Multiworker Household Travel Demand

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Executive Summary

The Nationwide Personal Transportation Survey (NPTS) data examined in this study confirm that there are increasing numbers of households with multiple workers and vehicles. The proportion of households with at least two workers rises with household size and with metropolitan area size, and is inversely related to the density within the residential zone and distance to public transportation. These characteristics describe a typical but not universal American dream: owning a home in a low density residential, metropolitan area, with access to jobs, services and urban opportunities, away from the problems of the inner city.

While the NPTS documents a rise in household vehicles and a rise in the number of vehicles per household, there is effectively no change in the number of vehicles per worker (1983-1990). The increase in vehicles can be attributed to the increase in the average number of workers per household (1.21 to 1.27 from 1983-1990) and to the increase in vehicle ownership in zero-worker households (from 0.9 to 1.1).

Multiworker households (MWHs) make longer trips in their daily travels than other households, but it is not because of the length of the work trip. While the work trip is the longest general class of trips, it is the social and recreational trips that increase in length with the number of workers in the household. In seeking low cost, low density settings, households may have increased the distance from their social network. Home-to-shop trips tend to be relatively short; in two-worker households, a subset of MWHs, shopping trips by males outnumber the total for females, while there is still a female bias in shopping trips for zero-, one- and three-or-more worker households.

In several cases there are associations between travel characteristics and the number of workers in the household, but once the household size is introduced into the analysis, the latter sometimes emerges as the dominant factor. Both solo driver work trips and the number of annual miles each vehicle is driven are more strongly correlated with household size than with number of workers, the former negatively, the latter positively.

MWHs are also more likely to take long trips (in excess of 75 miles, one way) but not if expressed in trips per worker. Almost half of these long trips are less than 100 miles from home; the longest trips are found in zero-worker households.

All these relationships are important. MWHs as a group are growing—though the rate of increase has slowed somewhat—and they exhibit travel behavior that is different from that of other households. Too frequently the number of workers per household is not used in transportation modeling, and yet, while all workers need to commute regularly, have the financial resources to purchase vehicles and thus influence peaking and congestion problems, having more than one worker per household changes the length, timing and purpose of trips made. Understanding MWHs' travel patterns could prove valuable to accurate forecasting of future transportation service demands.

A note on the primary data source: Given the paucity of MWH studies, this report uses the 1990 NPTS to study this group's travel behavior. The 1990 NPTS data, however, do not directly provide the number of workers per household; therefore it was necessary to discard about 20% of the household records and recompute household weights so that they would continue to represent the national population. This procedure is explained in the appendix and in the body of the report the data source is consequently the "Adjusted 1990 NPTS."

Introduction and Overview

During the last few decades major changes have occurred in lifestyles and household characteristics which have affected the demand for transportation services. Increasing rates of labor force participation have produced a more affluent population and stimulated the demand for private vehicles. From 1969 to 1990, when the U.S. population grew by 42 million, the NPTS reports that the number of households increased by 31 million, the number of workers by 44 million, licensed drivers by 60 million and the number of vehicles by a remarkable 93 million. Roads and highways across the nation are feeling the ramifications of increased traffic and its environmental effects.

The purpose of this study is to examine the travel behavior and related characteristics of MWHs (defined as households with at least two workers) and how they contribute to the ever-increasing demand for transportation services. On average they have incomes which exceed the national household average and often have multiple automobiles and as households they generate a considerable number of trips. The virtual dearth of previous studies of MWHs makes an overview of their characteristics and their travel behavior necessary.

This study reveals that the number of MWHs has continued to grow as has their use of highways; they are found in disproportionate numbers in low density urban areas distant from public transportation. They also have newer vehicles, and drive each vehicle more miles than other households. As households, MWHs travel more than do other households. However, an individual worker's ability and desire to travel is constrained by time factors, among others, and transportation use by MWHs, when calculated on a per worker basis, is relatively low.

Previous Studies

MWHs have received very little attention in all but the latest studies and their absence from transportation demand models raises questions about the completeness of older models. Boyce admonishes the transportation community for the lack of interest in MWHs and calls it an "embarrassment" to the field of transportation research (1). It should be noted that several planning organizations including, for example, the Chicago Area Transportation Study (2) use the number of workers as a key part of their travel models. There is, in some cases, a reluctance to use the number of workers because of definitional problems: who is a worker? Questions arise about part-time employees, seasonal workers, and temporarily unemployed individuals.

Most of the early literature focuses on two-earner households from the perspective of the gender differences in mode use and trip length. Singell and Lillydahl provide a thorough overview of this perspective and cite a multitude of studies emphasizing gender travel differences (3). Along with Schlesinger they describe the shorter, more public transit emphasis of trips by women, and how this may be derived from the housing location decision and how this relates to the male workplace (4). Many of these studies were conducted in the 1970s and early 1980s, using data generally describing the early 1970s. The NPTS data illustrate how the data on licensed drivers now shows little difference between men and women and, given the phenomenal increase in private vehicle use, the gender differences in mode use have begun to evaporate.

