inquiries into the Nature and Dimensions of America's Urban Crisis, James Q. Wilson, ed., Chamber of Commerce of the United States, Washington, D.C. (1967).

44. O'Hare, W.P., *The Urban Commuter*, Focus, *13*(1):5-6 (Jan. 1985).

45. Long, J., *Population Deconcentration in the United States*, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C., CDS-81-5 (1981).

46. *News Release — Consumer Prices: Energy and Food*, U.S. Dept. of Commerce, Bureau of Labor Statistics, Washington, D.C., monthly.

47. *1977 Nationwide Personal Transportation Study Users' Guide for the Public Use Tapes*, U.S. Dept. of Transportation, Federal Highway Administration, Washington, D.C. (April 1980).

48. *Consumption Patterns of Household Vehicles, June to August 1979*, U.S. Dept. of Energy, Energy Information Administration, Washington, D.C., DOE/EIA-0319 (April 1982).

49. *Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981*, U.S. Dept. of Energy, Energy Information Administration, Washington, D.C., DOE/EIA-0328 (Feb. 1983).

50. *Technical Documentation, Residential Energy Consumption Survey: Household Transportation Panel*, Response Analysis Corporation, prepared for U.S. Dept. of Energy Information Administration, Washington, D.C. (Oct. 1983).