

Recent Nationwide Declines in Carpooling

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Recent Declines in Carpooling

List of Tables		Page
Table 1	Carpooling Gas Price Elasticities	2-11
Table 2	Mode of Travel and Carpool Composition by Geographic Location	2-17
Table 3	Mode of Travel and Carpool Composition by Urban Area Size	2-18
Table 4	Mode of Travel and Carpool Composition by Household Poverty Level	2-26
Table 5	Mode of Travel and Carpool Composition by Sex of Person	2-26
Table 6	Mode of Travel and Carpool Composition by Number of Adults in Household	2-29
Table 7	Mode of Travel and Carpool Composition by Age of Youngest Child in Household	2-32
Table 8	Mode of Travel and Carpool Composition by Number of Persons in Household	2-39
Table 9	Mode of Travel and Carpool Composition by Number of Vehicles in Household	2-39
Table 10	Factors Influencing Carpool Formation	2-42
Table 11	Trends Affecting Carpool Formation 1970-90	2-45

List of Figures		Page
Figure 1	Mode of Travel to Work by Census Year	2-7
Figure 2	Mode of Travel to Work from the American Housing Survey	2-7
Figure 3	Carpooling and Average Vehicle Occupancy	2-9
Figure 4	Monthly Average Gasoline Price	2-9
Figure 5	Carpooling for the Work Trip Through the Years	2-11
Figure 6	Mode of Travel by Trip Purpose	2-13
Figure 7	Carpool Composition by Trip Purpose	2-13
Figure 8	Trip Accompaniment by Mode of Travel	2-14
Figure 9	Mode of Travel to Work by Work Trip Distance	2-14
Figure 10	1980 to 1990 Georgia Carpooling Trends	2-17
Figure 11	Mode of Travel by MSA Population Density	2-18
Figure 12	Mode of Travel and Carpool Composition by MSA Population Density	2-20
Figure 13	Mode of Travel by Non-MSA Population Density	2-20
Figure 14	Mode of Travel and Carpool Composition by Non-MSA Population Density	2-21
Figure 15	Mode of Travel by Age	2-21
Figure 16	Mode of Travel by Education	2-24

Recent Declines in Carpooling

List of Figures (cont.)		Page
Figure 17	Mode of Travel by Annual Household Income	2-24
Figure 18A	Mode of Travel by Number of Adults in Household and Sex	2-30
Figure 18B	Carpool Composition by Number of Adults in Household and Sex	2-30
Figure 19A	Mode of Travel by Age of Youngest Child in Household and Sex	2-33
Figure 19B	Carpool Composition by Age of Youngest Child in Household and Sex	2-33
Figure 20A	Mode of Travel by Head of Household Race/Ethnicity	2-35
Figure 20B	Carpool Composition by Head of Household Race/Ethnicity	2-35
Figure 21A	Mode of Travel by Ethnic Background and Sex	2-36
Figure 21B	Carpool Composition by Ethnic Background and Sex	2-36

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).

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 Population³ 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.

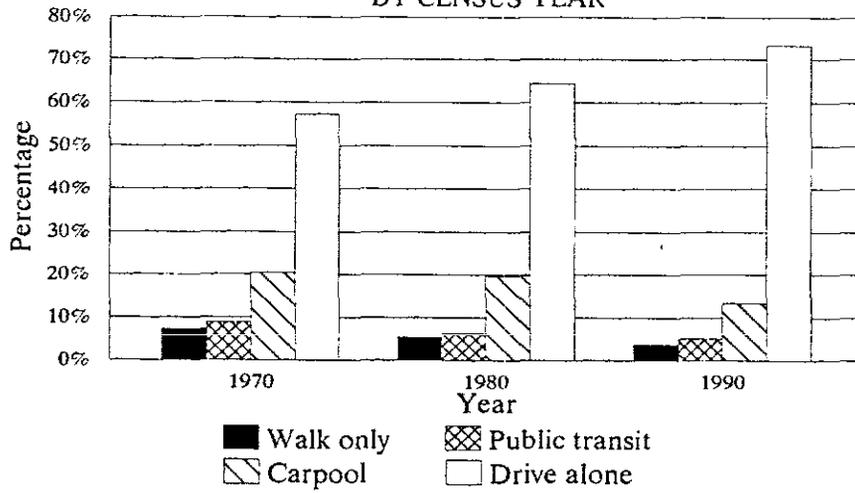
According to census journey to work data, carpooling declined from 19.7 percent of all U.S. work trips in 1980 to just 13.4 percent in 1990, a whopping 32 percent decline in ten years (Figure 1). Average vehicle occupancy (AVO) for the work trip as measured by the U.S. Census declined from 1.18 in 1970 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.

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.

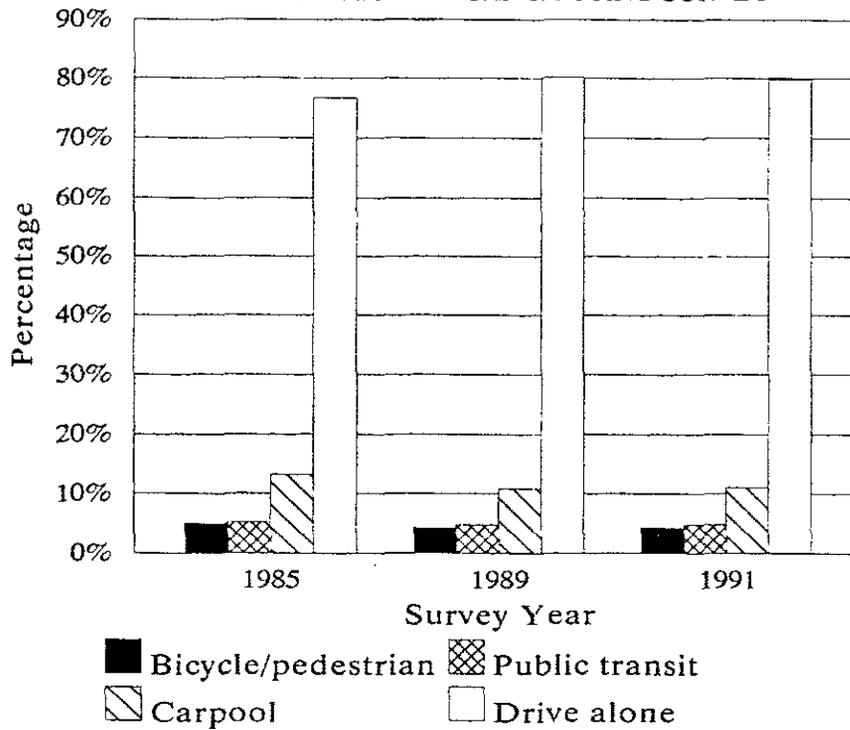
³ The 1970 Census of Population was the first to include questions on worktrips. The 1970 Census identified auto-driver and auto-passenger as separate modes. The purpose of this distinction was to measure average vehicle occupancy, defined as person trips by auto divided by vehicle trips by auto. Carpooling 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.

