1990 NPTS

NATIONWIDE PERSONAL TRANSPORTATION SURVEY

TRAVEL MODE SPECIAL REPORTS

1990 NPTS Publications Series:

User's Guide for the Public Use Tape
(for tape or diskette users)

Summary of Travel Trends

Travel Behavior Issues in the 90's

1990 NPTS Databook

NPTS Urban Travel Patterns

NPTS Special Subject Reports

U.S. Department of Transportation
Federal Highway Administration

1990 NPTS Report Series

Travel Mode Special Reports

Based on Data from the
1990 Nationwide Personal Transportation Survey (NPTS)

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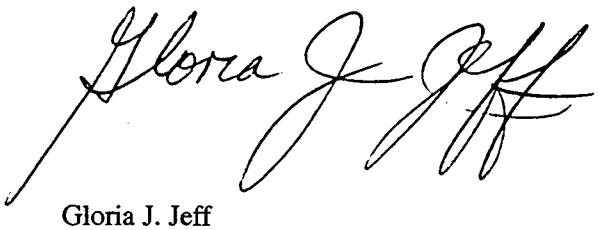
Foreword

This series of papers, using data from the Nationwide Personal Transportation Survey (NPTS), has forged new bridges between policy makers, planners, and the academic community. Too often, in the transportation field, we forget that people travel to accomplish activities important to their daily life—to travel to and from work, to take care of their family and themselves, and to enjoy recreational and social activities. NPTS has a specific focus on this personal travel, and allows researchers to examine a multitude of characteristics of persons, households, and vehicles relative to their daily travel.

These papers give us new insights into how people travel today, how this differs from past behavior, and understanding the complexity and variety of travel needs. We need better understanding of how our policy decisions may impact different groups and how our planning processes need to account for these variations.

In 1995, the next NPTS will be collected, adding to the data series started in 1969. This special series of papers has also contributed to improving the design and implementation of the NPTS.



Gloria J. Jeff

Associate Administrator for Policy

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Introduction

The Nature of These Documents

This document is one of three volumes that have been produced as a set, containing topical subject papers from the Nationwide Personal Transportation Survey, NPTS. These volumes represent something of a departure from standard approaches to reporting the NPTS. Traditionally, the survey results have been reported in large volumes with an extensive series of tables, organized around important sections of the survey, or main categories of data, such as Vehicle-miles of travel, or work travel. While such volumes continue to be produced for the 1990 NPTS, they are being supplemented by a different approach as exemplified by these documents.

This new approach examines important emerging travel behavior trends, seeking to understand better key public policy issues on which the survey data can shed light. This approach is an outgrowth of a special study of the NPTS, entitled *Travel Behavior Issues in the 90's*, which provided an early look at the insights the NPTS could provide regarding significant policy-related topics. As a product of that study a series of additional topics were identified for further examination. Individual researchers were selected to intensively examine each subject and to prepare a paper presenting their findings. These papers have been compiled in the three volumes.

Value of This Approach

The goal of this approach is to advance understanding beyond that possible by traditional means. While the large volumes of summary tabulations produced from the survey are of great value, particularly in getting fundamental facts about travel on the record, they represent only one facet of the immense capabilities provided by the NPTS results. These supplemental, interpretive products support the role of the NPTS as an early warning system for emerging travel behavior trends, and as a mechanism for informing public policy officials.

The kind of presentation approach developed for these subjects recognizes the intended audience - primarily public officials, but also researchers, analysts and planners, as well as interested citizens. The extensive use of tables and graphics to make trends and patterns clearer is one attribute of the approach. But the fundamental characteristic that permeates these volumes is the synthesis of large masses of data from the survey into those that are central to understanding what demographic forces are affecting travel behavior.

Why These Subjects?

The subjects selected are something of a "hit parade" of major topics of interest coming from the NPTS. Topics have been selected that:

- are of substantial public interest,
- have bearing on current policy concerns,
- fill-in important questions about the direction and weight of current trends, and
- are sufficiently bounded so that a small individual study can make an incisive contribution to our understanding of travel phenomena.

As the purpose of this undertaking is to mine the rich resources of data from NPTS; it is the 1990 NPTS data set and its predecessor data sets from 1983, 1977, and 1969 that are the predominant, almost exclusive source of data for these studies. Where appropriate, researchers have used other data sets to extend or corrorborate the data.

Selected Studies

The twelve studies have been clustered into three groups based on their general subject matter. These are:

Demographic Special Reports

Chapter 1. An Assessment of the Potential Saturation in Men's Travel, Joel R. Rey, Steven E. Polzin, Ph.D., and Stacey G. Bricka

Chapter 2. Travel by Women, Sandra Rosenbloom, Ph.D.

Chapter 3. Travel by the Elderly, Sandra Rosenbloom, Ph.D.

Chapter 4. Multiworker Household Travel Demand, Siim Sööt, Ph.D., and Ashish Sen, Ph.D.

Chapter 5. Household Structure and Travel Behavior, Joan Al-Kazily, Ph.D., Carol Barnes, Ph.D., and Norman Coontz

Travel Mode Special Reports

Chapter 1. Travel by Households Without Vehicles, Charles Lave, Ph.D., and Richard Crepeau, Ph.D. Cand.

Chapter 2. Recent Nationwide Declines in Carpooling, Erik Ferguson, Ph.D.

Chapter 3. Non-Motorized Transportation, Debbie A. Niemeier, Ph.D. Cand., and G. Scott Rutherford, Ph.D.

Special Reports on Trip and Vehicle Attributes

Chapter 1. Understanding Trip Chaining, James Strathman, Ph.D., and Kenneth Dueker, Ph.D.

Chapter 2. Geographic Factors Explaining Work Trip Length Changes, Peter Gordon, Ph.D., and Harry Richardson, Ph.D.

Chapter 3. The Demography of the U.S. Vehicle Fleet, Alan Pisarski

Chapter 4. Time-of-Day Characteristics of Travel, Ryuichi Kitamura, Ph.D.

There are many other NPTS products already available or underway that go well beyond these subject studies. They are listed on the inside cover of this document.

Broad Findings

It is not feasible to summarize the individual findings of these twelve studies in a brief fashion. Twelve studies cover a broad range of subjects; all address different facets of travel characteristics or travel behavior. However, there are major themes that emerge from the materials. These themes were developed in a two day conference held in Arlington, Va. on April 20 and 21, 1994, in which the researchers presented the findings of their work and invited panelists and other conference participants to discuss the implications of the findings. The themes arose as part of the presentations of the researchers and from the separate workshop discussions that followed.

One of the themes, which has to be expressed with some care, is that researchers have discovered, or re-discovered, how complex is travel behavior and its demographic determinants. It may sound overly simplistic, or even selfserving, to state that travel behavior is increasingly complex but it does appear to be the case. There are several interrelated factors contributing to this trend, but the dominant one is the changing role of women.

This phenomenon is expressed, of course, in the paper addressing the travel characteristics of women, but it also permeates the content of the papers on multi-worker households, household structure, and the topic of trip chaining. The topic of suburbanization and work trip lengths is also affected.

Perhaps the major theme that emerges from the papers is that of issues of equity - equity for women, low income groups, racial and ethnic groups, and the aged. Almost all of the papers make a contribution to this topic, expanding and revealing some of the elements of the key issues surrounding the subject. Even the topic of the aging of the vehicle fleet contains elements of equity concern.

The final major theme links to topics of relevance to environmental concerns. One of these, of course, is the study of the aging of the vehicle fleet. But this, by far, is not the only material of great relevance. Other pertinent papers include the studies of trip time patterns, multi-worker households, walking patterns, geographic factors in trip length, the potential saturation of male travel, and perhaps most significantly, trip chaining characteristics.

There are other themes as well, many of them sub-themes derivative of the major themes. For the most part, the subthemes relate to more technical and organizational aspects of current transportation planning processes. There are three important elements among these technical themes.

- The federal regulatory process, at DOT and other agencies needs to take these patterns and trends into account.
- The state and metropolitan planning processes need to better understand these behavioral patterns and their implications for local travel needs.
- The relationships identified in these studies need to be incorporated better in the current modeling and forecasting systems in use at the state and metropolitan levels.

A final theme that arose again and again concerned the need for better mechanisms to inform the policy process of the character of travel behavior and its changing implications for public policy.

The reader will want to be alert to these themes and to the many others that permeate these reports which the reader may discover.

Alan E. Pisarski

Authors' Biographies

Charles Lave, Ph.D., is Professor of Economics at the University of California, Irvine. He is the only researcher who has processed NPTS data from its inception in 1969. He has received the Transportation Research Board's Pyke Johnson award. He has been a consultant on Travel Behavior to several Federal and state agencies including the U.S. Department of Energy and the Environmental Protection Agency.

Erik Ferguson, Ph.D., of the School of Architecture, Georgia Institute of Technology, has conducted extensive research on carpool formation based on 1977 and 1983 NPTS and other databases. His work on the influence of household composition on journey to work, including average vehicle occupancy, was presented at TRB in 1990. Dr. Ferguson is the only published researcher who has conducted trend analysis of carpool behavior based on NPTS data.

G. Scott Rutherford, Ph.D., is Associate Professor, in the Department of Civil Engineering at the University of Washington. He was the director of the Washington State Transportation Center (TRAC) from 1983 to 1991. Dr. Rutherford, together with **Ms. Debbie Niemeier,** are now the national leaders in research on non-motorized transport, with regard to travel demand and travel forecasting. They are currently developing a bicycle demand model to forecast ridership on bicycle facilities. Their innovative, diary-based study of household travel in neighborhoods with high potential for non-motorized trip making seeks to develop trip reduction rates based on land use mix.

Travel Mode Special Reports

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Charles Lave, Ph.D., and Richard Crepeau, Ph.D. Candidate

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Executive Summary

Over the past thirty years the Federal Government has funded extensive programs to improve the travel options of those people who do not have their own vehicles.[1] During this same period, independent of government actions, economic and demographic trends have diminished the target population and made vehicle access nearly universal, even in the poorest households.

It is time to study the travel characteristics of the remaining zero-vehicle households. Where are they located and how do they travel: what kind of transit access do they have, how many have jobs and how do they commute, and how do they shop and accomplish errands? Such information will help us understand the needs of these households, and whether adjustments in Federal programs should be made.

Trends

In overall terms, the proportion of households (HHs) without vehicles has declined steadily over time. This is no surprise given the enormous increase in vehicle ownership among the general population. In 1969, 20.6 percent of HHs had no vehicle. By 1983 this had fallen to 13.5 percent. And by 1990, this had fallen to 9.2 percent of HHs. HHs without vehicles tend to be smaller than average, so in 1990, only 6.4 percent of people lived in HHs without vehicles.[2]

Who Are They?

The typical 0-vehicle HH (0-VHH) has no one in the labor force (either employed or searching for work), has a lower than average income, and lives in the central part of a large urban area. In life cycle terms, most of these HHs are either retired older people or single adults without children. Most 0-VHHs are headed by women.

Although 0-VHHs have lower incomes than HHs in the General Population, only 27 percent of them are below the poverty level (this figure excludes HHs in the New York MSA for reasons discussed below). Poverty alone is not sufficient to explain why HHs have no vehicles. Of all adults living in HHs below the poverty level, 76.1 percent are in HHs that have at least one vehicle.[3] (Again excluding data from the New York MSA.)

Where Are They?

There is a high geographic concentration of 0-VHHs along the East Coast (New England, Mid-Atlantic, South Atlantic). This region has 36 percent of the U.S. adult population, but it accounts for 46 percent of all the adults who live in 0-VHHs.

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[1] In this report the term "vehicle" includes all household-based cars, vans, and light trucks.

[2] Comparable Census data are: 1960 = 21.5 percent, 1970 = 17.5 percent, 1980 = 12.9 percent, 1990 = 11.5 percent.

[3] In this report, the term "adult" means all persons age 16 or older.

Most 0-VHHs are in central cities of Metropolitan Statistical Areas (MSAs). Looking at adults who live in 0-VHHs, 52.9 percent of them are in central cities, with the remainder about evenly split between suburbs and non-MSA locations. 0-VHHs outside the central city are less mobile: for adults living outside the central city, 52 percent took no trips at all on the sample day; inside the central city this drops to 37 percent.

To the extent that federal policy is motivated by a desire to assure mobility for all, it needs to concentrate more attention outside the central cities.

How Do They Travel?

Commuting is not an overwhelming concern since only 31.3 percent of 0-VHHs have a family member in the labor force.

Adults living in 0-VHHs make 43 percent of their daily trips by walking. Because most 0-VHHs are in central urban locations, their transit access is good: 53 percent report they have transit access within 3 blocks; and 65 percent have transit access within 12 blocks. Yet adults living in 0-VHHs use transit for only 16 percent of their trips. Surprisingly, adults living in HHs without vehicles make more than twice as many trips by private vehicle as they do on transit (36 percent versus 16 percent).

The share of travel on public transportation is essentially constant across education levels, but the private vehicle share declines as education increases, and the walk mode share increases with education.

It is interesting to examine the share of private vehicle travel in our largest cities. For cities greater than one million population, with rail transit, 23.5 percent of trips are made by private vehicle. For cities greater than one million population, without rail transit, the private vehicle share nearly doubles, to 41.7 percent of trips. Yet this significant change in mode shares is not due to the transit system itself: transit's mode share is 24.3 percent in cities with rail and 22.1 percent in cities without rail. Instead there is a large increase in the walk mode share. Perhaps the decline in the private vehicle mode, in cities with rail transit, occurs because these cities tend to be older, pre-automobile age cities with narrower streets and less parking capacity.

Trip purpose: the reason for travel tends to be about equally divided between errands, social activities, and shopping.

Mobility: How Much Do They Travel[4]

From a social viewpoint, we are interested in seeing how well the people in 0-VHHs get around, whether they have enough mobility options to lead reasonable lives. One possible measure of mobility is the average number of trips per day made by persons who live in 0-VHHs. (A trip is a one-way journey; the roundtrip commute to work would be two trips.) The average adult living in a 0-VHH made 1.8 trips per day. The corresponding figure for the General Population is 3.2 trips per day. This is a substantial difference, but we will see that much of it reflects the different proportions of workers and the elderly in the two groups.

Another possible measure of mobility is the total absence of trip-taking on the sample day: the proportion of people who took no trips at all. Of adults living in 0-VHHs, 46 percent made no trips during the sample day. The corresponding figure for the General Population is 21 percent. Again, a substantial

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[4] Data excludes the New York MSA.

difference in mobility, and again, much of it reflects the different proportions of workers and the elderly in the two groups.

In the tables below, we report both measures, "trips per day," and "percent who took no trips." Which is the better gauge? The zero-trip measure is a more sensitive measure of immobility. Trips per day, being an average, is more influenced by outliers—a few respondents with a large number of trips can affect the average, though the proportion of immobile people might still be the same.[5] From now on, we shall refer to average trips per day as a measure of *mobility*, and the zero-trip proportion as a measure of *immobility.*

Demographic Effects on Travel

Demographic differences within the 0-VHH population produce strong effects on mobility patterns:

A) Workers travel much more than non-workers: 2.85 trips/day vs. 1.35 trips/day.

B) The young (20–34) travel much more than the old (65–74): 2.48 trips/day vs. 1.34 trips/day.

C) Higher incomes produce more travel: 2.62 trips/day at $40,000 plus income vs. 1.91 trips/day for the under $10,000 income group.

D) Men travel more than women: 2.1 trips/day for men vs. 1.69 trips/day for women.

E) Education produces remarkably strong effects: 2.67 trips/day for college graduates vs. 1.28 trips/day for those without high school degrees—and only some of this change can be accounted for by income differences.

Travel Behavior of Persons Age 65 and Over

Persons 65 and older account for almost half of all 0-VHHs. Our major finding is that their travel is *not* affected by changes in most of the explanatory variables. For example, there is little difference in trips per day by gender or ethnicity, or across the observed range of income and education.

The geographic consistency is also quite striking. There is almost no difference in either trips per day, or the proportion of persons with zero-trips, as we look across the three MSA categories, or the size of the urban area, or the population density. Consider the implications of these findings. Transit access is certainly much better in the Central City of an MSA than it is in a non-MSA, yet there was no difference in mobility patterns. Transit access is certainly much better in large urban areas than in small ones, but again there was no difference in mobility patterns. Transit access is certainly much better in high density areas than in low density ones, but we find only small increases in mobility in the densest areas. Taken together, these three finding seem to indicate that the presence or absence of transit makes little difference in the mobility patterns of older people.

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[5] The survey question asked for details on *all* trips the respondent took on the sample day, where a "trip" is: "any time you went from one address to another by car, bus, walking, busying, or some other means." Taken literally, the question asks about any kind of trip at all, by any possible mode. Is it reasonable to have almost half the HHs answer that they took no trips during the sample day? Perhaps some respondents might not consider journeys made by walking to be "trips"; and perhaps some respondents might not consider very short journeys to be "trips." The 0-VHHs would be especially vulnerable to these biases. They have a high proportion of walking trips because they do not own vehicles, and they tend to take relatively short trips because of the high proportion who are retired and over age 65. There is no simple way to quantify these biases.

Immigration and Vehicle Ownership

New immigrants have much lower vehicle ownership rates than the native born population, but vehicle ownership increases strongly with length of stay in the U.S. The fastest rate of change is for Asian immigrants, the slowest is for Black immigrants. The change is inherently interesting because these immigrants come from cultures that are not as auto-obsessed as our own. What explains the change in their vehicle ownership patterns over time? The data indicate that it is increasing income, rather than any change in values toward the automobile, that is the overwhelming factor behind the decline in 0-VHHs among immigrant groups.

Exclusion of New York MSA Data [6]

Should we exclude data from New York when calculating the average characteristics of the 0-VHHs? New York is unique: no other city comes close to it in population density, difficulty and expense of operating a vehicle, or universality of transit access. Furthermore New York's 0-VHHs are atypical. Their demographic profile differs considerably from the rest of the sample, and the differences are strongly in the direction of greater trip making.

New York 0-VHHs have atypically high incomes: over 30 percent earn $30,000 or more, while only 7.8 percent of the non-New York 0-VHHs earn that much. Adults living in New York 0-VHHs have atypically high labor force participation: 64 percent are in the labor force compared to 37 percent in the rest of the country. Many fewer adults in New York 0-VHHs are retired: 18 percent versus 32 percent in the rest of the country. And adults in New York 0-VHHs are unusually well educated: 22 percent have college degrees compared to 8 percent in the rest of the country.

These demographic differences all work in the direction of much higher mobility for 0-VHHs in New York. Their combined effect is so strong that they produce essentially equal trip rates for New York HHs with and without private vehicles. The 0-VHHs have the same mobility as the HHs with vehicles. Something other than a vehicle is driving the relationship between HH mobility and various HH characteristics in the New York MSA.

Finally, New York accounts for a high proportion of the total data—almost 15 percent of all the 0-VHHs are located there. Including New York in any generalizations about the characteristics of the 0-VHHs, or their mobility patterns, will distort the results—and the distortions will be in the direction of downplaying the mobility problems of 0-VHHs. **Unless otherwise stated, from now on this Chapter excludes New York data from the statistical compilations.** (In effect we are discarding a very large, very distant outlier from the data.)

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[6] The New York Metropolitan Statistical Area (MSA) is the smallest unit of analysis in the 1990 NPTS that includes data from New York City. While it would be best to exclude only New York City, it is not possible. The New York MSA includes data from Bronx, Kings, New York, Putnam, Queens, Richmond, Rockland and Westchester Counties, and designates New York and White Plains as the Central Cities of the area. From now on, when this report refers to New York, it is referring to the New York MSA.

Introduction

Unless otherwise stated, for the remainder of this report all of the tables have the following characteristics:

1. Data for the New York MSA are excluded.
2. General Population" or "Total Sample" refers to all persons 16 years or olderliving outside New York, whether or not they own vehicles.
3. 0-VHHs" refers to HHs outside the New York MSA which do not own a car, van, or light truck.
4. Unless otherwise stated, the analyses were made using person-level data from the NPTS "Person File."[7]

Effects of Demographic Variables on Mobility

Table 1 shows the effect of employment status on travel. The top row shows the zero-trip percentage for persons living in HHs that do not own vehicles, the second row shows the corresponding data for the General Population.[8] Among workers (persons employed or actively looking for work) who live in 0-VHHs, 20 percent took no trips on the sample day. Immobility jumps to 57.5 percent for non-workers living in 0-VHHs. Contrast this to the data in the second row. Immobility increases only 7 percentage points (20 percent–13 percent) between workers living in 0-VHHs and those in the General Population. For non-workers, immobility increases 21.6 percentage points. One reason for this contrast is the unusually high proportion of older people and retired people in the 0-VHHs.

Rows 3 and 4 in Table 1 show trip rates, our measure of mobility. The average worker living in a 0-VHH made 2.85 trips on the sample day, compared to 3.61 trips in the General Population. The two categories of workers are more similar to each other than are the two categories of non-workers.

Table 1: EMPLOYMENT STATUS AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Employment Status	
	Worker	Non-Worker
% with no Trips		
HH without Vehicles	20.0%	57.5%
Total Sample	13.0%	35.9%
# of Trips per Day		
HH without Vehicles	2.85	1.35
Total Sample	3.61	2.51
Distribution of People		
HH without Vehicles	30.7%	69.3%
Total Sample	64.2%	35.8%

[7] Our "immobility" measure, the percentage of persons who took no trips on the sample day, causes distortions when it is applied at the HH level. The larger the number of persons in a HH, the greater the chance that at least one of them will take a trip. Hence the statistic "percentage of HHs that took no trip on the sample day" will make it seem that large households are more mobile than small ones, even though this is not true at the individual level. For example, consider the influence of ethnicity on the immobility rate. Since Hispanic HHs tend to be larger than white HHs, their immobility rate will be biased downward.

[8] For some purposes, one might wish to compare 0-VHHs to HHs with vehicles, rather than to the General Population. But since 93.6 percent of the General Population figure is HHs with vehicles, there will be essentially no difference between the two figures.

Rows 5 and 6 in Table 1 show the distribution of employment status in the General Population. Only 30.7 percent of the persons living in 0-VHHs are in the labor force, in contrast to 64.2 percent for persons in the General Population.

Table 2 shows the effect of age on travel. Consider the population distribution in rows 5 and 6 first: 37 percent of the persons in the 0-VHHs are over age 65 (13.8 percent + 23.2 percent), while only 14.9 percent of the General Population is that old.

Table 2: AGE OF RESPONDENT AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Age of Respondent					
	16-19	20-34	35-54	55-64	65-74	75 +
% with no Trips						
HH without Vehicles	26.2%	31.5%	32.7%	48.8%	52.5%	76.1%
Total Sample	18.1%	15.3%	17.0%	25.5%	34.2%	54.4%
# of Trips per Day						
HH without Vehicles	3.24	2.48	2.12	1.34	1.34	.68
Total Sample	3.50	3.63	3.44	2.76	2.32	1.39
Distribution of People						
HH without Vehicles	10.0%	26.5%	17.4%	9.0%	13.8%	23.2%
Total Sample	7.6%	32.4%	34.0%	11.3%	9.2%	5.7%

Immobility, rows 1 and 2, is roughly similar across the first three age groups but climbs sharply over the next three categories: among persons age 75 and older living in 0-VHHs, 76.1 percent took no trips on the travel day. A similar pattern holds for the sample as a whole, but at a lower level. The mobility measure in rows 3 and 4 shows a similar pattern to the immobility measure, with the exception of the 16-19 age group.

Figure 1 plots Age versus the Immobility Rate, the proportion of persons who took no trips on the sample day. Past age 45, immobility increases with age, and 0-VHHs track the general population in a parallel manner. Figure 2 plots Age versus Trips per Day. There is a general decline in trip taking as age increases; and again the curves for 0-VHHs and the general population are roughly parallel.

Table 3 shows the effect of Life Cycle Stage on travel.[9] Within 0-VHHs both the mobility and immobility measures are relatively constant across the first four life cycle stages, and then jump sharply upon retirement. The same pattern holds for the General Population as well.

The difference in population distributions is also of interest. Persons living in 0-VHHs are disproportionately retired, or living alone, or living without children: 46 percent of persons in 0-VHHs are

[9] The household life cycle variable (LIF_CYC) has been collapsed to assure that there are enough observations for each cell in the zero-vehicle household analysis. The following is a statement of the new life cycle variable categories, and the LIF_CYC components are in parenthesis. "1 Adult, no kids" (Single adult, no children); "2+ adults, no kids" (Two or more adults, no children; Single adult, youngest child age 16-21; Two or more adults, youngest child age 16-21); "1 adult with kids" (Single adult, youngest child age 0-5; Single adult, youngest child age 6-15); "2+ adults with kids" (Two or more adults, youngest child age 0-5; Two or more adults, youngest child age 6-15); "1 adult, retired" (Single adult, retired, no children); "2+ adults, retired" (Two or more adults, retired, no children).

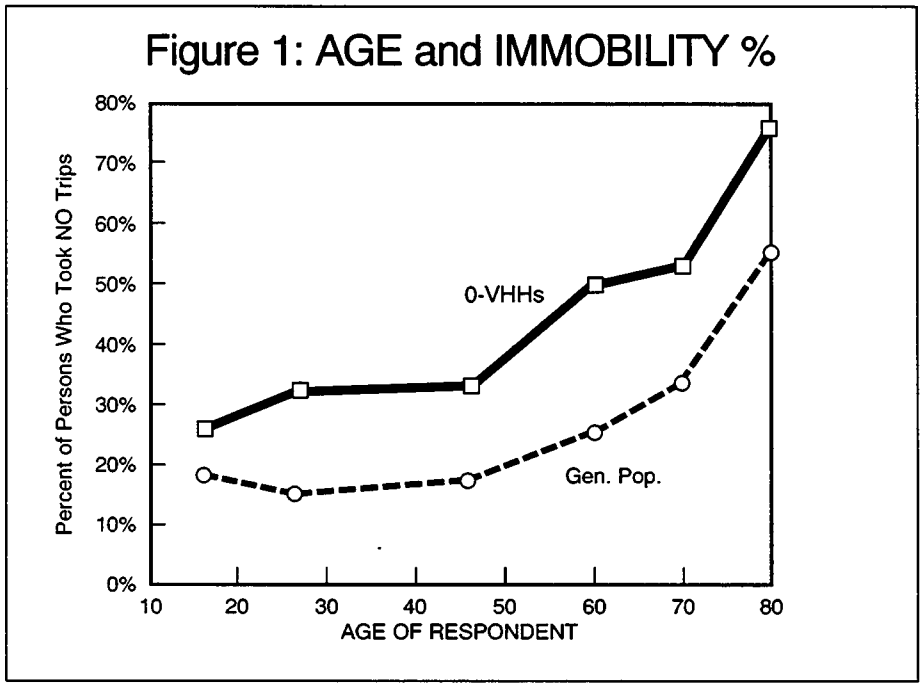


Table 3: HOUSEHOLD LIFE CYCLE AND ITS EFFECT ON TRAVEL
(Persons 16 and Older)

	Household Life Cycle					
	1 Adult no kids	2+ Adults no kids	1 Adult with kids	2+ Adults with kids	1 Adult retired	2+ Adults retired
% with no Trips						
HH without Vehicles	40.1%	32.7%	35.1%	38.7%	69.1%	58.0%
Total Sample	18.9%	17.9%	16.5%	18.1%	42.9%	34.8%
# of Trips per Day						
HH without Vehicles	2.07	2.58	1.98	2.06	.87	1.10
Total Sample	3.46	3.30	3.85	3.48	2.01	2.29
Distribution of People						
HH without Vehicles	24.0%	20.6%	10.4%	13.0%	22.0%	9.9%
Total Sample	9.2%	37.2%	3.0%	34.0%	4.3%	12.3%

lone adults, versus 13.5 percent for the General Population; 23.4 percent of persons in 0-VHHs have children, compared to 37 percent in the General Population; and 31.9 percent of persons in 0-VHHs are retired, compared to 16.6 percent in the General Population. (In HH-level data: 29.8 percent of 0-VHHs are retired, 44.7 percent have no children in the HH, two-thirds are one-person HHs, and 75.4 percent of 0-VHHs are headed by females.)

Recall that Table 1 showed the travel behavior of workers was relatively similar across the two samples (0-VHHs and the General Population), but that travel behavior of non-workers differed sharply across the two samples. We are now in a position to explore this further. We have learned that travel falls

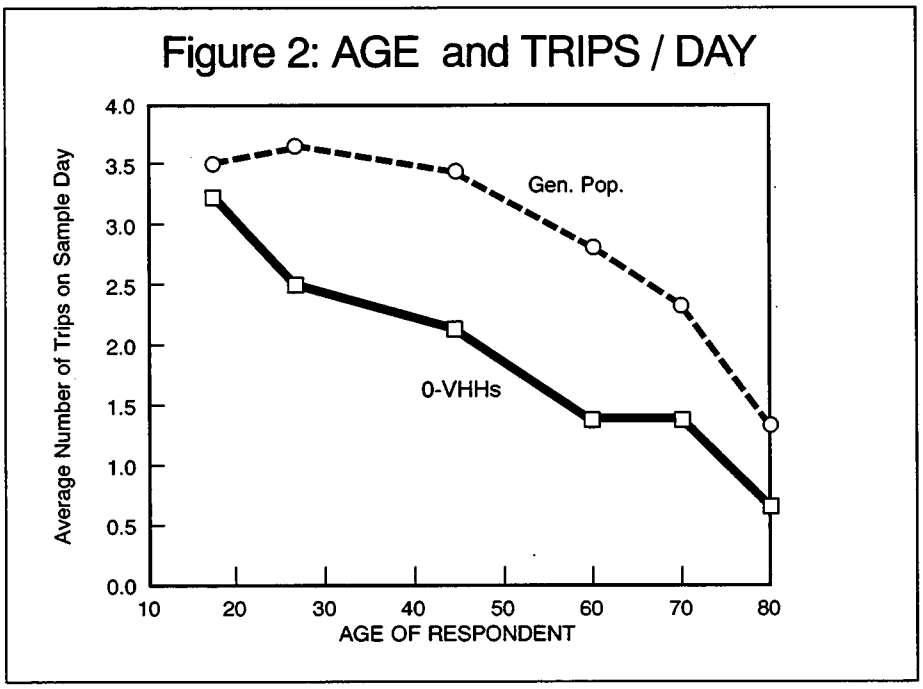


Table 4: EMPLOYMENT STATUS AND ITS EFFECT ON TRAVEL (Non-Retired Persons 16-54)

	Employment Status	
	Worker	Non-Worker
% with no Trips		
HH without Vehicles	19.9%	39.3%
Total Sample	12.5%	24.3%
# of Trips per Day		
HH without Vehicles	3.03	1.97
Total Sample	3.69	2.81
Distribution of People		
HH without Vehicles	37.4%	62.6%
Total Sample	60.1%	39.9%

off sharply by retirement status and by age, and we have learned that the 0-VHHs have a much higher proportion of retired people and old people. Thus the demographic characteristics of the non-worker portions of the population differ substantially between the two samples, and they differ in a way that exaggerates the effects on average travel behavior.

To make a more accurate comparison of non-worker travel, we should even out the demographic differences between the two samples. Table 4 does this by screening out observations on persons older than 54, and retired persons.[10] As expected, the gap in non-worker travel falls sharply.

[10] "Retired" status is approximated. Due to the nature of the household life cycle variable, only one adult had to be retired in order for the household to qualify for the reclassified category, "2+ adults, retired." There may also be a few retired individuals in the reclassified categories, "adults with children."

In Table 1, there was a difference of 21.6 percentage points between the two samples. In Table 4 the difference falls to 15 percentage points.

Table 5 shows the effect of poverty on travel. The distribution statistics in row 5 are surprising: only 28.3 percent of adults living in 0-VHHs are below the poverty level. Row 6 shows that 6 percent of the General Population are below the poverty level (This sample, however, includes the zero-vehicle households as well as those that own vehicles). Table 6 separates vehicle ownership by poverty status and shows that 76.1 percent of adults with incomes below the poverty level live in households that have vehicles. The desire to own a vehicle must be very high if so many people below the poverty level choose to do so. In addition, Table 6 illustrates that the proportion of persons in households with vehicles increases as households move out of poverty.

Table 7 compensates for differences in the age and retirement distributions in the two samples (0-VHHs and the General Population) by screening out retired persons and those over age 64. As expected the gap in mobility and immobility between the two samples is reduced. In Table 5, there was a gap of 20.8 percentage points in the immobility rates for the above poverty category. In Table 7 this gap falls to 11.3 percentage points. This is still an important difference in travel between 0-VHHs and the General Population, but it is nowhere near so large as the gross sample statistics suggest.