The number of workers per household has increased with the increasing size of the labor force. Prevedouras and Schofer attributes this to three factors: the baby-boom generation entering the labor force, the increased supply of labor from female participation, and the need for more than one income (5). They also point to the increasing number of young adults returning to the family home as a cause of MWHs. Their paper finds that growing suburbs attract large families with young children and concludes that suburban congestion is a product of household structure, with the number of workers a principal element of the latter.

Oster reflects the perspective of the modelling community and he states that the presence of a second worker decreases the number of separate non-work destinations while increasing the number of non-work destinations accessed via workplace related travel (6). Previous traffic models have made the home-to-work trip the main topic of study, but Gordon et al. take issue with this (7). They state that travel behavior can be influenced by the increase in two-worker households and that the growth in peak hour nonwork travel is closely associated with two-worker households. Strathman et al. also indicate that households are most likely to link non-work trips with work trips and that household structure was the most significant variable (8).

Organization of Paper

This paper will first describe general trends in labor force and household composition and will then closely examine MWHs: Where do they live? What are their household financial and vehicle-owning characteristics? What are their travel patterns? These findings will be summarized and finally, certain implications that MWH travel patterns have for transportation planning and policy will be considered.

Trends

There is growing interest in the causes of growing private vehicle use, congestion, and air quality. A correlation exists between these problems and increases in the number of jobs and of MWHs.

Growth of Employment

In 1960 there were approximately 66 million workers in the nation,which was 37% of the population (9). By 1990, 47% of the population was employed, accounting for 115 million workers or a 75% increase. The number of persons not in the labor force increased during the same period by less than 33%.

A large segment of this increase in labor force participation was the increase of women with children entering the job market. In 1960, 19% of women with children under six were in the labor force, but this increased to 60% by 1991 (3). The greatest growth period occurred in the 1970s, but growth continued at a slower pace into the 1980s.

Household and Family Trends

Concurrent with this rapid rise in the size of the labor force there was an increase in household formation, offsetting what may have otherwise been an even larger increase in the number of MWHs. Between 1983 and 1990, the NPTS reports an increase in the multiworker percentage from 34.9 to 38.8 (Table 1). There is an increase in the number of two-worker households, but both the absolute and relative data (number and percent) show a decline in the number of three-or-more worker households, perhaps a consequence of the rapid rate of household formation, households splitting into two smaller units.

Table 1: NUMBER OF WORKERS PER HOUSEHOLD, 1983-1990

Number of Workers	1983 (in millions)	1990 (in millions)	1983 (percent)	1990 (percent)
0	22.6	23.3	26.5%	24.9%
1	33.0	33.9	38.6%	36.3%
2	23.3	30.0	27.3%	32.1%
3+	6.5	6.2	7.6%	6.7%
Total Households	85.3	93.5	100.0%	100.0%
2+ (multiworker)	29.8	36.2	34.9%	38.8%

Source: NPTS 1983, 1990

A long-term comparison with U.S. Census data cannot be made because the Census reports the number of workers by "family," defined as two or more related people living together, rather than by "household." In 1970, families accounted for 80% of all households, but by 1990, accounted for only 70% of all households, largely reflecting the increase in one-person households.

From 1960 to 1990, three of the four "workers per family" categories increased (Table 2); even the percentage of zero-worker families increased from 9% to 13%, a result of an aging population. More dramatic has been the growth of two-worker families,

Table 2: NUMBER OF WORKERS PER FAMILY, 1960 - 1990

Number of Workers	1960	1970	1980	1990
0	9%	12%	13%	13%
1	53%	45%	33%	28%
2	30%	34%	42%	46%
3+	7%	9%	12%	13%
Total	100%	100%	100%	100%
2+ (multiworker)	37%	43%	54%	59%
Number of Families (in millions)	—	50	58	76

Source: U.S. Bureau of the Census

increasing from 30% to 46%, and for three-or-more-worker families, increasing from 7% to 13 % over the 30-year period. The largest change has been the decrease in families with only one worker. In 1960, 53% of families had one worker; in 1990 this fell to 28%!

The increase in MWHs seems to fit the classical S-shaped curve of slow growth in the early period of development, followed by rapid growth, then a condensation period and ultimately, near saturation. From 1960 to 1970 the two-or-more worker families grew by only 6 percentage points, the early period of growth, and then grew by 11 percentage points in the next decade. This growth slowed in the decade from 1980 to 1990, showing a growth of only 5 percentage points for multiworker families. This illustrates the declining rate of growth.

Contributing Elements

A household with more than one worker has different financial and vehicle-owning characteristics than do other types of households. It also has a different set of living requirements, including place of residence. That household's circumstances also engender its own particular traffic patterns. This section examines MWHs and their household structure's relationship to household characteristics, place of residence and travel patterns. Variations in travel demands, especially private vehicle versus public transportation use, can thereby be better understood.