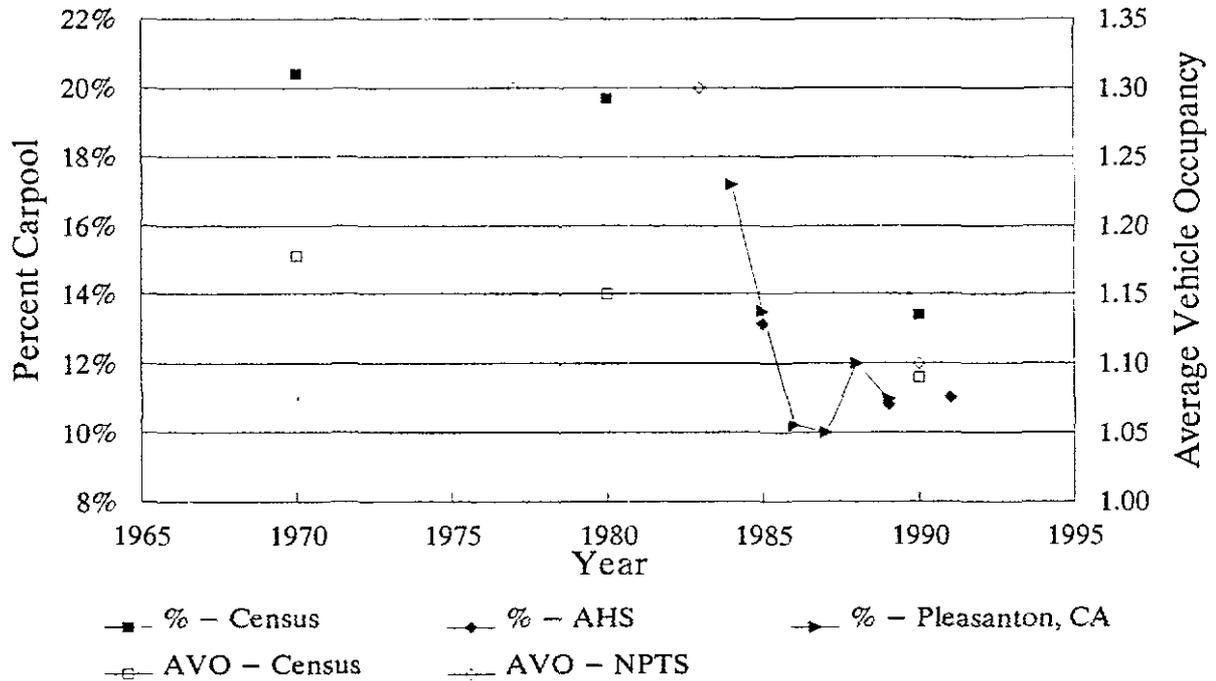
The decline in carpooling during the eighties appears to match the decline in oil prices in terms of both timing and relative magnitude. Carpooling declined by 32 percent between 1980 and 1990, while gasoline prices declined by 45 percent. This suggests that the elasticity of demand for carpools with 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 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

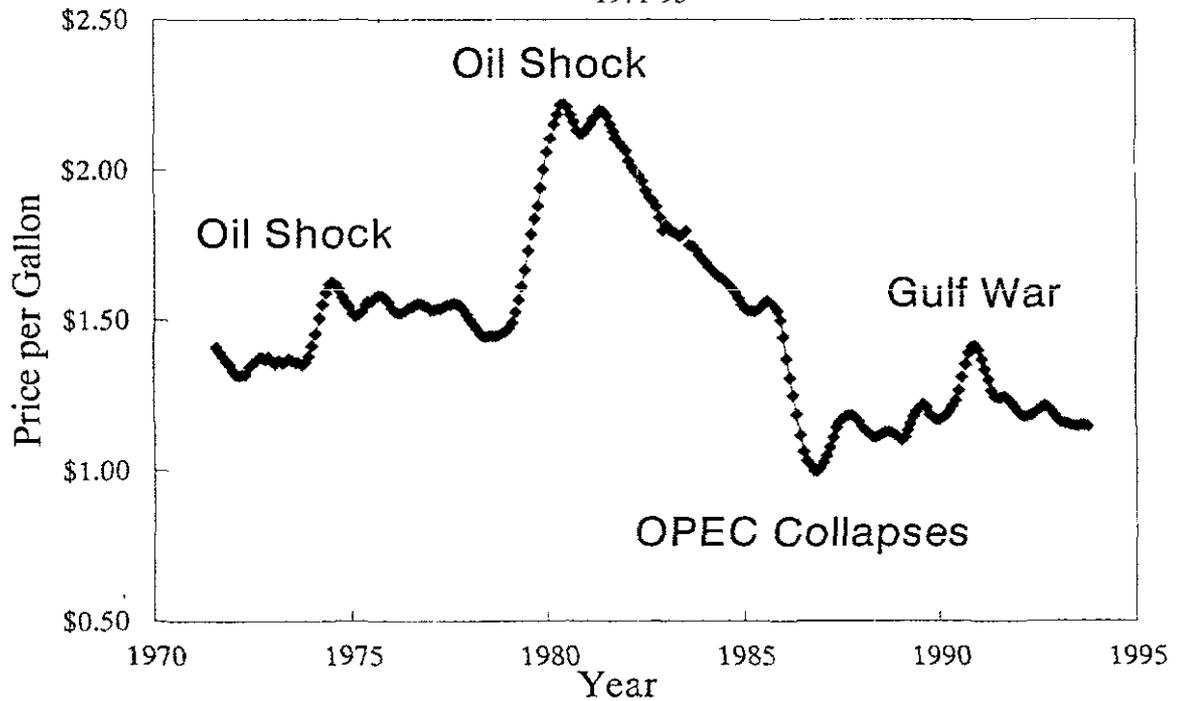
⁴ Pleasanton was the first community in the United States to pass a so-called trip reduction ordinance (TRO) into law, which took effect in 1984. The Pleasanton TRO specified certain classes and sizes of employers and developers to offer incentives to employees at certain work sites to choose alternatives 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
CARPPOOLING 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.

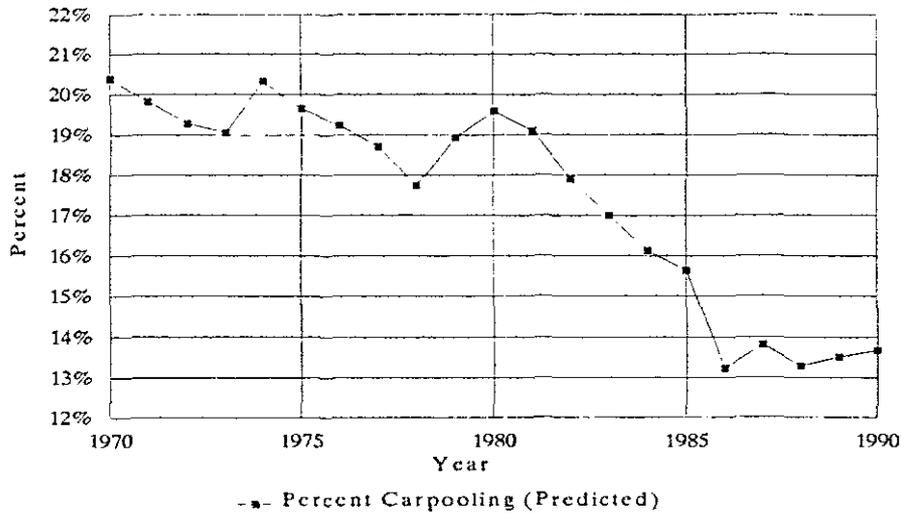
Remarkably little is known about the composition of shared rides in automobiles for anything other than the work trip. Indeed, it is not clear whether such shared-ride, non-work trips can even be referred to legitimately as carpools. Perhaps a new word should be coined to distinguish the true purpose 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%
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
	marginal fuel cost (\$/VMT)	-10.7%	64.3%	34.9%	-14.6%	11.2%
Gasoline Price Increase Required to Offset Trends and Maintain 1990 Carpool Rate in 2000	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 and Fuel Economy (MPG)	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).