Table 5: HOUSEHOLD POVERTY LEVEL AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Poverty Level of Household		
	Below	Near	Above
% with no Trips			
HH without Vehicles	41.7%	48.2%	38.0%
Total Sample	28.2%	29.9%	17.2%
# of Trips per Day			
HH without Vehicles	2.40	1.43	2.23
Total Sample	2.94	2.65	3.50
Distribution of People			
HH without Vehicles	28.3%	30.1%	41.5%
Total Sample	6.0%	8.0%	86.0%

Table 6: VEHICLE OWNERSHIP AND POVERTY LEVELS (Persons 16 and Older)

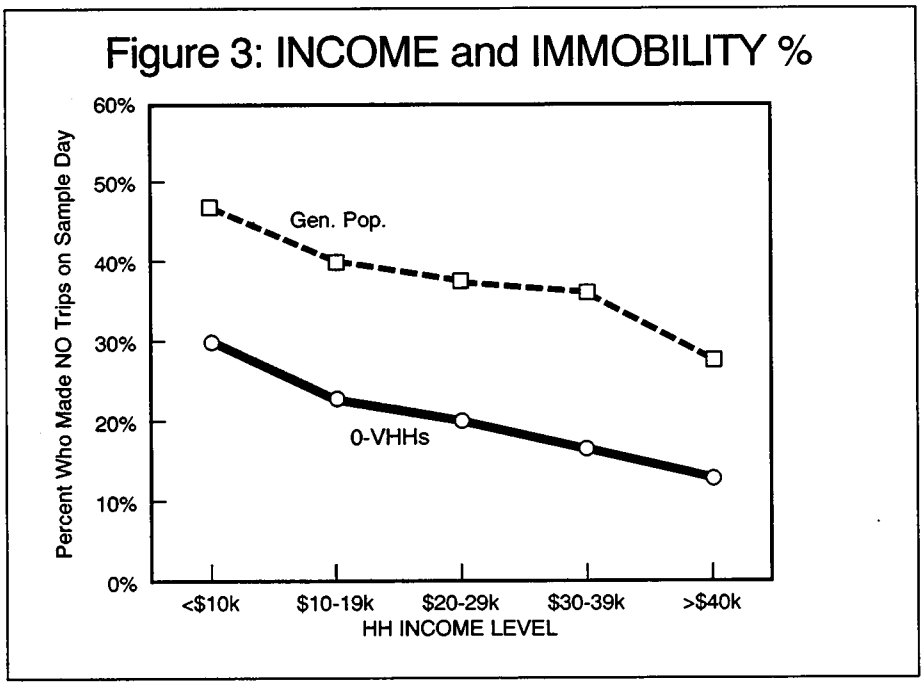
	Household Vehicle Ownership	
	One or More Vehicles	No Vehicles
Below Poverty	76.1%	23.9%
Near Poverty	81.1%	18.9%
Above Poverty	97.6%	2.4%

Table 7: HOUSEHOLD POVERTY LEVEL AND ITS EFFECT ON TRAVEL (Non-Retired Persons 16-64)

	Poverty Level of Household		
	Below	Near	Above
% with no Trips			
HH without Vehicles	30.4%	37.2%	26.3%
Total Sample	23.5%	23.8%	15.0%
# of Trips per Day			
HH without Vehicles	2.62	1.80	2.81
Total Sample	2.96	2.97	3.52
Distribution of People			
HH without Vehicles	41.1%	21.7%	37.3%
Total Sample	7.0%	6.3%	86.7%

Table 8: HOUSEHOLD FAMILY INCOME AND ITS EFFECT ON TRAVEL
(Persons 16 and Older)

	Level of Income				
	< 10,000	10,000 to 19,000	20,000 to 29,000	30,000 to 39,000	40,000 and over
% with no Trips					
HH without Vehicles	45.9%	40.1%	36.7%	35.4%	26.5%
Total Sample	30.9%	24.1%	19.0%	16.6%	14.0%
# of Trips per Day					
HH without Vehicles	1.91	1.99	2.62	2.24	2.62
Total Sample	2.70	2.99	3.39	3.51	3.73
Distribution of People					
HH without Vehicles	52.3%	30.4%	9.4%	4.4%	3.5%
Total Sample	10.5%	17.0%	17.7%	17.5%	37.3%



The income measure used in Tables 5, 6, and 7 is the poverty line, a measure that looks simultaneously at income and family size. Table 8 shows the effect of income alone. Figure 3 plots the relationship between Income and the percent of persons who took no trips on the sample day: increased income produces a large and consistent drop in immobility, and the trend lines for the General Population and the 0-VHHs show a parallel decline. Figure 4 plots the relationship between income and trips per day. Increased

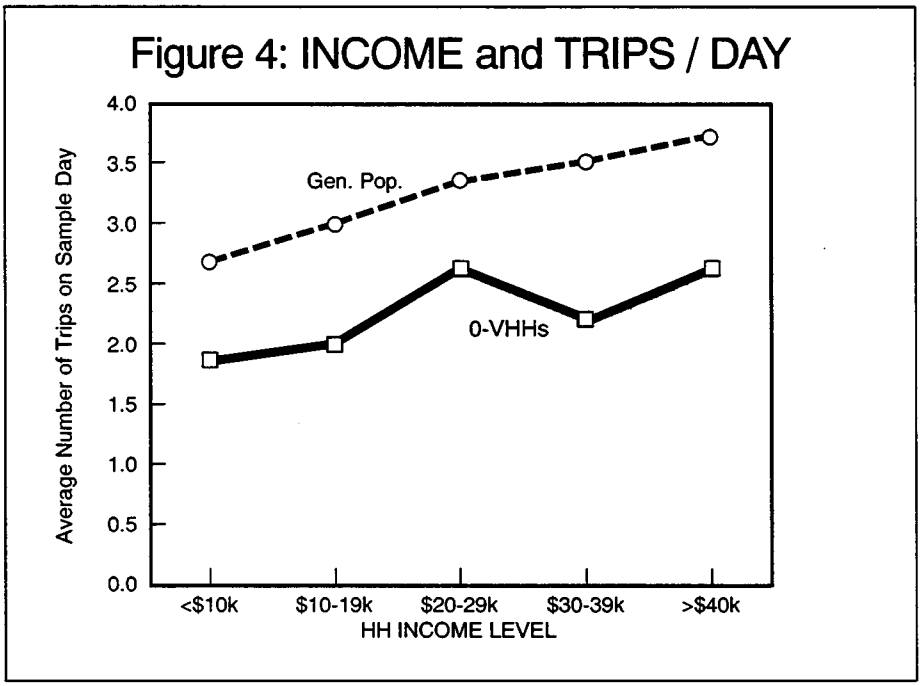


Table 9: SEX OF RESPONDENT AND ITS EFFECT ON TRAVEL (Persons 16 and Over)

	Sex of Respondent	
	Male	Female
% with no Trips		
HH without Vehicles	36.5%	50.1%
Total Sample	18.8%	23.3%
# of Trips per Day		
HH without Vehicles	2.10	1.69
Total Sample	3.17	3.25
Distribution of People		
HH without Vehicles	30.6%	69.4%
Total Sample	47.3%	52.7%

income produces a generally upward trend in mobility, though the effect is not quite as clear as the effect of income on the immobility rate.

Table 9 shows the relationship between gender and travel. Almost 70 percent of the adults living in 0-VHHs are women. (And the HH-level data show that 74.6 percent of 0-VHHs have a female head of household.) For adults living in 0-VHHs, there are large differences between men's and women's mobility and immobility. For the General Population, the differences disappear: women are slightly higher on the immobility measure, but they are also slightly higher on the mobility measure. Again, we suspect large differences in population distributions are causing the contrast. Table 10 shows the effect of holding some of the population distribution factors constant: persons who are older than age 64, or retired are screened

Table 10: SEX OF RESPONDENT AND ITS EFFECT ON TRAVEL (Non-Retired Persons 16-64)

	Sex of Respondent	
	Male	Female
% with no Trips		
HH without Vehicles	28.3%	35.9%
Total Sample	15.8%	18.2%
# of Trips per Day		
HH without Vehicles	2.50	2.29
Total Sample	3.34	3.60
Distribution of People		
HH without Vehicles	36.6%	63.4%
Total Sample	48.4%	51.6%

Table 11: LICENSED DRIVER STATUS AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Licensed Driver Status	
	Licensed	Not Licensed
% with no Trips		
HH without Vehicles	34.3%	51.1%
Total Sample	18.3%	45.2%
# of Trips per Day		
HH without Vehicles	2.53	1.49
Total Sample	3.39	1.75
Distribution of People		
HH without Vehicles	30.0%	70.0%
Total Sample	89.2%	10.8%

out. Women's immobility gap falls from 26.8 percentage points (Table 9) to 17.7 percentage points (Table 10).

Table 11 shows the relation between having a drivers' license and travel. For persons living in 0-VHHs, 70 percent are unlicensed, compared to only 10.8 for the General Population. And for either the 0-VHHs or the General Population, there is a sharp increase in immobility, and a sharp decline in mobility, for those persons who are unlicensed.

Table 12 shows one of the most interesting results, the relationship between education and travel.[11] Figures 5 and 6 plot the data. They both show a strong, consistent effect of increased education on travel. And both the 0-VHHs and the General Population show the same effect. What's going on here? One's first inclination is to assume the education-effect is merely an artifact of the income-effect: increased education produces increased income, which in turn produces more travel. As a rough test of this idea, compare Figure 5 with Figure 3: the slope in Figure 5 is steeper; the change in education produces a greater change in immobility than the change in income.[12] Likewise, comparing Figure 6 to Figure 4, the change in education produces a greater overall effect on trip rates than the change in income. That is, it looks like the rise in travel, as education increases, is being produced by something more than the income increase. The next section tests this more precisely: we hold income effects constant, while examining the relationship between education and travel.

[11] The original education categories have been collapsed for the purposes of this analysis.

[12] Since the visual comparison can be distorted by the scales used on the axes, we can also make direct numerical calculations. Across the range of incomes, trips per day increases from 1.91 to 2.62, a 37 percent increase. Across the range of education, trips per day increases from 1.28 to 2.95, a 130 percent increase. Clearly, the effect of variation in education is greater than the effect of variation in income.

Table 12: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL
(Persons 16 and Older)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	54.4%	42.2%	35.8%	30.3%	19.6%
Total Sample	31.3%	22.2%	15.3%	15.5%	12.7%
# of Trips per Day					
HH without Vehicles	1.28	2.10	2.36	2.67	2.95
Total Sample	2.44	3.06	3.77	3.70	3.94
Distribution of People					
HH without Vehicles	42.8%	36.7%	12.3%	5.9%	2.4%
Total Sample	18.9%	39.5%	19.6%	14.0%	7.9%

Figure 5: EDUCATION and IMMOBILITY %

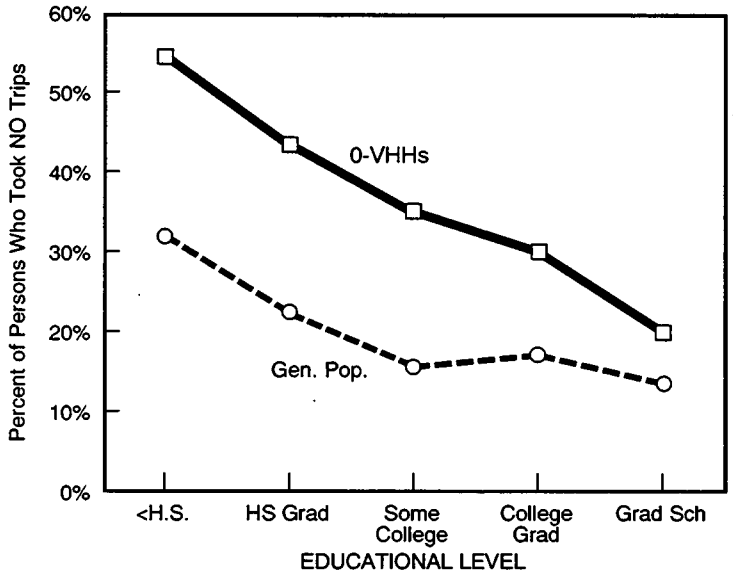


Figure 6: EDUCATION and TRIPS / DAY

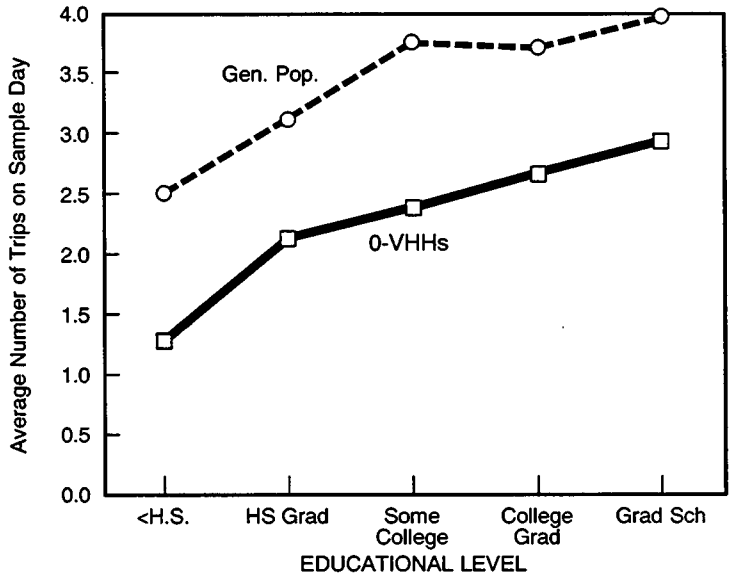


Table 13: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL
(Annual Household Family Income = $15,000 - $20,000)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	34.6%	33.7%	36.2%	9.1%	34.2%
Total Sample	26.3%	22.4%	17.5%	10.4%	22.1%
# of Trips per Day					
HH without Vehicles	2.08	2.16	2.64	3.60	2.30
Total Sample	2.64	2.98	3.74	3.89	3.50
Distribution of People					
HH without Vehicles	35.1%	30.6%	22.2%	7.9%	4.1%
Total Sample	25.1%	46.2%	17.1%	8.3%	3.3%

Tables 13, 14, and 15 examine the relationship between education and travel at three different income levels: $15–20 thousand, $30–40 thousand, and $60–70 thousand. Within each narrow income range, there is still a strong positive effect of education on mobility. Figure 7 plots trips per day for the General Population. The dark line shows the effect on the entire population, it repeats the trace from Figure 5. The lighter lines show the relations between education and trips per day at different income levels. The lighter lines are nearly as steep as the dark line — even within a narrow range of incomes, increased education is associated with increased mobility. Figure 8 makes a similar plot for the 0-VHHs. Again, we can see that education increases travel, even when income is held approximately constant.

Table 14: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL
(Annual Household Family Income = $30,000 - $40,000)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	67.4%	40.7%	36.1%	12.1%	—
Total Sample	20.3%	16.9%	15.3%	15.6%	13.3%
# of Trips per Day					
HH without Vehicles	0.91	1.85	2.81	2.60	3.46
Total Sample	3.16	3.31	3.79	3.76	4.11
Distribution of People					
HH without Vehicles	21.8%	21.4%	26.4%	20.0%	10.4%
Total Sample	12.7%	43.3%	22.3%	14.5%	7.2%

Table 15: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL
(Annual Household Family Income = $60,000 - $70,000)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	100%	—	—	—	0%
Total Sample	20.9%	19.0%	12.5%	11.0%	11.8%
# of Trips per Day					
HH without Vehicles	0.0	—	—	6.0	—
Total Sample	3.14	3.37	3.87	4.08	4.26
Distribution of People					
HH without Vehicles	91.6%	—	—	8.4%	—
Total Sample	9.1%	30.5%	22.0%	24.3%	14.1%

Why does education increase travel? A small part of the effect is caused by the increase in income, but the remainder of the effect is very much open to speculation. The authors of this chapter, who are in the education business, are tempted to suppose the answer is this: Education gives people an increased range of interests and destinations, a greater connection to the outside world.

Figure 7: EDUCATION and TRIPS / DAY

(AT DIFFERENT INCOME LEVELS)

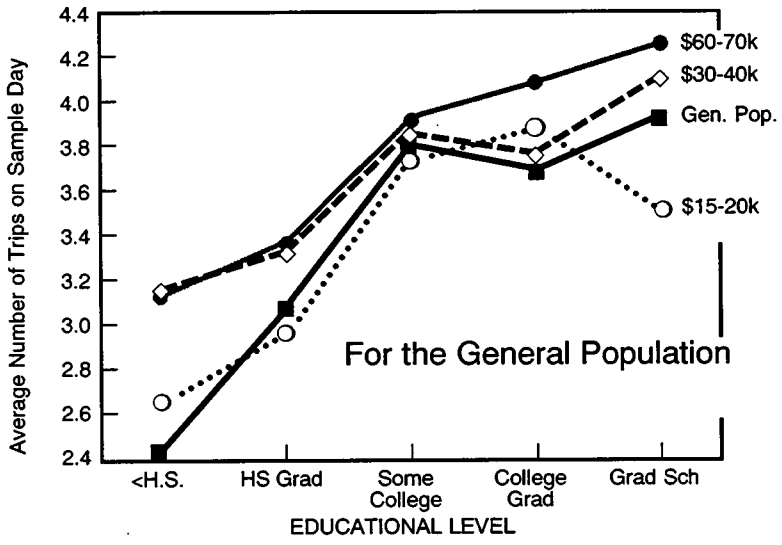


Figure 8: EDUCATION and TRIPS / DAY

(AT DIFFERENT INCOME LEVELS)

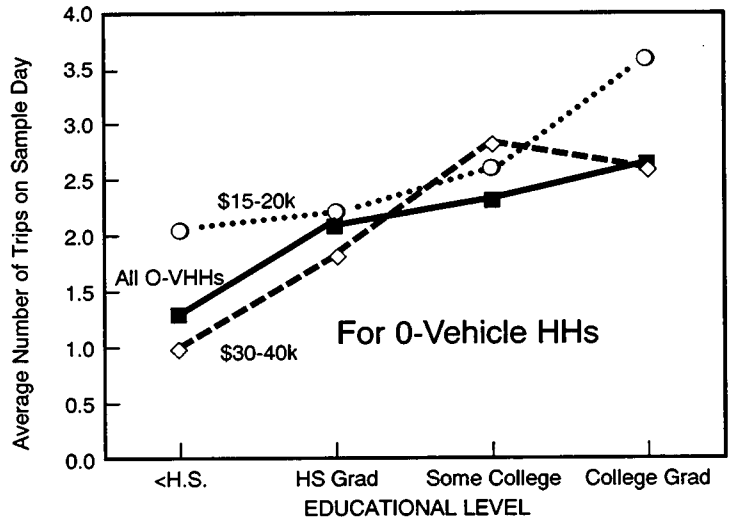


Table 16: HOUSEHOLD ETHNICITY AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Household Ethnicity			
	White	Black	Hispanic	Other
% with no Trips				
HH without Vehicles	50.4%	39.5%	51.4%	29.2%
Total Sample	20.0%	26.0%	27.3%	22.9%
# of Trips per Day				
HH without Vehicles	1.82	1.83	1.48	2.46
Total Sample	3.31	2.87	2.75	2.79
Distribution of People				
HH without Vehicles	52.2%	33.8%	10.3%	3.7%
Total Sample	80.3%	10.0%	6.8%	3.0%

Table 17: HOUSEHOLD SIZE AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Household Size					
	1	2	3	4	5	6 +
% with no Trips						
HH without Vehicles	53.9%	43.8%	41.5%	29.5%	34.9%	32.6%
Total Sample	26.6%	22.2%	18.6%	17.8%	20.1%	24.7%
# of Trips per Day						
HH without Vehicles	1.50	1.99	1.92	2.72	2.08	1.86
Total Sample	3.00	3.05	3.33	3.48	3.36	3.05
Distribution of People						
HH without Vehicles	45.8%	22.8%	13.1%	7.4%	6.2%	4.7%
Total Sample	13.3%	31.8%	20.1%	19.0%	10.0%	5.9%

Table 16 shows the relationship between ethnicity and travel.[13] Contrasting rows 5 and 6, we see that Blacks appear in the 0-VHH category three times more frequently than we would expect from their population proportions. On the other hand, if we try to gauge the travel handicap stemming from absence of a vehicle, Blacks show the greatest ability to maintain travel mobility: their difference in trip rates is only about one trip per day (2.87 - 1.83). Blacks also have the least increase in immobility stemming from absence of a vehicle: an increase of 13.5 percentage points (39.53–26.0).

[13] Ethnicity is a constructed variable which selects out hispanic ethnicity from the white, black and other categories of the race variable.

Table 17 shows the effect of household size. The expected direction of the effect is ambiguous. The economic argument predicts that number of trips per person will decline as household size increases because of economies of scale. Each HH has a minimal number of shopping trips and errands necessary for its maintenance; with more persons in the household, there are more persons available to split the work, hence trips per person should decline as HH size increases. The social interaction argument predicts that trips per person will increase: people stir each other into action, and it's more fun to go places with others than it is to go alone, hence trips per person will increase as HH size increases. The social interaction effect seems to dominate. Table 17 shows a small, and relatively consistent, increase in travel as HH size increases: trips per day grows, and the immobility rate falls.

Table 18: HOUSEHOLD LOCATION AND ITS EFFECT ON TRAVEL (Persons 16 and Older)

	Inside MSA		
	Inside Central City	Outside Central City	Not in MSA
% with no Trips			
HH without Vehicles	40.6%	52.2%	54.0%
Total Sample	21.7%	19.8%	23.0%
# of Trips per Day			
HH without Vehicles	1.97	1.72	1.45
Total Sample	3.21	3.26	3.13
Distribution of People			
HH without Vehicles	57.5%	22.5%	20.0%
Total Sample	34.8%	42.2%	23.0%

Table 19: POPULATION DENSITY OF HOUSEHOLD LOCATION AND ITS EFFECT ON TRAVEL

	Population Per Sq. Mile of Household Zip Code (Persons 16 and Older)				
	0 to 249	250 to 999	1,000 to 3,999	4,000 to 9,999	10,000 to 49,000
% with no Trips					
HH without Vehicles	54.9%	48.9%	47.8%	43.6%	34.0%
Total Sample	22.8%	19.2%	20.0%	21.3%	25.6%
# of Trips per Day					
HH without Vehicles	1.70	1.75	1.69	1.61	2.40
Total Sample	3.14	3.37	3.27	3.17	2.82
Distribution of People					
HH without Vehicles	24.2%	13.1%	20.4%	23.8%	18.5%
Total Sample	31.8%	19.8%	27.0%	16.9%	4.5%

Effects of Urban and Geographic Variables on Mobility

Table 18 shows the effect of urban location on travel. There are two major effects to notice here. First, the strong difference in the population distributions: 57.5 percent of adults in 0-VHHs live in the Central City contrasted to only 34.8 percent of the General Population. Second, urban location has no significant effect on either the mobility or immobility measure for the General Population. For the adults in 0-VHHs, a Central City location produces better scores on these measures.

Table 19 shows the effect of population density on travel.[14] Again we see that 0-VHHs are disproportionately represented in high density areas, columns 5 and 6. And their immobility increases sharply in low density areas: in the densest location, only 34 percent took no trips on the sample day; in the least dense locations, 54.9 percent took no trips. The same effect shows in trip rates, though not as sharply. For the General Population, neither travel measure changes much as a function of density.

Table 20 shows the effect of urban size on travel. The most interesting contrast here is between large cities with and without rail transit systems. There is a small improvement in travel for 0-VHHs located in cities with rail systems, but this is not a function of the transit system itself — we will see later that transit's modal share is almost identical in the two city types. Rather, the increase in travel is an increase in walking trips, and this is a function of other city characteristics. Cities with rail transit tend to be those that were largely built before the automobile age, hence they are denser and more pedestrian friendly. (Table 30, below, returns to this question.)

Table 20: SIZE OF URBAN AREA AND ITS EFFECT ON TRAVEL
(Persons 16 and Older)

	Population of Urbanized Areas (thousands)				
	50-199	200-499	500-999	1,000 + without rail	1,000 + with rail
% with no Trips					
HH without Vehicles	47.0%	46.0%	38.9%	47.8%	38.8%
Total Sample	19.7%	21.1%	19.9%	21.1%	20.8%
# of Trips per Day					
HH without Vehicles	1.92	1.53	1.68	1.64	2.10
Total Sample	3.44	3.30	3.28	3.24	3.10
Distribution of People					
HH without Vehicles	16.2%	10.0%	10.5%	25.3%	38.0%
Total Sample	14.2%	11.4%	10.8%	33.0%	30.5%

[14] For this analysis, the population density categories were collapsed, and the original category 14 (1,000 or more and not in MSA) was excluded. Besides being a category with few observations, the category is too broad for the purposes of this report.

Table 21: CENSUS DIVISION AND ITS EFFECT ON TRAVEL
(Persons 16 and Older)

	Population of Census Division								
	NE	MA	ENC	WNC	SA	ESC	WSC	Mtn	Pac
% with no Trips									
HH without Vehicles	47.7%	40.3%	45.2%	48.2%	46.7%	49.5%	55.5%	43.3%	43.9%
Total Sample	20.4%	20.8%	19.7%	20.9%	21.3%	22.5%	23.1%	19.4%	22.3%
# of Trips per Day									
HH without Vehicles	1.86	1.99	2.01	1.54	1.83	1.60	1.30	1.67	1.84
Total Sample	3.25	3.10	3.26	3.38	3.19	3.20	3.22	3.35	3.14
Distribution of People									
HH without Vehicles	6.8%	18.4%	18.3%	5.7%	21.1%	5.9%	9.4%	2.3%	12.2%
Total Sample	5.4%	12.9%	17.8%	7.3%	17.9%	6.3%	11.0%	5.7%	15.7%

Table 21 shows the broader geographic patterns of travel behavior.[15] For the General Population, there is very little difference in either travel measure across regions, rows 2 and 4 seem remarkably uniform. There is some variation for the 0-VHHs: the West South Central area has the highest immobility rate, 55.5 percent took no trips; Mid-Atlantic has the lowest, 40.3 percent. On the trips per day measure, again, West South Central shows the lowest mobility, 1.3 trips/day, but this time East North Central is highest at 2.01, with Mid-Atlantic close behind at 1.99 trips/days. In terms of population distributions, the East Coast has disproportionately more adults in 0-VHHs: NE + MA + SA add up to 36.2 percent of persons in the General Population, but have 46.3 percent of persons living in 0-VHHs. And the West Coast and Mountain regions have disproportionately few: Mtn + Pac have 21.4 percent of persons in the General Population, but only 14.5 percent of persons living in 0-VHHs.

Modal Choice: How Do They Travel?[16]

How do persons living in 0-VHH accomplish their travel, what modes do they utilize? To keep the tables manageable, the modes are consolidated as follows: the "private vehicle" mode includes trips made by automobiles, vans, and light trucks, as either a passenger or driver; the "public transit" mode includes all trips by bus, subway, or railroad; the "walk" mode is as expected; and "other" includes all the remaining modes.

Table 22 contrasts the modal split of 0-VHHs inside and outside the New York MSA. The first row shows the mode split of HHs living outside New York. Only 16 percent of their trips are made on public transit, and despite the absence of a HH vehicle, 36 percent of their trips are made in private vehicles, presumably by ride sharing with friends. For persons living within New York, public transit use increases sharply to 36 percent of all trips. In general terms, the proportion of trips made by walking is about the same, but what changes is the split between private vehicles and Transit.

[15] NE = New England; MA = Middle Atlantic; ENC = East North Central; WNC = West North Central; SA = South Atlantic; ESC = East South Central; WSC = West South Central; Mtn = Mountain; Pac = Pacific.

[16] Unless otherwise stated, all data exclude the New York MSA.

Table 22: MODAL SPLIT OF ZERO VEHICLE HOUSEHOLDS
Inside and Outside New York MSA

	Private Vehicle	Public Transport	Walk	Other
Outside NY	36%	16%	43%	5%
Inside NY	11%	36%	46%	7%

Table 23: RESPONDENT'S AGE AND ITS EFFECT ON TRAVEL MODE - 0-VHH
(Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
16-19	16.7%	8.5%	68.2%	6.7%
20-34	38.1%	19.1%	38.1%	4.7%
35-54	38.4%	18.1%	39.3%	4.2%
55-64	43.9%	15.3%	38.3%	2.5%
65-74	39.3%	15.3%	38.8%	6.6%
75+	49.3%	14.9%	30.1%	5.7%

Table 24: LIFE CYCLE AND ITS EFFECT ON TRAVEL MODE - 0-VHH
(Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
1 Adult, No Kids	36.6%	11.9%	46.9%	4.6%
2+ Adults, No Kids	22.6%	14.7%	56.4%	6.4%
1 Adult, With Kids	49.4%	13.5%	33.1%	4.0%
2+ Adults, With Kids	40.2%	24.8%	31.1%	4.0%
1 Adult, Retired	44.6%	17.2%	31.4%	6.8%
2+ Adults, Retired	41.9%	22.3%	32.7%	3.2%

Table 25: HOUSEHOLD INCOME AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
< 5,000	21.7%	8.1%	65.7%	4.4%
5,000 - 9,999	41.1%	18.3%	36.6%	4.0%
10,000 - 14,999	32.8%	18.0%	45.5%	3.6%
15,000 - 19,999	37.7%	18.8%	37.2%	6.3%
20,000 - 29,999	34.1%	16.5%	43.5%	5.8%
30,000 +	32.2%	17.3%	45.0%	5.5%

Table 26: GENDER AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
Male	28.8%	17.0%	45.6%	8.7%
Female	39.7%	15.4%	41.8%	3.1%

The rest of this section explores these relationships in more detail. The tables are based on the NPTS Trip File; each observation is a trip by one person on the sample day. Thus one HH, or one person, may be represented by many observations. The tables take account of all trips by adults living in 0-VHHs outside of New York.

Table 23 shows the effect of age on mode split. In general, there is little difference in mode split among age groups 20 years old and up. But the 16–19 year old group is quite different from the others: 68.2 percent of its trips are made by walking.

Table 24 shows the effect of life cycle on mode split. There are no strong trends here, but in general, people in the earlier life cycle stages walk more.

Table 25 shows the effect of HH income on mode split. The contrast here is the comparison between the under $5,000 group and the others. There is general similarity in travel modes above $5,000 HH income level, but below it there are sharp drops in use of private vehicles and transit, and a correspondingly sharp increase in walking.

Table 26 shows the effect of gender on mode split. Interestingly, women use private vehicles for a higher proportion of their trips than men do, perhaps because of concerns about security.

Table 27: ETHNICITY AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
Hispanic	32.7%	28.0%	30.9%	8.4%
Black	36.7%	23.5%	36.6%	3.2%
Other	33.0%	21.4%	37.6%	8.1%
White	35.8%	8.7%	50.0%	5.5%

Table 28: EDUCATION AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
Non-H.S. Grad	44.3%	15.9%	33.2%	6.6%
High School Grad	32.5%	16.4%	48.4%	2.8%
Some College	27.9%	15.8%	51.8%	4.5%
College Grad/ Grad School	29.9%	16.7%	42.3%	11.0%

Table 27 shows the effect of ethnicity on mode split. Travel patterns of minorities (Hispanics, Blacks, Other) are relatively similar to each other. Whites use private vehicles the same amount as minorities do, but Whites make much less use of transit, and do much more walking.

Table 28 shows the effect of education on mode split. There is a strong decline in use of private vehicles as education increases, and a corresponding increase in walking as education increases. Use of public transit is about the same across education levels.

Table 29: POPULATION DENSITY AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
0-249	40.5%	4.7%	51.8%	3.1%
250-999	40.8%	7.5%	39.3%	12.4%
1,000-3,999 and in MSA	46.6%	18.0%	30.0%	5.5%
4,000-9,999 and in MSA	41.3%	19.2%	34.9%	4.5%
10,000-49,999 and in MSA	17.2%	26.3%	52.8%	3.6%

Table 30: URBANIZED AREA SIZE AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
50,000-199,999	35.8%	13.4%	39.2%	11.5%
200,000-499,999	47.6%	13.5%	35.0%	4.0%
500,000-999,999	56.2%	14.6%	23.9%	5.2%
1,000,000 or More Without Rail	41.7%	22.1%	31.6%	4.6%
1,000,000 or More With Rail	23.5%	24.3%	49.0%	3.2%

Table 29 shows the effect of population density on mode split. As expected, use of transit increases sharply with density. Use of private vehicles is quite constant until the very highest density level. And walking is high at the two ends of the density scale.

Table 30 shows the effect of urban size on mode split. The pattern seems to split at the one million mark. In the size range 50 thousand to one million: as urban size increases, transit usage is constant, vehicle usage increases sharply, and walking falls sharply. In the one million and up category there is a sharp difference between cities with and without rail transit systems. In the large rail-cities, vehicle usage is sharply lower and walking is sharply higher compared to the non-rail large cities. But credit for this socially desirable change cannot be attributed to the presence of the rail system since the modal share of transit is essentially the same in the two city types (22.1 percent and 24.3 percent). It seems likely that what we are observing is a side effect of city age: most rail transit cities were built before the automobile age. They are older, denser, more pedestrian-oriented and have less road and parking capacity.

Table 31: CENSUS DIVISION AND ITS EFFECT ON TRAVEL MODE - 0-VHH (Trips for Persons 16 and Older)

	Share of Travel Day Trip Mode			
	Private Vehicle	Public Transport	Walk	Other
Middle Atlantic	23.3%	20.4%	52.2%	4.2%
New England	24.3%	16.5%	56.3%	3.0%
Mountain	29.2%	10.3%	50.3%	10.2%
East North Central	33.0%	13.0%	48.3%	5.8%
Pacific	35.0%	17.6%	40.3%	7.0%
South Atlantic	41.0%	19.3%	36.1%	3.7%
West South Central	50.3%	14.1%	26.7%	9.2%
West North Central	52.3%	9.7%	34.4%	3.6%
East South Central	60.1%	3.3%	32.9%	3.7%

Table 31 shows the variation in mode split across geographic regions. The table has been ordered by the degree to which private vehicles are used. The Mid-Atlantic and New England regions have relatively low use of private vehicles, while West South Central, West North Central, and East South Central are more than twice as high. Transit use is similar across most of these regions (until a sharp drop in East South Central). And walking declines steadily in the opposite pattern to private vehicle usage.

The Journey to Work

Only 30.7 percent of adults in 0-VHHs are in the labor force (employed or looking for work), but the journey to work is one of the most important trip purposes. This section analyzes the mode split for work trips as a function of demographic and geographic characteristics. The data are for persons 16 and over, in the labor force, who do not live in the New York MSA.

Table 32 shows that Whites walk to work nearly twice as often as Blacks and more than three times as often as Hispanics. Black work trips are almost evenly split among private vehicles and public transport. Hispanics utilized private vehicles much more than public transportation. The bottom row, "Col. as percent of all Persons" shows that 9.6 percent of all workers in 0-VHHs are White, reflecting the high proportion of retired persons in White 0-VHHs.

Table 32: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS BY ETHNICITY - 0-VHH (Trips by Persons 16 Years and Older)

	Household Ethnicity			
	White	Black	Hispanic	Other
Private Vehicle	30.7%	38.9%	46.7%	32.6%
Public Transport	20.4%	36.4%	30.2%	48.1%
Walk	41.3%	22.7%	12.4%	14.5%
Other	7.5%	2.1%	10.4%	4.9%
Total	100%	100%	100%	100%
Col. as % of all Persons	9.6%	41.9%	44.4%	4.1%

Table 33: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS - 0-VHH (Trips by Persons 16 Years and Older)

	Family Income				
	< 10,000	10,000-19,999	20,000-29,999	30,000-39,999	Over 40,000
Private Vehicle	36.4%	33.6%	22.6%	19.9%	40.2%
Public Transport	26.5%	34.3%	33.5%	45.7%	27.6%
Walk	35.7%	26.8%	28.2%	28.3%	29.0%
Other	1.4%	5.4%	15.7%	6.1%	3.2%
Total	100%	100%	100%	100%	100%
Col. as % of all Persons	35.6%	34.0%	12.6%	8.1%	9.6%

Table 33 shows the relations of mode split to income. Walking is relatively consistent across income categories. The private vehicle mode decreases with income until $40,000, where it doubles. The public transportation mode moves in the opposite pattern.

Table 34 shows that the private vehicle mode increases as persons move from central city, to suburb, to non MSA. There is a corresponding decrease in public transportation use. The share of walking is relatively constant. The bottom row shows that 68.8 percent of all the 0-VHH *workers* live in the MSA Central City, while Table 18 showed that 57.5 percent of all the 0-VHH *persons* live in the MSA Central City. That is 0-VHH persons living in the MSA Central City are much more likely to be in the labor force.

Table 35 shows a general increase of transit's mode share for work trips as population density increases. The biggest change is between the MSA and non-MSA categories, with a corresponding

Table 34: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS BY MSA STATUS - 0-VHH (Trips by Persons 16 Years and Older)

	MSA Status		
	In MSA Central City	In MSA non-Central City	Not in MSA
Private Vehicle	31.3%	42.5%	51.1%
Public Transport	34.7%	30.1%	7.9%
Walk	28.0%	25.0%	35.0%
Other	5.9%	2.5%	5.9%
Total	100%	100%	100%
Col. as % of all Persons	68.8%	14.9%	16.3%

Table 35: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS BY POPULATION DENSITY - 0-VHH (Trips by Persons 16 Years and Older)

	Population Density				
	0-249	250-999	1,000-3,999 in MSA	4,000-9,999 in MSA	10,000-49,999 in MSA
Private Vehicle	52.4%	56.6%	37.2%	40.2%	12.2%
Public Transport	10.3%	8.9%	34.7%	34.0%	41.7%
Walk	34.0%	24.0%	19.2%	21.3%	43.4%
Other	3.3%	10.5%	8.9%	4.5%	2.7%
Total	100%	100%	100%	100%	100%
Col. as % of all Persons	14.9%	10.6%	20.8%	30.6%	23.1%

decrease in private vehicle use. There is a decrease in walk trips until the highest density is reached, where the walking to work doubles.

Table 36 compares work trip mode across sexes. Females use private vehicles and public transport more than males. The bottom row shows that 57.4 percent of the 0-VHH labor force are women: this is well below their share of the 0-VHH population, 69.4 percent (Table 9). This is an expected result given the substantial share of retired women among persons in 0-VHHs.

Table 37 shows that the private vehicle mode generally decreases with urban size, and there is a generally corresponding increase in use of public transportation. In both the 200-499 and 500-999 categories, private vehicles are used for over half the work trips. The table has two surprising results: First, looking at the 500-999 category, although its share of private vehicle is very high, its transit share is nearly equal to that of the largest urban areas with rail. Second, looking at the 1,000+ urban areas, it is the areas without rail transit that have the greatest transit mode share of the 0-VHH work trips.