Relationship with Household Characteristics

Partly due to their greater size, MWHs have more vehicles and drivers than other households (Table 3). Their members (especially in two-worker households) are younger and tend to be more educated. Conversely, zero-worker households are the most unique, having an average adult age more than twenty years greater than other households.

Table 3: AVERAGE DEMOGRAPHIC CHARACTERISTICS BY WORKERS PER HOUSEHOLD

Number of Workers	Drivers (per household)	Vehicles (per household)	Age (years) (adult population only)	Some College Education (%) (adult population only)
0	1.12	1.10	65.1	25.0
1	1.50	1.57	43.1	45.4
2	2.09	2.19	38.8	50.8
3+	3.26	3.05	40.8	39.1
All Households	1.75	1.77	45.7	42.7

Source: Adjusted NPTS 1990

Household Income

As may be anticipated, there is a positive relationship between household income and the number of workers in a household. For households with annual incomes less than $10,000, the multiworker percentage is under 10 (Figure 1). Both two-worker and three-or-more-worker household percentages increase with income and peak before the highest category. MWHs households account for 70% of the households in the $75,000 - 79,999 income bracket, even though they account for only 39% of all households (regardless of income). At incomes beyond this level the percentage of multiworker households drops; it is 64% in the highest bracket, $80,000 and over.

Conversely, zero-worker households increase at incomes above $70,000. Over 36% of the households in the top bracket were not multiworker households. This represents a class of affluent individuals or small households who likely have strong travel demands. The size of the affluent non-working population and its travel demands merit closer study than what is feasible here.

Number of Household Vehicles

The association between the rise in the vehicular population and employment can be seen in Figure 2. MWHs households typically have more than one car and in three-or-more worker households almost two thirds have at least three cars. The number of vehicles per household increases with the number of workers, rising from 1.1 for households without workers to 3.1 for three-or-more-worker-households (Table 3). Since the one-worker households have automobile ownership rates of 1.6 per household, the rate per worker declines as the number of workers per household increases. Therefore, the number of workers per household is not the only factor contributing to the number of vehicles in a household.

Similarly, the zero-worker households also have a fair number of vehicles. Remarkably, approximately one-third of the households with zero workers have more than one vehicle and more than one in twenty has at least three vehicles. The vehicular ownership pattern in zero-worker households is atypical. Unlike other households where the number of vehicles is correlated with household size, for zero-worker

Figure 1. Workers by Household Income

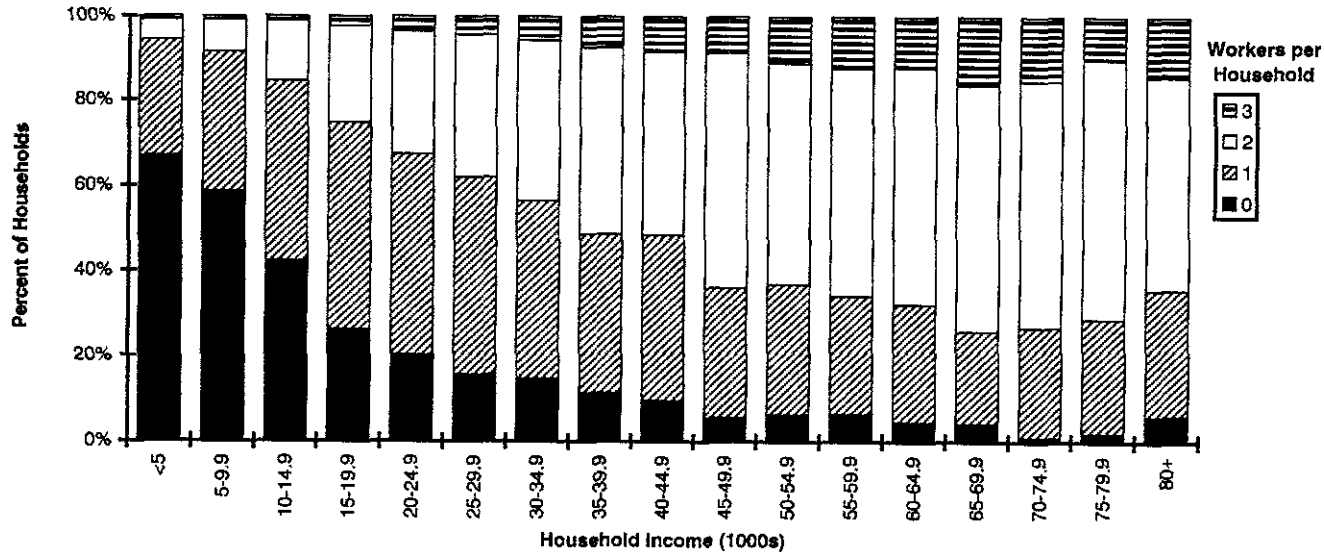
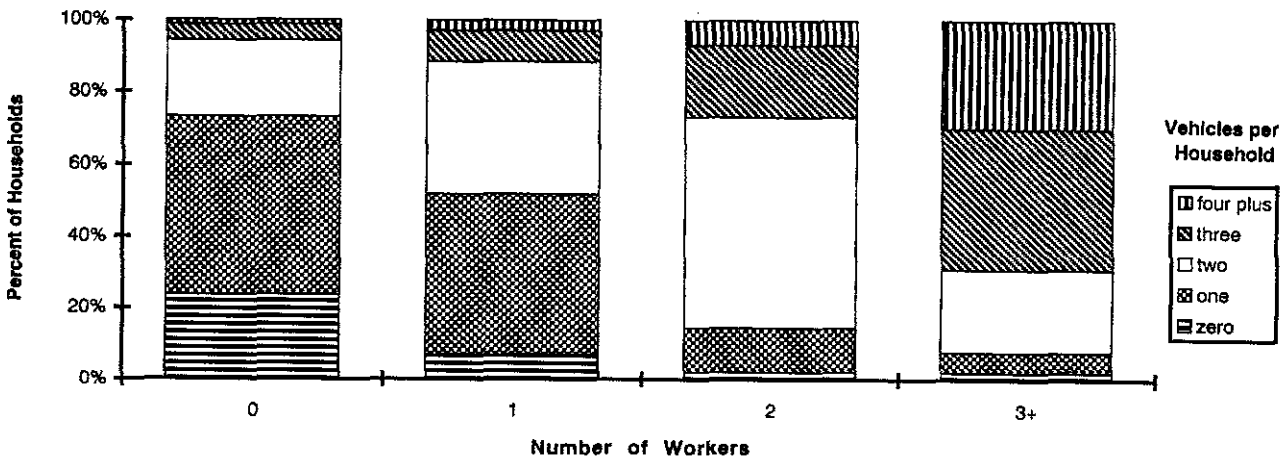