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

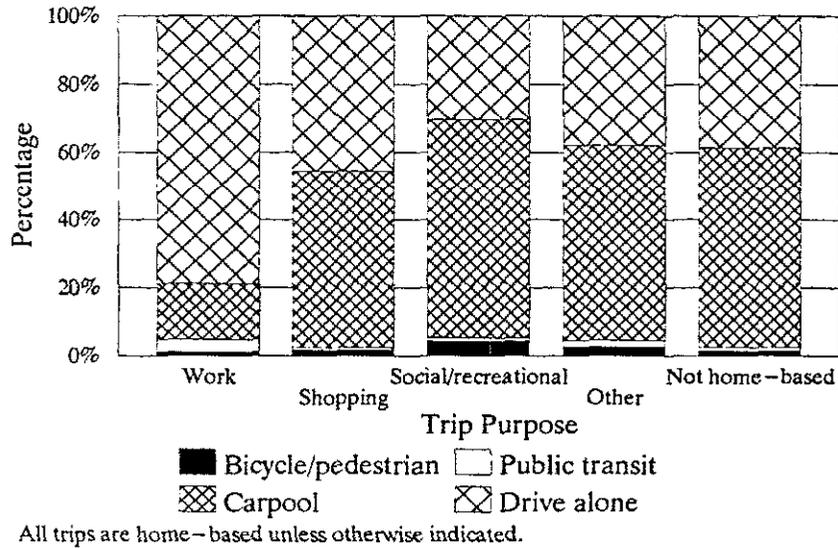


FIGURE 7
CARPOOL COMPOSITION
 BY TRIP PURPOSE

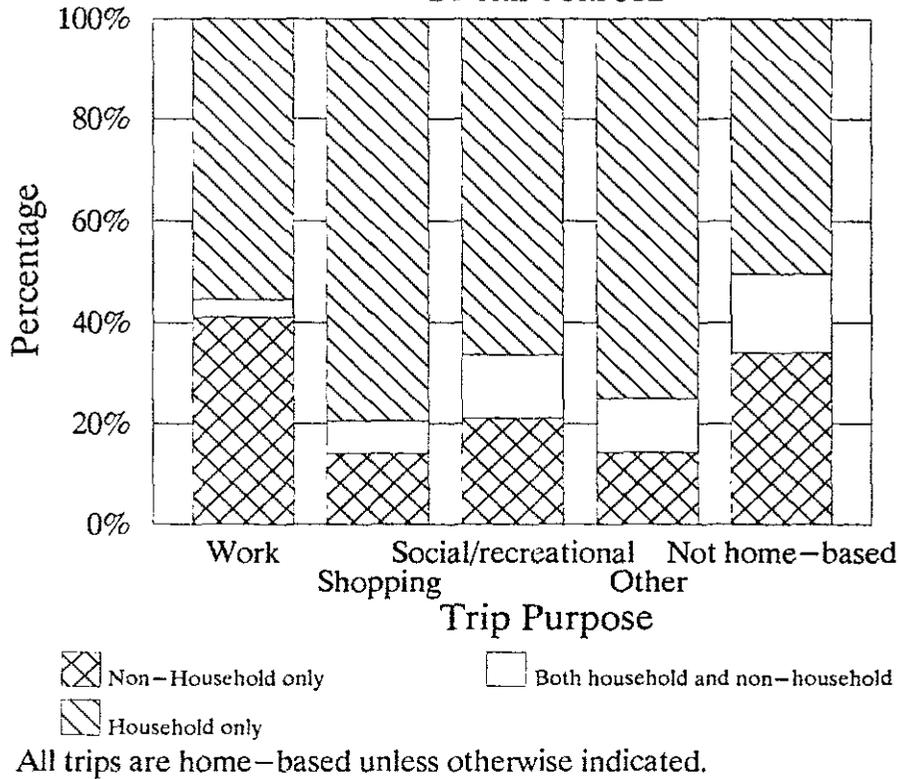


FIGURE 8
TRIP ACCOMPANIMENT
BY MODE OF TRAVEL

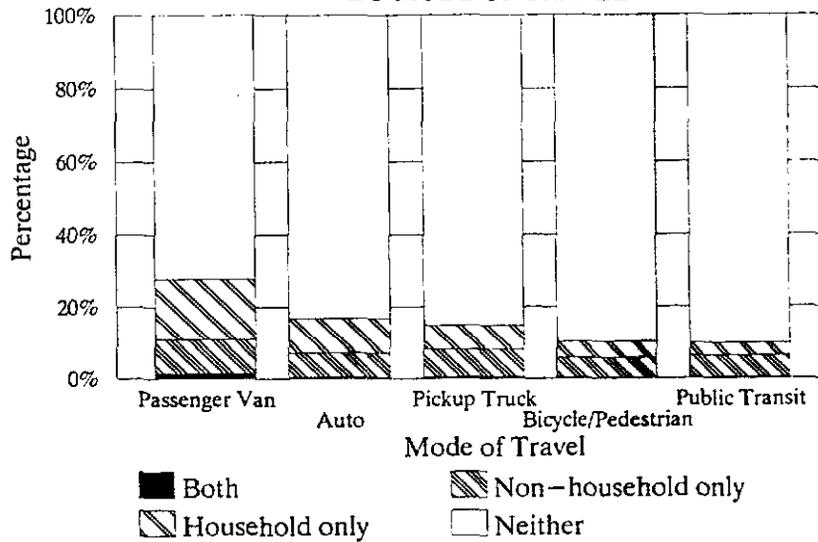
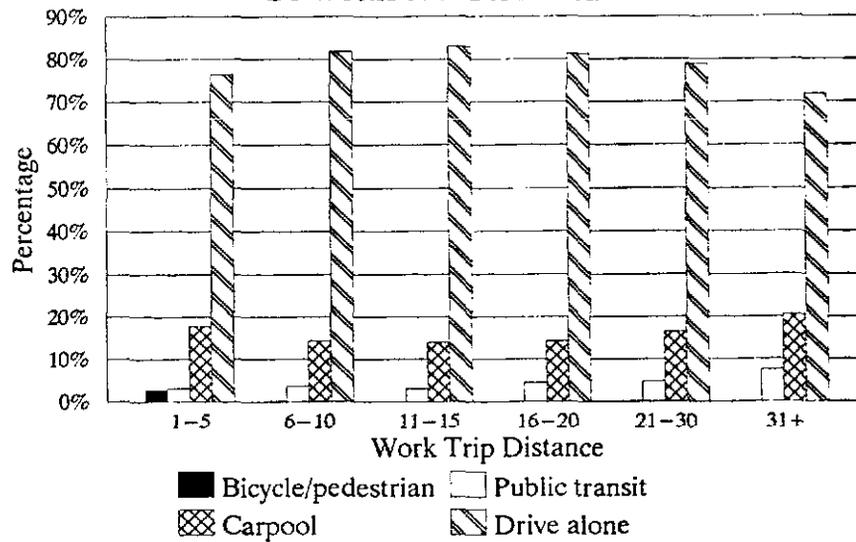


FIGURE 9
MODE OF TRAVEL TO WORK
BY WORK TRIP DISTANCE



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).^a

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.