TABLE 36: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS BY SEX - 0-VHH
(Trips by Persons 16 Years and Older)

	Sex	
	Male	Female
Private Vehicle	33.5%	38.3%
Public Transport	24.2%	33.8%
Walk	33.2%	25.4%
Other	9.1%	2.6%
Total	100%	100%
Col. as % of all Persons	42.6%	57.4%

Table 37: DISTRIBUTION OF TRIP MODE FOR WORK TRIPS BY URBAN AREA SIZE - 0-VHH
(Trips by Persons 16 Years and Older)

	Urbanized Area Size (in thousands)				
	50-199	200-499	500-999	1,000 + No Rail	1,000 + With Rail
Private Vehicle	36.3%	52.7%	51.8%	33.7%	26.4%
Public Transport	29.4%	10.3%	33.4%	48.0%	34.8%
Walk	19.2%	33.4%	11.0%	14.2%	34.5%
Other	15.0%	3.6%	3.8%	4.1%	4.2%
Total	100%	100%	100%	100%	100%
Col. as % of all Persons	12.7%	6.7%	9.0%	21.3%	50.2%

Travel Behavior of Persons Age 65 and Older

Persons 65 and older account for 49.1 percent of all 0-VHHs. What can we say about their travel behavior? The major finding is that their travel is not affected by changes in most of the explanatory variables. All differences in mobility are primarily between 0-VHH's and the General Population (65 and older). Though the absence of a connection between mobility and transit access is, itself, significant. (As an abbreviation, we shall refer to persons age 65 and over as "older persons.")

Table 38 shows that MSA location does not matter. Immobility rates are almost the same across the three MSA categories, and trip rates are only slightly different.

Table 38: HOUSEHOLD LOCATION AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Inside MSA		
	Inside Central City	Outside Central City	Not in MSA
% with no Trips			
HH without Vehicles	64.6%	68.3%	70.1%
Total Sample	43.7%	40.6%	41.9%
# of Trips per Day			
HH without Vehicles	1.00	0.88	0.86
Total Sample	1.95	1.94	2.02
Distribution of People			
HH without Vehicles	41.6%	29.3%	29.1%
Total Sample	31.6%	38.1%	30.3%

Table 39: SIZE OF URBAN AREA AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Population of Urbanized Areas (thousands)				
	50-199	200-499	500-999	1,000 + without rail	1,000 + with rail
% with no Trips					
HH without Vehicles	65.8%	64.0%	66.8%	66.6%	63.8%
Total Sample	39.0%	45.0%	42.9%	40.2%	42.6%
# of Trips per Day					
HH without Vehicles	0.82	0.93	1.02	0.98	1.03
Total Sample	2.16	1.89	1.88	2.06	1.86
Distribution of People					
HH without Vehicles	18.1%	12.5%	9.9%	29.3%	30.2%
Total Sample	16.2%	13.8%	11.0%	31.5%	27.6%

Table 39 shows that size of urban area does not matter. Immobility rates are almost the same across the five urban size categories, and trip rates are only slightly different.

Table 40: POPULATION DENSITY OF HOUSEHOLD LOCATION AND ITS EFFECT ON TRAVEL

	Population Per Sq. Mile of Household Zip Code (Persons 65 and Older)					
	0 to 249	250 to 999	1,000 to 3,999	4,000 to 9,999	10,000 to 49,000	50,000 +
% with no Trips						
HH without Vehicles	70.9%	64.4%	68.4%	62.9%	62.0%	—
Total Sample	43.1%	40.6%	41.8%	39.0%	52.5%	—
# of Trips per Day						
HH without Vehicles	0.81	1.00	0.88	0.98	1.26	—
Total Sample	1.93	2.08	1.99	1.99	1.50	—
Distribution of People						
HH without Vehicles	34.4%	16.2%	21.2%	18.3%	9.9%	—
Total Sample	38.0%	18.0%	23.9%	16.9%	3.2%	—

Table 40 shows that population density makes a small difference, and only in the very densest category.

Consider the implications of the geographic findings. Transit access is certainly much better in the Central City of an MSA than it is in a non-MSA, yet there was no difference in mobility patterns. Transit access is certainly much better in large urban areas than in small ones, but again there was no difference in mobility patterns. Transit access is certainly much better in high density areas than in low density ones, but we find only small increases in mobility in the densest areas. *Taken together, these three finding seem to indicate that the presence or absence of transit makes little difference in the mobility of older people.*

Table 41 shows there is little difference across the census-geographic areas, except that older persons in the West South Central area are considerably less mobile, and the East South Central, Mountain, and Pacific regions show somewhat higher mobility.

Table 41: CENSUS DIVISION AND ITS EFFECT ON TRAVEL
(Persons 65 and Older)

	Population of Census Division								
	NE	MA	ENC	WNC	SA	ESC	WSC	Mtn	Pac
% with no Trips									
HH without Vehicles	63.8%	68.0%	70.9%	70.3%	67.7%	56.2%	77.4%	56.5%	62.5%
Total Sample	42.1%	41.0%	40.9%	39.4%	41.8%	47.9%	46.8%	41.2%	39.8%
# of Trips per Day									
HH without Vehicles	0.87	0.88	0.91	0.70	0.89	1.28	0.49	1.47	1.17
Total Sample	1.87	1.95	2.02	2.21	1.91	1.63	1.93	2.12	2.00
Distribution of People									
HH without Vehicles	6.2%	13.7%	17.4%	6.9%	21.8%	8.3%	9.7%	1.9%	14.1%
Total Sample	4.9%	12.7%	16.2%	9.1%	19.9%	6.6%	10.7%	5.0%	14.8%

Table 42: SEX OF RESPONDENT AND ITS EFFECT ON TRAVEL
(Persons 65 and Over)

	Sex of Respondent	
	Male	Female
% with no Trips		
HH without Vehicles	64.6%	67.9%
Total Sample	35.2%	46.9%
# of Trips per Day		
HH without Vehicles	0.91	0.93
Total Sample	2.25	1.77
Distribution of People		
HH without Vehicles	19.4%	80.6%
Total Sample	42.0%	58.0%

Table 42 shows that gender does not matter. The immobility rate and the trip rate are almost identical for men and women—an important finding given that 80.6 percent of older persons in 0-VHHs are women.

Table 43: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	66.6%	64.6%	68.1%	69.4%	62.6%
Total Sample	48.7%	41.8%	31.5%	31.6%	25.9%
# of Trips per Day					
HH without Vehicles	0.91	1.07	0.94	0.83	0.91
Total Sample	1.56	1.99	2.51	2.62	2.95
Distribution of People					
HH without Vehicles	56.5%	28.4%	8.6%	4.7%	1.8%
Total Sample	35.5%	38.9%	11.8%	8.1%	5.7%

Table 43 shows that education does not matter. The immobility rate and the trip rate are almost identical across education levels. This is surprising because of the strong positive influence of education on travel for the age 16 and up sample. In fact, there is a strong positive education effect for older persons who live in HHs with vehicles, but there is none in the 0-VHHs.

Table 44 shows that ethnicity does not matter. The immobility rate is essentially identical, and the trip rate is quite similar across the White/Black/Hispanic categories. The "Other" category has double the mobility level, but this may not be an accurate finding as "Other" is only 2.5 percent of what is already a small sample.

Table 44: HOUSEHOLD ETHNICITY AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Household Ethnicity			
	White	Black	Hispanic	Other
% with no Trips				
HH without Vehicles	68.6%	66.7%	66.2%	29.8%
Total Sample	40.6%	52.3%	56.6%	40.9%
# of Trips per Day				
HH without Vehicles	0.91	0.95	0.68	1.71
Total Sample	1.38	2.04	1.42	1.56
Distribution of People				
HH without Vehicles	74.1%	19.3%	4.0%	2.5%
Total Sample	87.8%	7.3%	3.4%	1.6%

Table 45 shows that income level does not matter. Immobility rates and trip rates are almost identical across income categories.

Table 45: HOUSEHOLD FAMILY INCOME AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Level of Income			
	< 10,000	10,000 to 19,000	20,000 to 29,000	Above 30,000
% with no Trips				
HH without Vehicles	62.5%	60.1%	64.5%	63.6%
Total Sample	49.7%	41.0%	34.6%	32.6%
# of Trips per Day				
HH without Vehicles	0.98	1.28	1.28	1.04
Total Sample	1.51	1.99	2.44	2.52
Distribution of People				
HH without Vehicles	57.8%	30.1%	6.2%	6.0%
Total Sample	22.8%	32.2%	17.8%	27.1%

Table 46 shows that poverty level makes a small difference. This is an income measure that balances income and family size. There is a small increase in the immobility rate in the below poverty category, and a larger change in the trip rate. (It's also interesting to compare the relative distributions of the over-16 sample (Table 5) to the over-65 sample. For persons living in 0-VHHs: in the 16 and over sample, 28.3 percent of the persons are in HHs below the poverty line; in the 65 and over sample, this falls to 16.5 pecent.)

Table 46: HOUSEHOLD POVERTY LEVEL AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Poverty Level of Household		
	Below	Near	Above
% with no Trips			
HH without Vehicles	74.9%	58.0%	60.8%
Total Sample	62.3%	46.0%	36.3%
# of Trips per Day			
HH without Vehicles	0.76	1.06	1.26
Total Sample	1.11	1.64	2.29
Distribution of People			
HH without Vehicles	16.5%	42.1%	41.4%
Total Sample	5.5%	18.6%	75.9%

Table 47: LICENSED DRIVER STATUS AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Licensed Driver Status	
	Licensed	Not Licensed
% with no Trips		
HH without Vehicles	57.3%	68.8%
Total Sample	34.2%	67.0%
# of Trips per Day		
HH without Vehicles	1.22	0.88
Total Sample	2.30	0.89
Distribution of People		
HH without Vehicles	13.1%	86.9%
Total Sample	76.3%	23.7%

Table 47 shows that drivers' license status makes a small difference in trip behavior for the 0-VHHs, but it makes an enormous difference in the households with vehicles. The relative proportions of the groups are also of interest. For only 13.1 percent of persons in 0-VHHs are licensed, compared to 76.3 percent in the General Population.

Table 48: HOUSEHOLD LIFE CYCLE AND ITS EFFECT ON TRAVEL (Persons 65 and Older)

	Household Life Cycle			
	1 Adult no kids	2+ Adults no kids	1 Adult retired	2+ Adults retired
% with no Trips				
HH without Vehicles	59.5%	55.6%	70.4%	68.1%
Total Sample	38.0%	38.3%	44.9%	40.8%
# of Trips per Day				
HH without Vehicles	1.32	1.13	0.82	0.79
Total Sample	2.28	2.04	1.92	1.97
Distribution of People				
HH without Vehicles	18.8%	5.4%	57.1%	17.4%
Total Sample	8.9%	10.6%	26.1%	50.4%

Table 48 shows that life cycle stage makes a small difference: retired persons are somewhat less mobile. It is no surprise that 74.5 percent of older persons are retired, but it is noteworthy that 75.9 percent of older persons are living alone.

Appendix A:

Characteristics of 0-VHHS in New York

We begin by looking at New York's population distribution.[17] Its demographic profile differs considerably from the rest of the sample.

Table 49 shows that comparatively few 0-VHHs in New York are in the Retired stage of the life cycle, 22.0 percent for New York versus 36.5 percent in the rest of the country. It also shows that comparatively many 0-VHHs in New York live in "2 or more Adult" HHs: 40.3 percent for New York versus 20.8 percent for the rest of the country.

Table 49: HOUSEHOLD LIFE STYLE STATUS FOR NEW YORK / NON NEW YORK MSA 0-VHH

	Percentage of Household Life Cycle	
	New York 0-VHHs	Non New York 0-VHHs
1 Adult, No Kids	27.5%	32.5%
2+ Adults, No Kids	28.3%	12.9%
1 Adult, With Kids	10.3%	10.2%
2+ Adults, With Kids	12.0%	7.9%
1 Adult, Retired	15.1%	30.3%
2+ Adults, Retired	6.9%	6.2%

Table 50: HOUSEHOLD POVERTY LEVEL FOR NEW YORK / NON NEW YORK 0-VHH

	Percentage of Household Proverty Levels	
	New York 0-VHHs	Non New York 0-VHHs
Below Poverty Level	14.8%	27.0%
Near Poverty Level	17.6%	32.4%
Above Poverty Level	67.6%	40.6%

Table 50 shows that comparatively few New York 0-VHHs are below the poverty line: 14.8 percent versus 27.0 percent for the rest of the country. And comparatively many New York 0-VHHs are above the poverty line: 67.6 percent for New York versus 40.6 percent for the rest of the country.

[17] All New York data in this appendix are for persons age 16 and over who live in the New York MSA.

TABLE 51: HOUSEHOLD INCOME FOR NEW YORK / NON NEW YORK 0-VHH

	Percentage of Income Categories	
	New York 0-VHHs	Non New York 0-VHHs
Under 10,000	27.5%	55.5%
10,000-19,999	23.6%	28.5%
20,000-29,999	18.1%	8.1%
30,000-39,999	12.2%	4.3%
Over 40,000	18.5%	3.5%

Table 51 shows more detail on the income distribution. Only 27.5 percent of New York 0-VHHs earn less than $10,000 per year, while 55.5 percent of HHs in the rest of the country are below that line. On the high end, 18.5 percent of New York 0-VHHs earn more than $40,000 per year compared to only 3.5 percent in the rest of the country.

These unique demographic characteristics of New York 0-VHHs tend to move these HHs in the direction of greater travel mobility. Their combined effect is so strong that they produce essentially equal trip rates for New York HHs with and without private vehicles. The 0-VHHs have nearly the same mobility as the HHs with vehicles.

Table 52 shows that mobility increases as a function of education. What is noteworthy about this table is the similarity of mobility measures between the 0-VHHs and the Total New York Sample. Any small differences in rows 1 and 2 (the "immobility measure") largely disappear in rows 3 and 4 (the "mobility measure").

Table 52: RESPONDENT'S EDUCATION AND ITS EFFECT ON TRAVEL (Persons 16 and Older, New York MSA)

	Respondent's Education Level				
	Non High School Grad	High School Grad	Some College	College Grad	Grad School
% with no Trips					
HH without Vehicles	44.9%	33.2%	27.8%	12.8%	18.3%
HH with Vehicles	39.4%	31.1%	23.2%	17.2%	15.5%
# of Trips per Day					
HH without Vehicles	1.59	2.25	3.11	3.20	3.49
HH with Vehicles	1.86	2.24	2.84	3.23	3.47
Distribution of People					
HH without Vehicles	30.9%	32.8%	14.6%	16.1%	5.5%
HH with Vehicles	14.9%	34.7%	19.6%	20.4%	10.4%

Table 53: HOUSEHOLD FAMILY INCOME AND ITS EFFECT ON TRAVEL (Persons 16 and Older, New York MSA)

	Level of Income				
	< 10,000	10,000 to 19,000	20,000 to 29,000	30,000 to 39,000	40,000 and over
% with no Trips					
HH without Vehicles	44.2%	28.3%	20.4%	15.1%	25.1%
HH with Vehicles	32.3%	30.2%	22.9%	33.2%	17.0%
# of Trips per Day					
HH without Vehicles	1.85	2.30	3.09	3.58	3.11
HH with Vehicles	2.47	2.36	2.65	2.60	3.05
Distribution of People					
HH without Vehicles	24.0%	24.3%	17.4%	12.3%	22.0%
HH with Vehicles	3.7%	12.5%	14.2%	15.6%	54.0%

The same similarities are seen in Table 53—the effects of HH income. Up to $30,000, there is very little variation in mobility or immobility across levels of income. These become somewhat larger beyond $30,000 for the immobility measures, but they actually reverse for the mobility measure—0-VHHs have higher trip rates.

Table 54: HOUSEHOLD LIFE CYCLE AND ITS EFFECT ON TRAVEL (Persons 16 and Older, New York MSA)

	Household Life Cycle					
	1 Adult no kids	2+ Adults no kids	1 Adult with kids	2+ Adults with kids	1 Adult retired	2+ Adults retired
% with no Trips						
HH without Vehicles	27.7%	24.8%	22.5%	28.9%	54.8%	64.2%
HH with Vehicles	21.1%	23.0%	19.7%	28.5%	30.1%	40.7%
# of Trips per Day						
HH without Vehicles	2.76	2.49	2.64	2.62	1.20	1.09
HH with Vehicles	3.19	2.75	3.43	2.40	2.80	2.09
Distribution of People						
HH without Vehicles	18.4%	37.7%	9.6%	16.2%	9.0%	9.1%
HH with Vehicles	7.8%	41.9%	1.8%	36.3%	2.0%	10.2%

Table 54 shows the effect of HH life cycle. HHs with and without vehicles are quite similar until the retirement stage is reached.

Table 55 shows the effect of gender on travel behavior. Again there is little difference between HHs with and without vehicles.

Table 56 shows the effect of employment status on mobility. Again there is no difference between HHs with and without vehicles.

Table 55: SEX OF RESPONDENT AND ITS EFFECT ON TRAVEL (Persons 16 and Older, New York MSA)

	Sex of Respondent	
	Male	Female
% with no Trips		
HH without Vehicles	29.8%	33.6%
HH with Vehicles	25.2%	28.3%
# of Trips per Day		
HH without Vehicles	2.50	2.21
HH with Vehicles	2.54	2.66
Distribution of People		
HH without Vehicles	40.6%	59.4%
HH with Vehicles	50.0%	50.0%

Table 56: EMPLOYMENT STATUS AND ITS EFFECT ON TRAVEL (Non-Retired Persons 16-64, New York MSA)

	Employment Status	
	Worker	Non-Worker
% with no Trips		
HH without Vehicles	18.9%	36.9%
HH with Vehicles	17.6%	40.2%
# of Trips per Day		
HH without Vehicles	2.96	1.99
HH with Vehicles	2.96	2.02
Distribution of People		
HH without Vehicles	64.0%	36.0%
HH with Vehicles	74.4%	25.6%

Appendix B:

Immigration and Vehicle Ownership

In general, new immigrants arrive with lower incomes and different values regarding automobiles, compared to the native born population. This appendix examines the way their vehicle ownership patterns evolve with length of stay.[18]

Table 57 shows the overall picture. Of the 91 million U.S. HHs, 83 million were born here, and 10.7 percent of these HHs are 0-VHHs. Among the 8 million immigrant HHs, 18.5 percent are 0-VHHs. The right hand column shows that the proportion of 0-VHHs declines over time. In fact, length of stay in the U. S. appears to be the strongest predictor of 0-VHH status. This trend is generally consistent in the following immigration tables as well, which show the relation between 0-VHHs status and various demographic categories. (All the tables omit the pre-1970 category. Although it showed large proportions of 0-VHHs, this seemed an artifact of age of householder; older persons in general own fewer cars.)

Table 57: Percentage of Zero Vehicle Households by Householder's Year of Immigration

	Households Without Vehicles	Total Households	Percentage without Vehicle
Total U.S.	9,498,000	91,077,000	11.6%
Born in U.S.	8,011,800	83,059,800	10.7%
Foreign Born	1,486,200	8,017,200	18.5%
Year of Immigration			
1987-1990	155,300	572,800	28.5%
1985-1986	87,700	426,900	22.1%
1982-1984	96,300	513,200	20.9%
1980-1981	113,200	654,800	19.1%
1975-1979	133,000	1,012,100	14.8%
1970-1974	129,400	913,100	16.3%

Does the increase in vehicle ownership, over length of stay, occur because immigrant HHs increase their income, or because they gradually adopt conventional U.S. attitudes toward automobiles? Table 58 shows the pattern of vehicle ownership as a function of HH income. Looking at the first two columns, income less than $10,000 per year, there is no increase in vehicle ownership with length of stay. Even for

[18] Data for these tables comes from the 1990 U.S. Census 1 percent Public Use Microdata Sample (PUMS). The tables were run by Dr. Blair Cohen of the Massachusetts Department of Public Health.

Table 58: ZERO VEHICLE HOUSEHOLDS BY HOUSEHOLDER'S YEAR OF IMMIGRATION AND BY HOUSEHOLD INCOME

	Household Income				
	Under 5,000	5,000 to 9,999	10,000 to 12,499	12,500 to 14,999	15,000 or More
Total U.S.	44.5%	35.9%	19.7%	16.1%	5.0%
Born in the U.S.	43.8%	34.1%	18.2%	14.6%	4.3%
Year of Immigration					
1987-1990	43.9%	41.2%	31.3%	34.6%	20.4%
1985-1986	37.0%	43.4%	27.8%	33.0%	15.7%
1982-1984	48.7%	40.2%	28.5%	16.0%	15.1%
1980-1981	44.6%	43.3%	28.5%	25.6%	12.2%
1975-1979	45.5%	41.6%	23.5%	21.5%	8.8%
1970-1974	50.2%	43.5%	25.5%	25.5%	9.7%

the $10-12.5k column, the increase is very slight. That is, holding income constant, there is no evidence that values shift toward vehicle ownership. Instead, the observed overall shift toward vehicle ownership in Table 57, seems to occur because immigrant groups become richer over time; they transition from the low-income columns of Table 58 to the high-income columns.

Table 59 breaks down the time-patterns by race of householder. Blacks and "Other" start out with the highest 0-VHH proportion, probably reflecting initial income difference across races. Asians show the fastest rate of change, from 26.7 percent to 10.2 percent, probably reflecting faster income growth. Whites and "Other" show the same proportional change over time.

Table 59: Zero Vehicle Households by Householder's Year of Immigration and by Householder's Race

	Race of Householder			
	White	Black	Asian	Other
Total U.S.	8.8%	30.8%	13.8%	21.3
Born in U.S.	8.1%	30.4%	8.9%	15.8
Year of Immigration				
1987-1990	24.7%	46.7%	26.7%	35.6
1985-1986	18.8%	40.6%	16.9%	28.3
1982-1984	16.8%	37.2%	16.4%	26.4
1980-1981	17.2%	31.8%	14.9%	20.5
1975-1979	12.6%	30.9%	10.0%	17.8
1970-1974	13.6%	31.9%	10.2%	19.7

Table 60: ZERO VEHICLE HOUSEHOLDS BY YEAR OF IMMIGRATION AND BY HISPANIC ORIGIN OF HOUSEHOLDER

	Hispanic Origin of Householder					
	Non-Hispanic	Mexican	Puerto Rican	Cuban	Dominican	Other Hispanic
Total U.S.	11.1%	12.6%	43.2%	17.4%	56.5%	19.6%
Born in U.S.	10.6%	11.2%	36.8%	14.4%	37.8%	13.8%
Year of Immigration						
1987-1990	26.9%	24.4%	49.7%	18.9%	56.8%	30.1%
1985-1986	18.9%	20.9%	42.5%	15.4%	60.2%	23.5%
1982-1984	18.4%	16.0%	46.8%	20.3%	62.9%	21.5%
1980-1981	17.3%	14.3%	46.0%	22.0%	54.5%	20.7%
1975-1979	12.6%	10.8%	43.4%	27.2%	54.4%	17.7%
1970-1974	13.4%	9.2%	48.2%	19.9%	60.8%	21.4%

Table 60 shows the patterns for Hispanic groups. Immigrants of Mexican origin show the fastest change in 0-VHH status. While Puerto Ricans, Dominicans, and Cubans show essentially no change over time.

Recent Nationwide Declines in Carpooling

Erik Ferguson, Ph.D., A.I.C.P.

Acknowledgments

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Recent Declines in Carpooling

List of Figures (cont.)

Introduction

Carpooling first appeared on the national scene during the forties, when oil and rubber shortages dictated a more sparing use of private vehicles for personal transportation.[1] After World War II, carpooling was quickly dropped as a national policy concern. Carpooling did not reappear until the mid-seventies, when oil crises, stimulated by the cartelization of the international oil market under the leadership of the Organization of Petroleum Exporting Countries (OPEC), renewed our national interest in alternatives to driving alone.

Carpooling was not viewed at first as a suitable subject for academic discourse in the form of journal articles. The first publications on carpooling as a research topic began to appear in the late seventies, shortly after carpool demonstration projects funded by the Federal Government in the mid-seventies had been reviewed by practitioners and academic pragmatists who first entered the nascent field (Hartgen 1977; Margolin, Misch, and Stahr 1978; Brunso, Kocis, and Ugolik 1979). The late seventies and early eighties were a time of great hope for carpooling enthusiasts. Early studies indicated that carpoolers were almost indistinguishable from those who drove alone in terms of demographic characteristics, making the market for carpooling potentially quite large (Oppenheim 1979).

In the eighties, suburban employment in addition to suburban residences boomed, and carpooling declined (Pisarski 1987). By the end of the decade, the 1990 U.S. Census and the 1990 Nationwide Personal Transportation Survey confirmed that the national stock of carpools had fallen dramatically just as many of the most ambitious and innovative programs to promote increased carpooling had been put in place.

What led to this result? Critics of mandatory trip reduction ordinances pointed to significant social and demographic changes in the composition of the general commuting public and the continuing rapid evolution of automotively inspired urban form in U.S. towns and cities. Increasing numbers of women in the labor force, the baby boomlet, the random scattering of trip destinations among edge cities and other suburban employment activity centers, and the increasingly time compressed and therefore complex travel patterns of urbanites and suburbanites in the eighties and nineties all contributed to the demise of carpooling in the United States.

The observed decline in carpooling was not related in any way, however, to economic principles. Pricing was not relevant to carpool formation. The gradual shift in the dissipation of urban densities and energies toward suburban and exurban areas made it increasingly difficult to find carpool partners. Social and demographic trends toward the nuclearization of ever-smaller families with increasing time commitments made carpooling irrelevant because it was less responsive to the real and pressing travel needs of U.S. families (Edmondson 1993; Edmondson and Jacobsen 1993).

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[1] The spontaneous creation of a jitney industry during World War I was a parallel phenomenon. The success of the transit industry in having jitneys legally banned from operation in almost every American city during or shortly after World War I might then be responsible for carpooling's prominence during World War II. Note that jitneys are remarkably similar to carpools in all respects save one: jitneys always operate publically on a for-hire basis, while carpools almost always are private compacts that are freely entered into.

Historical Comparisons

One of the most amazing things about carpooling is how little is known about it in any systematic or historical context. Auto ownership and vehicle miles of travel have increased almost every year in the United States for almost a century, with small exceptions in the thirties and forties corresponding to the Great Depression and World War II. Transit ridership increased dramatically from the turn of the century until the Great Depression, when falling real incomes made public transit a luxury rather than a necessity. Transit ridership increased dramatically during World War II, only to fall continuously through 1970, with a slight rebound during the seventies and eighties that was basically equivalent to a national policy of transit ridership stabilization. Describing the national evolution of carpooling based on trend analysis using historical data is not possible because the data simply are not available.[2]

The first attempt to measure carpooling at the national level came in 1977 with the second Nationwide Personal Transportation Survey (NPTS). This was followed in 1980 by the U.S. Census of Population[3] and in 1985 by the American Housing Survey (AHS). These are the only national databases that include carpooling as a distinct mode choice. Of these databases, only the NPTS considers travel other than to and from work. The AHS is the most frequently conducted of the three surveys. It is conducted every two years; the NPTS every five to eight years, and the Census every ten years. Even so, it is clear that we are not even at the beginning of an annual time series data base for carpooling that might compare with those that have been and continue to be available for auto, transit, aviation, and freight movements.

According to census journey to work data, carpooling declined from 19.7 percent of all U.S. work trips in 1980 to just 13.4 percent in 1990, a whopping 32 percent decline in ten years (Figure 1). Average vehicle occupancy (AVO) for the work trip as measured by the U.S. Census declined from 1.18 in 1970 to 1.15 in 1980 and 1.09 in 1990. According to NPTS data, work trip AVO remained stable at 1.3 in 1977 and 1983, then fell to 1.1 in 1990 (Hu and Young 1992). According to AHS data, carpooling fell from 13.8 percent in 1985 to 10.8 percent in 1989 (Pisarski 1992). Work trip carpooling rebounded slightly to 11.1 percent in 1991, the latest year for which AHS estimates are available (Figure 2).

U.S. Census, NPTS, and AHS carpooling estimates are far from being consistent with one another in terms of the specific measurements each provides. This is no doubt due to known differences in sampling and survey design or to unknown response biases. The set of carpooling estimates generated by each of the three national carpooling databases, when considered separately from one another, are each internally consistent about one thing: at some point during the mid-eighties, a large decrease in carpooling occurred rather suddenly.

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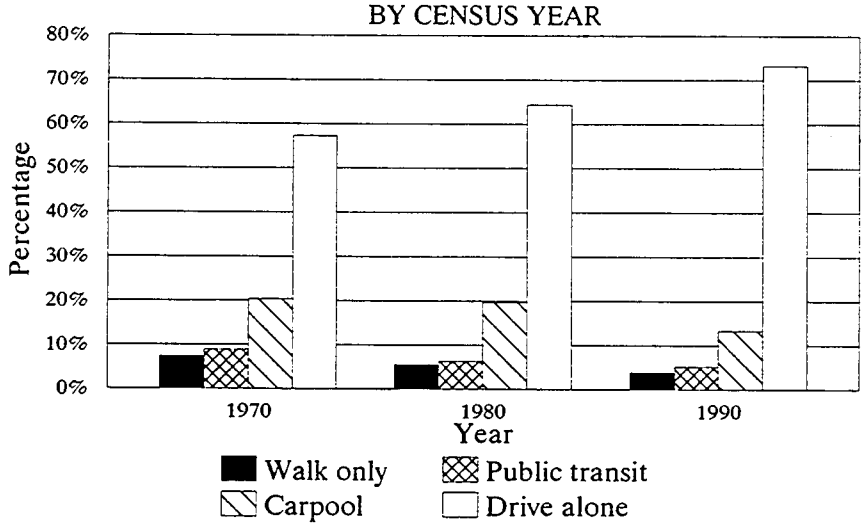
[2] To be fair, even less is known about non-motorized transportation, including bicycling and walking. We have come to define transportation in purely economic terms based exclusively on motorized vehicular movements. The nature of personal travel decisions remains elusive, external to the fare or tariff-based market for vehicular travel.

[3] The 1970 Census of Population was the first to include questions on worktrips. The 1970 Census identified auto-driver and auto-passenger as separate modes. The purpose of this distinction was to measure average vehicle occupancy, defined as person trips by auto divided by vehicle trips by auto. Carpooling was not yet distinguished as a mode of travel in its own right, distinct from driving alone, in 1970.

FIGURE 1

MODE OF TRAVEL TO WORK

BY CENSUS YEAR

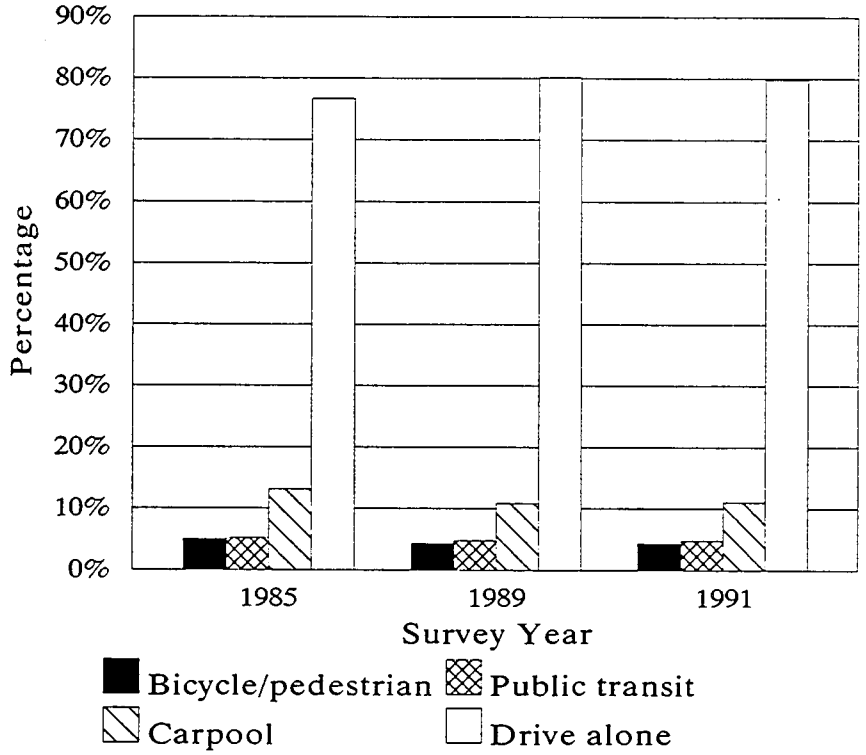


Public transit includes taxicab.
Bicycle was not separately reported in 1970.

FIGURE 2

MODE OF TRAVEL TO WORK

FROM THE AMERICAN HOUSING SURVEY



Bicycle/pedestrian includes motorcycle.

The apparent rapidity with which carpooling declined during the mid-eighties is clearly illustrated in Figure 3. A six-year annual carpooling mode choice time series for the rapidly growing suburban community of Pleasanton, California, is included as an additional reference.[4]

All these data suggest that carpooling was relatively stable throughout the seventies and even during the early eighties. The rapid decline in carpooling in the mid-eighties could have taken place over one, two, or even three years. It is hard to say given the lack of consistent annual data at the national level. Carpooling appears to have stabilized during the late eighties and early nineties, albeit at a much lower level than before.

Carpooling and the Price of Gasoline

What might cause such a massive decline in carpooling over such a relatively short time? One intriguing possibility is purely economic in nature, namely, the price of motor fuel. As Figure 4 shows, average monthly retail gasoline prices increased modestly after the 1973 oil crisis and much more dramatically during the 1979 oil crisis. Beginning in 1982, oil prices began to decline, reaching pre-1979 levels in 1985. During 1986, oil prices fell sharply to well below 1973 levels and, with the exception of a brief period during the Gulf War, have remained there ever since.

The decline in carpooling during the eighties appears to match the decline in oil prices in terms of both timing and relative magnitude. Carpooling declined by 32 percent between 1980 and 1990, while gasoline prices declined by 45 percent. This suggests that the elasticity of demand for carpools with respect to gasoline prices is 0.71, which means that a 100 percent increase in the price of gasoline should result in a 71 percent increase in the share of work trips made by carpools. This compares with typical gasoline price elasticities of demand with respect to vehicle miles of travel of -0.1 (short term) to -0.3 (long term), and with respect to transit ridership of about 0.1. A carpool elasticity of 0.71 appears to be too high. An elasticity of this magnitude would suggest that as gasoline prices increase, vehicle trips will naturally decrease, but person trips might conceivably increase, a result that contradicts intuition.

A focus exclusively on the eighties ignores the fact that carpooling appears to have declined slightly in the seventies, even though the real price of gasoline grew by 64 percent! Clearly, other factors must be involved. If we assume that all other factors are part of more gradual trends such as increasing numbers of women in the labor force and the suburbanization of U.S. major metropolitan areas, it may be possible to estimate the independent effects of highly volatile gasoline prices and more stable social and demographic transformations separately based on the limited data are available.