Figure 2. Vehicles by Number of Workers



households vehicular ownership peaks at two-member households (Table 4). Expectedly, large households with small incomes would not be likely to have many vehicles.

Table 4: AVERAGE NUMBER OF VEHICLES IN HOUSEHOLD BY NUMBER OF WORKERS

Number of Workers	Household Size 1	2	3	4+	All
	Number of Vehicles				
0	0.77	1.5	1.29	1.17	1.1
1	1.11	1.7	1.74	1.94	1.57
2	—	2.1	2.21	2.29	2.19
3+	—	—	2.84	3.14	3.05
All Households	0.94	1.8	2.05	2.27	1.75

Source: Adjusted NPTS 1990

This table also indicates that vehicular ownership is related more to the number of workers than to household size. Both clearly contribute to vehicular ownership rates but on average each additional worker contributes about 0.5 vehicles to the household while each additional member contributes considerably less: 0.2 vehicles from two to three and then again, from three to four members in the household (Table 4).

There is also a strong relationship between household income and the number of household vehicles. As the income rises so does automobile ownership, with over a third of the households with incomes over $55,000 having at least three vehicles. The majority of households have at least two vehicles (57%) and this is true for all but the lowest income households, those with annual household incomes of less than $25,000. This has direct implications for vehicles ownership rates; as MWHs increase, so will vehicle ownership, but at a decreasing rate. The growth of vehicles would be even greater if more zero- and one-worker households were formed from larger households, provided that they demonstrate the same propensity to own vehicles as persons in these households do today.

Not surprisingly, the same pattern applies to the average age of vehicles. They get progressively newer with increasing numbers of workers. Averaging the model years from the 1990 study (in which all cars pre-dating 1955 are given a 1955 model year) yields an average model year of 1982.2 for zero worker households and a high of 1983.6 for both two-worker and three-or-more worker households. The zero-worker households may have members who have maintained the same car for many years, thereby increasing the average age of their vehicles.

Table 5: CHANGES IN HOUSEHOLD CHARACTERISTICS, 1983 - 1990

Number of Workers	Average Number of Vehicles per Household and per Worker 1983	1990
0	0.9	1.1
1	1.6	1.6
2	2.2	2.2
3+	3.2	3.1
All Households	1.68	1.77
Vehicles per Worker	1.39	1.40
	Household Characteristics	
Workers per Household	1.21	1.27
Persons per Household	2.69	2.56

Sources: 1983 NPTS, 1990 NPTS and Adjusted 1990 NPTS

While the number of automobiles increased between 1983 and 1990, the increase seems to be partially attributable to zero-worker households. It is the only group that experienced an increase in the number of vehicles per household (Table 5). In households with workers the number of vehicles per worker remained stable, changing only from 1.39 to 1.40 in the seven-year period. But since the number of workers per household has increased from 1.21 to 1.27 during the same

period, the average number of vehicles per household has risen from 1.68 to 1.77. If household size were not declining during this period, perhaps the rate of workers per household would have increased even more. In sum, these data suggest that the number of workers in a household is a major determining factor to the number of vehicles in a household.