^a 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.

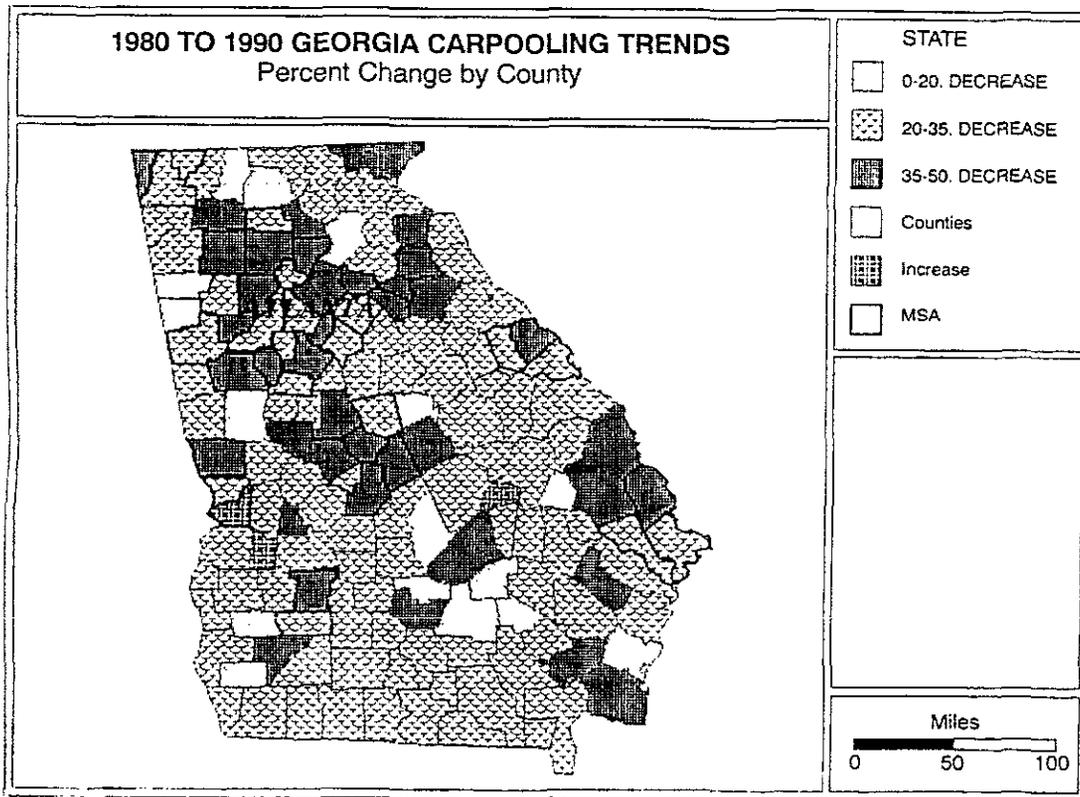
Size of Urban Area

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.

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

Figure 10



MODE OF TRAVEL AND CARPOOL COMPOSITION BY GEOGRAPHIC LOCATION

TABLE 2

Mode of Travel	Geographic Location			Total	Percent
	Urban-- Inside Central City	Urban-- Outside Central City	Not Urban		
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

Recent Declines in Carpooling

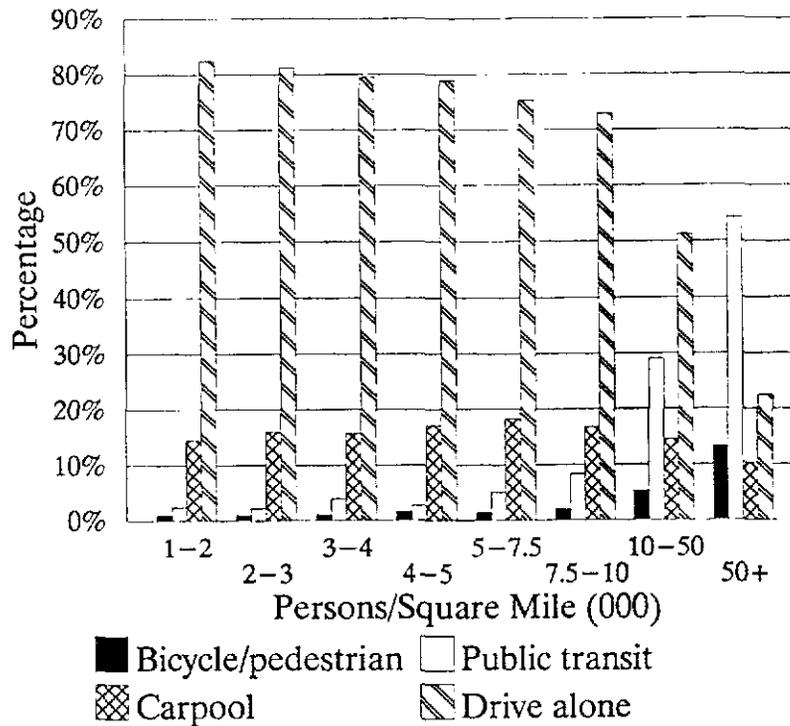
MODE OF TRAVEL AND CARPOOL COMPOSITION BY URBAN AREA SIZE

TABLE 3

Mode of Travel	Urban Area Size					Total	Percent
	50,000-199,999	200,000-499,999	500,000-999,999	1,000,000+ Without Rail	1,000,000+ With Rail		
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%	1,008	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.