If we can assume that all other factors change only gradually and are persistent over the longer term, it is easy to assume that such other factors had roughly the same effect on carpooling during the seventies

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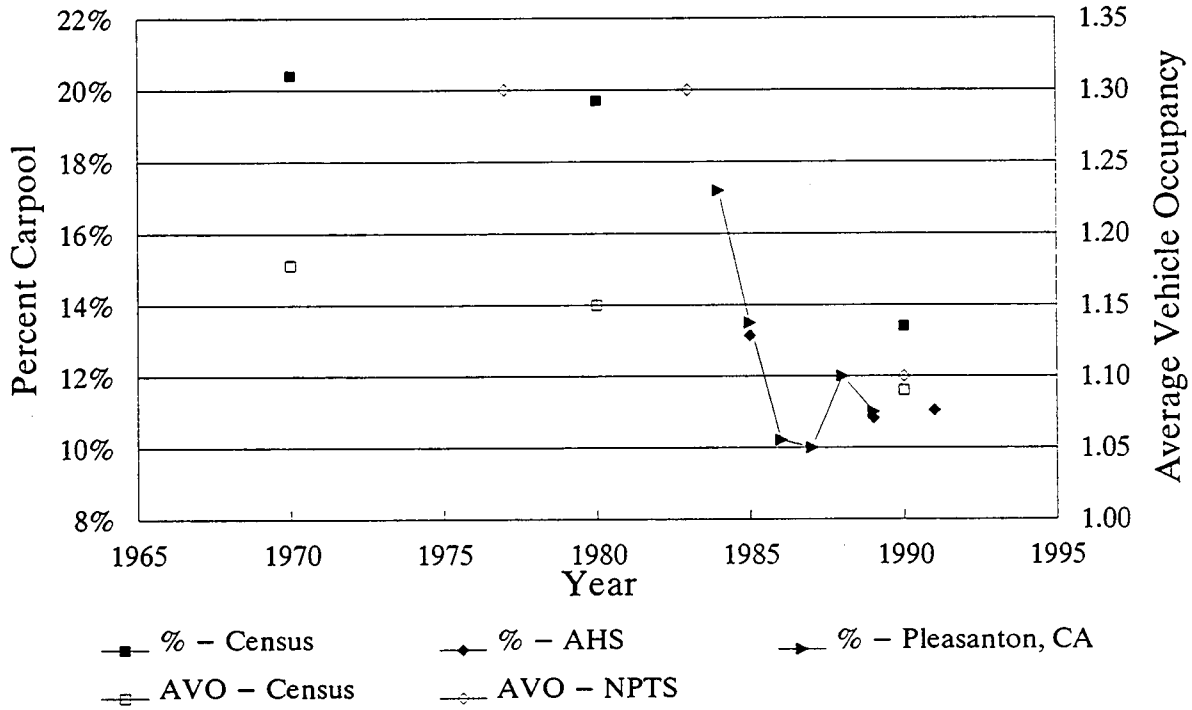
[4] Pleasanton was the first community in the United States to pass a so-called trip reduction ordinance (TRO) into law, which took effect in 1984. The Pleasanton TRO specified certain classes and sizes of employers and developers to offer incentives to employees at certain work sites to choose alternatives to driving alone during the peak morning travel period. In addition, employers were required to document the results of their programs based on annual employee travel behavior surveys. The Pleasanton carpooling estimates in Figure 3 are based on annual survey results for 1984 through 1989. Cervero and Griesenbeck (1988) analyzed the data for 1984 through 1986. The City of Pleasanton publishes an annual report on the status of the TRO that includes performance measures for the preceding five years. The 1984 Pleasanton carpooling estimate is based on a random sample of about 300 commuters. Data for all other years are based on much larger sample sizes (each of which is approximately equivalent to a census of affected employers and their employees) ranging from 10,000 to 20,000 as Pleasanton grew as an employment center.

FIGURE 3

CARPOOLING AND AVERAGE VEHICLE OCCUPANCY

1970-91

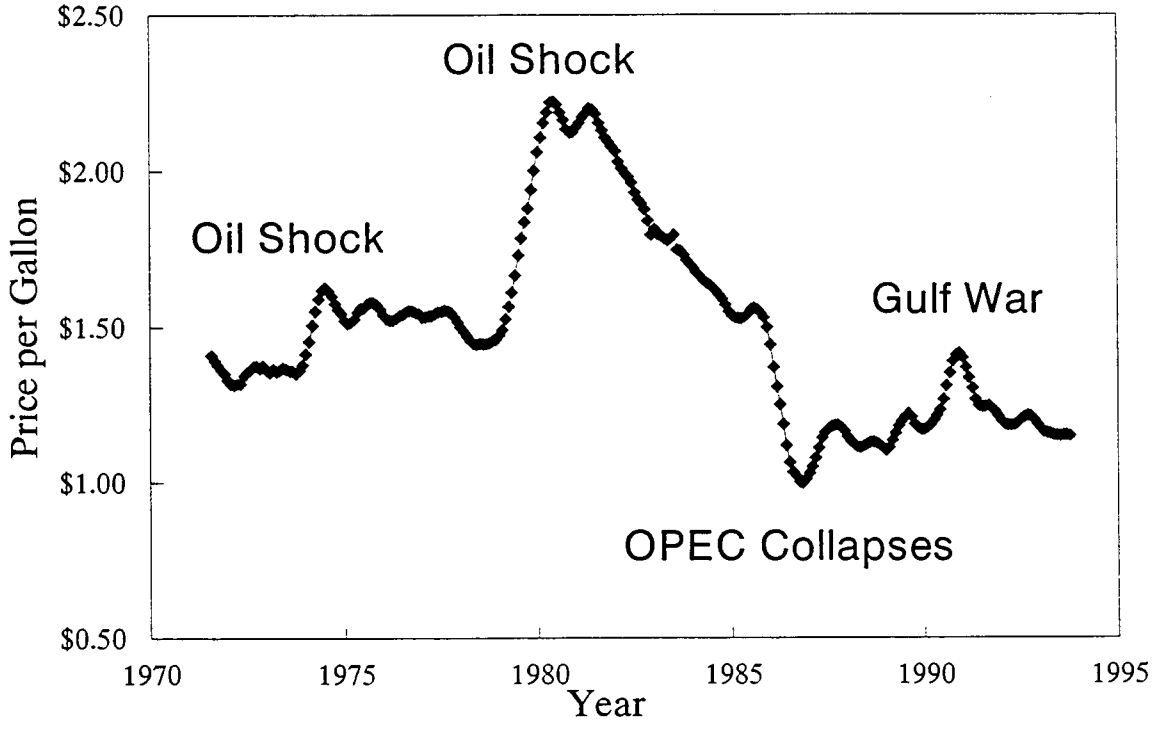


U.S. Census of Population, Nationwide Personal Transportation Study, American Housing Survey, and Pleasanton TRO Annual Survey

FIGURE 4

MONTHLY AVERAGE GASOLINE PRICE

1971-93



Seven month running average.
Price is expressed in constant 1993 dollars.

as these did during the eighties. It is then possible to separate the positive effect of increasing oil prices during the seventies from the negative effect of decreasing oil prices during the eighties using comparative statics. Basically, we have two equations (two decades) and two unknowns (two elasticities). The results are shown in Table 1.

Whether you use the average retail price of gasoline or the marginal cost of motor fuel (which takes increasing fuel economy explicitly into account), the results are quite similar. It appears that the elasticity of demand for carpooling with respect to average retail gasoline prices is actually about 0.25 to 0.35, a much more reasonable range of values, although still surprisingly high. This suggests that during the seventies and eighties, most changes in Vehicle Miles of Travel (VMT) with respect to gasoline price fluctuations probably were compensated for entirely through changes in vehicle occupancy rather than person trips. In other words, personal travel was far less sensitive than vehicular travel to gasoline price changes.

Based on annual data for gasoline prices and fuel economy, and the model implied by the elasticities calculated in Table 1, annual changes in national carpooling can be reconstructed. The reconstructed carpool trend line, shown in Figure 5, appears to match reasonably well with the limited data available from the Census, NPTS, and AHS surveys. It appears that carpooling has gone through several periods of decline, including 1970-1973, 1974-1978, and 1980-1985. The last period of decline was the longest and produced the most dramatic and therefore the most noticeable results. Carpooling since 1986 appears to have stabilized to a large degree, although at a much lower level than during the heyday of transportation systems management in the seventies.

In conclusion, the general trend in work-trip carpooling, after controlling for average retail gasoline prices, has been steadily downward over the last two decades. The estimated 15 to 20 percent average decennial decline in carpooling associated with all other factors is large, because it is an absolute measure of decline, not a relative measure of elasticity. To offset similar declines in carpooling during the nineties, it might be necessary to increase average retail gasoline prices by as much as 45 percent to 80 percent over and above current levels. Put another way, according to these results, a return to 1980 real gasoline prices should be sufficient to maintain carpooling at 1990 levels through the year 2000, assuming that current long-term trends continue. (This could be a tough sell.)

Comparative Statics

In this section, 1990 NPTS data are used to identify current salient characteristics of carpoolers and therefore carpooling in the United States. Appropriate references are added to set these results in a broader context.

Travel Characteristics

Much is known about the characteristics of carpooling as a viable commute option. Little is known about shared rides for other trips. It is clear that trips for social, recreational, and indeed all other purposes enjoy much higher average vehicle occupancy ratios than do trips to and from the workplace. Workers are supposed to carpool with other workers, so that peak period traffic congestion can be reduced. Workers are not supposed to carpool with transit users, bicyclists, or pedestrians because this might result in increased fuel consumption and air pollution.

Remarkably little is known about the composition of shared rides in automobiles for anything other than the work trip. Indeed, it is not clear whether such shared-ride, non-work trips can even be referred to legitimately as carpools. Perhaps a new word should be coined to distinguish the true purpose and meaning of shared rides for other than the work trip.

CARPOOLING GAS PRICE ELASTICITIES

TABLE 1

Background Information	1970	1980	1990	Percent Change 70-80	Percent Change 80-90	Percent Change 70-90
% carpool	20.4%	19.7%	13.4%	-3.4%	-32.0%	-34.3%
gas price ($/gallon)	$1.35	$2.22	$1.22	64.4%	-45.0%	-9.6%
fuel economy (MPG)	14.29	17.80	19.47	24.6%	9.4%	36.2%
marginal fuel cost ($/VMT)	$0.0945	$0.1247	$0.0627	32.0%	-49.8%	-33.7%

Carpool Elasticities and Gasoline Price Effects	Naive Carpool Elasticity 70-80 Only	Naive Carpool Elasticity 80-90 Only	Calibrated Carpool Elasticity 70-80 and 80-90	Calibrated "Other" Effect 70-80 and 80-90	Estimated Gasoline Price Effect 70-80	Estimated Gasoline Price Effect 80-90
gas price ($/gallon)	-5.3%	71.0%	26.1%	-20.2%	16.8%	-11.7%
marginal fuel cost ($/VMT)	-10.7%	64.3%	34.9%	-14.6%	11.2%	-17.4%

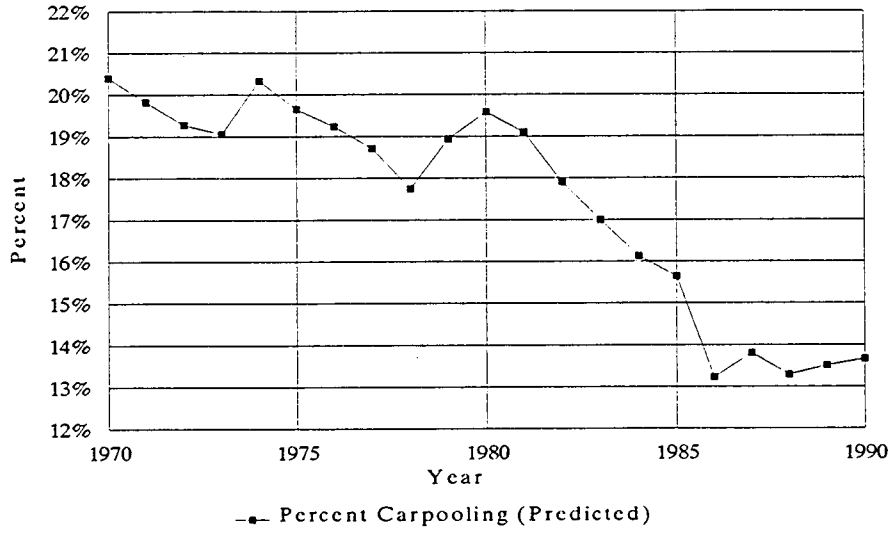
Fuel Economy Elasticities and Gasoline Price Effects	Naive MPG Elasticity 70-80 Only	Naive MPG Elasticity 80-90 Only	Calibrated MPG Elasticity 70-80 and 80-90	Calibrated "Other" Effect 70-80 and 80-90	Estimated Gasoline Price Effect 70-80	Estimated Gasoline Price Effect 80-90
gas price ($/gallon)	38.1%	-20.8%	13.9%	15.6%	9.0%	-6.3%
marginal fuel cost ($/VMT)	76.7%	-18.9%	18.6%	18.6%	6.0%	-9.3%

Gasoline Price Increase Required to Offset Trends and Maintain 1990 Carpool Rate in 2000		Offset Carpool Trend	Offset MPG Price Effect	Offset MPG Trend Effect	Restore 1980 Carpool Rate	Restore 1970 Carpool Rate
relative price increase		41.8%	2.8%	9.0%	107.8%	10.0%
additive price increase		$0.51	$0.03	$0.11	$1.31	$0.12
final gasoline price		$1.73	$1.76	$1.87	$3.19	$3.31
fuel economy (MPG)		24.11	24.21	24.55	28.67	29.05

FIGURE 5

CARPOOLING FOR THE WORK TRIP

THROUGH THE YEARS



Mode Choice by Trip Purpose

Oppenheim (1979) stated that only 10 percent of U.S. commuters carpooled during the seventies, quoting Hartgen (1977) as his principal source for this assertion.[5] Oppenheim went on to argue that shared rides were even less common for trip purposes other than commuting. Neither of these statements was factually correct then, nor is either true today. The statement concerning non-work travel is particularly strange considering that AVO is much lower for work trips than it is for non-work trips, now as it was then (Hu and Young 1992).[6]

Carpooling, broadly defined as any shared-ride, private vehicle trip, was the dominant mode of transportation in the United States for all personal travel as late as 1990, with a combined mode share of 48.7 percent versus a mere 47.2 percent for driving alone, based on NPTS data (Figure 6).[7] The opposite is true for the lonely work trip: only 16.3 percent of work commuters carpool, according to 1990 NPTS data. The work trip is unusual in other respects as well. Carpools for the work trip are far less likely to involve household members and far more likely to include exactly one other person than shared rides for any other trip (Figure 7). Workers are twice as likely to drive alone or to use public transit, but only half as likely to walk or ride bicycles, as are all other types of travelers combined.

Trip Accompaniment by Transportation Technology

Carpooling has been defined traditionally as sharing the ride to work in a private motorized vehicle. No prior research of which this author is aware has undertaken to explore whether or not transit users, bicyclists, or pedestrians are ever accompanied by others on their trips and if so, by whom. By focusing on work travel exclusively, we see that, in fact, workers are sometimes accompanied on their trips to work using any or all available transportation modes, not just the private automobile. Transit users, pedestrians, and bicyclists are only about half as likely as auto users to be accompanied on their trip to work by someone else. When carpooling in autos was more common than it is now, this ratio may have been significantly different. Because no data are readily available on carpooling using other modes prior to 1990, this can only be surmised (Figure 8).

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[5] The true figure was probably closer to 20 percent at all times during the seventies. Perhaps Oppenheim was referring to the percentage of carpoolers who were passengers rather than drivers, relying on the 1970 Census as his source. Hartgen (1977), his sole source for the 10 percent figure, may have measured carpooling only in New York State, or some smaller region. Oppenheim's erroneous figure of 10 percent was later quoted as gospel by Daniels (1981). Daniels ended his article with the cheery thought that his results and those of all others who had gone before him, were inconclusive and contradictory. According to Daniels, no universal pattern in carpooling was ever likely to be established.

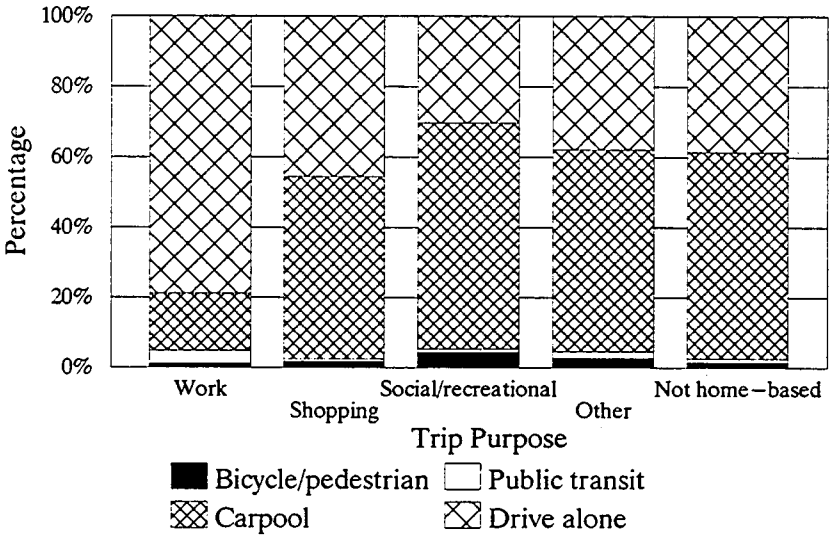
[6] Assuming NPTS data on AVO for work and non-work travel were unavailable or generally not well known prior to publication, this glaring error might be forgiven, or at least explained.

[7] It should be noted that, even though 1990 Census and 1990 NPTS data are consistent in terms of AVO estimates, these data are inconsistent with respect to work-trip, mode-share estimates. NPTS work-trip data underestimate bicycle, pedestrian, and transit trips and overestimate drive alone and carpool trips in comparison with Census data. Household weights are used in the NPTS data to reflect known geographical sample biases. These household weights do not adequately reflect unknown sample biases associated with variations in travel behavior. Although the use of these weights moves sample mode shares in the direction of Census estimates, the movement is slight, and the discrepancy between Census and NPTS estimates remains correspondingly large. For this reason, raw (unweighted) sample data are used throughout this analysis to reflect more closely what the sample actually has to offer in terms of behavioral insights.

FIGURE 6

MODE OF TRAVEL

BY TRIP PURPOSE

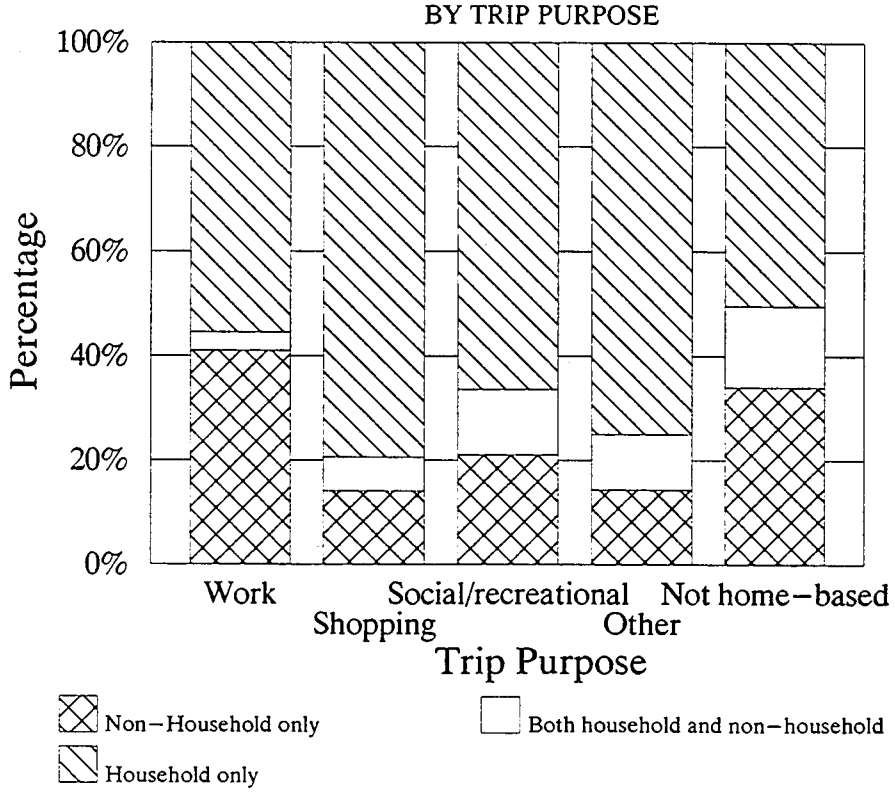


All trips are home–based unless otherwise indicated.

FIGURE 7

CARPOOL COMPOSITION

BY TRIP PURPOSE



All trips are home–based unless otherwise indicated.

FIGURE 8

TRIP ACCOMPANIMENT

BY MODE OF TRAVEL

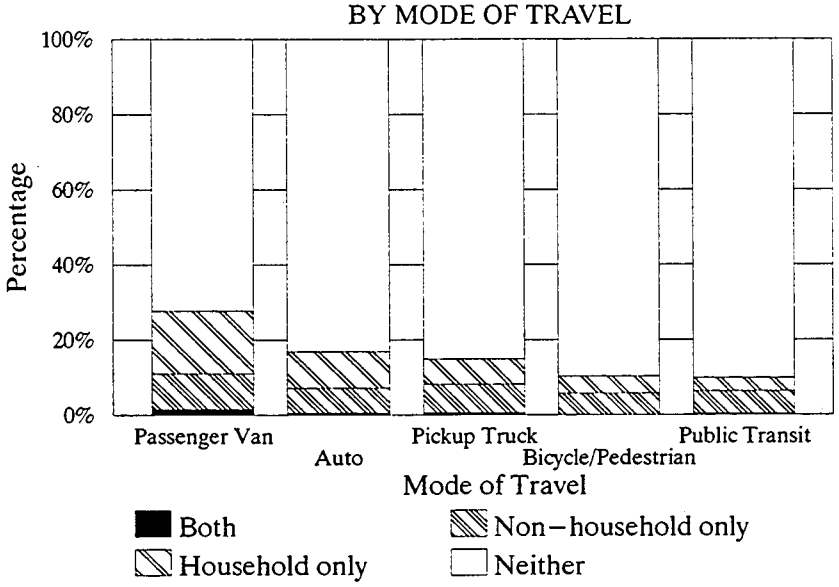
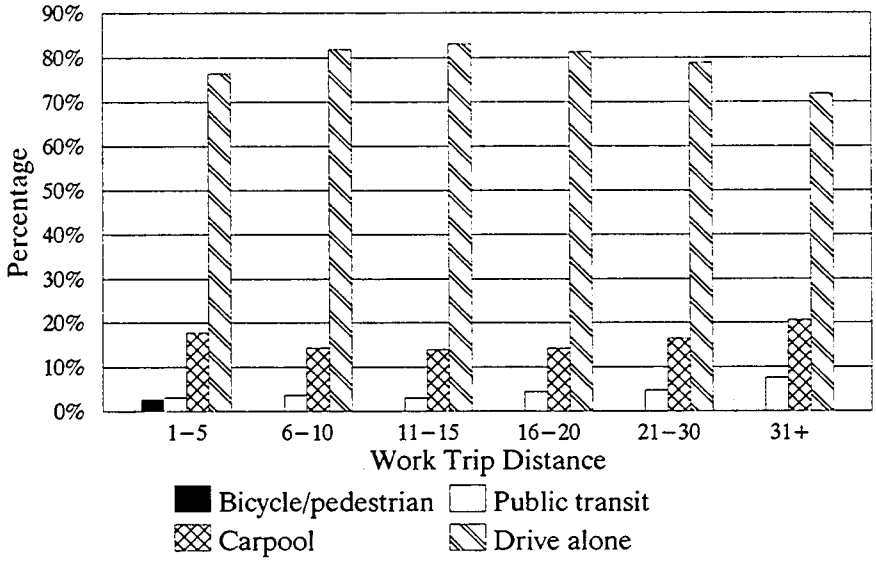


FIGURE 9

MODE OF TRAVEL TO WORK

BY WORK TRIP DISTANCE



Transit users, bicyclists and pedestrians are rarely accompanied on their trip to work by household members. These alternative transportation mode users are almost as likely as auto users to be accompanied by non-household members on the journey to work. Carpooling rates vary by type of private vehicle. Pickup truck drivers are less likely than auto drivers to travel with others. Passenger van drivers are much more likely than auto drivers to be accompanied by others. Carpooling today is not the exclusive domain of any particular commuter group separated by their preferences for different transportation modes. Any type of transportation technology can and will be used for group travel, with or without household members, at least on occasion.

Urban Characteristics

There has been conjecture but little evidence that carpooling increases with trip distance, firm size, and population density (Oppenheim 1979).[8]

Work-Trip Distance

Daniels (1981), Richardson and Young (1982), Teal (1987), and Cervero and Griesenbeck (1988) found that carpooling increases linearly with trip distance and/or time. Ferguson (1991b) showed that carpooling decreases with distance for trips of less than 10 miles, increases with distance for trips of 10 to 35 miles, and decreases with distance for trips longer than 35 miles in Orange County, California.

The 1990 NPTS data reveal that transit use increases and non-motorized transportation decreases steadily with distance, a similar relationship to that shown by Dasgupta, Frost, and Spence (1988) for the cities of Manchester and Sheffield in Great Britain. Nationwide, carpooling decreases with distance for work trips of less than 15 miles and increases with distance for work trips of 16 miles or more (Figure 9). The percentage of carpools comprised of non-household members increases linearly with distance. Drive-alone mode split mirrors that of carpooling, first increasing with distance and then decreasing. Household-based carpools apparently compete most effectively with non-motorized transportation as a substitute for driving alone in the short work-trip market. Non-household-based carpools compete most effectively with public transit in the long work-trip market. Alternatives to driving alone are least competitive for work trips of medium length.

Firm Size

Oppenheim (1979), Ferguson (1985), Cervero and Griesenbeck (1988), and Ferguson (1990b) agree that the propensity to carpool increases with firm size. Daniels (1981) and Ferguson (1986, 1990a) also agree that larger firms are more likely to offer carpool incentives to their employees. Ferguson (1991b) found that urbanized counties with low average firm sizes had above average resident commuter carpool rates. Ferguson (1991b) concluded that smaller firms tend to locate on the periphery of urbanized areas, to compete indirectly for qualified employees with larger, more centrally located firms by offering shorter commutes.

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[8] His sole source for these three rather complex and interrelated assertions is a single report from Alan M. Voorhees & Associates to the Secretary of Transportation in 1974. Given the urgency in the timing of the report, it is likely that Oppenheim's assertions are based more on theoretical speculations than on confirmation through hypothesis testing using valid experimental controls or real empirical data.

The 1990 NPTS data do not include any variables describing firm characteristics such as size, industry, or location. The 1977 and 1983 NPTS data did include the industrial classification of employers for all workers. Ferguson (1991a) showed that manufacturing and government employees were significantly more likely to carpool than those employed in other industries. Manufacturing tends to be more concentrated than other industries, and the public sector tends to be more concentrated than the private sector. The Federal Government is by far the largest employer in the country. These results support the notion that industrial concentration lends itself, albeit indirectly, to carpool formation.

Geographic Location

Teal (1987) suggested that non-metropolitan (rural) residents were more likely than others to carpool based on his analysis of 1977 NPTS data. Hartgen and Bullard (1993) used 1980 and 1990 Census data to show that rural residents of North Carolina were more likely to carpool than urban residents of that state. Matthews (1993) also used Census data and found that the greatest decline in Georgia carpooling during the eighties occurred in the ring of rapidly growing suburban counties around Atlanta (Figure 10). Most other authors have been silent on the topic of geographic location and carpooling, perhaps because so much previous research has been in the form of case studies, focusing on urban, suburban, or rural settings, but not all three simultaneously.

According to 1990 NPTS data, mode choice is moderately to strongly influenced by geographic location, while carpool composition is only weakly affected, if at all (Table 2). Public transit and non-motorized transportation are used most frequently in central cities, least often outside urban areas. Carpooling is most common outside urban areas and least common inside urban areas, but outside the central city.[9] Carpooling has been championed as the savior of the suburbs, at least in terms of alternative modes of travel (Orski 1985 and 1987), because public transit and non-motorized transportation are not options there. These results suggest that public transit and non-motorized transportation may be more viable in suburban communities than was previously thought. In addition, carpooling may not be a workable alternative in edge cities.

Size of Urban Area

Hartgen (1977) and Oppenheim (1979) both asserted that carpooling increased with urban size. Teal (1987) demurred, with a table of carpooling by Standard Metropolitan Statistical Areas (SMSA) size using 1977 NPTS data that showed a weak negative relationship or, as Teal would have it, none at all. Ferguson (1991a) used multiple nonlinear logit regression analysis, to demonstrate that the relationship between carpooling and SMSA size was negative and significant in both 1977 and 1983.

As expected, the use of public transit and non-motorized transportation increased with urban area size in 1990 (Table 3). In addition, among auto commuters, carpooling also increased continuously with urban size. Ferguson (1991a) captured the effect of urban location with his SMSA size variable, a statistical artifact. Oppenheim's assertion regarding a positive urban size effect is then correct, although the measured effect appears to be quite small.

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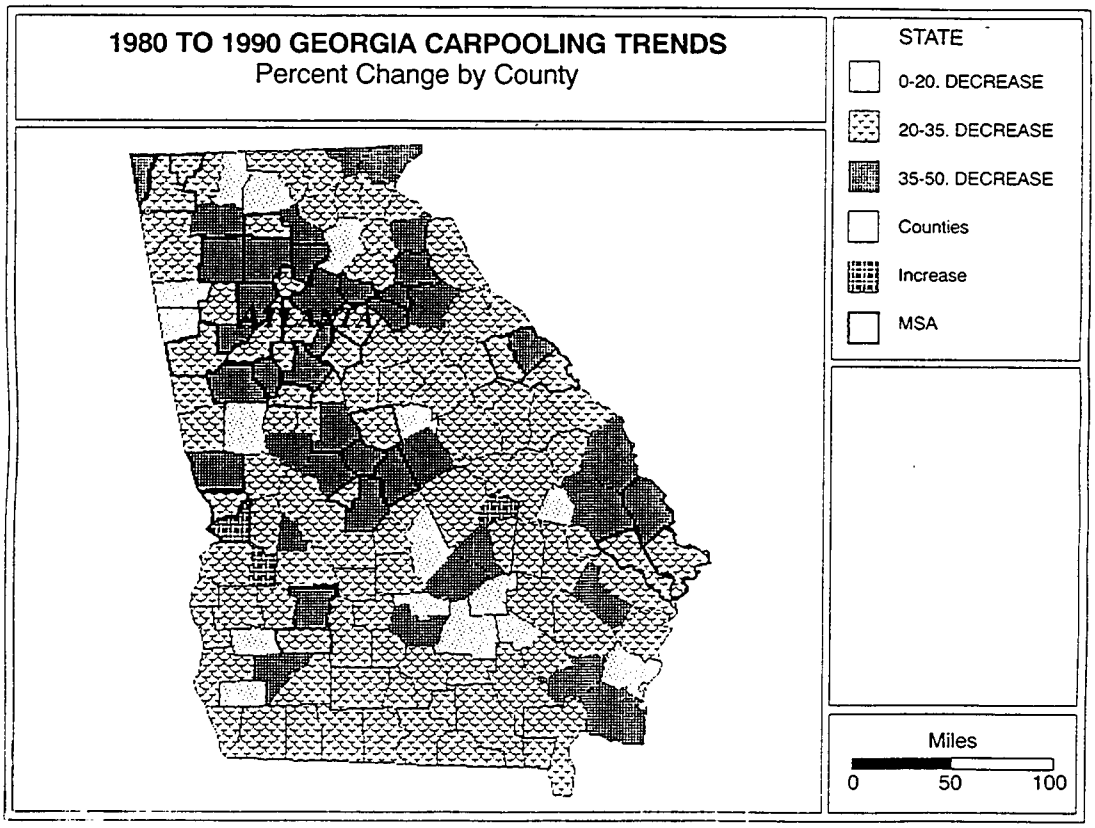
[9] A common, if somewhat loose, definition of "the suburbs."

Figure 10



MODE OF TRAVEL AND CARPOOL COMPOSITION BY GEOGRAPHIC LOCATION

TABLE 2

	Geographic Location				
Mode of Travel	Urban--Inside Central City	Urban--Outside Central City	Not Urban	Total	Percent
Drive Alone	74.36%	81.53%	80.82%	22,552	78.79%
Carpool	16.51%	14.05%	17.99%	4,664	16.29%
HH	9.24%	8.23%	10.35%		
Non-HH	7.27%	5.82%	7.64%		
Transit	7.19%	3.40%	0.50%	1,057	3.69%
Nonmotorized	1.94%	1.02%	0.68%	350	1.22%
Total	9,929	8,590	10,104	28,623	100.00%
Percent	34.69%	30.01%	35.30%	100.00%	
CP/(DA+CP)	***18.2%***	***14.7%***	***18.2%***		
Carpool Composition					
HH Only	54.42%	56.92%	55.50%	2,581	55.34%
Both HH and Non-HH	3.05%	3.31%	4.07%	164	3.52%
Non-HH Only	42.53%	39.77%	40.43%	1,909	40.93%
Total	1,639	1,207	1,818	4,664	100.00%
Percent	35.14%	25.88%	38.98%	100.00%	

Note: home-based work trips only

MODE OF TRAVEL AND CARPOOL COMPOSITION BY URBAN AREA SIZE

TABLE 3

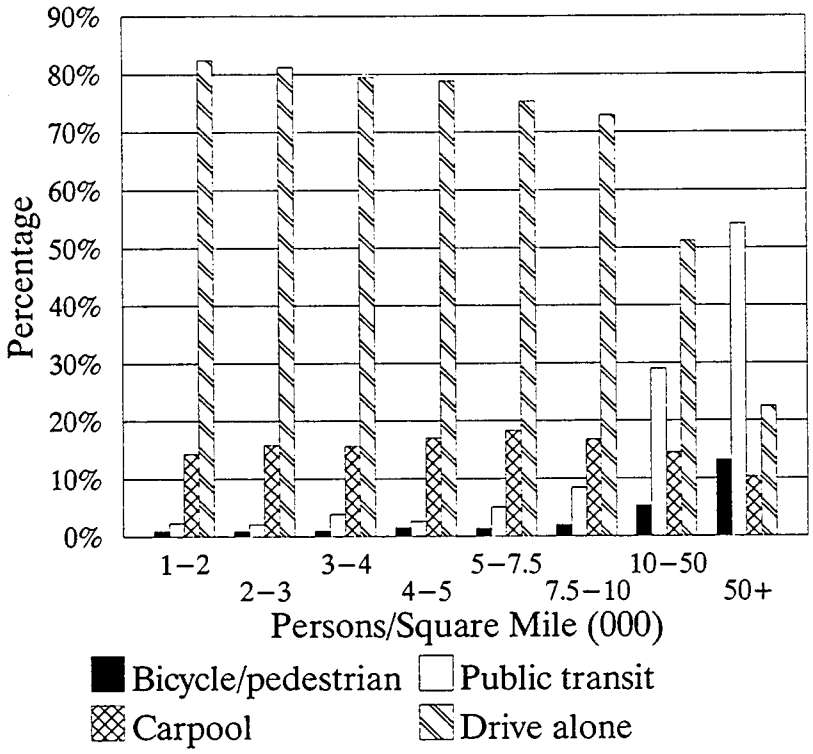
	Urban Area Size						
Mode of Travel	50,000-199,999	200,000-499,999	500,000-999,999	1,000,000+ Without Rail	1,000,000+ With Rail	Total	Percent
Drive Alone	83.41%	82.24%	81.20%	80.10%	70.45%	14,386	77.68%
Carpool	13.88%	15.67%	16.19%	16.12%	14.91%	2,846	15.37%
HH	8.03%	9.28%	9.49%	9.84%	7.76%		
Non-HH	5.85%	6.39%	6.70%	6.28%	7.15%		
Transit	1.41%	1.29%	1.79%	2.66%	12.19%	1,006	5.43%
Nonmotorized	1.30%	0.80%	0.82%	1.13%	2.46%	281	1.52%
Total	2,616	1,627	3,298	4,708	6,270	18,519	100.00%
Percent	14.13%	8.79%	17.81%	25.42%	33.86%	100.00%	
CP/(DA+CP)	***14.3%***	***16.0%***	***16.6%***	***16.8%***	***17.5%***		
Carpool Composition							
HH Only	55.92%	57.65%	57.49%	59.42%	50.37%	1,579	55.48%
Both HH and Non-HH	3.86%	3.14%	2.25%	3.29%	3.32%	90	3.16%
Non-HH Only	40.22%	39.22%	40.26%	37.29%	46.31%	1,177	41.36%
Total	363	255	534	759	935	2,846	100.00%
Percent	12.75%	8.96%	18.76%	26.67%	32.85%	100.00%	

Note: home-based work trips only

FIGURE 11

MODE OF TRAVEL

BY MSA POPULATION DENSITY



Population Density

Oppenheim (1979) asserted that carpooling increased with population density, basing his argument entirely on Voorhees (1974). Most other authors have been silent on this important relationship, perhaps due to lack of data. Ferguson (1991a) included residential density terms in his 1977 and 1983 carpool regression equations, but neither was found to be statistically significant.[10]

Using truer measures of population density, it turns out that public transit and, to a lesser extent, non-motorized transportation increase continuously with Metropolitan Statistical Areas (MSA) population density (Figure 11). Carpooling also increases with population density but much more modestly, and only at lower population densities. Above 5,000 persons per square mile, carpooling begins to decline in absolute terms. Relative to driving alone, carpooling increases continuously, even at the highest population densities.