Place of Residence

The 1990 NPTS data show that nationally, 32.1% of the households have two workers and another 6.7% have three or more workers (Table 1) but that the country is far from being a homogeneous entity. Given the great diversity of residential areas, it is useful to consider the differences in the frequency of MWHs by place of residence. The discussion here begins with large regional patterns throughout the country and works down the scale to how close households reside to public transportation.

Variations by Census Division and Region

The U.S. Bureau of the Census has divided the country into four regions and nine divisions. An examination of the frequency of MWH rates reveals higher values in the traditional Rust Belt, from New England to the East North Central Divisions (Figure 3). The New England Division has the highest rate of MWHs, but the other two divisions which constitute the Rust Belt, Middle Atlantic and East North Central, have respectively the second and third highest percentages. High rates are also found in the rapidly growing South Atlantic and Mountain Divisions. The lowest rates are located in the traditional South (West and East South Central Divisions), followed by the Pacific Division. The West South Central, dominated by Texas, has the lowest rates.

At the regional level (the four census Regions) the Northeast and the Midwest have the highest multiworker levels at approximately 40% and the other two regions, the South and the West have the lowest, both with 37.5%.

Female participation in the labor force accounts for most of the variation across the nation. Female workers account for over 70% of the female population aged 18 to 64 in the New England Division, where the MWH percentage is the highest (Figure 4). Again the West South Central has the lowest level: 61.9%.

Size of the Metropolitan Area

The 1990 Adjusted NPTS data provide evidence of a relationship between the size of the metropolitan area of residence and the frequency of MWHs; as the metropolitan area increases in size, so does the percentage of MWHs. It increases steadily from 36.2% in non-metropolitan areas to 38.0% in places with less than 250,000 residents to 40.0% in places with over 3 million residents (Table 6). It is plausible that as the metropolitan area increases, housing and transportation costs increase, creating additional pressure for a second or third income. Moreover, as the metropolitan population increases, so does the likelihood of finding a job which could entice workers into the labor force (though there is no data from NPTS to confirm either conjecture). Lastly, since patterns of one-worker households follow MWH trends, there is a strong negative relationship between zero-worker households and metropolitan area size, the only category left.

Density by Zip Code of Residence

The positive relationship with the size of the metropolitan area implies that higher density areas have more MWHs, but the opposite is true when the data are examined at a less aggregate level (Figure 5—equivalent data were not reported in 1983). For those residing in urbanized areas (population densities over 1000 per square mile) the highest multiworker percentages, especially two-worker households, are in low density ZIP-code areas and the lowest percentages are in the highest density zones. There is little variation in multiworker percentages for densities from 2,000 - 7,500 inhabitants per square mile, but with higher densities it declines rapidly (Figure 5). The multiworker percentage drops from 38.5% to 28.3% in these high