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

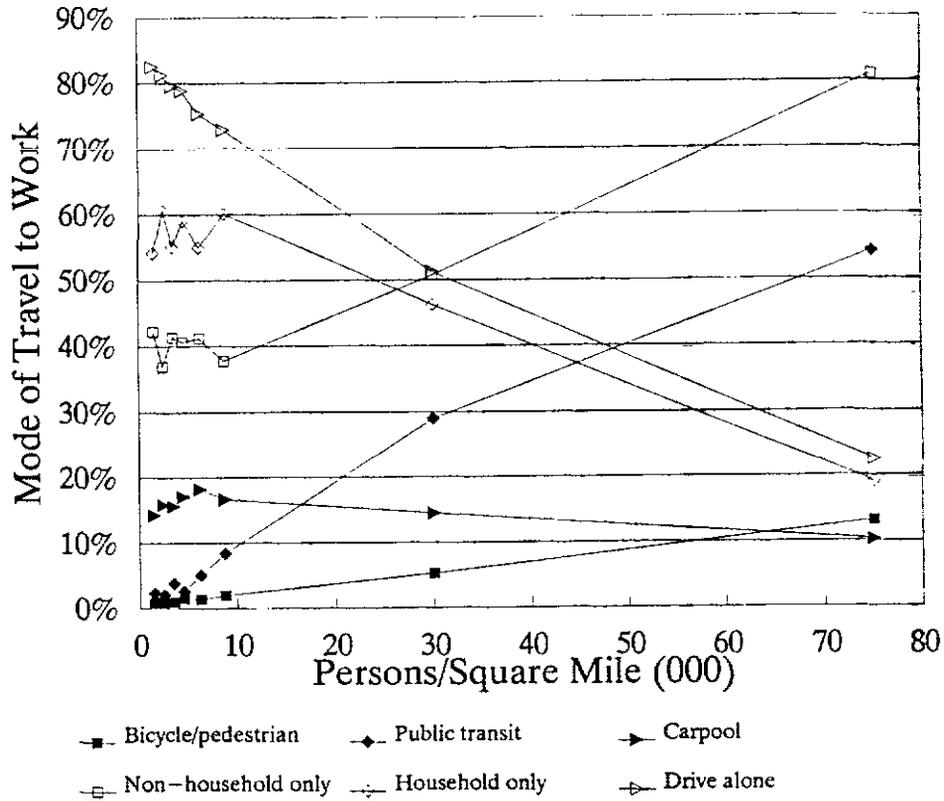


FIGURE 13
MODE OF TRAVEL
 BY NON-MSA POPULATION DENSITY

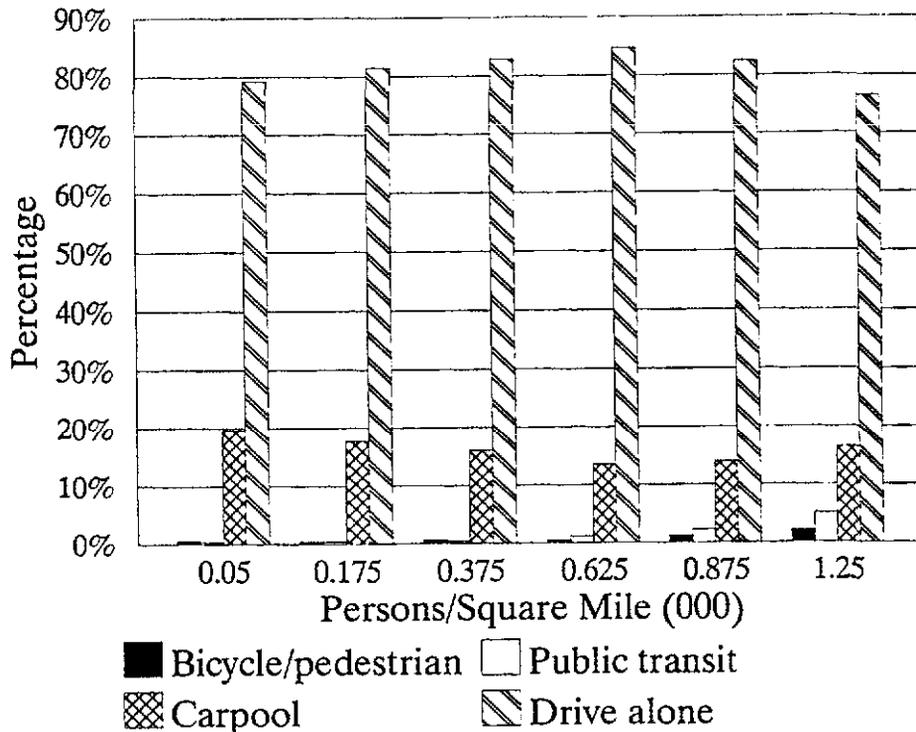


FIGURE 14
MODE OF TRAVEL AND CARPOOL COMPOSITION
 BY NON-MSA POPULATION DENSITY

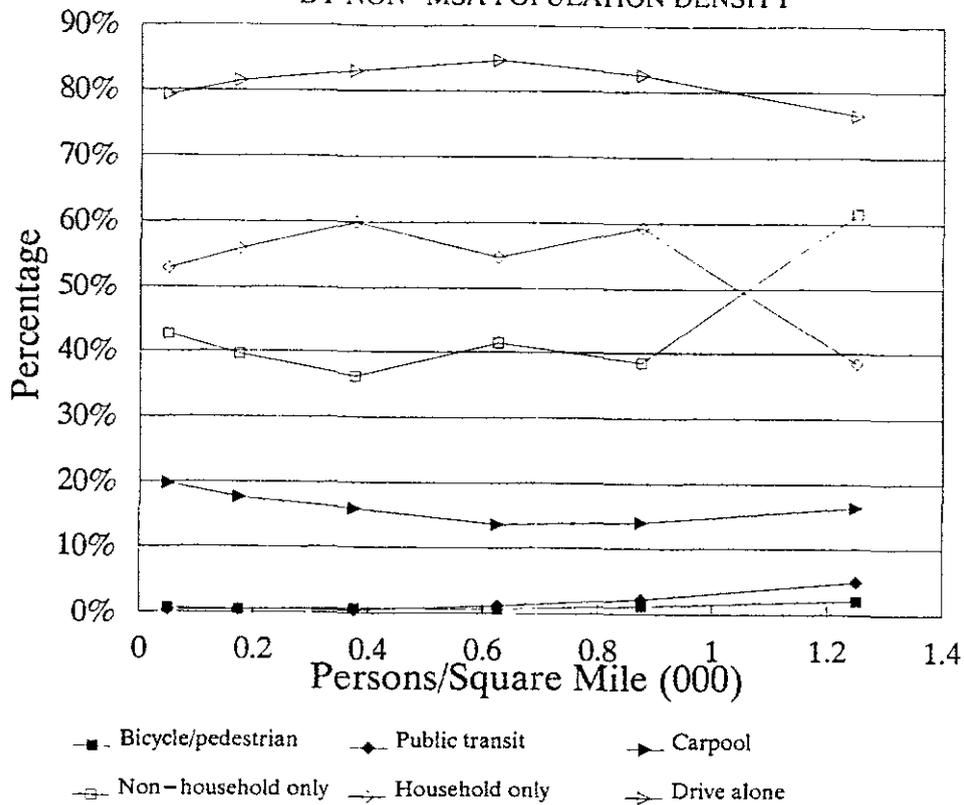
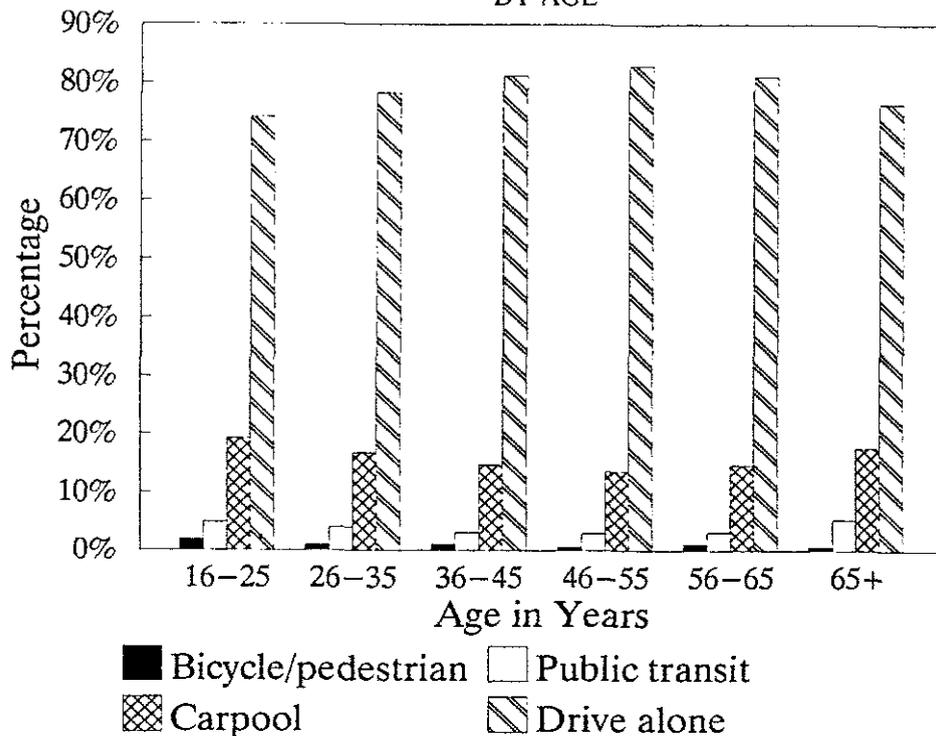