MSA population density is measured categorically in the 1990 NPTS data, with much wider ranges used to describe the highest population densities. Treating these categorical range descriptions as actual point estimates located at the midpoint of each such range, we see that all the modal relationships are roughly linear (Figure 12). Elasticities of demand for particular modes can be measured as the slope of each line. It is clear that carpooling is less sensitive to population density than driving alone, public transit, non-motorized transportation, or even carpool composition.

The median MSA population density in the 1990 NPTS sample appears to be between 3,000 and 4,000 persons per square mile. The average population density in the 1990 NPTS sample would probably come in at about 5,000 to 7,000 persons per square mile. If the median population density were somehow increased to the current mean value, carpooling would probably benefit as much as or more than either public transit or non-motorized transportation. Above the current mean population density, carpooling begins to decline overall, even though it continues to increase relative to driving alone.

Outside MSAs, a different picture emerges. As non-MSA population density increases above about 500 persons per square mile, a similar set of relations to those observed for MSAs appears, with driving alone decreasing and carpooling, public transit, and non-motorized transportation increasing in terms of modal split (Figure 13). Below 500 persons per square mile, driving alone increases and carpooling decreases with increasing population density. Public transit and non-motorized transportation are largely unaffected by population density in such sparsely settled regions. Carpooling neither gains nor loses relative to driving alone, from changes in public transit and non-motorized transportation outside MSAs because these modes are relatively insignificant at all non-MSA population densities.

Neither mode split nor carpool composition are particularly sensitive to variations in population density outside MSAs (Figure 14). It appears that higher than average density non-MSA regions emulate lower than average density MSAs in terms of modal characteristics, and in fact these two types of regions often are contiguous.

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[10] Ferguson defined residential density as the number of units in the building occupied by the commuter. This is obviously only a rough estimate for the true population density of surrounding residential areas, so it is not too surprising that it was not significant. This was the only thing to a measure of density available in either of the earlier two NPTS databases.

FIGURE 12

MODE OF TRAVEL AND CARPOOL COMPOSITION

BY MSA POPULATION DENSITY

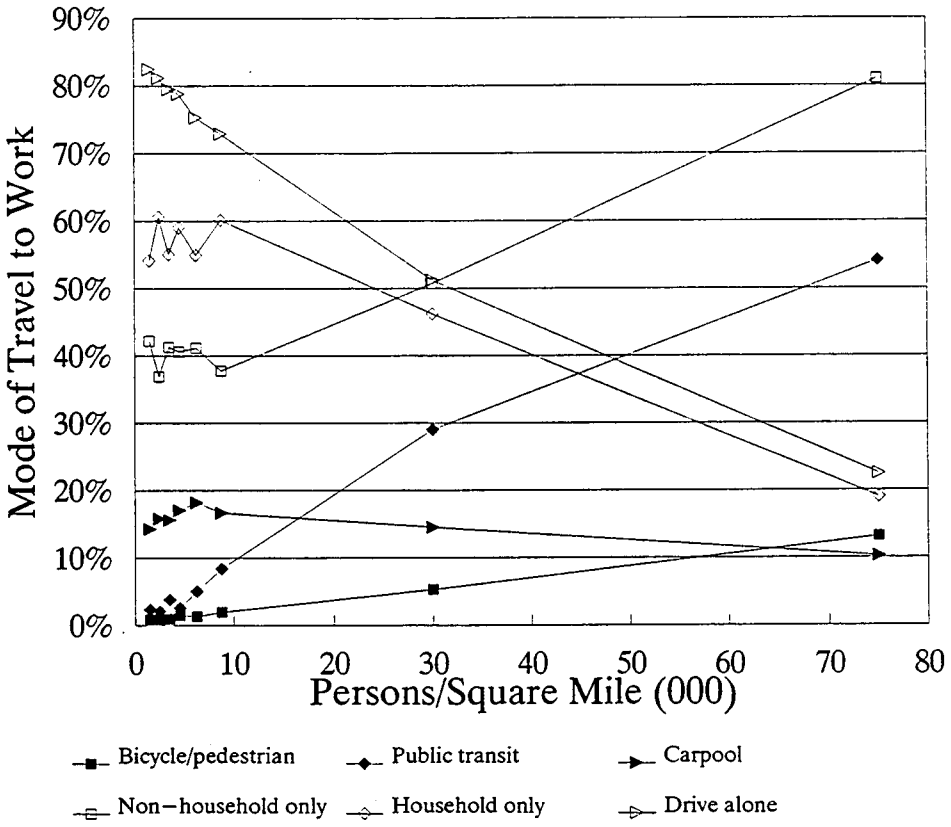


FIGURE 13

MODE OF TRAVEL

BY NON−MSA POPULATION DENSITY

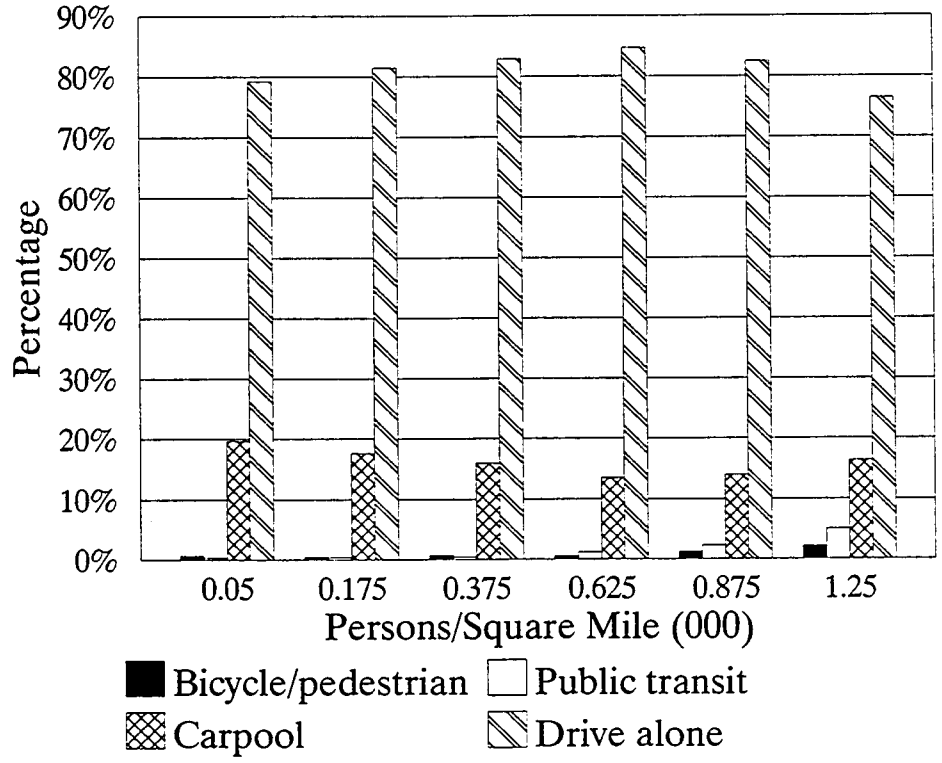


FIGURE 14

MODE OF TRAVEL AND CARPOOL COMPOSITION

BY NON-MSA POPULATION DENSITY

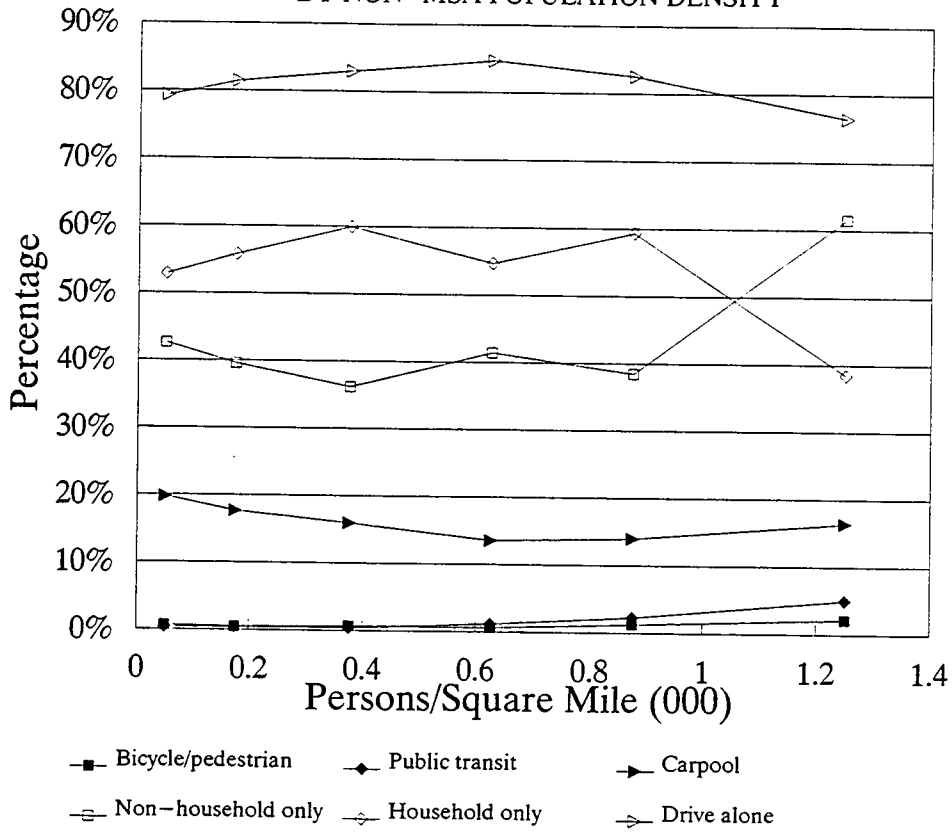
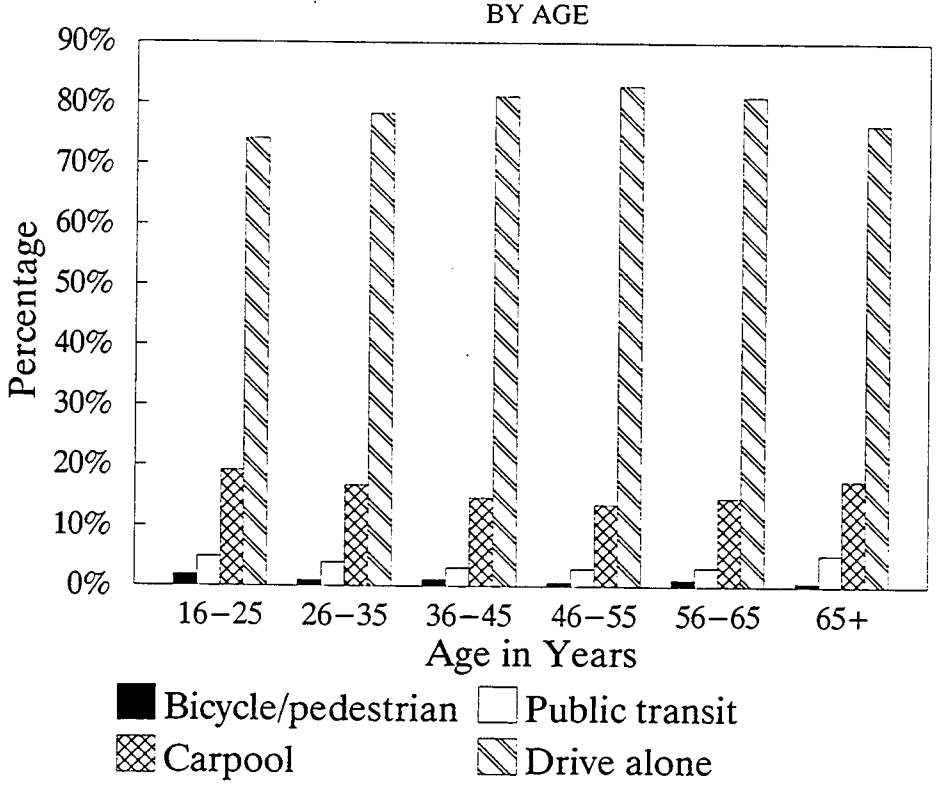


FIGURE 15

MODE OF TRAVEL

BY AGE



Social and Demographic Characteristics

Oppenheim (1979) reported that age, income, gender and ethnicity were all completely unrelated to carpooling, citing Davis (1975) as his sole source. In general, however, most published studies have ignored the effects of demographic variables on carpooling, either stating or implicitly assuming that prior studies had demonstrated adequately that no such effects existed. This assumption is clearly mistaken, however, as can and will be shown using 1990 NPTS data.

Tischer and Dobson (1979) reported that commuters who drove alone to the Los Angeles central business district (CBD) and who indicated having a higher than average propensity to switch to carpooling under appropriate conditions were more likely to be young, female, and black, with lower family incomes than those drive-alone commuters who showed little propensity to switch modes. Gensch (1979) reported that commuters who drove alone on the Santa Monica Freeway during the infamous Diamond Lane experiment and who indicated having a higher than average propensity to switch to public transit under appropriate conditions were more likely to be young, female, and Hispanic, with lower family incomes than those drive-alone commuters indicating little desire to switch modes. Both of these seminal Southern California case studies dealt with stated rather than revealed preferences for alternatives to driving alone. Neither study necessarily reflects the underlying attitudes, beliefs, preferences, or choices of the general population of the United States.

Age

Teal (1987) dismissed the effects of most demographic variables on carpooling and did not even mention age. He is not alone, for most authors neither confirm nor deny that they even looked at age as a determinant of or covariant with mode choice. Ferguson (1991a) showed a statistical association between age and carpooling which is negative and highly significant, based on non-linear regression analysis of 1977 and 1983 NPTS data.

Although statistically significant, the relationship between age and carpooling is not compelling (Figure 15). Driving alone to work increases gradually while all major modal alternatives decrease gradually with age from about 16-25 up to 46-55. Beyond middle age, when the average worker typically reaches his or her peak performance and earning power, driving alone decreases, carpooling and public transit use increase, and non-motorized transportation remains largely unaffected. Because there are fewer workers in the later age groups, the effect of their changing modal preferences has less of an impact on linear regression estimates, which are dominated by more numerous younger workers. As the general population continues to age, these older workers will become more important. Future older workers may be less likely to change drive-alone habits than are current older workers, especially if the health of older workers continues to improve and their earning power is maintained at a higher level.

Highest Educational Attainment

Education has been ignored in the literature on carpooling, even more emphatically than has been age. The only source I found was Teal (1987), who refers to Horowitz and Sheth (1978) as:

> ...a well-designed study of Chicago commuters [that] found that sex, income, education and the number of automobiles and licensed drivers in the household did not distinguish between carpoolers and those who drove alone.

Of course, the title of Horowitz and Sheth's (1978), "Ride Sharing to Work: An Attitudinal Analysis," might lead one to believe that they were not looking for significant demographic variables in the first place. Nonetheless, it has become an article of faith in the ridesharing (also known as travel demand management,

or TDM) industry that carpoolers are almost indistinguishable from those who drive alone, which suggests, on the positive side, that there is a large aggregate market potential. However, on the negative side, specific characteristics that could be used for targeted marketing of ride sharing have generally been ignored.

Teal (1987) goes on to show that income and vehicles per worker are indeed significant determinants of carpooling, while gender (jointly with marital status) is not, using 1977 NPTS data. Teal somehow forgot to demonstrate that education, like gender, was not significantly related to carpooling in his analysis. Ferguson (1991a) showed that there is a negative and moderately significant statistical association between education and carpooling, based on nonlinear regression analysis of 1977 and 1983 NPTS data. Specifically, Ferguson found that those auto commuters who had attended at least some college were less likely to carpool than those who had not.

There appears to be a more powerful relationship between education and carpooling, based on 1990 NPTS data (Figure 16). The 10 percent of 1990 NPTS sample commuters who possess less than a high school diploma are much different than those who have high school diplomas or college educations.[11] This relatively uneducated group are twice as likely to carpool, bicycle, or walk as are all others combined.

Among the 90 percent of commuters in the 1990 NPTS sample who possess at least a high school diploma, driving alone and the use of public transit and non-motorized transportation all increase with higher educational achievement. Only carpooling declines with education above the high school level. Whereas 17 percent of commuters with high school diplomas carpool, only 14 percent of commuters with some college education carpool and only 11 percent of commuters with some graduate school carpool. As education increases above the high school level, the propensity to carpool with strangers declines steadily as well. Education is one of the few demographic variables to show any kind of systematic relationship with carpooling. (However, observed variations in carpooling with respect to education may be an economic effect masquerading as a demographic effect.

Annual Household Income

Oppenheim (1979) argued that income had no effect on the propensity to carpool. Tischer and Dobson (1979) and Gensch (1979), using disaggregate data, found that the propensity to switch from driving alone to carpooling or public transit under the influence of suitable modal incentives was higher for individuals with lower incomes. Teal (1987) found that carpooling was more prevalent among lower income groups. In particular, Teal (1987) found that when the ratio of out-of-pocket drive-alone commuting costs exceeded 5 percent of average family income per worker, the propensity to carpool increased by a factor of 2 or 3. Ferguson (1991a) found that family income was unrelated to the likelihood of carpooling after controlling for other variables through multiple regression. Hartgen and Bullard (1993) and Matthews (1993), using aggregate data, found that the percentage of commuters who carpooled decreased significantly with per capita income at the county level in the states of North Carolina and Georgia using 1990 Census data.

As Figure 17 shows, the 1990 NPTS data indicate that carpooling declines with income at lower income levels, but is largely unrelated to income at higher income levels. Workers living in households with annual family incomes of less than $30,000 show large increases in driving alone and even larger relative

---

[11] The U.S. Census revealed that 25 percent of the population aged 25 or over lacked high school diplomas in 1990. Since only 10 percent of commuters in the 1990 NPTS sample revealed lacking this credential, therefore, this population is underrepresented in NPTS, or people lacking this credential are reluctant to admit not having their high school diploma or its equivalent to telephone surveyors who are not related to the Census.

FIGURE 16

MODE OF TRAVEL

BY EDUCATION

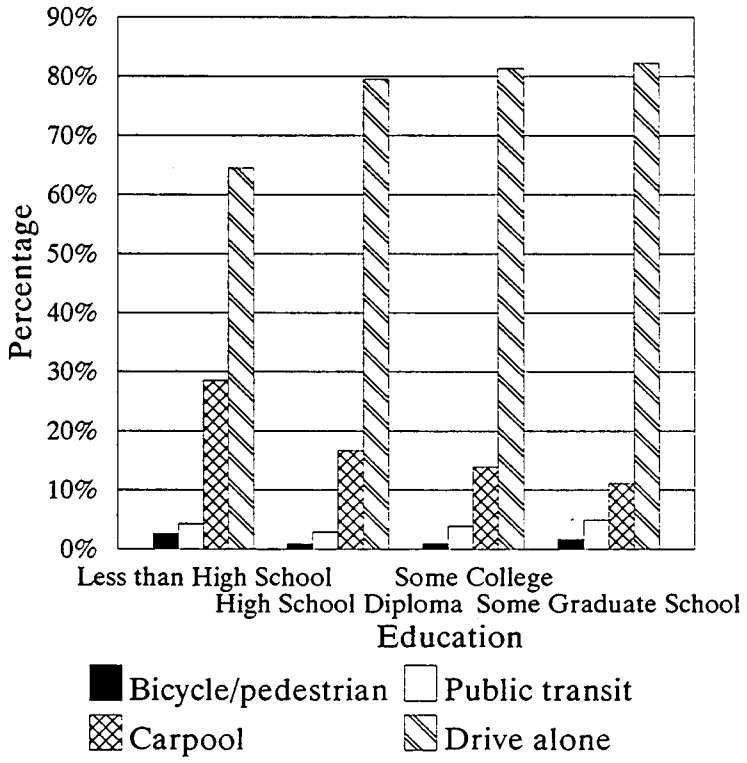
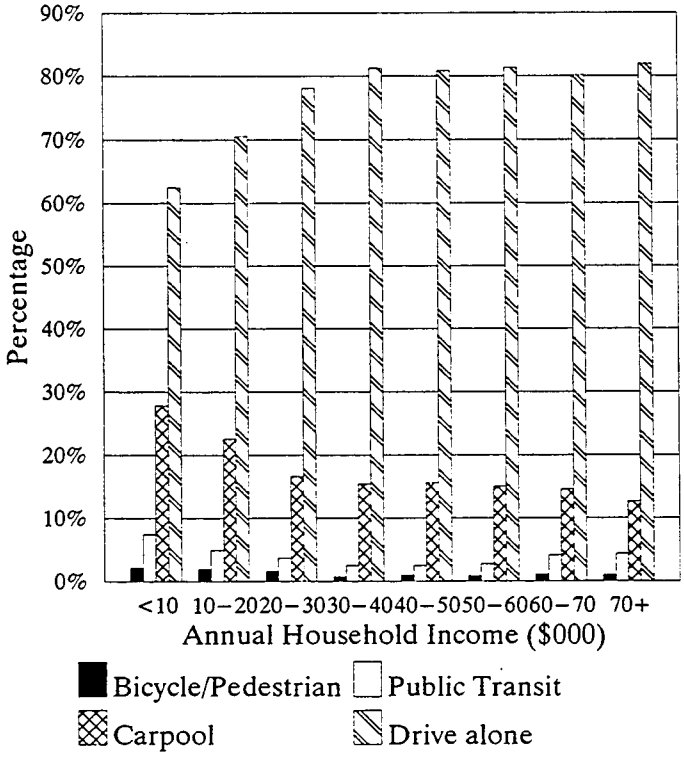


FIGURE 17

MODE OF TRAVEL

BY ANNUAL HOUSEHOLD INCOME



decreases in carpooling, public transit, and non-motorized transportation use as income increases from $0 to $30,000. Workers living in households with family incomes of $30,000 or more show almost no change in driving alone as income increases, although there is some slight substitution of public transit for carpooling at the highest income levels. Workers living in households with family incomes of less than $20,000 are somewhat more likely than their higher income counterparts to carpool with non-household members.

Workers living in households with family incomes below the poverty line are more than twice as likely as workers living in households with family incomes above the poverty line to carpool or to use public transit or non-motorized transportation to get to work (Table 4). Workers living in households with family incomes above or below the poverty line are equally likely to carpool with other household members. Workers living in households with family incomes near the poverty line are much more likely to carpool with non-household members. This is probably a statistical artifact of some sort (or an economic necessity).

It would appear that Teal's budget-constrained commuters are roughly equivalent to workers living at or below the poverty line. Workers from lower income households are more likely to choose alternatives to driving alone, particularly when the cost of living (including the cost of commuting) is taken into account. Workers living in households with family incomes well above the poverty line appear to make their commuting choices based mainly on considerations other than household budget constraints. All of the standard urban modes of travel are affordable to this group, which constitutes fully 93 percent of the 1990 NPTS sample.[12] The findings of Hartgen and Bullard (1993) and Matthews (1993) appear to reflect variations in location decisions rather than mode choices as these relate to family income and the cost of living in different places.

Gender

Oppenheim (1979) argued that gender was unrelated in any way to carpooling. Subsequent researchers were far from silent on this demographic issue, almost unanimously agreeing that female and/or clerical workers were significantly more likely to carpool than male and/or professional and managerial workers (Tischer and Dobson 1979; Gensch 1979; Teal 1987; Cervero and Griesenbeck 1988; Dasgupta, Frost, and Spence 1988).

Much of the research on gender and travel behavior has focused on trip length rather than mode of travel (Madden 1981; Hoffman and Beck 1983; Michaelson 1985; Hanson and Johnston 1985; Singell and Lillydahl 1986). Women travel shorter distances to work than men, often but not always to accommodate the travel needs of small children.

Teal (1987) showed that married females were more likely to carpool than unmarried females, married males, or unmarried males. He argued that the relationship was statistically insignificant, based on a chi-square test of a two-by-four outcome matrix. Ferguson (1991a), using the same data structure but a different analysis method (multiple regression), showed that married females were significantly more likely to carpool than unmarried females, married males, or unmarried males in 1977. Ferguson (1991a) further demonstrated that married males or females were significantly more likely to carpool than single males or females in 1983.

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[12] According to the 1990 Census, 13 percent of the U.S. population were living in poverty. The 1990 NPTS sample appears to significantly underrepresent this group.

MODE OF TRAVEL AND CARPOOL COMPOSITION BY HOUSEHOLD POVERTY LEVEL

TABLE 4

Mode of Travel	Annual Household Income in Relationship to Poverty Level Based on Local Cost of Living: Below	Near	Above	Total	Percent
Drive Alone	56.86%	66.06%	79.88%	17,329	78.78%
Carpool	32.49%	25.15%	15.63%	3,610	16.41%
HH	19.04%	11.37%	9.27%		
Non-HH	13.45%	13.78%	6.36%		
Transit	8.30%	6.26%	3.39%	796	3.62%
Nonmotorized	2.35%	2.53%	1.11%	263	1.20%
Total	554	831	20,613	21,998	100.00%
Percent	2.52%	3.78%	93.70%	100.00%	
CP/(DA+CP)	***36.4%***	***27.6%***	***16.4%***		
Carpool Composition					
HH Only	56.11%	43.54%	57.53%	2,045	56.65%
Both HH and Non-HH	5.00%	3.35%	3.54%	130	3.60%
Non-HH Only	38.89%	53.11%	38.93%	1,435	39.75%
Total	180	209	3,221	3,610	100.00%
Percent	4.99%	5.79%	89.22%	100.00%	

Note: home-based work trips only

MODE OF TRAVEL AND CARPOOL COMPOSITION BY SEX OF PERSON

TABLE 5

Mode of Travel	Sex: Male	Female	Total	Percent
Drive Alone	81.09%	75.95%	22,548	78.79%
Carpool	14.01%	19.11%	4,664	16.30%
HH	6.92%	12.29%		
Non-HH	7.09%	6.81%		
Transit	3.60%	3.81%	1,057	3.69%
Nonmotorized	1.30%	1.12%	350	1.22%
Total	15,790	12,829	28,619	100.00%
Percent	55.17%	44.83%	100.00%	
CP/(DA+CP)	***14.7%***	***20.1%***		
Carpool Composition				
HH Only	48.01%	62.23%	2,588	55.49%
Both HH and Non-HH	2.76%	4.20%	164	3.52%
Non-HH Only	49.23%	33.56%	1,912	40.99%
Total	2,212	2,452	4,664	100.00%
Percent	47.43%	52.57%	100.00%	

Note: home-based work trips only

Cervero and Griesenbeck (1988) used multiple regression analysis to show that professional and managerial workers constituting about 25 percent of the total work force in suburban Pleasanton, California were significantly less likely to carpool, significantly more likely to have flexible work hours, and significantly less likely to commute during non-peak periods than all other workers. Although women constituted over 60 percent of the work force in Pleasanton during the mid-eighties, Cervero and Griesenbeck (1988) failed to address the role of gender in mode choice, although they do mention it explicitly as a factor in the location of corporate "back" offices, where administrative functions not requiring direct interaction with customers often are performed.

Rosenbloom and Burns (1993) found that women were more likely than men to drive alone in Tucson, Arizona. This is the only example of a study with results showing that women are more likely to drive alone than men. Although Tucson women earned lower salaries and held lower status occupations on average, they nonetheless were more likely to drive alone than men and less likely to carpool, use public transit, or ride bicycles to work.

As Table 5 shows, the 1990 NPTS data indicate that female workers are about 35 percent more likely than male workers to carpool. Male workers are almost 50 percent more likely than female workers to carpool with non-household members. The use of public transit and nonmotorized transportation for the work trip varies little with gender in the NPTS data. Females are 5 percent more likely than males to use public transit. Males are 15 percent more likely than females to use nonmotorized transportation. Overall, these results support the finding of most previous research that females are less likely to drive alone and more likely to use alternative modes to go to work.

At least three hypotheses have been offered in the past as possible explanations for differences observed between men and women in terms of individual travel behavior:

- The first hypothesis is gender-based and may be primarily psychological in nature as it relates to mode choice and travel behavior. Men and women differ from one another physically, mentally, and emotionally in many ways. Perhaps one should not expect men and women to behave the same under similar circumstances all or even most of the time.
- The second hypothesis is purely economic in nature. Men tend to earn higher salaries on average than do women, even in the same occupation, with the same basic quality of education and the same number of years of relevant work experience. Any and all observed travel behavior differences between men and women might be explained in terms of personal and household income or expenditure differentials.
- The third hypothesis is role-based and may combine elements of psychology and/or economics. Men and women may carry out much different roles and responsibilities within particular households. For example, even after one controls for family income and employment status women may still be more likely to nurture infants, raise children, maintain households or go shopping. Even if men and women do not differ fundamentally in terms of either psychological profiles or economic well-being, they may still differ in terms of the travel behavior associated with their daily routines and activity patterns.

The issues raised by these three competing hypotheses will be addressed in the following sections.

Household Life-cycle Characteristics

The "life cycle" of a household is defined traditionally as a categorical variable based on the number of adults (1 or 2+), the age of the youngest child (none, <6, 6-15, 16-21) and whether a retired person is living in the household. Oppenheim (1979) argued that workers later in their life-cycle (i.e., as their children grew to adulthood) would become more amenable to carpooling. Although later authors discussed

household characteristics such as number of persons, household workers, and/or vehicles in relationship to carpooling, only Oppenheim referred explicitly to the household life cycle as a possible determinant of carpool formation.

A preliminary analysis of the 1990 NPTS data revealed that the life-cycle variable did indeed appear to be related quite meaningfully to mode choice for the work trip. However, the number of adults and the presence of children appear to operate more or less independently of one another in terms of their individual effects on mode choice. For this reason, the discussion of the effects of life-cycle characteristics on mode choice is presented here in two parts, one regarding adults and the other children.

Number of Adults in Household

Ferguson (1991a) showed that the likelihood of carpooling increased with the number of adults in the household. The number of working adults had a much larger positive impact than did the number of nonworking adults. Other authors have argued that the likelihood of carpooling increases with the total number of persons in the household (Oppenheim 1979) or with the number of workers only (Tischer and Dobson 1979; Teal 1987).

As Table 6 shows, workers in multiple-adult households were 35 percent more likely than those in single-adult households to carpool. Most of this increase came from the adults in the public transit and nonmotorized transportation categories, not from those workers driving alone. Workers in single adult-households were almost twice as likely as those in multiple-adult households to carpool with non-household members. Nonetheless, 30% of all single adult household workers who carpooled did so with household members, who presumably must have been children.

Figure 18 shows an interesting interaction between gender and the number of adults in the household. Men and women are remarkably similar in terms of mode choices, once the number of adults in the household is a controlled variable.[13] Workers in single-adult households are more likely than those in multiple-adult households to drive alone. Men are more likely than women to drive alone. However, men and women in single- and multiple-adult households are about equally likely to use non-motorized transportation, public transit, and non-household carpools.

The sole difference between men and women in either single- or multiple-adult households involves apparent trade-offs between driving alone and household-based carpools. Female workers in single-adult households are four times as likely as male workers in single-adult households to form household-based carpools. Female workers in multiple-adult households are only twice as likely as male workers in multiple-adult households to form household-based carpools. These results suggest that role differences may be more important than either psychological or economic differences in explaining gender variations in travel behavior.

Age of Youngest Child in Household

Ferguson (1991a) showed that the likelihood of carpooling decreased with the number of children in the household.[14] No one else has modeled this relationship explicitly, although many have argued that child-care needs limit the ability of women to participate in formal carpool programs offered by employers

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[13] Particularly given that female workers are 70 percent more likely than male workers to reside in single adult households.

[14] The estimated effect of the number of children on carpooling was negative in both 1977 and 1983 but statistically significant only in 1977.

MODE OF TRAVEL AND CARPOOL COMPOSITION BY NUMBER OF ADULTS IN HOUSEHOLD

TABLE 6

	Number of Adults			
Mode of Travel	1	2+	Total	Percent
Drive Alone	79.63%	78.64%	22,431	78.76%
Carpool	12.50%	16.86%	4,654	16.34%
HH	3.63%	10.12%		
Non-HH	8.87%	6.74%		
Transit	5.72%	3.41%	1,050	3.69%
Nonmotorized	2.15%	1.09%	347	1.22%
Total	3,393	25,089	28,482	100.00%
Percent	11.91%	88.09%	100.00%	
CP/(DA+CP)	***13.6%***	***17.7%***		
Carpool Composition				
HH Only	27.83%	58.23%	2,581	55.46%
Both HH and Non-HH	2.36%	3.64%	164	3.52%
Non-HH Only	69.81%	38.13%	1,909	41.02%
Total	424	4,230	4,654	100.00%
Percent	9.11%	90.89%	100.00%	

Note: home-based work trips only

FIGURE 18A

MODE OF TRAVEL

BY NUMBER OF ADULTS IN HOUSEHOLD AND SEX

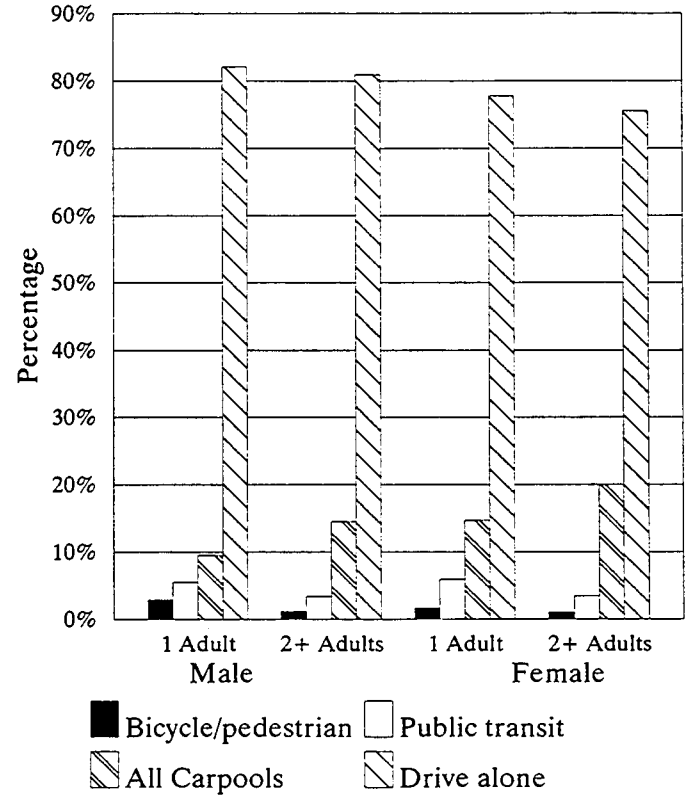
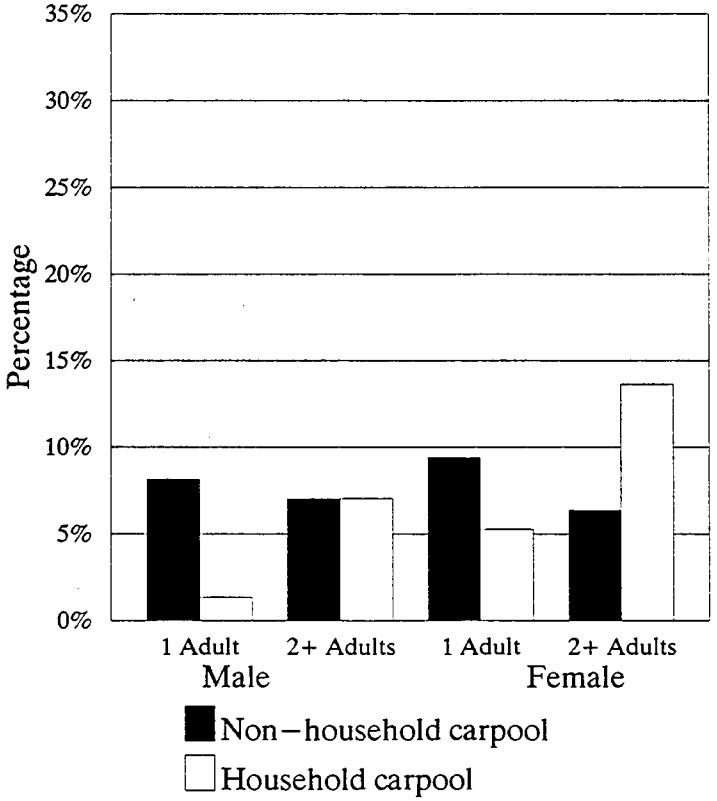


FIGURE 18B

CARPOOL COMPOSITION

BY NUMBER OF ADULTS IN HOUSEHOLD AND SEX



under regional air quality regulations and local trip reduction ordinances (Rosenbloom and Burns 1993; Edmondson 1993; Orski 1994).