Figure 3. Percent Multiworker Households

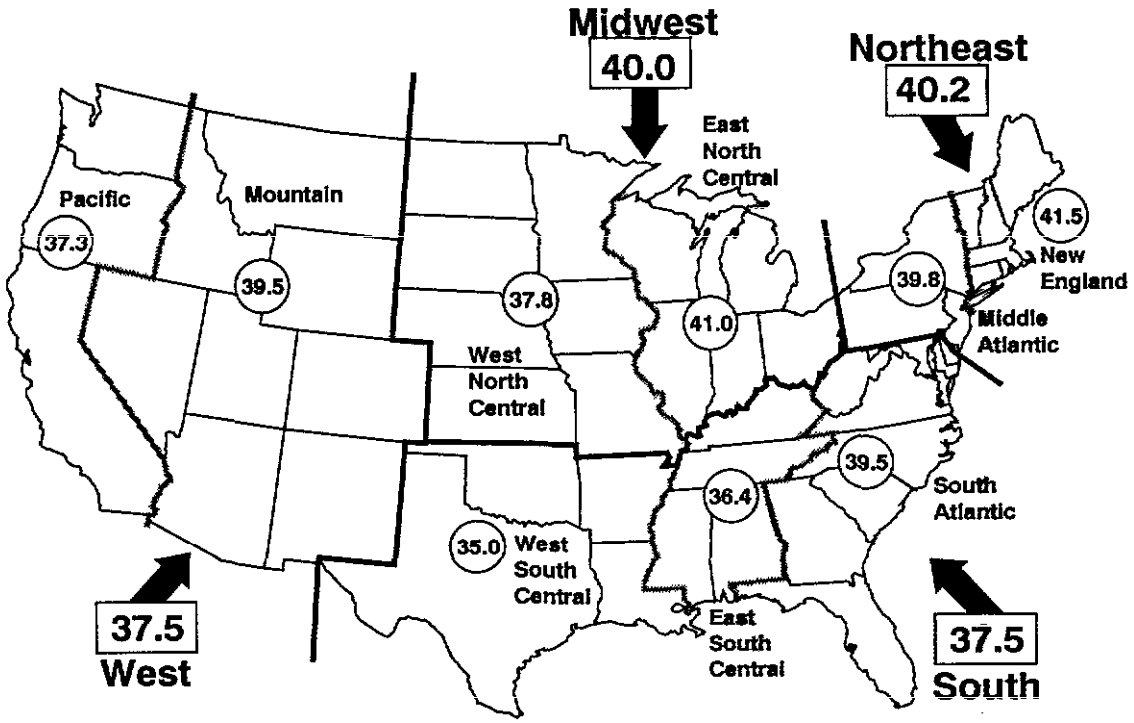


Figure 4. Female Workers as a Percentage of the Female Population Aged 18-64

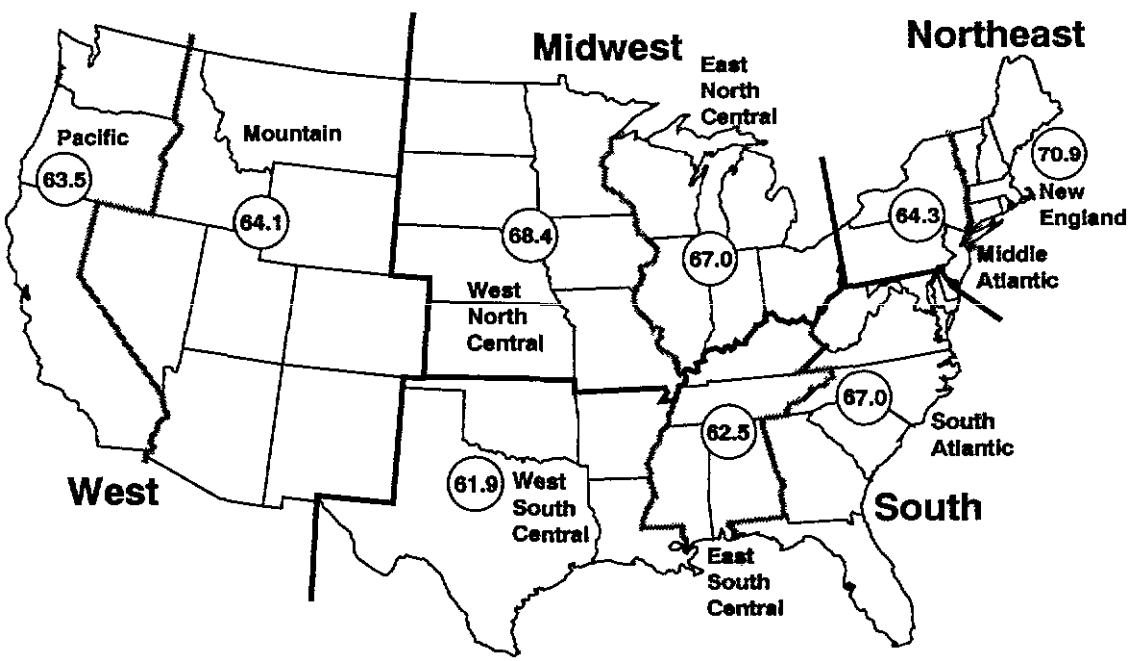


Table 6: HOUSEHOLDS BY METROPOLITAN POPULATION AND WORKERS PER HOUSEHOLD, 1990

Number of Workers	All	Non-Metro	<250 K	250 K-500 K	500 K-1 mil	1 mil-3 mil	3 mil +
		(Percentage by Population Size)					
0	24.9%	30.6%	26.2%	24.9%	24.7%	23.1%	21.0%
1	36.3%	33.2%	35.9%	36.7%	35.9%	37.8%	38.1%
2	32.1%	30.4%	31.8%	33.0%	33.9%	32.3%	32.7%
3+	6.7%	5.8%	6.2%	5.5%	5.5%	6.8%	8.2%
All Households	100%	100%	100%	100%	100%	100%	100%
2+ (multi)	38.8%	36.2%	36.2%	38.4%	39.4%	39.1%	40.0%
Average no. of workers	1.23	1.14	1.20	1.22	1.23	1.24	1.30

Source: Adjusted NPTS 1990

density zones (from 32.2% to 23.7% for two-worker households). In other words, MWHs tend to reside in the suburbs.

The lowest multiworker percentages are in the highest density ZIPs, those with more than 50,000 people per square mile. Since the city of New York has a density of approximately 25,000 per square mile and cities like Chicago, San Francisco and Philadelphia approximate 15,000 per square mile, the highest density category (50,000) is found in only a limited number of places. The most likely areas are in neighborhoods with closely-spaced, high-rise residences, such as Manhattan and the Chicago lakefront. These are areas with considerable public transportation and they attract retired individuals and, since they are generally high rent districts, they also attract young professionals. Many high density areas are also characterized by poverty and unemployment. In short, many small households and households with few workers are found in this exceptionally high density setting.