FIGURE 15
MODE OF TRAVEL
 BY AGE



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

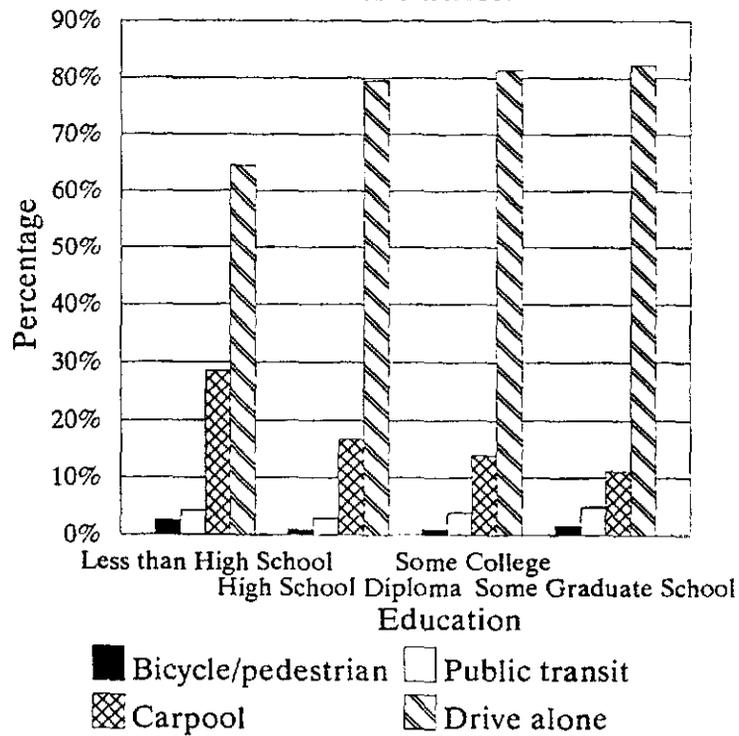
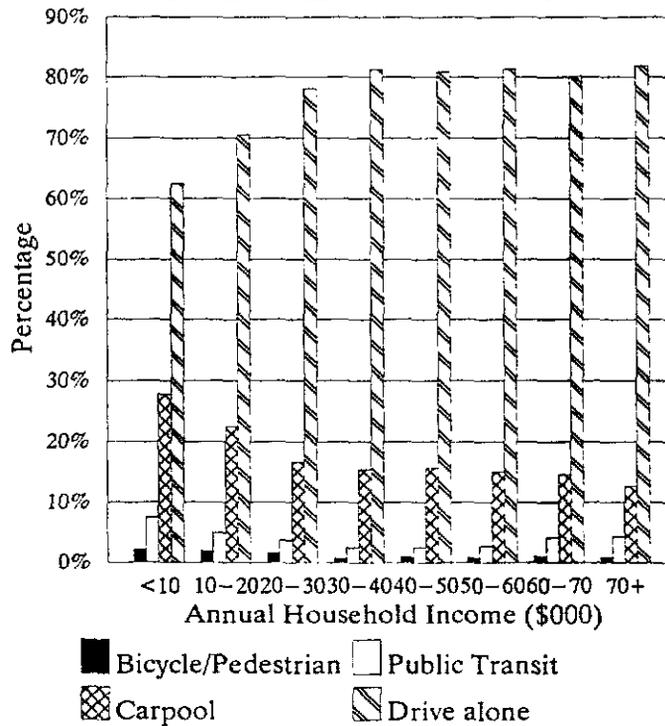


FIGURE 17
MODE OF TRAVEL

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.

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			Total	Percent
	Below	Near	Above		
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		Total	Percent
	Male	Female		
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

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

Mode of Travel	Number of Adults		Total	Percent
	1	2+		
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

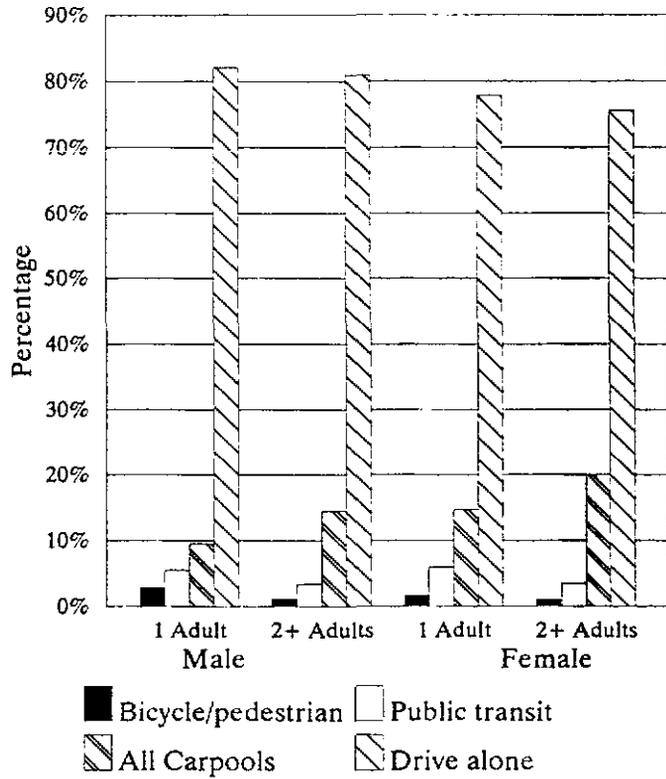
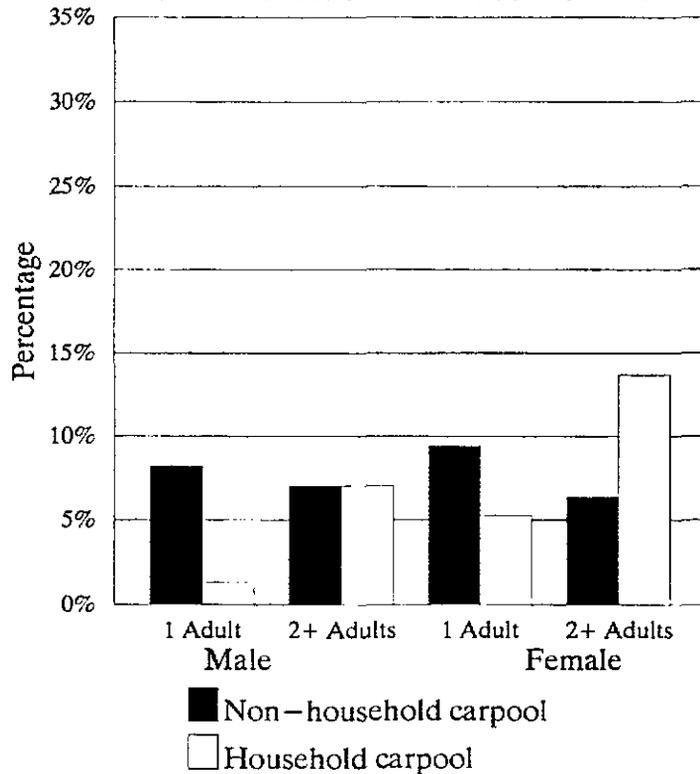