Table 7 shows that workers in households with children of any age exhibit a greater propensity to carpool. Among workers who carpool, those with children exhibit a greater propensity to carpool with other household members. As the youngest child in the household increases in age, these effects are lessened somewhat but not eliminated entirely. Workers in households with young children requiring pre-school child care are most likely to carpool and most likely to carpool with other household members. Of course, many of these household carpoolers may be children traveling to day care or school rather than to work. The traditional definition of a carpool includes two or more adults traveling together with a common trip purpose, if not indeed a common destination. This definition would exclude a shared ride for any trip purpose other than work as a "serve passenger" trip combined with a drive-alone work trip in a bi-level trip chain that manages to change travel mode, trip purpose, and final destination.[15]

In Figure 19, we see an interaction effect between gender and the presence of children in the household. Men and women are almost identical in terms of travel behavior, if there are no children or retirees present in the household. Female workers with small children in the household are more than three times as likely as women with no children to carpool with fellow household members; there is almost no difference between these two groups of women in terms of non-household carpooling. Male workers with small children are 50 percent more likely than men with no children to carpool with other household members and 25 percent more likely to carpool with non-household members.

Women are much more likely than men to serve the travel needs of small children. Men appear to be slightly more likely to travel with strangers (presumably in the stranger's car) so that women will have an auto available to serve their small children's needs. The presence of older children in the household has a similar effect, but it is far less pronounced for either gender. Male and female workers respond similarly to the presence of children in the household, but females make adjustments more frequently. These results provide further evidence to support the hypothesis that gender differences in travel behavior are the result of differences in gender roles, not economics.

Racial or Ethnic Background of Head of Household

Oppenheim (1979) asserted that ethnicity had no effect on carpooling. Most other authors have remained silent on this issue. Tischer and Dobson (1979) found that blacks had a higher propensity to switch to carpooling from driving alone. Gensch (1979) found that Hispanics had a higher propensity to switch to public transit from driving alone. Both of these studies deal with stated rather than revealed preferences, however.

Figure 20 shows that ethnicity and mode choice are indeed related. Whites are more likely than all other ethnic groups to drive alone to work. Blacks are more likely than all other ethnic groups to use

[15] In Minneapolis, Minnesota, a controversy recently arose as to whether or not small children destined for child care facilities qualified as carpool members during the rush hour in a high occupancy vehicle (HOV) lane of a highway leading in to the CBD. The eventual policy decision was in the affirmative. Children cannot be excluded from consideration for the purposes of determining vehicle occupancy, regardless of whether the benefit relates to the original intent or purpose of the HOV facility, namely, traffic reduction or congestion relief.

MODE OF TRAVEL AND CARPOOL COMPOSITION BY AGE OF YOUNGEST CHILD IN HOUSEHOLD

TABLE 7

	Presence of Children						
Mode of Travel	None--Active	Youngest <6	Youngest 6-15	Youngest 16-21	None--Retired	Total	Percent
Drive Alone	81.47%	74.08%	77.93%	79.29%	76.26%	22,431	78.76%
Carpool	12.60%	21.88%	17.76%	17.27%	18.09%	4,654	16.34%
HH	6.29%	14.62%	10.27%	9.86%	8.95%		
Non-HH	6.31%	7.26%	7.49%	7.41%	9.14%		
Transit	4.49%	3.02%	3.17%	2.59%	4.28%	1,050	3.69%
Nonmotorized	1.44%	1.02%	1.14%	0.84%	1.36%	347	1.22%
Total	12,194	5,703	6,587	2,970	1,028	28,482	100.00%
Percent	42.81%	20.02%	23.13%	10.43%	3.61%	100.00%	
CP/(DA+CP)	***13.4%***	***22.8%***	***18.6%***	***17.9%***	***19.2%***		
Carpool Composition							
HH Only	48.60%	64.58%	55.73%	55.75%	48.39%	2,581	55.47%
Both HH and Non-HH	2.67%	4.49%	4.19%	2.73%	2.15%	164	3.52%
Non-HH Only	48.73%	30.93%	40.09%	41.52%	49.46%	1,909	41.03%
Total	1,536	1,248	1,170	513	186	4,653	100.00%
Percent	33.02%	26.82%	25.14%	11.02%	4.00%	100.00%	

Note: home-based work trips only

FIGURE 19A

MODE OF TRAVEL

BY AGE OF YOUNGEST CHILD IN HOUSEHOLD AND SEX

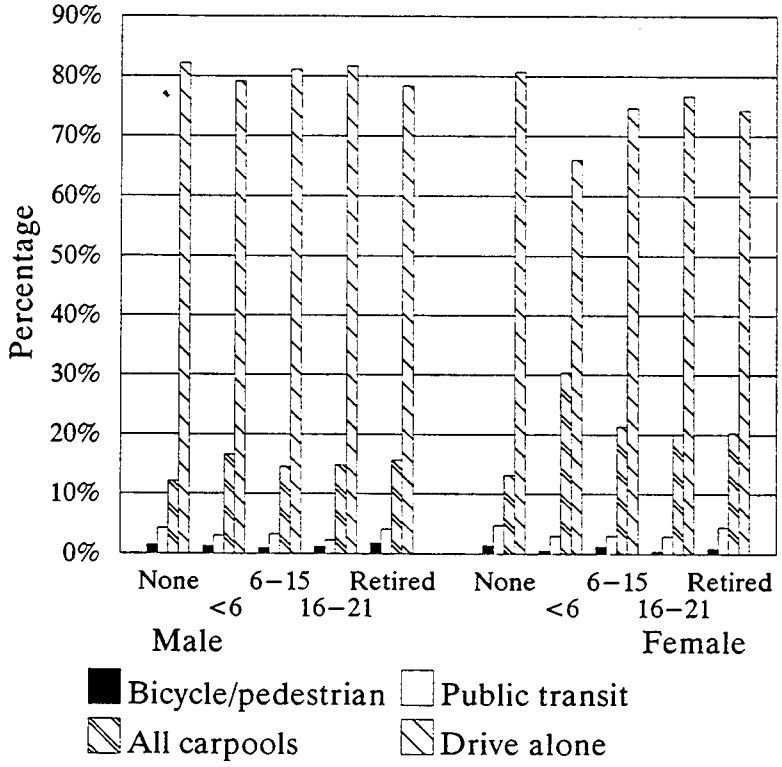
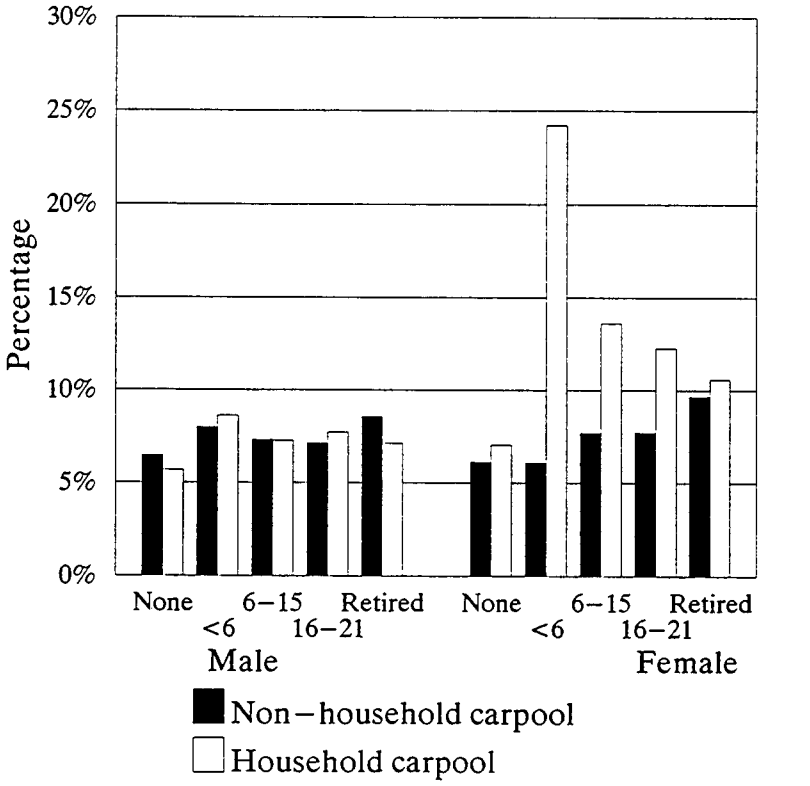


FIGURE 19B

CARPOOL COMPOSITION

BY AGE OF YOUNGEST CHILD IN HOUSEHOLD AND SEX



public transit to get to work. Hispanics are more likely to carpool to work.[16] Members of other racial or ethnic groups ("others") are least likely overall to carpool with non-household members.[17]

It appears from a cursory examination of the data that the influence of ethnicity on mode choice can be explained almost entirely as a function of differences in family income and/or residential location. Whites generally have the highest incomes and are most likely to live in the suburbs. The fact that whites are most likely to drive alone and least likely to use any other alternatives should come as no surprise. Blacks have lower family incomes and are less likely to live in suburbs than whites. Blacks are least likely to drive alone, most likely to use public transit, second most likely to carpool, and third most likely to use nonmotorized transportation.

Hispanics are more likely to drive alone and less likely to use public transit than blacks, which may be the result of economic factors. Hispanics are perhaps somewhat more likely than blacks to live in suburbs. Other ethnic groups position somewhere between whites, on the one hand, and blacks and Hispanics, on the other hand, in terms of family incomes, residential location decisions, and observed travel behavior.[18]

What is odd about Figure 20 is the proportion of carpools composed of non-household members. Black carpoolers are the most likely to share rides with non-household members, followed closely by white, Hispanic, and other carpoolers.[19] In aggregate terms, non-household carpools are most common among blacks and Hispanics. Household-based carpools are most common among Hispanics and others. Despite an overall greater than average propensity to carpool, blacks are least likely to carpool with both household and non-household members simultaneously. These results do not lend themselves to explanations based on either family income or residential location. It appears that social and cultural variations among ethnic groups do influence some aspects of mode choice for the work trip.

Gender and Ethnicity

A look at the relationship between gender and ethnicity provides further interesting clues but still no easy answers (Figure 21). White males and white females are practically identical to one another, at least in terms of mode choice for the work trip. Overall, men are more likely than women to carpool with non-household members and to use nonmotorized transportation, while women are more likely than men to use public transit. Exclusively among whites, men and women are equally likely to use each of these three modes of travel go to and from work. White women are more likely than white men to carpool with household members, and white men are correspondingly more likely than white women to drive alone to work. That is the sole difference between white men and women in terms of mode choice for the journey to work. This seems to reflect gender roles within the household as they relate to the travel needs of dependent children.

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[16] Hispanics are defined here to include whites, blacks, and others of Hispanic origin. Thus, whites and blacks as defined here include non-Hispanic whites and blacks only.

[17] The "other" category here is defined to include anyone who is not white, black, or Hispanic. This category may include Asians, Pacific Islanders, Native Americans, Eskimos, or those who failed to specify their ethnic origin by claiming to be "other" rather than refusing to answer the question outright.

[18] Recent immigrants in this group may bear greater similarities to blacks and Hispanics in terms of average incomes and residential location, with a high concentration in central cities. Asians who have been in the United States for some time (for example, several generations) often bear greater similarities in economic and demographic characteristics to whites than to recent Asian immigrants.

[19] This is odd because blacks and whites are somewhat similar in terms of non-household carpool formation. One would expect much greater differences given variations in household income and residential location.

FIGURE 20A

MODE OF TRAVEL

BY HEAD OF HOUSEHOLD RACE/ETHNICITY

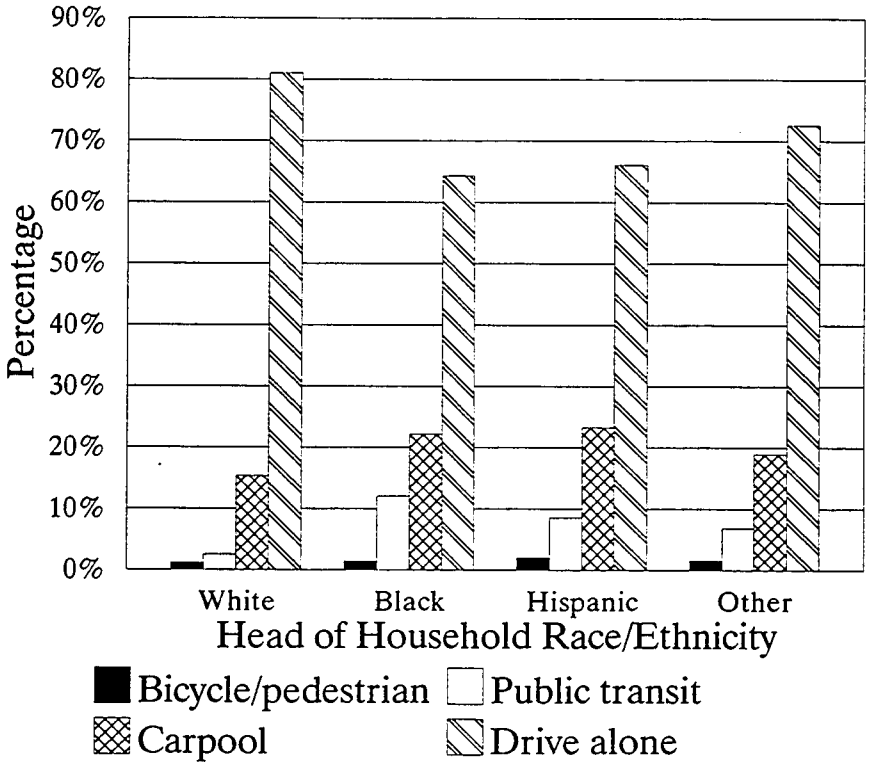


FIGURE 20B

CARPOOL COMPOSITION

BY HEAD OF HOUSEHOLD RACE/ETHNICITY

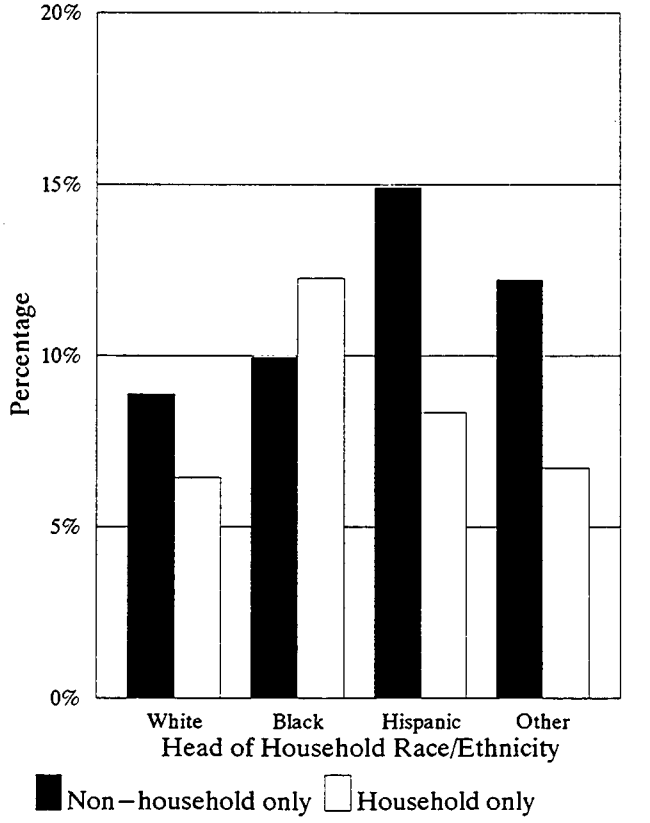


FIGURE 21A

MODE OF TRAVEL

BY ETHNIC BACKGROUND AND SEX

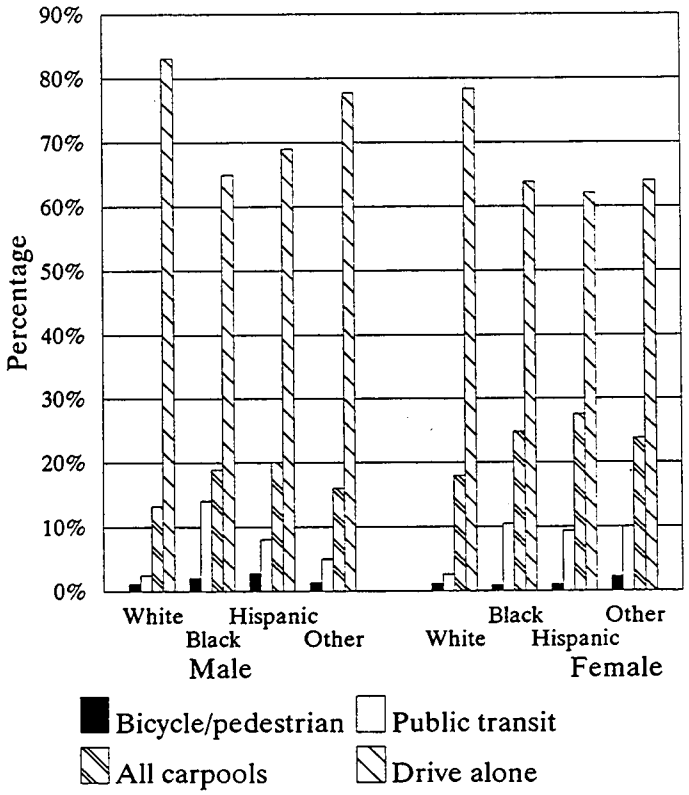
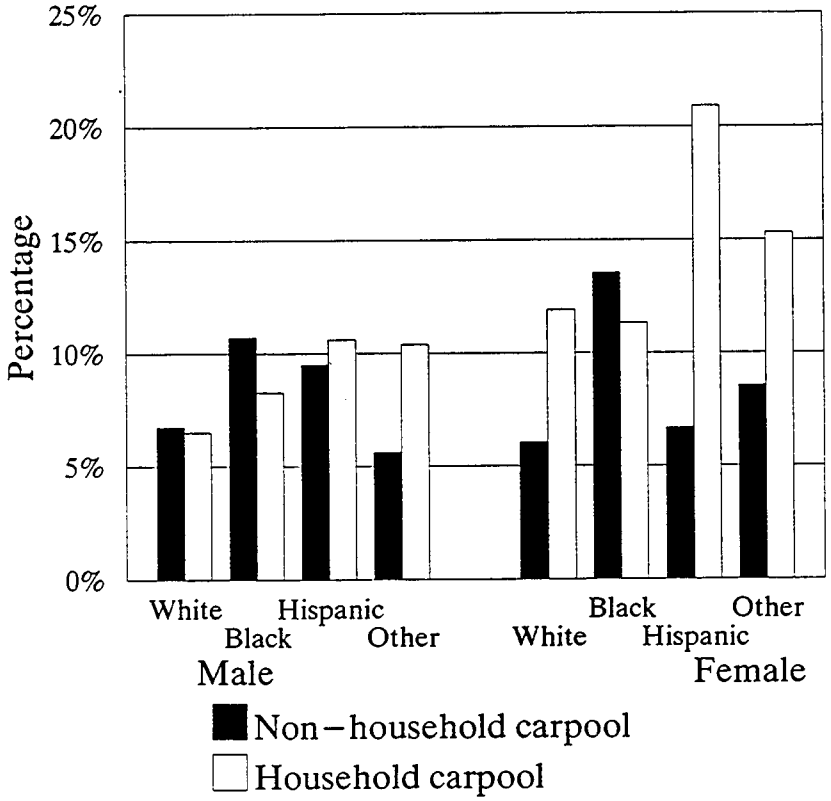


FIGURE 21B

CARPOOL COMPOSITION

BY ETHNIC BACKGROUND AND SEX



These results also suggest that white men and women live and work in similar locations, with similar accessibility to different modes of transportation. White men and women are equally likely to use private autos for commuting. White females are more likely to serve the travel needs of other household members, particularly small children. For this reason and this reason alone, they are more likely to substitute carpooling for driving alone more often than do white males.

There are considerable differences in the relationship between mode choice for the work trip by race and gender. Black men are five times as likely to use public transit, twice as likely to use nonmotorized transportation, and 43 percent more likely to carpool than white men. Black women are four times as likely to use public transit and 39 percent more likely to carpool than white women.

Unlike whites, black men and women are about equally likely to drive alone to work. Unlike whites, black men are much more likely than black women to use either public transit or nonmotorized transportation to get to work. Black men and women presumably live in similar locations but often work in different places. Blacks are far less likely to live in suburbs than whites. It appears that more black women than black men work in suburban locations. This helps explain the greater dependence of black women on private automobiles for commuting.

Fewer than half of white male carpools and less than one third of white female carpools are non-household based. More than half of both black male and black female carpools are non-household based. This suggests that black women are more independent in terms of travel behavior than are white women, which is not too surprising given the far greater proportion of black households headed by single females.

Hispanics are different than either whites or blacks in terms of the relationship between mode choice for the work trip and gender. Hispanic males are three times as likely to use nonmotorized transportation and public transit and 52 percent more likely to carpool than white males. Hispanic males are only half as likely as black males to use public transit to go to work. Hispanic females are three and a half times as likely to use public transit and 54 percent more likely to carpool than white females. Hispanic females are only half as likely as black females to carpool with non-household members.

Hispanic males and females, like white males and females, are equally likely to use private autos for commuting. Hispanic males, like white males, are more likely than their female counterparts to drive alone to work. Hispanic females, like white females, are more likely than their male counterparts to carpool. Hispanic males are 63 percent more likely to carpool with household members and 41 percent more likely to carpool with non-household members than white males. Hispanic females are 76 percent more likely to carpool with household members but only 11 percent more likely to carpool with non-household members than white females.

These results suggest that Hispanics are more like blacks than whites in terms of mode choice for the journey to work. Hispanic males are less dependent than either black males or Hispanic females on public transit, which suggests that Hispanic males are more likely to work in suburban locations. Hispanic females are less likely to carpool with non-household members than either black females or Hispanic males, suggesting that Hispanic females are less independent than black females in terms of travel behavior.

"Others" (mainly Asians) are also different from whites, blacks and Hispanics in terms of the relationship between mode choice for the journey to work and gender. "Other" males are twice as likely as white males to use public transit. "Other" males appear to be more similar to white males than to either black or Hispanic males in terms of mode choice for the work trip. "Other" females are four times as likely to use public transit, twice as likely to use nonmotorized transportation and 33 percent more likely to carpool than white females. "Other" females appear to be more similar to black and Hispanic females than to white females in terms of mode choice for the work trip.

Almost all the greatest disparities between males and females in terms of mode choice for the work trip occur in the "other" category. "Other" females are 18 percent less likely to drive alone, 50 percent more likely to carpool, 65 percent more likely to use nonmotorized transportation, and 100 percent more likely to use public transit than are "other" males. These data suggest that there are greater intra-ethnic disparities between males and females in terms of family or personal incomes, work locations, or traditional roles and responsibilities within "other" households. The fact that the "other" category includes many different racial and ethnic groups is not helpful in discerning the underlying reasons for this largest of all work-trip mode-choice gender gaps.

Only in the singular category of household-based carpools are "other" females exceeded by their female counterparts in better-defined racial and ethnic groups. Among Hispanics, Whites, Blacks, and "Others," females are 97 percent , 83 percent, 37 percent, and 48 percent, respectively, more likely than males to carpool with household members. These results suggest that the "other" ethnic group, work-trip, mode-choice gender gap cannot be explained in terms of child-care responsibilities alone, if at all.

Household Size and Vehicle Availability

Oppenheim (1979) suggested that persons living in larger households and those owning larger automobiles were more likely to carpool. Tischer and Dobson (1979); Gensch (1979); Teal (1987); and Dasgupta, Frost and Spence (1988) all found that, as the number of vehicles per household increased, the likelihood of choosing alternatives to driving alone fell. Tischer and Dobson (1979) and Teal (1987) found that carpooling increased with the number of workers in the household. Gensch (1979) found that public transit use fell with the number of workers in the household. Clearly, the propensity to carpool to work should increase with the number of persons, adults, and/or workers and should fall with the number of vehicles, particularly as this relates to the number of drivers, licensed or unlicensed, within the household.

Ferguson (1991a) found that carpooling was positively correlated with the number of adults in the household and negatively correlated with the number of vehicles to the household. Ferguson estimated that carpooling for the work trip was three times more sensitive to the presence of working adults than it was to the presence of nonworking adults. Ferguson also estimated that carpooling was about twice as sensitive to the number of vehicles, up to and including the number of working adults in the household, as it was to the number of vehicles in the household that exceeded the number of working adults.

Number of Persons in Household

Table 8 shows that carpooling is fairly sensitive to the number of persons in the household. Commuters living in households with 5 or more persons are two and one half times more likely to carpool than those living in one-person households. The biggest leap in carpooling propensity occurs between one- and two-person households, however. Commuters in two-person households are 77 percent more likely to carpool than those in one-person households.

As household size increases, household-based carpools increase dramatically, while non-household-based carpools remain relatively unaffected. In fact, one-person-household commuters are slightly more likely to carpool with non-household members than are commuters in households with more than one person. Much of the increase in carpooling that occurs with increasing household size appears to be drawn from alternatives to driving alone, such as public transit and nonmotorized transportation.

Number of Vehicles in Household

We see from Table 9 that carpooling is also sensitive to the number of vehicles in the household. Commuters in households with zero vehicles are almost twice as likely to carpool as those in households with four or more vehicles. Commuters living in households with one vehicle are in several ways more

MODE OF TRAVEL AND CARPOOL COMPOSITION BY NUMBER OF PERSONS IN HOUSEHOLD

TABLE 8

	Number of Persons						
Mode of Travel	1	2	3	4	5+	Total	Percent
Drive Alone	83.36%	81.17%	78.00%	79.02%	73.14%	22,552	78.79%
Carpool	7.88%	13.98%	17.47%	17.61%	20.99%	4,664	16.29%
HH	0.00%	7.93%	10.82%	10.49%	12.58%		
Non-HH	7.88%	6.05%	6.65%	7.12%	8.41%		
Transit	6.47%	3.71%	3.38%	2.42%	4.54%	1,057	3.69%
Nonmotorized	2.29%	1.15%	1.15%	0.95%	1.33%	350	1.22%
Total	2,271	8,357	6,767	6,560	4,668	28,623	100.00%
Percent	7.93%	29.20%	23.64%	22.92%	16.31%	100.00%	
CP/(DA+CP)	***8.6%***	***14.7%***	***18.3%***	***18.2%***	***22.3%***		
Carpool Composition							
HH Only	0.00%	54.97%	60.41%	57.75%	57.65%	2,588	55.49%
Both HH and Non-HH	0.00%	3.51%	3.05%	3.64%	4.59%	164	3.52%
Non-HH Only	100.00%	41.52%	36.55%	38.61%	37.76%	1,912	40.99%
Total	179	1,168	1,182	1,155	980	4,664	100.00%
Percent	3.84%	25.04%	25.34%	24.76%	21.01%	100.00%	

Note: home-based work trips only

MODE OF TRAVEL AND CARPOOL COMPOSITION BY NUMBER OF VEHICLES IN HOUSEHOLD

TABLE 9

	Number of Household Vehicles						
Mode of Travel	0	1	2	3	4+	Total	Percent
Drive Alone	11.02%	67.24%	82.40%	83.90%	85.17%	22,552	78.79%
Carpool	26.48%	23.41%	14.92%	13.81%	13.48%	4,664	16.29%
HH	0.99%	13.74%	9.13%	7.97%	7.29%		
Non-HH	25.49%	9.67%	5.79%	5.84%	6.19%		
Transit	49.01%	7.12%	1.83%	1.91%	0.82%	1,057	3.69%
Nonmotorized	13.49%	2.23%	0.84%	0.37%	0.52%	350	1.22%
Total	608	5,165	13,410	6,162	3,278	28,623	100.00%
Percent	2.12%	18.04%	46.85%	21.53%	11.45%	100.00%	
CP/(DA+CP)	***70.6%***	***25.8%***	***15.3%***	***14.1%***	***13.7%***		
Carpool Composition							
HH Only	2.48%	57.65%	59.07%	56.17%	51.36%	2,588	55.49%
Both HH and Non-HH	2.48%	2.07%	4.25%	3.06%	5.43%	164	3.52%
Non-HH Only	95.03%	40.28%	36.68%	40.78%	43.21%	1,912	40.99%
Total	161	1,209	2,001	851	442	4,664	100.00%
Percent	3.45%	25.92%	42.90%	18.25%	9.48%	100.00%	

Note: home-based work trips only

similar to those living in households with zero vehicles than they are to those living in households with two or more vehicles. Commuters in households with either zero or one vehicle are more likely to carpool, to use public transit and to use nonmotorized transportation to go to work. One-vehicle-household commuters nonetheless drive alone 67 percent of the time, while zero-vehicle-household commuters drive alone a mere 11 percent of the time.[20]

Zero- and one-vehicle households account for only 20 percent of the total commuters in the 1990 NPTS sample.[21] For households with two or more vehicles, which together account for more than four out of five sampled commuters, mode of travel to work is far less sensitive to the number of vehicles in the household. Household-based carpooling, public transit, and nonmotorized transportation use decline slightly with vehicle ownership in this range, while non-household-based carpools actually increase, if only slightly. These results suggest that households with two or more vehicles are less influenced in terms of the marginal effect of adding another vehicle to the household for the purpose of driving to work.

Comparative Dynamics

The results of the 1990 NPTS on the demographics of carpooling reveal what was left of the carpool market after the eighties. But how did carpooling change during the eighties, other than to decline precipitously? Were carpools then substantially different in composition than carpools today? Given the limited availability of consistent data on carpooling over the years, this is a difficult question to answer. Teal (1987) worked exclusively with the 1977 NPTS, which included far more detailed questions on carpools than any NPTS survey before or since. Ferguson (1991a) compared 1977 and 1983 NPTS results using an ordered logit regression model of carpool formation, predicated on the notion that carpool partners are added one at a time, assuming that any are desired. Ferguson (1994) compared unordered logit and ordered probit regression analysis of carpool formation models using 1990 NPTS data, including a model that distinguished household from non-household carpools.

Teal (1987) reported that only 40 percent of carpools were household-based in 1977. Ferguson (1994) found that 60 percent of 1990 carpools were household-based.[22] Teal derived his measure of carpool association from the person file, which asks about the usual mode of travel to work. Ferguson got his data from the day trip file, which asks about actual trips on a particular day. Teal's measure defined carpools as shared rides for work trips only. Ferguson's measure defined carpools as shared rides for any purpose, as long as at least one person was traveling to work.

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[20] Technically, zero-vehicle household commuters should never be able to drive alone to work or anywhere else. While this may indicate an inconsistency in the data collected from sample households, it could also reflect the possibility of borrowing cars from other households to commute. The 67 individuals who said they drove alone to work despite not owning a car constitute less than one quarter of one percent of all commuters, a rather small number.

[21] Assuming that vehicle ownership is related to family income and residential location, this figure probably understates the percentage of households in this category. The Census does not include information on vehicle ownership, so no direct verification is possible.

[22] In fact, far fewer than 60 percent of 1990 NPTS carpools were household-based. Shared rides with others not on their way to work technically do not count, according to the traditional definition of a carpool. Household carpools are counted at least twice in the NPTS, because both household members are included in the sample, whereas non-household carpools are represented only by household members. Maybe the proportion of carpools that are household-based has remained reasonably stable over time, even as carpooling itself decreased in significance.

The 1969, 1977, and 1983 NPTS data were collected through home interviews based on clusters of households in close proximity on residential blocks selected for inclusion in the survey. The 1990 NPTS data were collected through telephone surveys based on pure random samples of selected regions using random digit dialing.

Despite the significant sample frame, survey design, and methodological differences among the different NPTS studies, it would be useful nonetheless to compare results across the years to get a better sense of the dynamics of carpool formation. A brief overview and comparison of Ferguson (1991a) and Ferguson (1994) will illustrate the relative stability of influences on carpool formation, at least over the last 15 years.

Household Characteristics

Ferguson (1991a) showed that the likelihood of carpooling increased with the number of adults and decreased with the number of vehicles in the household, setting vehicle availability so that it could not exceed the number of adults, and differentiating between working and nonworking adults.[23] The number of nonworking adults has decreased because the number of women in the labor force has increased and the number of household vehicles has approached the number of household adults (auto ownership saturation). Ferguson (1994) was forced to treat the number of persons and the number of vehicles as two variables rather than four to avoid collinearity problems in model estimation. The results are much the same, however, whether one is looking at carpools overall, or carpools separated into household and non-household categories (Table 10).

Ferguson (1991a) treated the number of children as an independent variable, which was associated negatively with carpool formation in 1977, and unrelated in 1983. Ferguson (1994) treated children as a life-cycle phenomenon and found that the presence of children, particularly of toddlers and teens, increased the likelihood of carpooling in 1990. This relationship varied significantly between men and women and as it related to the formation of household and non-household carpools.

Men with children younger than age 16 were less likely to carpool, while those with children over age 15 were more likely to do so. Women with children under age 6 or over age 16 were more likely to carpool. Men with children over age 15 were more likely to carpool with household members. Women with children over age 15 were more likely to carpool with both household and non-household members. Men with children under age 16 were less likely to carpool with non-household members. Women with children under age 16 were more likely to carpool with household members and less likely to carpool with non-household members.

Men were less sensitive than women to the travel needs of children, and they were less likely to carpool when children were present. This suggests that men with children may fulfill some of the family responsibilities normally associated with women, such as grocery shopping or personal errands, while women remain primarily responsible for serving the travel needs of children as passengers in private autos.