In non-urbanized areas (densities less than 1000 persons per square mile) there is a positive relationship between density and proportion of households with more than one worker. Small communities (lowest density category) have the highest percentages of zero-worker households; over 30% in places with densities of less than 100 people per square mile. This suggests that there are many rural poor or that many retirees have moved to low density areas where proximity to jobs and other urban opportunities are not a priority. In this setting, however, services are not plentiful and longer distances are typically necessary to satisfy some consumer needs.

Proximity to Public Transportation

Over 40% of the nation's households live where no public transit is available but almost 60% of those that answered the proximity to pubic transit question indicated they were within three blocks of the nearest public transportation. Another 25% lived farther than three blocks but less than a mile (less than 12 blocks) from transit. These two groups represent the first three proximity categories on Figure 6, but unfortunately from a transit perspective, the percentage of multiworker households, especially two-worker households, increases with distance from transit.

Looking at the data from another angle, only 28.7% of the families in the less than three block group have two workers and it rises to 41.2% in the third distance group (1/2 to one mile). For MWHs the corresponding figures are 35% and 50%. As distances greater than one mile increase, the percentage of two-worker and multiworker households declines gradually, but this is of limited importance to transit use.

Figure 5. Workers by Population Density

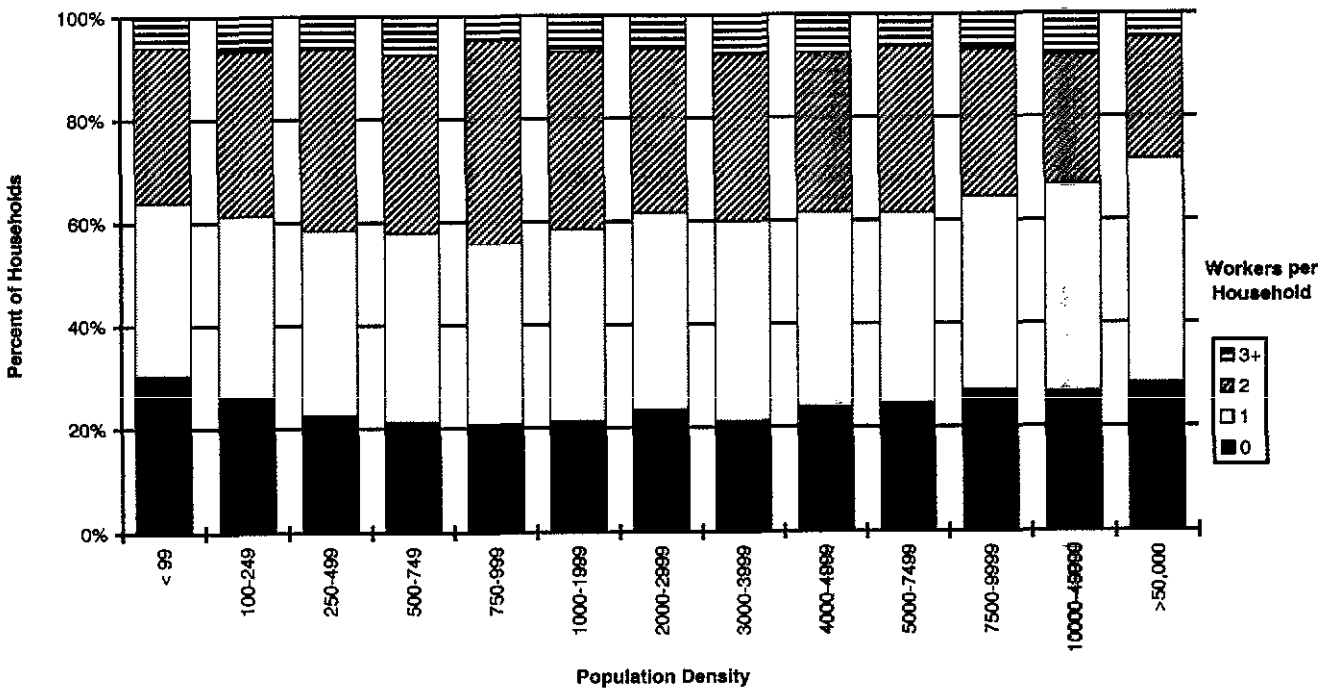
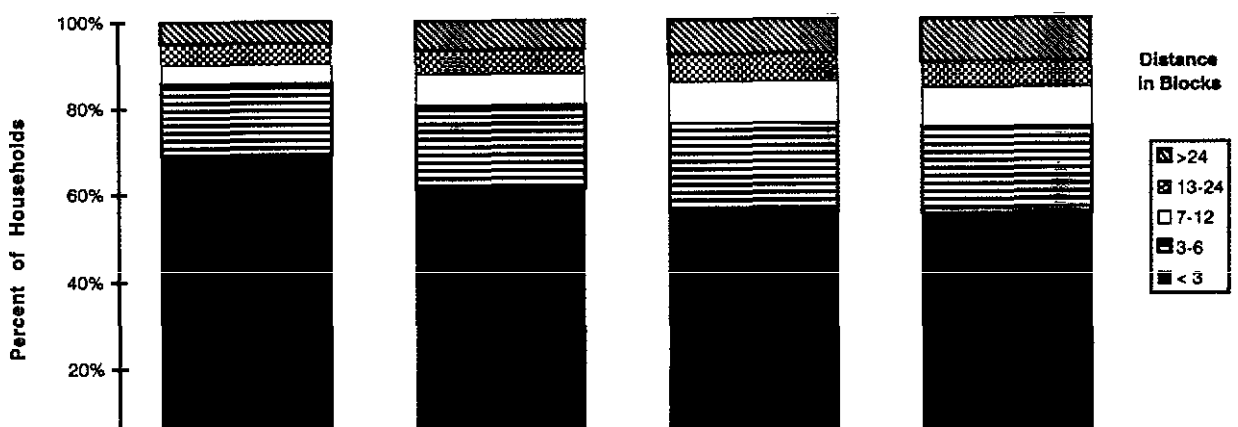