FIGURE 18B
CARPOOL COMPOSITION

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

Mode of Travel	Presence of Children					Total	Percent
	None-- Active	Youngest <6	Youngest 6-15	Youngest 16-21	None-- Retired		
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%	
<i>CPI/(DA+CP)</i>	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

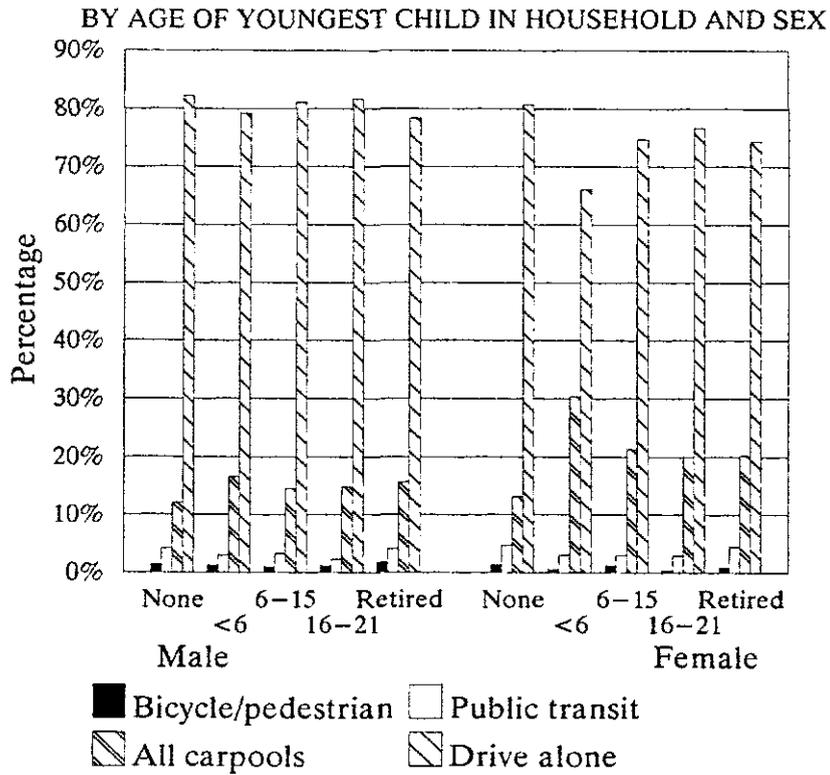
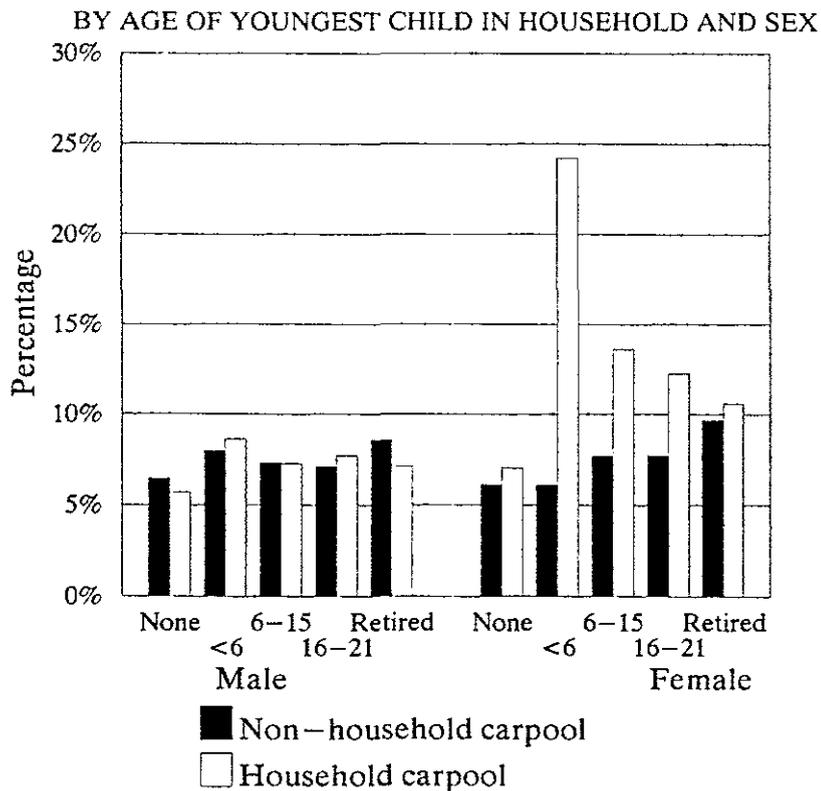


FIGURE 19B
CARPOOL COMPOSITION



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.