Ferguson (1991a) found that family income treated as a linear variable was completely unrelated to carpool formation. This is confirmed by the 1990 NPTS, with the caveat that those living at or below the poverty line are much more likely to carpool. Poverty increases the propensity to carpool with non-household members rather than household members.

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[23] Ferguson tested vehicle availability in relation to the number of adults and the number of licensed drivers in the household. He found that the statistical relationship between the number of adults and carpooling was stronger than the one between the number of licensed drivers and carpooling. This suggests that U.S. citizens tend to act as if driving is a right rather than a privilege, perhaps because it has become so much of a necessity to our standard of living and life-style.

Table 10: FACTORS INFLUENCING CARPOOL FORMATION

	Data and Models				
	1977 NPTS	1983 NPTS	1990 NPTS	1990 NPTS	1990 NPTS
Influencing Agents	**Group Size**	**Group Size**	**Group Size**	**HH Only**	**Non-HH Only**
Household Characteristics					
n adults (working)	+++	+++			
n adults (non-working)	+++	+++			
n children	---	0			
n vehicles (working)	---	---			
n vehicles (non-working)	---	---			
n persons			+++	++	+++
n vehicles			---	---	---
male — youngest child 0-5			--	0	---
male — youngest child 6-15			---	0	---
male — youngest child 16-21			+++	+++	0
female — youngest child 0-5			+++	+++	---
female — youngest child 6-15			0	++	---
female — youngest child 16-21			+++	+++	+++
family income	0	0	0	0	0
below poverty level			+++	+	+++
near poverty level			+++	0	+++
black head			+++	0	+++
hispanic head			+	++	0
other non-white head			+	0	+
Personal Attributes					
less than h.s. diploma			+++	+++	0
attended college	--	--	---	0	---
attended graduate school			---	0	---
age, in years	---	0	---	0	---
single male	0	0	0	--	0
married male	0	+++	+++	+++	-
married female	+++	+++	+++	+++	-
Trip Characteristics					
travel time, distance	+++	+++	+++	---	+++
employee pays for parking		+++			
Employment Characteristics					
public sector	+++	+++			
manufacturing	+++	+++			
management	0	0			
professional	0	+			
clerical	0	0			
construction	0	+++			
drive as part of work	---	---			
Residential Location					
SMSA size	---	---	+		
central city			--	-	--
suburb			---	--	---
multi-family housing	0	+			
MSA population density			0	0	+++
non-MSA population density			--	---	0

Minorities were somewhat more likely to carpool in 1990 than were whites. Blacks in particular were more likely to carpool with non-household members. Although it is likely that ethnic differences in carpool formation are at least partially related to differences in gender roles across ethnic groups, these relationships could not be tested explicitly using regression analysis due to the limited sample sizes involved.

Personal Attributes

Ferguson (1991a) found that persons who had attended some college were less likely to carpool than those who never had in both 1977 and 1983. In 1990, persons with some college (or graduate school) were again less likely to carpool, while those who had less than a high school diploma were much more likely to carpool than the typical high school graduate. Those with less than a high school diploma were more likely to carpool with household members, but not with non-household members. In all education categories, carpooling with household members predominates over carpooling with non-household members.

Ferguson (1991a) found that the propensity to carpool decreased with age in 1977, but not in 1983. The 1990 NPTS confirms that the likelihood of carpooling decreases with age but only for non-household carpools. Given the possibly increasing significance of household-based carpools over time, this may partially explain the inconsistency between the 1977 and 1983 results concerning age.

Ferguson (1991a) found that married females were more likely than single females to carpool in both 1977 and 1983. Married males were more likely than single females to carpool in 1983 only. Single males and females were equally likely to carpool in both 1977 and 1983. In 1990, males and females in households with two or more adults were more likely to carpool than males or females in single-adult households.[24] Both males and females in households with two or more adults were much more likely to carpool with other household members and slightly less likely to carpool with non-household members. Single-adult-household males were less likely to carpool with other household members than were single-adult-household females. This was probably a reflection of limited availability. Single males are far less likely than single females to be living with children.

Trip Characteristics

Ferguson (1991a) showed that carpooling increased with travel time and distance in 1977 and 1983. In 1990, carpooling increased with travel distance overall. Somewhat unexpectedly, household-based carpools declined with distance, while non-household-based carpools increased. The net result is an increase in the likelihood of carpooling with distance because the estimated positive non-household distance effect is two and one half times as great as the negative household effect.

Employment Characteristics

Ferguson (1991a) showed that employees of large firms were more likely to carpool in both 1977 and 1983.[25] Occupational status was not a particularly powerful factor in carpool formation, showing no effect in 1977 and little effect in 1983. Employees whose job included driving as part of their regular work responsibilities were much less likely to carpool in 1977 and 1983. Employment characteristics were dropped entirely from the 1990 NPTS and so cannot be compared directly with these prior results.

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[24] In 1977 and 1983, but not in 1990, the marital status of respondents was identified in the NPTS. The number of adults in the household appears to serve as a reasonable proxy for marital status, at least as far as carpooling is concerned.

[25] Technically, he showed that employees in certain industries known to be more concentrated than others, including the government sector, were more likely to carpool.

Residential Location

Ferguson (1991a) showed that the likelihood of carpooling decreased with SMSA size in both 1977 and 1983. In 1990, central city residents and especially suburbanites were less likely than rural residents to carpool to work. The likelihood of carpooling increased marginally with SMSA size in 1990 once urban versus rural residency was taken into account.[26] It appears that geographic location is more important than urban area size as a determinant of carpooling. Non-household carpools are affected twice as much as household carpools by both central city and suburban location factors.

Ferguson (1991a) showed that carpooling increased slightly with the number of residential units in the type of housing occupied by the commuter and her family in 1983 only. This variable was replaced by a much more precise measure of residential population density in the 1990 NPTS study. Overall, population density was associated only weakly with carpool formation.[27] Household-based carpooling decreased with population density outside MSAs, while non-household-based carpooling increased with population density inside MSAs. The former probably is a result of exurban communities on the periphery of urbanized areas operating more like distant suburbs than true rural places. The latter may be an uninteresting statistical artifact.

Discussion

The comparative results for 1977, 1983, and 1990 are remarkably consistent, despite numerous potential problems. The 1977 and 1983 results are based on poor model fit. The 1990 results are based on a different definition of carpooling, type of sample, and method of survey implementation and include many different independent variables and definitions. Despite the vast differences in data and methods, the 1977, 1983, and 1990 results are quite similar.

The 1990 NPTS results are compared qualitatively with demographic trends from the Census in Table 11. As expected, demographic trends between 1970 and 1990 seem to be working against carpooling, with seven of ten leading indicators working against carpool formation. Contrary to initial expectations, non-household carpools seem to have more positive factors than do household carpools, at least in demographic terms. Only two of ten leading indicators favor household carpools. Leading indicators are evenly split on non-household carpools, with five in favor and five opposed.

Based on the limited information available, it seems unlikely that non-household carpools were reduced less between 1970 and 1990 than were household carpools. Anecdotal evidence suggests quite the opposite, that non-household carpools almost disappeared while household carpool use remained stable or decreased only slightly.

Apparently, this analysis is missing some important variable. Maybe that the magnitudes of the individual effects associated with leading indicators in this analysis are not strictly additive. It is likely that an external agent is at work. Non-household carpools probably respond more to economic influences than do household carpools. If this is the case, the price elasticity of demand for carpooling may be higher than 0.349 for non-household carpools, and much lower for household carpools.

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[26] SMSA size could not be included in the household and non-household carpool equations in 1990 due to collinearity with central-city and suburban location. The negative coefficient for SMSA size in 1977 and 1983 can be explained as the effect of urban versus rural carpooling propensities being captured by SMSA size, which is treated as 0 for rural residents in the model.

[27] This contrasts sharply with public transit, the use of which increases greatly with population density in both urban and rural areas, and nonmotorized transportation, which is highly sensitive to population density in urban areas only.

Table 11: TRENDS AFFECTING CARPOOL FORMATION 1970-90

Population Characteristic	Observed Trend	Net Carpool Effect	Household Carpool Effect	Non-HH Carpool Effect
n persons/household	-	-	-	-
n vehicles/household	+	-	-	-
single adult household	+	-	-	+
presence of children	-	-	-	+
poverty	+	+	+	+
diversity	+	+	+	+
education	+	-	-	-
age	+	-	-	-
trip distance	+	+	-	+
suburban location	+	-	-	-
n +		*3*	*2*	*5*
n -		*7*	*8*	*5*

Recent Declines in Carpooling

What have been the principal sources of the recent decline in carpooling? The single largest source of recent declines in carpooling appears to be related to household size. The average number of persons per household fell from 3.16 in 1969 to 2.56 in 1990. Meanwhile, the average number of vehicles per household increased from 1.16 in 1969 to 1.77 in 1990.[28] These two attributes of household size taken together account for 35 percent of the decline in household carpools, 47 percent of the decline in non-household carpools, and 38 percent of the decline in carpools overall between 1970 and 1990.

The second largest demographic source of the recent decline in carpooling appears to be related to age and education. The most dramatic demographic shift in the United States between 1970 and 1990 was a rapid increase in the average educational attainment of U.S. workers. The percentage of the U.S. population aged 25 and older holding a high school diploma rose from 44.6 percent in 1970 to 75.2 percent in 1990. The percentage of the U.S. population aged 25 and older with a bachelor of arts degree rose from 7.1 percent in 1970 to 20.3 percent in 1990. The mean age of U.S. residents increased from 28.1 years in 1970 to 33.0 years in 1990. These changes in social stature and maturity account for 18 percent of the decline in household carpools, 31 percent of the decline in non-household carpools, and 24 percent of the decline in carpools overall between 1970 and 1990.

The third largest demographic source of the recent decline in carpooling appears to be related to gender and life-cycle. Male labor force participation fell from 76.6 percent in 1970 to 74.4 percent in 1990. Female labor force participation increased from 41.4 percent in 1970 to 56.8 percent in 1990. The share of

[28] The 1969 NPTS survey defined household vehicles differently than later NPTS surveys, omitting pickup trucks, for example. Trends in the 1977, 1983, and 1990 data suggest that 1.50 would be a comparable number, but this seems too high in relationship to the reported value of 1.16. A value of 1.35 was used in this analysis as a compromise value. Any value between 1.16 and 1.50 makes the number of vehicles per household the first or second most important factor in explaining recent declines in carpooling.

households in the United States composed of single persons increased from 17.6 percent in 1970 to 24.6 percent in 1990. The percentage of children in the population fell from 37.9 percent in 1970 to 28.6 percent in 1990. These lifestyle and life-cycle changes account for 17 percent of the decline in household carpools and 9 percent of the decline in carpools overall between 1970 and 1990. Life-cycle changes would have caused an 8 percent increase in non-household carpools were it not for other social and demographic changes producing overwhelmingly larger relative declines.[29]

Increasing suburbanization has been blamed as a leading source of recent declines in carpooling by many authors. The percentage of the U.S. population living in suburbs grew from 27% in 1970 to perhaps as much as 35% in 1990. Meanwhile, the average U.S. commute increased in distance from 9 miles in 1969 to 11 miles in 1990, which would tend to encourage carpool formation. These changes in urban form together account for a mere 4% decline in household carpools, a 2% increase in non-household carpools, and a net 0.3% decline in carpools overall between 1970 and 1990.[30]

The percentage of U.S. families with incomes below the poverty line increased from 10 percent in 1970 to 13 percent in 1990. Meanwhile, the percentage of the U.S. population who are white decreased from 84 percent in 1970 to 76 percent in 1990. According to the model, these changes in adversity and diversity should have led to a 4 percent increase in household carpools, a 6 percent increase in non-household carpools, and a 5 percent increase in carpools overall between 1970 and 1990.

The real marginal cost of motor fuel fell by 34 percent between 1970 and 1990, the combined effect of a 10 percent fall in the real price of gasoline and a 36 percent increase in the average fuel economy of U.S. cars. Falling marginal motor fuel costs account for 30 percent of the decline in household carpools, 38 percent of the decline in non-household carpools, and 34 percent of the decline in carpools overall between 1970 and 1990. The marginal cost of motor fuel thus ranks second only to household size (including vehicle ownership) as a determinant of recent declines in carpooling.

Conclusions

What are the prospects for reversing current downward trends in carpool formation? Clearly, gasoline, parking, and/or road pricing strategies would have some positive effect, particularly on non-household carpools. However, the price increases necessary to restore carpooling to its 1970 level would be prohibitive, due to the compounding effects of social and demographic changes in recent decades.

Carpooling is generally less sensitive than public transit or nonmotorized transportation to variations in urban form. Therefore, it may be easier to implement carpool programs in suburban environments. Even so, carpooling fares worst relatively in suburban environments, indicating that significant barriers to carpool formation do exist and must be resolved in order to penetrate this market niche.

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[29] The 8 percent increase refers to an offset of observed declines (a relative measure), rather than an absolute increase, for ease of comparison with contributors to the predominant downward trend.

[30] Unfortunately, Census designations of "inside central city" and "inside urbanized area, outside central city" have changed in meaning and definition from one decade to the next and would not adequately reflect the phenomenon of suburbanization even if such designations did not change. There may also be different types of suburbs to consider, particularly in terms of their effects on travel behavior. A better measure of "suburb" might reveal a higher sensitivity to carpool formation, which would increase the magnitude of the effect above the 0.3 percent decline given here for geographic location as a conservative estimate.

Non-white families and those living below the poverty line generally appear to be more receptive to carpooling than are more affluent white commuters. Large families and those with relatively few household vehicles are much more likely to share the ride to work. Single adults are more likely to carpool with non-household members, while married adults and those living together are more likely to travel with household members. Older children behave much like adults in relationship to carpool formation. The travel needs of younger children continue to be served by women more often than men. Some of these long-term social and demographic trends are conducive to carpool formation; others are not.

What should be done about recent declines in carpooling? Public policy could seek to address the air quality and traffic congestion implications of declining carpool formation through local land use or regional transportation planning efforts. Non-household-based carpools might be promoted most effectively through economic incentives such as pricing measures or preferential treatment.

The marginal cost of motor fuel has fallen by a third over the past two decades. Restoration of the marginal cost of motor fuel to 1970 levels through gasoline price increases alone would require a $0.50 gasoline tax increase. Reducing average fuel economy to 1970 levels to stimulate the formation of carpools is not a realistic solution to the problem.[31]

Household-based carpool formation should not be promoted directly. However, the formation of certain types of household carpools could be assisted, for example, by on-site services at employment centers and adequate developmental child-care facilities.

Based on unanswered questions from this analysis is any additional research necessary? The theory of carpool formation lacks development. Most prior research in this area has been purely empirical, with little time and energy devoted to the basic principles of carpool formation. Why do some people carpool and others do not? Is carpooling a submode of auto travel or a completely separate mode? How does carpool formation fit into the traditional urban transportation planning process?

A major drawback for carpool researchers is the lack of reliable data on the subject. Methods of analysis cannot be developed to test alternative models of carpool formation if there are no data. The NPTS has emerged as the single best source of data on the travel behavior implications of carpooling. This advantage can be extended through continued attention to better definitions of trip sharing in future NPTS surveys.

Local and regional agencies could monitor carpooling to the same extent that private auto and public transit trends are observed, in other words, on a comprehensive, continuing, and cooperative basis. Carpool programs such as regional ridesharing agencies and transportation management associations should be encouraged to collect more and better carpool data and to share it with their colleagues in the research community.

The market for carpooling appears to have bottomed out. It is unlikely that marginal fuel prices will continue to fall, and indeed some increase might be expected in world market prices, government tax surcharges, or both. The next generation is likely to reflect similar educational attainment levels as the current generation. Households are not likely to get much smaller than they already are, and vehicle ownership, although not necessarily vehicle use, is nearing saturation.

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[31] Ironically, Lee (1984) expressed great concern that programs designed to promote carpooling might result in increased fuel consumption. For this to happen, according to Lee, it is necessary only that a) carpoolers spend a great deal of time driving around looking for each other, b) average travel speeds off arterials are vastly lower than on arterials, and c) average fuel consumption at lower speeds is vastly lower than it is at higher speeds. If it is true that lower fuel consumption has resulted in less carpooling over the years, then Lee is exactly right about the importance of the relationship. His only error concerns the direction of causality.

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Non-Motorized Transportation

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Non-Motorized Transportation

Introduction

The contribution of non-motorized modes to personal transportation has, in some respects, remained an enigma over the past years. Little empirical data exists exploring the effects, for example, of higher population densities, and personal or family demographics on the rate of non-motorized trips. Additionally, there is little broad based inferential data that is suitable for drawing general conclusions about who non-motorized trip-makers are and the types of activities these trips are used to accomplish. There are many compelling motives for gathering basic data about non-motorized travel, not the least of which are the recent passage of federal legislation and the increasing conviction that certain types of community structure will reduce vehicle travel.

For example, the long-term effectiveness of mixed use neighborhoods for reducing vehicle travel hinges on fundamental assertions regarding non-motorized travel. Assertions that, for the most part, have not been empirically validated. It is difficult, if not impossible, to predict the relationships between travel patterns and the underlying neighborhood structure without a better understanding of non-motorized travel. Additionally, recent federal legislation, such as ISTEA, requires the preparation of multi-modal transportation plans; plans that require assessment and integration of non-motorized modes.

The purpose of this paper is to present the results of an evaluation of travel characteristics associated with households and individuals making non-motorized trips. The data were collected as part of the National Personal Transportation Study (NPTS). The size and representation of the NPTS dataset facilitates not only comparisons between households making no non-motorized trips (i.e., bike or walk trips) and households making one or more non-motorized trips but is also sufficiently large to allow detailed examination of bike and walk trips alone.

The report is organized into three sections. The first section highlights recent research exploring travel characteristics of non-motorized trip-makers. The limitations of the previous research are also reviewed in this discussion. Using the NPTS data, the second section presents a comparison between households making one or more non-motorized trips and households making only motorized trips during an average day. Finally, the last section presents an in-depth evaluation of the characteristics of the NPTS bike and walk trips.

Literature Review

Much of the more recent research in non-motorized transportation has focused in the areas of safety and design standards and, more topically, policy implementation. Studies on the safety related aspects of biking and walking, ranging from education to accident analysis, may be found throughout the literature (for example, see Smith and Walsh (1) and Stutts, et al (2)). Policy papers have tended to focus more on discussion of future funding opportunities, implementation of ISTEA requirements and, general planning issues (for example, see Broeg et al (3), Replogle (4), and Hope (5)).

Noticeable is the absence of a large body of literature related to the characteristics of the walker or biker and/or the geographic or regional attributes associated with non-motorized trip making. In part this is due to the difficulty in surveying the non-motorized population. Limited numbers of bike and walk trips make small scale surveys difficult. Consequently, survey designs often limit the applicability of the results. As will be seen in the following discussions, the majority of bicycle data, and consequently research findings, often occur in localities that differ substantially from most other urban areas.

In the following sections the state of research associated with non-motorized transportation will be explored. In particular, past research identifying household and person characteristics for trips made by walk and bicycle modes will be summarized and reviewed.

Bicycling and Walking

Previous research on bicycling and walking in the U.S. can be divided into four basic topic areas. These include planning and policy aspects, demand, facilities design, and education and safety. Although these boundaries are artificial to a certain extent, they are useful organizers nonetheless. The major focus of this study are the demographic and geographical characteristics of those individuals electing to travel by non-motorized modes. This information is most often found in the demand related literature. The discussion begins with a summary of findings on trip-maker demographic characteristics and culminates with geographical attributes.

Trip Demographics

Perhaps the most studied demographic characteristics associated with non-motorized travel are those of sex, age, and income. In the following discussion, a review of study findings with respect to each of these major demographic characteristics is presented for both bicycle and walk modes. As will be noted, it is clear from this evaluation that the demographics of those making non-motorized trips vary by mode, i.e., cycling or walking and by trip purpose.

Sex. Recent work by Goldsmith (6) indicates that cyclists are predominantly men. These findings are also consistent with recent count data taken on citywide commuter routes in Phoenix, Arizona (7) in which men accounted for approximately 75 percent of the observed bicyclists. Similarly, a recent Harris Poll found that 60 percent of all cyclists were male (8). Data on the proportions of men and women walk trips is less known. Echoing sentiments expressed by Goldsmith (6), there is little concrete data investigating the characteristics of walkers, particularly those utilizing walking for employment purposes. Recent data gathered in several Seattle neighborhoods suggest that the proportions of men and women walking are approximately equal for most trip purposes (9).

Age. Not unexpectantly, age has also been found to vary between modes. Based on cycling patterns gathered from the Harris Poll (8) and the cities of Seattle and Boulder, Goldsmith (6) found that propensity to cycle declines as age increases. It is clear from the data that the majority of cyclists are also under the age of 45. As Table 1 suggests there is a pattern of younger cyclists in university cities, such as Boulder and Davis, when compared to a more diverse market such as Seattle. How-ever, it is important to note that all three areas would generally be considered as highly bicycle supportive.

Table 1: PERCENT OF CYCLISTS BY AGE GROUP

	Age Group		
Age Group	Seattle, WA	Davis, CA	Boulder, CO
16-25	12	52	43
26-35	30	27	22
36-45	30	9	13
46-55	13	5	10
56-65	6	0	6
65 and Older	7	0	7

Income and Employment. Other demographic characteristics, such as income and employment have also been shown to correlate well with cycling trips. In a study of downtown bicycle worktrips by Lott et al (10), it was found that commuting cyclists were more heavily represented in employment categories of sales, clerical, service, and laborer than those in professional or technical positions. Ashley and Banister (11) found that higher social classes in England tended to result in fewer bicycle trips. Equally revealing are

results from the Harris Poll also indicating diminishing ridership with increasing income (8). Income and employment effects on walking are less well known. In fact, very little recent empirical data exists and that which is available suggests that walk trips decline as income increases (9).

Trip Characteristics

Turning to trip characteristics, the research focus centers on developing estimates of certain trip attributes or characteristics. These attributes primarily include trip distance and trip purpose.

Trip Distance. Review of previous research suggests that cycling distances often vary by geographic region and trip purpose; maximum distances rarely exceed five to six miles. Deakin (12) drawing on earlier research in the San Francisco Bay Area indicates that the average bicycle distance is one to two miles while bike commuters travel on average five to six miles. Recent survey data drawn in Boulder, Colorado (13) indicates a mean bicycle trip distance slightly longer than two miles. Data from Davis, California indicates cycling work trip distances of less than three miles for downtown employees (10).

In contrast, there is limited data on the maximum walking distances for trip-making purposes. Sparse survey data from a variety of locations indicates that walking distances generally do not exceed two miles for commuting purposes (6). In the Boulder, Colorado survey, the average travel time for a walk work trip was slightly more than 12 minutes while the average bike trip took approximately 14 minutes; distances were noted as one mile and 2.7 miles, respectively.

Trip Purpose. The proportion of trips by trip purposes tends to be similar between modes, with non-motorized recreational trip making consistently higher than trip making for employment or shopping purposes. A recent survey in Portland, Oregon (14) indicated that well over 95 percent of the trips made by active bicyclists are for recreational purposes. This finding is similar to that noted in the Harris Poll in which approximately 82 percent of the respondents used a bicycle in the past month for recreational purposes (8). These results do not differ substantially from earlier observations by Floyd (15), in which he concluded commuting to school and recreational trips account for the majority of cyclists trips in the U.S. Similarly the majority of walk trips also tend to be for recreational purposes. The Harris Poll (8) notes that over 70 percent of its respondents undertook a walk trip for exercise or recreation in the previous year.

Trip making for commuting purposes continues to be relatively small for either bike or walk modes. In the city of Seattle, commuting by bicycle and walking constitutes less than 8 percent of the total commuting volume. The 1980 Census data indicates that approximately 5.6 percent of all workers walked to their place of employment while less than 0.5 percent rode a bicycle (16). Those walking or biking to work in 1990 were appreciably smaller, with 0.4 percent biking and approximately 3.9 percent walking (18). Nationally, very few urban areas, in the 1990 census, reported the percent of those biking to work over 0.8 or those walking to work over 3.5 percent (19).

However, higher percentages of walk or bicycle commute trips can be found in several areas throughout the country. In Boulder, Colorado roughly 14 percent commute by walk with approximately 20 percent in Annapolis, Maryland. Both bicycle and walk commuting levels are higher than national averages in areas with universities. In Gainesville, Florida, approximately 6 percent bike to work and in Eugene, Oregon slightly less than 6 percent commute to work by bike (16).

Limitations of Current Research

As might be expected from the previous section, there are numerous limitations to much of the published research. These include surveys that are small, frequently not random, and usually conducted in localities in which extrapolation to other regions is limited at best. Additionally, there is little recent quantitative investigation into the associations between geographic attributes, such as population densities,

and trip maker characteristics, such as age and household structure, and the effects on non-motorized trip-making. For example, although preliminary work by Goldsmith (6) suggests some positive correlation between increased density and the rate of walking, he also notes the evidence is far from conclusive. In the remainder of this paper many of these relationships will be explored. Bicycle and walk trips rates will be developed for a variety of variables to better identify the attributes of non-motorized trip making.

The National Picture: Results from the NPTS

The NPTS is unique in that it provides a sufficiently large database to allow examination of most of the important trip-making characteristics associated with non-motorized travel modes. In the remaining sections, the results of an analysis of the NPTS dataset, with respect to non-motorized travel, are presented. The major discussions are arranged in two sections. In the first section, the differences between households making no non-motorized trips and households making one or more non-motorized trips are compared. These comparisons include, for example, differences by income and household size categories. Following this discussion is a more detailed presentation focusing exclusively on bicycle and walking characteristics. Comparisons again include distinctions by household and person variables.

A Comparison Between Households Making No Bike or Walk Trips and Households Making One or More Bike or Walk Trips

Approximately 81 percent of the interviewed households made zero bike or walk trips while the remaining 19 percent of the households made one or more non-motorized trips. In this section, we will examine the household differences between the two groups. The discussion centers primarily on comparisons of trip rates between household types. Trip rates are calculated independently for households making no bike or walk trips and households making one or more non-motorized trips. Trip rates represent the total number of trips (regardless of mode) per variable category divided by the total households in that category.

Income. Beginning first with income as shown in Table 2, it is notable that non-motorized households, i.e., those households making one or more bike or walk trips, consistently have higher trip rates than those households making only motorized trips. Households with one or more non-motorized trips make approximately 33 to 50 percent more daily trips than those households with only motorized trips. The data also suggest that trip rates, for both motorized and non-motorized households, increase in an exponential manner leveling off around $50,000. At lower income levels, differences in trip rates are smaller between households making only non-motorized trips and households making one or more non-motorized trips than at higher levels of income. Above $20,000, differences hover around four trips per day, below $20,000, between two and three trips per day.

Table 2: DAILY HOUSEHOLD TRIPS BY INCOME

	HH's Making *No* Bike/ Walk Trips	HH's Making *1or More* Bike/Walk Trips	Difference (#)
<$10,000	5.91	8.75	2.84
$10,000-$19,999	6.80	9.06	2.26
$20,000-$29,999	7.82	12.08	4.26
$30,000-$39,999	8.76	13.08	4.32
$40,000-$49,999	9.91	15.01	5.10
$50,000-$59,999	9.90	13.90	4.00
$60,000-$69,999	10.18	14.14	3.95
>$70,000	10.40	14.32	3.92

Household Size. As Table 3 demonstrates, the same pattern of higher daily trip rates (20 to 30 percent greater) for those households making one or more bike or walk trips continues when rates are examined using household size as a discriminator. Changes in trip rates are greatest between household sizes of one and two persons, increasing by 50 to 60 percent, and flattening as household size increases.

Table 3: DAILY HOUSEHOLD TRIPS BY HOUSEHOLD SIZE

	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
1	4.46	5.37	0.91
2	6.88	8.76	1.88
3	8.82	11.54	2.72
4	11.55	13.70	2.15
5 or more	13.31	17.25	3.94

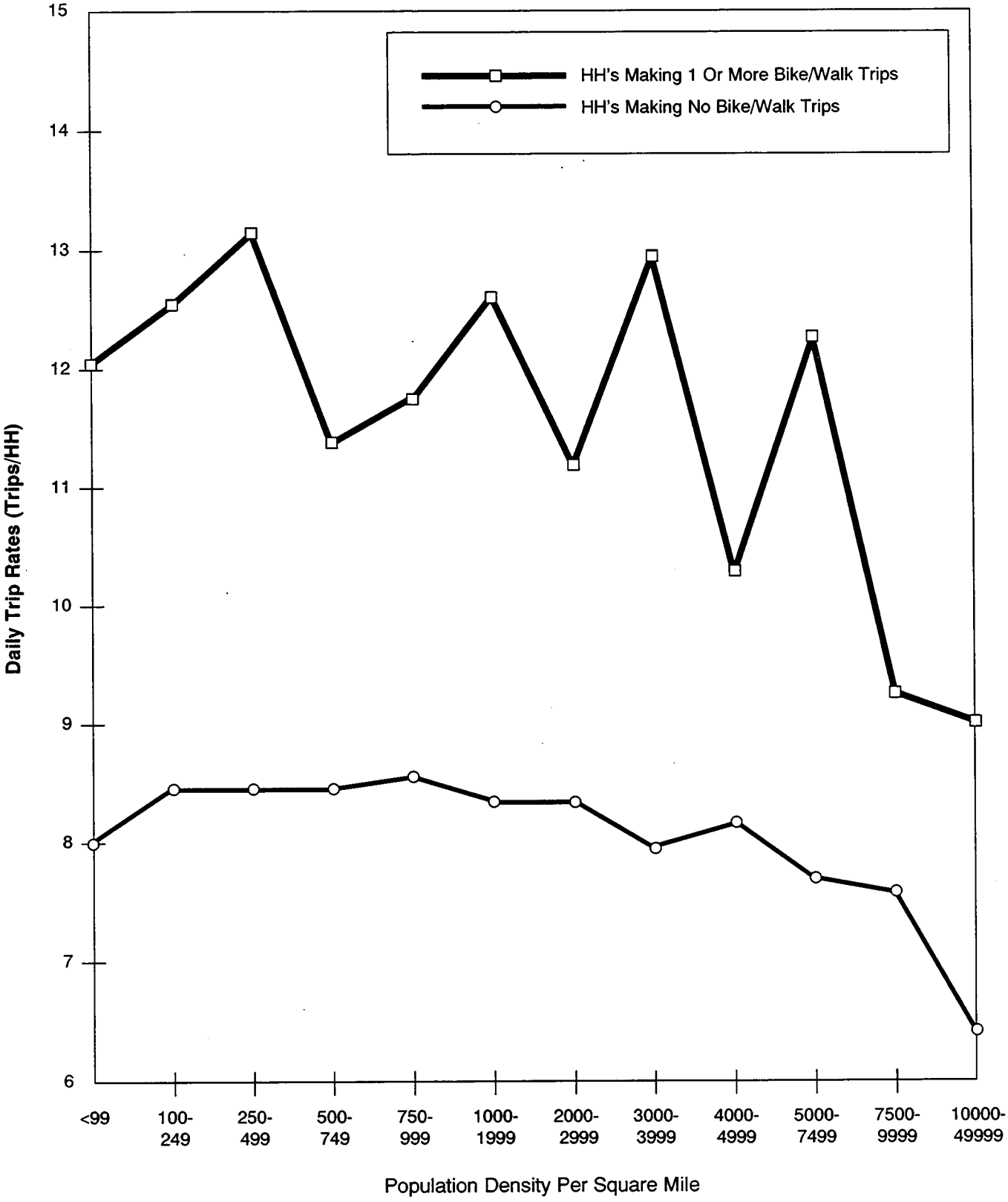
Table 4: DAILY HOUSEHOLD TRIPS BY POP. DENSITY

	HH's Making *No* Bike/Walk Trips	HH's Making *1 or More* Bike/Walk Trips
<99	8.03	12.12
100-249	8.43	12.46
250-499	8.44	13.16
500-749	8.41	11.41
750-999	8.57	11.65
1000-1999 (MSA)	8.30	12.63
2000-2999 (MSA)	8.28	11.24
3000-3999 (MSA)	7.86	12.94
4000-4999 (MSA)	8.19	10.32
5000-7499 (MSA)	7.67	12.27
7500-9999 (MSA)	7.56	9.28
10000-49999 (MSA)	6.38	9.04

Population Density. Examining Table 4, it can be seen that daily trip rates by population density reveals much the same pattern noted in earlier summaries. Households making one or more bike or walk trips consistently make more daily trips than those households making only motorized trips. As can be seen on Figure 1, daily trip rates for households making only motorized trips generally decrease with increasing density, a well established finding. Alternatively, households making one or more non-motorized trips tend to make greater numbers of daily trips, with some indication of a slightly decreasing trend in daily trip rates as densities increase. However, some caution should be exercised when evaluating this figure. Although trip rates are expressed for both households making no non-motorized trips and those making at least one non-motorized trip, it should be noted that motorized trips still dominate rates in both categories.

Vehicle Miles of Travel. The comparative analysis between households making only motorized trips and households making one or more non-motorized trips indicates that daily trip rates are not reduced when non-motorized trips are made. In other words, households making one or more non-motorized trips may make them in addition to their motorized trips. This suggests that many of the bike and walk trips may not be a strict replacement of vehicle trips but rather serve as supplemental trips, perhaps augmenting social or recreational tripmaking behavior. A brief examination of vehicle trips rates yield mixed evidence.

Figure 1:
TOTAL DAILY HOUSEHOLD TRIPS by POPULATION DENSITY



Tables 5 and 6 present daily vehicle trip rates for households making one or more non-motorized trips and for households making only motorized trips by income category and household size. The data suggest that at lower income levels some vehicle trip replacement may occur. However, as income increases the differences become less distinct. Table 6 provides slightly more indication of vehicle trip replacement. For household sizes of four or fewer, vehicle trip rates differ by as much as approximately two vehicle trips per day. When household size reaches five or more persons, daily vehicle trip rates become very close.

Table 5: AVERAGE DAILY HOUSEHOLD VEHICLE TRIPS BY INCOME

	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
<$10,000	4.90	2.84	-2.06
$10,000-$19,999	5.56	4.23	-1.33
$20,000-$29,999	6.39	6.68	0.29
$30,000-$39,999	7.16	7.03	-0.13
$40,000-$49,999	8.18	9.77	1.59
$50,000-$59,999	8.25	8.39	0.14
$60,000-$69,999	8.65	8.73	0.08
>$70,000	9.15	9.45	0.30

Table 6: AVERAGE DAILY HOUSEHOLD VEHICLE TRIPS BY HOUSEHOLD SIZE

	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
1 Person	3.86	1.64	-2.22
2 People	5.71	3.99	-1.72
3 People	7.29	6.36	-0.93
4 People	9.65	7.99	-1.66
5 or more People	10.82	10.22	-0.60

A second means to assess whether non-motorized trips supplant vehicle trips is to evaluate the differences in daily vehicle miles of travel (VMT) between the household types. In the remaining portions of this discussion, various cross-classifications of VMT for households making only motorized trips and households making one or more non-motorized trips are presented. These data suggest that VMT is less for households making one or more non-motorized trips.

Table 7: AVERAGE DAILY VMT BY INCOME

	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
<$10,000	30.0	30.6	0.6
$10,000-$19,999	34.7	31.4	-3.3
$20,000-$29,999	45.6	42.8	-2.8
$30,000-$39,999	53.6	49.0	-4.6
$40,000-$49,999	60.1	53.1	-7.0
$50,000-$59,999	61.5	59.6	-1.9
$60,000-$69,999	67.3	56.0	-11.3
>$70,000	71.7	58.2	-13.5

Table 7 suggests that households making one or more non-motorized trips accumulate less daily VMT. The differences are greatest in the higher middle income categories. This is slightly different from previous research but consistent with findings outlined in the next section which suggest that high middle income households tend to make greater numbers of non-motorized trips for work related purposes. These trips may actually be vehicle replacement trips, however, additional evaluation would be necessary to validate this hypothesis. At high income levels, differences in daily VMT are more pronounced between household types.

Table 8: AVERAGE DAILY HOUSEHOLD VMT BY HOUSEHOLD SIZE

	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
1 Person	31.5	29.7	-1.8
2 People	45.5	34.7	-10.8
3 People	58.0	46.3	-11.7
4 People	61.0	51.2	-9.8
5 or more People	59.9	46.5	-13.4

Table 9: AVERAGE DAILY VMT BY LIFE CYCLE

	HH's Making *No* Bike/Walk Trips	HH's Making *1 or More* Bike/Walk Trips
Single Adult, No Children	36.9	31.4
Single Adult, Youngest Child 0-5	31.9	20.9
Single Adult, Youngest Child 6-15	35.7	40.9
Single Adult, Youngest Child 16-21	46.4	34.4
Single Adult, Retired, No Children	17.8	20.3
> 2 Adults, No Children	54.8	42.7
> 2 Adults, Youngest Child 0-5	56.2	50.5
> 2 Adults, Youngest Child 6-15	60.7	50.9
> 2 Adults, Youngest Child 16-21	73.2	61.5
> 2 Adults, Retired, No Children	33.9	35.7

Table 10: DAILY HOUSEHOLD VMT BY POP. DENSITY

Persons Per Square Mile	HH's Making *No* Bike/ Walk Trips	HH's Making *1 or More* Bike/Walk Trips	Difference (#)
<99	57.1	58.1	1.0
100-249	52.9	50.2	-2.7
250-499	53.5	48.0	-5.5
500-749	53.3	45.9	-7.4
750-999	52.7	33.6	-19.1
1000-1999 (MSA)	46.1	51.8	5.7
2000-2999 (MSA)	43.6	50.7	7.1
3000-3999(MSA)	42.8	45.7	2.9
4000-4999 (MSA)	41.3	35.9	-5.4
5000-7499 (MSA)	42.4	37.6	-4.8
7500-9999 (MSA)	38.8	38.6	-0.2
10000-49999 (MSA)	37.8	24.2	-13.6

Table 8 presents results of cross-classification of VMT by household size. As might be expected, larger households tend to have greater daily VMT's. Comparisons between household types suggests that households making only motorized trips tend to have larger daily VMT's than those households making one or more non-motorized trips.

Turning to an evaluation of households with and without children, there is a clear indication that households with one or more children are more likely to undertake non-motorized travel. These same households also exhibit less daily VMT (Table 9). The implication is that these households are more likely to utilize non-motorized travel for social and recreational trips.

Finally, Table 10 provides a breakdown of VMT by population density. Below 1000 in population density, differences in VMT are fairly dramatic between households making only motorized trips and households making one or more non-motorized trips. However, when densities are between 1000 and 4000 there is an indication that VMT is slightly greater for non-motorized households. However, at densities greater than 4000, VMT for households making one or more non-motorized trips is substantially less than VMT for households making only motorized trips.

Bicycle and Walking Trip-Making Characteristics

The purpose of this section is to present the demographic and geographic characteristics associated with only bicycle or walk trips. In this section, trip rates represent the ratio of daily bike or walk trips to total households or persons. Thus, the trip rates provide some guidance for assessing the number of non-motorized trips that might be expected in different regions. The section begins with an overview of trip maker characteristics for bike and walk trips. The daily bike and walk trip rates are examined with respect to individual characteristics, such as age, sex, and the presence of a drivers license, and household characteristics, such as income, life cycle, and geographic location. Finally, the same type of analysis is undertaken delineating trips by trip purpose.

All Trip Purposes - an Overview of Bike and Walk Trips

The NPTS survey indicates that approximately 1,767 million annual bike person trips (0.7% of total annual person trips) were reported while annual walk trips approached roughly 18,000 million (7.2% of total annual person trips). These results compare to 8.5 percent annual person walk trips and 0.75 percent annual person bike trips reported in the 1983-84 NPTS (17).

As will be seen, the demographics of those making bike and walk trips in the NPTS dataset are consistent with results reported by many of the smaller sample studies described in the literature review. The populations of those making the walk and bike trips vary by sex, family income and composition, and population density. In the following section, the individual and household characteristics associated with those individuals and households making the walk and bike trips are presented.

Sex. Of the total annual nonmotorized person trips, approximately 49 percent of the trips were made by men while 51 percent were made by women. However, the breakdown by the type of mode reveals remarkably different splits by sex. Men made 72 percent of the total annual person bike trips while women made 28 percent. Of those annual person trips by walk, men made approximately 47 percent while women made 53 percent. Viewed alternatively, the daily walk trips by person reveal that men and women have roughly comparable walk trip rates while men have a much

Table 11: DAILY NON-MOTORIZED PERSON TRIPS BY SEX AND MODE

	Bike	Walk
Male	0.04	0.27
Female	0.01	0.29

Table 12: ANNUAL (MILLIONS) AND DAILY PERSON NON-MOTORIZED TRIPS BY DRIVER'S LICENSE[1]

	Bike		Walk	
	Annual Trips	Daily Rate	Annual Trips	Daily Rate
Have Driver's License	763 *(78.6%)*	0.02	9300 *(71.2%)*	0.19
Do Not Have Driver's License	208 *(21.4%)*	0.05	3760 *(28.8%)*	0.85

[1] Includes only those individuals older than age sixteen.

Table 13: DAILY NON-MOTORIZED TRIPS BY AGE

	Bike	Walk
5-15	0.07	0.46
16-19	0.04	0.56
20-29	0.03	0.30
30-39	0.02	0.21
40-49	0.01	0.16
50-59	Ins[1]	0.19
60-64	Ins[1]	0.19
65+	Ins[1]	0.20

[1] Insufficient Data

Table 14: DAILY NON-MOTORIZED HOUSEHOLD TRIPS BY LIFE CYCLE

	Bike	Walk
Single Adult, No Children	0.03	0.53
Single Adult, Youngest Child 0-5	Ins[1]	1.02
Single Adult, Youngest Child 6-15	0.20	1.57
Single Adult, Youngest Child 16-21	Ins[1]	0.64
Single Adult, Retired, No Children	Ins[1]	0.41
> 2 Adults, No Children	0.04	0.54
> 2 Adults, Youngest Child 0-5	0.08	0.62
> 2 Adults, Youngest Child 6-15	0.14	1.01
> 2 Adults, Youngest Child 16-21	0.06	0.52
> 2 Adults, Retired, No Children	0.03	0.31

[1] Insufficient Data

larger daily bike trip rate. As Table 11 suggests, daily trip rates by either sex, and mode, are substantially less than one.

Driver's License. As Table 12 indicates, nearly one-fourth of all annual non-motorized trips were made by those having no drivers license. It is also important to note that this breakdown includes only those individuals greater than age sixteen. Bike and walk trip rates are very different when drivers license is taken into consideration. It is clear that those without a drivers license make two to four times the number of daily bike or walk trips as those with a drivers license.

Age. Previous research suggests that age plays an important role in non-motorized trip behavior. The NPTS data show increased non-motorized trip-making activity for individuals less than age 29. As Table 13 indicates daily trip rates vary between 0.01 and 0.07 for bike trips and 0.16 and 0.56 for walk trips.

Life Cycle. Various household characteristics have also been associated with travel patterns. Beginning with life cycle, bike and walk trip rates are examined in Table 14. The daily trip rates per household vary considerably between life cycle category. As might be anticipated, bike trips are among the lowest for those classified as a retired households with no children. Households with children may make as much as two to three times as many non-motorized trips as households with no children. Interestingly, single adult households with the youngest child between six and fifteen tend to make greater numbers of bike or walk trips than similar two adult households.

Income. Finally, from Table 15, the daily household trip rates by income suggest several interesting aspects of the non-motorized trips. It is clear that the number of daily bike and walk trips per household generally decreases as income increases. Most dramatic is the decrease in walk trip rates between households earning less than $10,000 and those earning more than $10,000. The data also suggests that households making less than $10,000 income make nearly four times as many daily walk trips as those households making more than $10,000.

Table 15: DAILY NON-MOTORIZED HOUSEHOLD TRIPS BY INCOME

	Bike	Walk
<$10,000	0.08	1.45
$10,000-$19,999	0.05	0.62
$20,000-$29,999	0.07	0.61
$30,000-$39,999	0.09	0.57
>$40,000	0.06	0.49

Table 16: DAILY HOUSEHOLD NON-MOTORIZED TRIPS BY URBAN SIZE

	Bike	Walk
50,000-199,999	0.10	0.58
200,000-499,999	0.06	0.55
500,000-999,999	0.03	0.42
> 1,000,000 no subway/rail	0.07	0.58
> 1,000,000 with subway/rail	0.06	1.07

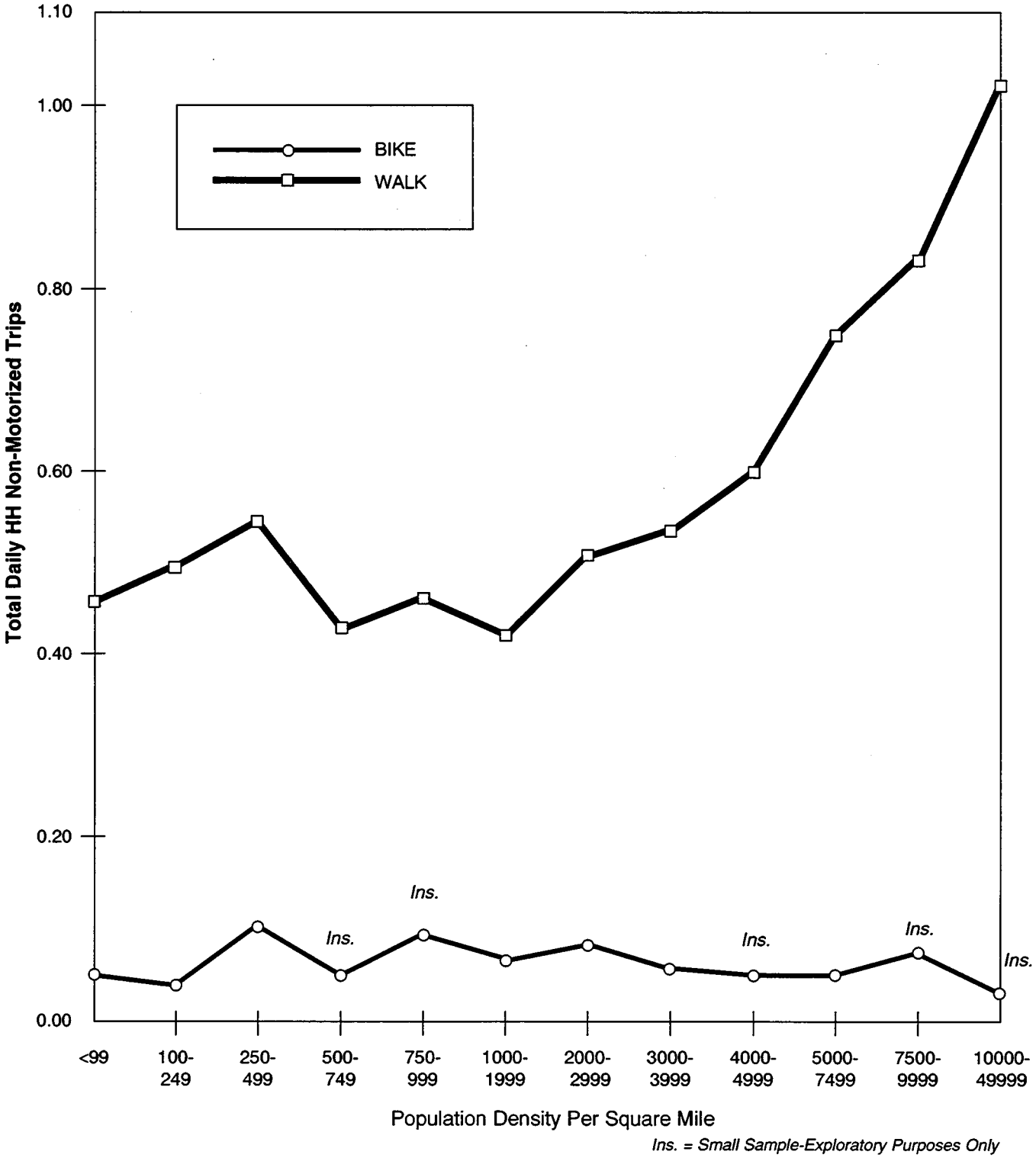
Urban Size. As noted in the literature review, the effects of urban size and density on non-motorized trip rates have not been well documented. From the NPTS data it is clear that the largest proportion of annual non-motorized trips occur in urban areas with greater than one million in population (approximately 42 percent for bike and 54 percent for walk). Breaking travel down to daily trip rates by urban size, as in Table 16, suggests that daily household non-motorized trip rates are slightly higher in the larger urban areas when compared to areas under 500,000 in population. As might be expected urban areas with greater than one million population and a subway or rail system have much higher daily walk trip rates than the same size area without rail or subway; the presence of subway and rail systems are also indicative of higher population densities. The data also suggests that there may be a certain size of urban area that is somewhat more amenable to non-motorized travel; rates are generally higher when the urban size is less than 200,000. However, it must also be noted that the preponderance of non-motorized trips for social and recreational purposes may obscure the relationship between urban size and non-motorized tripmaking for commuting purposes.

Finally, the effects of population density on daily non-motorized trip rates can be examined using Figure 2. Contrary to Goldsmith's (6) findings, there appears to be little to no trend between daily bike trips and population density. However, there is also clearly insufficient data, as evidenced by the note shown above certain densities, for definitively assessing possible trends. Walk trip rates show a more defined pattern, with steady increases in total daily walk trips as density increases.

Bike and Walk Trip Characteristics by Trip Purpose

Additional insight into non-motorized trip-making may also be gained by examining trips by trip purpose. As might be expected, the majority of annual non-motorized person trips were made for social and recreational purposes; approximately 55 percent of the annual bike trips and 34 percent of the annual walk trips. This represents a slight increase over both 1983 social-recreational annual bike trips (53%) and walk trips (33%).

Figure 2:
TOTAL DAILY BIKE and WALK TRIPS by POPULATION DENSITY



Ins. = Small Sample-Exploratory Purposes Only

Alternatively, the proportion of 1990 NPTS work related trips suggest a declining modal share from 1983 estimates (Table 17). Work related trips accounted for roughly 10 percent of the annual bike trips and 12 percent of the annual walk trips. This compares to 1983 estimates of 14 percent for bikes and 14 percent for annual walk trips. Expressing annual trips in terms of daily rates by trip purpose (Table 18) confirms higher trip rates for social recreational purposes. Rates also tend to be higher for family and personal business trips (which include shopping trips).

Table 17: PERCENT OF ANNUAL TRIPS BY TRIP PURPOSE: 1983 AND 1990 NPTS

	Bike		Walk	
	1990	1983	1990	1983
Earning a Living	9.9	14.1	12.0	14.3
Family and Personal Business	19.7	19.7	32.4	30.3
Civic, Educational and Religious	14.1	8.8	20.3	20.6
Social and Recreational	55.4	52.6	34.1	32.7

Table 18: DAILY NON-MOTORIZED HOUSEHOLD TRIPS BY TRIP PURPOSE

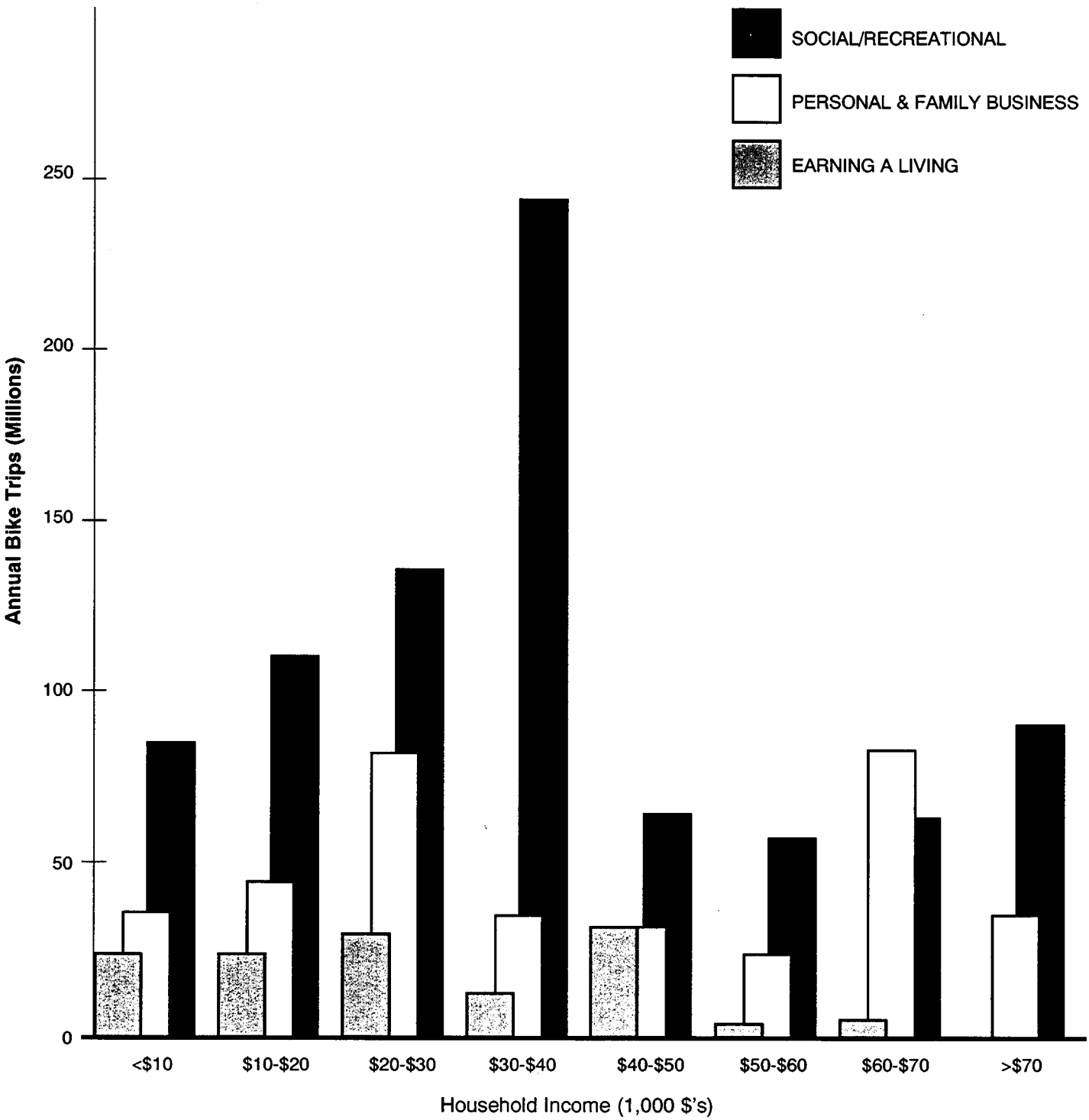
	Bike	Walk
Earning a Living	0.002	0.033
Family and Personal Business	0.004	0.079
Civic, Educational and Religious	0.001	0.022
Social and Recreational	0.008	0.069

The remainder of this section provides trip rates cross classified by the four basic trip purposes in terms of household and individual trip-maker characteristics. The section begins with a discussion of bicycle trips and finishes with a similar discussion of walk trips.

Bicycle Trips. Beginning with basic household characteristics, such as income and life cycle, daily trip rates are discussed in the context of household and individual trip making characteristics. Finally, daily trip rates by geographic characteristics are calculated to help identify trends and patterns in non-motorized travel behavior.

As Figure 3 illustrates, annual trips, by trip purpose and household income, indicate higher numbers of annual social and recreational trips. As was noted in earlier studies, there is an indication of slightly higher numbers of annual trips in certain income categories that is somewhat incongruent with the philosophy of decreasing non-motorized trips with increasing income.

Figure 3:
ANNUAL BIKE TRIPS by TRIP PURPOSE and HOUSEHOLD INCOME



As Table 19 demonstrates, the pattern of trip making activity varies greatly depending upon income and the type of trip undertaken. It is notable that daily household trip rates increase substantially in the $20,000 to $29,999 income category for personal and work related trips. However, any work related trip data must be viewed very cautiously, as sample sizes are generally very small and preclude definitive analysis. Data are presented mainly for exploratory purposes; data may suggest the type of additional research needed to more clearly define trends.

Table 19: DAILY HOUSEHOLD BIKE TRIPS BY INCOME

	Earning a Living	Personal and Family Business	Social and Recreational
<$10,000	0.001[1]	0.015	0.035
$10,000-$19,999	0.001[1]	0.012[1]	0.028
$20,000-$29,999	0.007[1]	0.020[1]	0.034
$30,000-$39,999	0.003[1]	0.009[1]	0.065
>$40,000	0.005[1]	0.014	0.037

[1] Sample sizes too small for analysis (presented strictly for exploratory purposes).

Daily bike trip rates also vary depending upon purpose and household life cycle (Table 20). Of those individuals making social and recreational trips, daily household bike trip rates vary between 0.011 and 0.092. Trip rates tend to be higher for those households with children. The lack of sufficient data in the single adult households precludes any clear definition of trends between single and two adult households. As with previous analyses, there are not enough data to evaluate rates for work related purposes.

Table 20: DAILY HOUSEHOLD BIKE TRIPS BY LIFE CYCLE AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
One or More Adults, No Children	0.006	0.008	0.016
One Adult, Youngest Child ≤15	0.005[1]	0.015[1]	0.092
One Adult, Youngest Child 16-21	0.016[1]	0.000[1]	0.038
One or More Adults, Retired	0.001[1]	0.008[1]	0.011
Two or More Adults, Youngest Child ≤15	0.002	0.020	0.063
Two or More Adults, Youngest Child 16-21	0.012[1]	0.009[1]	0.033

[1] Sample sizes too small for analysis (presented strictly for exploratory purposes).

Table 21: DAILY PERSON BIKE TRIPS BY AGE AND TRIP PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
5-15	0.002[1]	0.011[1]	0.046
16-19	0.005[1]	0.011[1]	0.017
20-29	0.005	0.008	0.016
30-39	0.003[1]	0.003[1]	0.011
40-49	0.002[1]	0.002[1]	0.004
50-59	0.000[1]	0.000[1]	0.002
60-64	0.000[1]	0.003[1]	0.003[1]
65+	0.001[1]	0.004[1]	0.007[1]

[1] Sample sizes too small for analysis (presented strictly for exploratory purposes).

Not unexpectantly, daily bike trip rates by trip purpose and age suggests that trip rates are highest among younger populations, generally less than 30 years of age. As Table 21 readily identifies, it is difficult to assess trends for work related trips although there is an indication of generally younger bike/walk commuters.

Finally, the average travel distance by bike is approximately two miles. As Figure 4 illustrates, average travel distances are generally higher in areas with densities below 750. However, there is not any clear indication that higher densities result in overall shorter bike trips. Social and recreational trips were longest at 2.2 miles followed by work related and family/personal business trips at 2.1 and 1.6 miles, respectively; the bike trip length, for any purposes, rarely exceeds five miles. Travel times follow much the same pattern with an average travel time for a social/recreational trip at 15.5 minutes, work related trips at 15.3 minutes and family/personal business trips at 11.5 minutes.

Walk Trips. Daily walk trip rates vary depending upon trip purpose. As Table 22 indicates slightly larger trip rates may be found for social and recreational daily walk trips for lower income categories. There is a consistent trend for declining numbers of trips as income increases.

Table 22: DAILY HOUSEHOLD WALK TRIPS BY INCOME AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
<$10,000	0.110	0.516	0.464
$10,000-$19,999	0.071	0.212	0.213
$20,000-$29,999	0.075	0.232	0.177
$30,000-$39,999	0.083	0.167	0.179
>$40,000	0.062	0.142	0.193

Figure 4:
AVERAGE BIKE TRIP LENGTH by POPULATION DENSITY

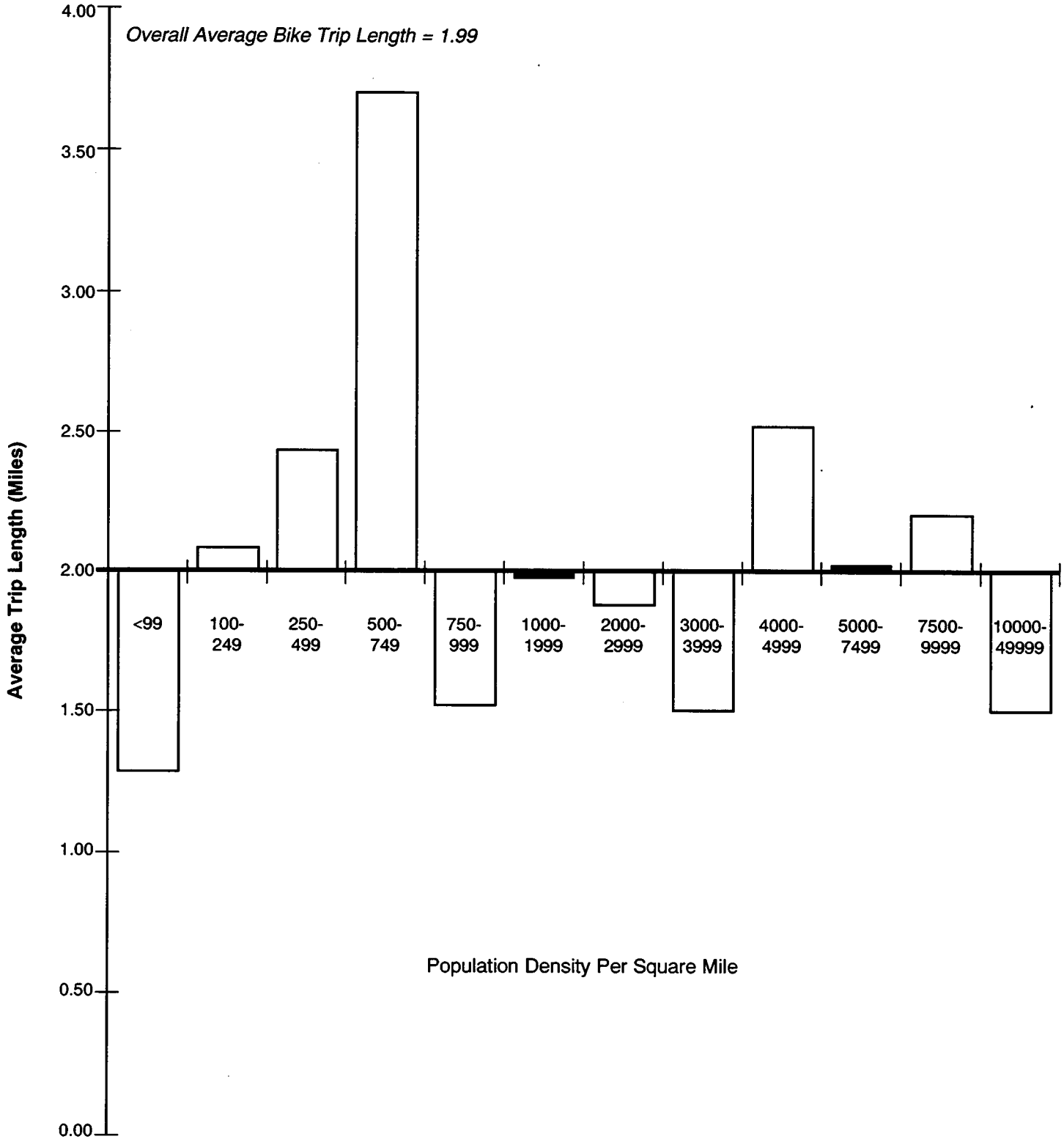


Table 23: DAILY HOUSEHOLD WALK TRIPS BY LIFE CYCLE AND PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
One or More Adults, No Children	0.100	0.206	0.161
One Adult, Youngest Child ≤15	0.043	0.409	0.510
One Adult, Youngest Child 16-21	0.066[1]	0.213[1]	0.294[1]
One or More Adults, Retired	0.016	0.153	0.145
Two or More Adults, Youngest Child ≤15	0.073	0.198	0.285
Two or More Adults, Youngest Child 16-21	0.089	0.195	0.166

[1] Sample sizes too small for analysis (presented strictly for exploratory purposes).

As with bike trips, daily walk rates in Table 23 are considerably smaller for single adult households. The presence of older children in two adult households also seems to increase walk rates. As might be expected social and recreational daily trip rates are generally higher regardless of the household life cycle.

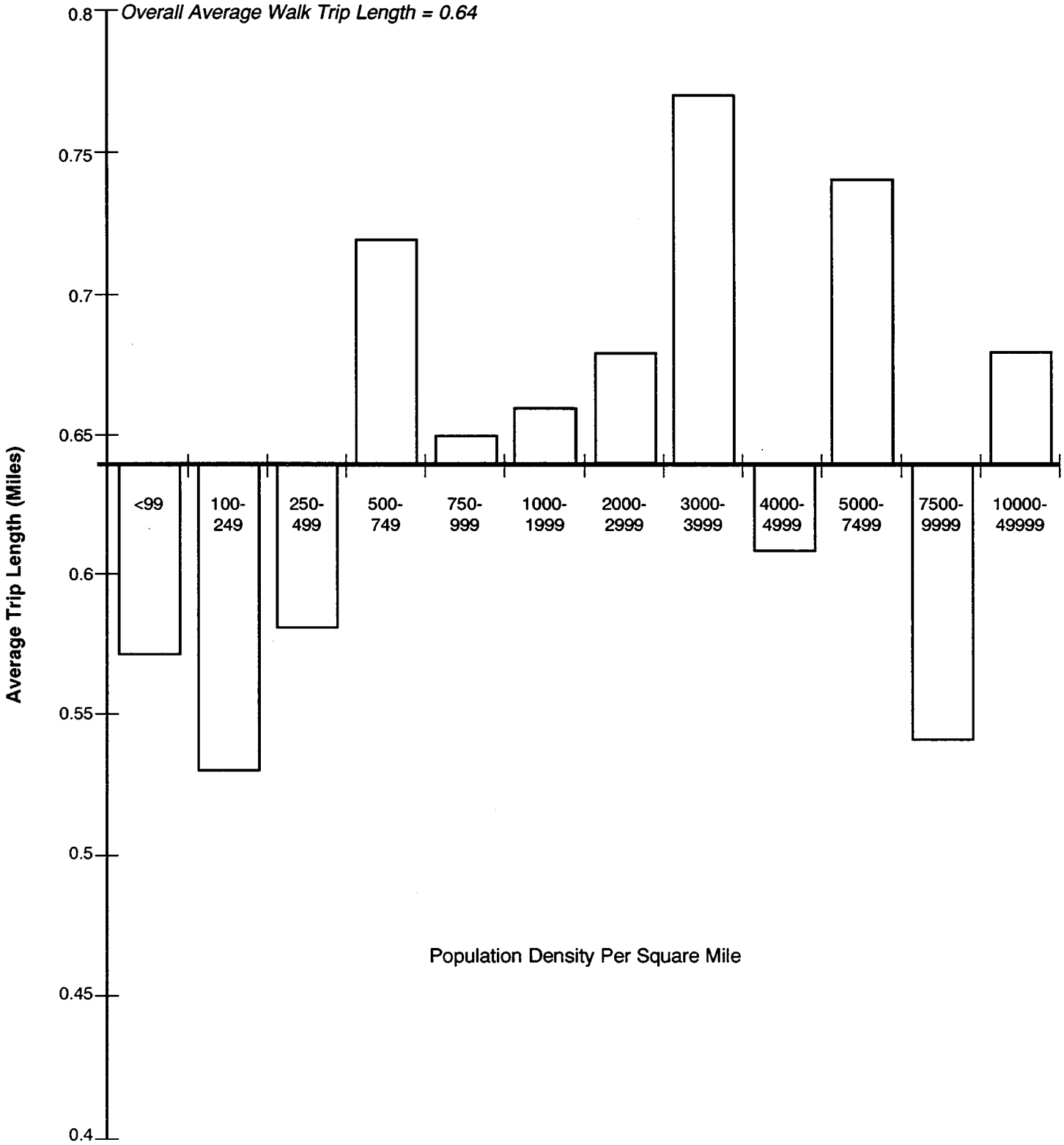
As might be expected, trips rates vary considerably with age (Table 24). Social and recreational trips are made most frequently by younger individuals; rates decrease as age increases for this trip purpose. Trip rates appear to increase as age increases for daily work trips.

Table 24: DAILY PERSON WALK TRIPS BY AGE AND TRIP PURPOSE

	Earning a Living	Personal and Family Business	Social and Recreational
5-15	0.004	0.069	0.165
16-19	0.043	0.147	0.220
20-29	0.054	0.111	0.093
30-39	0.046	0.095	0.063
40-49	0.038	0.065	0.045
50-59	0.038	0.077	0.057
60-64	0.023	0.008	0.076
65+	0.006	0.089	0.083

Finally, the average walk trip travel distance for social and recreational trips were longest at 0.62 miles followed by work related and family/personal business trips at 0.54 and 0.47 miles, respectively; the average daily walk trip length, for all purposes, rarely exceeds 0.6 miles. Figure 5 provides strong evidence that walk trip lengths decrease at higher densities. Travel times follow much the same pattern with an average travel time for a social/recreational trip at 11.5 minutes, work related trips at 9.9 minutes and family/personal business trips at 8.8 minutes.

Figure 5:
AVERAGE WALK TRIP LENGTH by POPULATION DENSITY



Summary

The NPTS data confirm much of the previous research and provide a needed empirical basis for further study. The differences between households making only motorized trips and households making one or more non-motorized trips reveal several interesting aspects of travel behavior. First, it is clear that households making only motorized trips consistently make fewer trips than non-motorized households, regardless of the demographic or geographic cross-classificiation variables. Alternatively, an examination of VMT between household types suggest that households making any bike or walk trips accumulate less average daily VMT than those households making no non-motorized trips. It is not obvious from the data that non-motorized trips replace motorized trips yet the presence of non-motorized trips seems to indicate a clear propensity for less daily VMT.

The data show some indication that daily trip rates for both types of households (those making only motorized trips and those making one or more non-motorized trips) decline as density increases. However, this decline does not appear to be any faster for the households making one or non-motorized trips than for the households making only motorized trips. The data, throughout the analysis, suggest that there may be optimal densities for encouraging greater non-motorized travel. Additional research in the relationship between density, infrastructure (such as sidewalks and bike lanes), and non-motorized trip rates would be very useful.

Examining bike and walk trip rates independently serves to highlight several potentially important findings. There is a clear indication of increasing walk trip rates as density increases, particularily striking is the rapid increase in rates as densities approach and exceed 2000. Conversely, there is little evidence that bike trip rates increase as densities increase. In part, this is due to a lack of data. Bike populations are clearly elusive and, although the NPTS data provides a remarkably large sample to evaluate, it is often still too small to properly interpret findings.

Finally, there is a clear need for sufficient data for disaggregation by trip purposes. Currently, the NPTS provides enough data for only social-recreational trip disaggregation and interpretation. To fully understand non-motorized trip behavior, at the minimum, there should be sufficient data for disaggregating and interpreting work related and personal business bike and walk trips as well. The NPTS provides an extremely valuable beginning point by clearly identifying and confirming household and person characteristics. These, in turn, should provide the basis for greater evaluation of how infrastructure and density affects non-motorized trip-making.

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