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

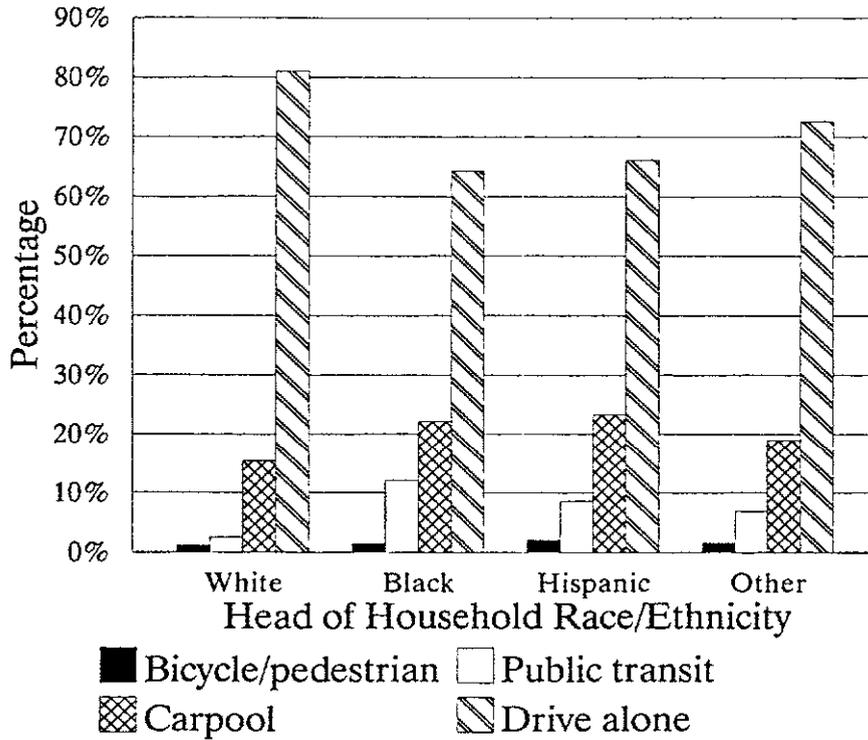


FIGURE 20B
CARPOOL COMPOSITION

BY HEAD OF HOUSEHOLD RACE/ETHNICITY

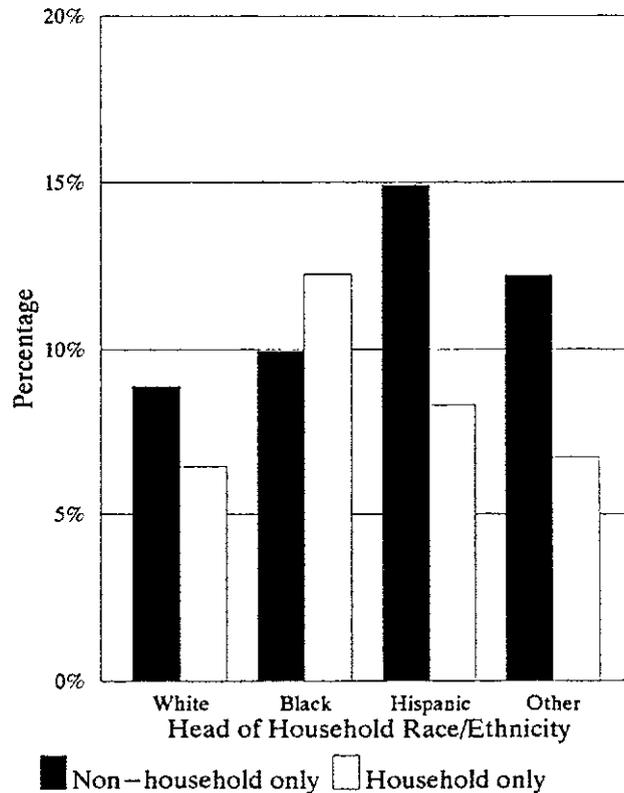


FIGURE 21A
MODE OF TRAVEL
 BY ETHNIC BACKGROUND AND SEX

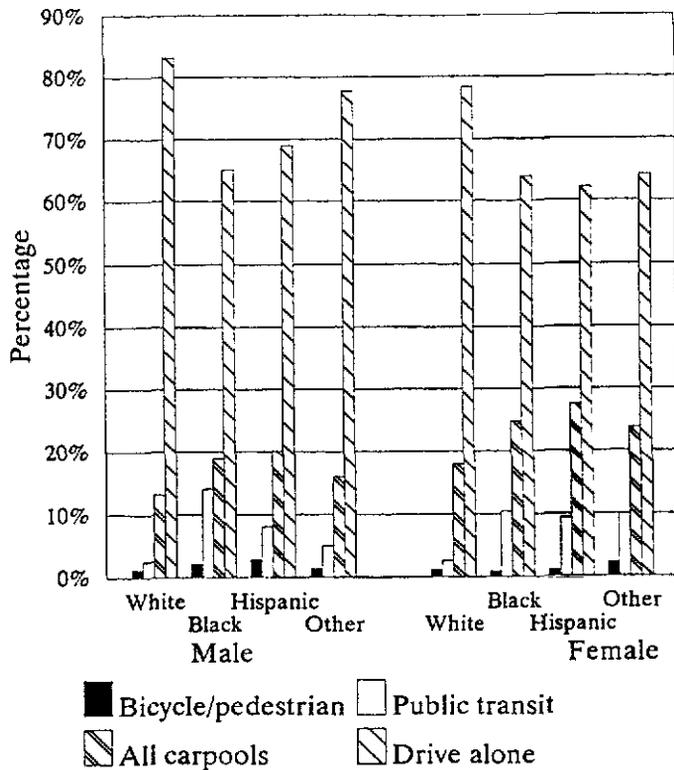
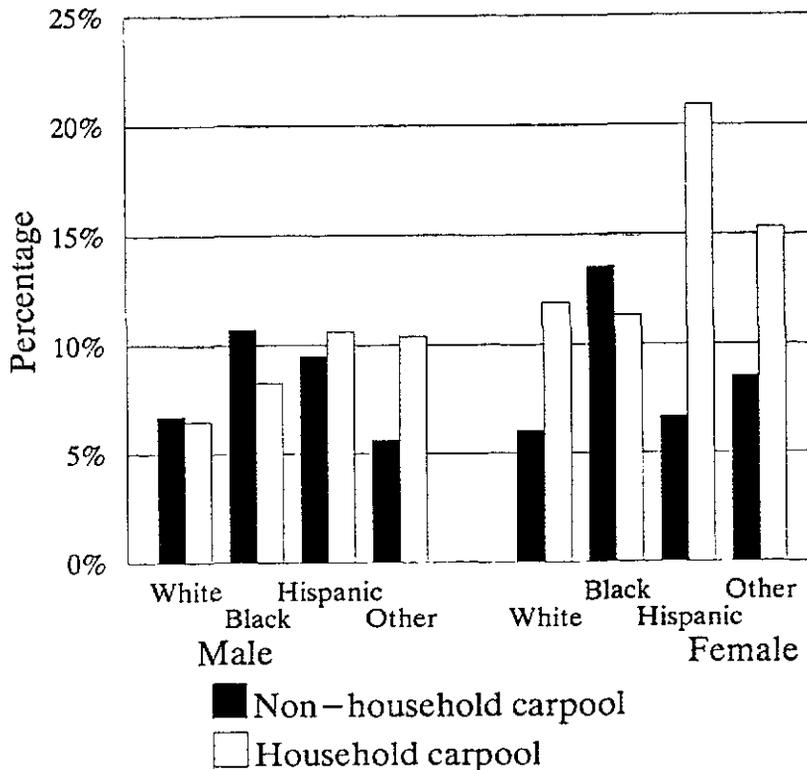


FIGURE 21B
CARPPOOL COMPOSITION
 BY ETHNIC BACKGROUND AND SEX



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

Mode of Travel	Number of Persons					Total	Percent
	1	2	3	4	5+		
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%	
CPI/(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

Mode of Travel	Number of Household Vehicles					Total	Percent
	0	1	2	3	4+		
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%	
CPI/(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.

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.

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

Influencing Agents	Data and Models				
	1977 NPTS Group Size	1983 NPTS Group Size	1990 NPTS Group Size	1990 NPTS HH Only	1990 NPTS Non-HH Only
<i>Household Characteristics</i>					
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	+
<i>Personal Attributes</i>					
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	+++	+++	+++	+++	-
<i>Trip Characteristics</i>					
travel time, distance	+++	+++	+++	---	+++
employee pays for parking		+++			
<i>Employment Characteristics</i>					
public sector	+++	+++			
manufacturing	+++	+++			
management	0	0			
professional	0	+			
clerical	0	0			
construction	0	+++			
drive as part of work	---	---			
<i>Residential Location</i>					
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.

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.

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	+	-	-	-
<i>n</i> +		3	2	5
<i>n</i> -		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.

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.

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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