Figure 6. Distance from Public Transit by Workers per Household



The paucity of MWHs close to public transportation places greater emphasis on the use of private vehicles. This spatial pattern also partially explains the declining use of public transportation among women. In the MWH setting, they tend to be distant from public transportation.

The proximity to public transportation has displayed some irregular trends from 1983 to 1990. The proportion of all households—including households with no access to public transit—within three blocks of transit has dropped from 40% to 34%, suggesting either less transit service or a decentralization of the population away from such service. But since the number of households has grown dramatically, there has been an increase in the absolute number of MWHs this close to transit.

Both the 1983 and 1990 data show an increase in MWHs with increasing distance from transit, but in 1983, the multiworker percentage increased even more sharply with distance from transit, rising from 29% in the first distance band to 46% in the third. In this regard, while the 1990 data are not encouraging for transit, they represent a relative improvement from 1983.

Travel Demand

In this section we examine the relationship between the number of workers in a household and travel demand, with an emphasis on trip length.

Miles Per Vehicle

There is a strong positive relationship between the number of workers and number of household vehicles, but the number of vehicles per worker declines with increasing number of workers. This decline in the rate is slightly offset by the rise in annualized miles per vehicle. Partly because work trips are longer than other trips, as the number of workers per household increases, so does the number of annualized vehicle miles. Vehicles in households with no workers log approximately 8,800 miles annually, while vehicles in one-worker households are driven an average of 12,600 miles each year (Table 7). The miles per vehicle statistic is over 13,000 for two-, three- and four-worker households, and it peaks with the latter group (not shown on Table 7).

Table 7: ANNUALIZED MILES PER VEHICLE BY HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

	Household Size				
Number of Workers	1	2	3	4+	All Households
0	7,900	8,600	10,100	15,800	8,800
1	12,700	12,100	12,600	13,300	12,600
2	—	13,400	13,000	13,300	13,200
3+	—	—	13,100	13,200	13,100
All Households	10,800	11,900	12,700	13,300	12,400

Source: Adjusted NPTS 1990

Annualized miles also increase with household size, from 10,900 in single person households to 13,300 in four-or-more member households. The increase is, however, not as steep as the jump from zero to one worker households; once someone in the household starts working, mileage per vehicle quite plausibly jumps greatly. Nevertheless, once there is at least one worker in the household, household size affects the annualized miles per vehicle more than the number of workers does.

Adding the number of vehicles in the household to this mix indicates that the most common pattern is for annualized vehicle miles per vehicle to decline with increasing numbers of vehicles in the household (Table 8). In nearly all household size and number of worker categories each vehicle is driven less in three-or-more vehicle households than in single and double vehicle households. The relationship does not hold between one- and two-vehicle households. For Dual Income No-Kids (DINK) households—those households with two workers and two members—the highest mileage levels are for two-vehicle rather than one-vehicle households. This is true for two-person households and for all households as a whole.

Nevertheless, in many household categories, the single-vehicle household is characterized by the highest per vehicle mileage.

Annualized Vehicle Miles Traveled

The ultimate question here may be: "Which households drives more, for example, two one-worker, single-person households or one DINK household"? Table 9 shows that there is no effective difference, about 14,000 miles per person. The difference begins to unfold as the number of members and workers increase. The three-member, three-or-more worker household drives just over 12,000 miles per person.

As in previous examples, the number of workers seems to contribute more to total traffic than does the number of household members. Starting with zero-worker households, each additional worker adds approximately 10,000 miles to the household's total. Regarding additional members, from one to two members the increase is 11,000 but only 5,000 thereafter (Table 9).

Long-Distance Trips (LDTs)

The NPTS also asks about trips with distances over 75 miles during the preceding two-week period. There were 54 million such trips, of which 44% were to destinations less than 100 miles from the place of residence.

Table 8: ANNUALIZED MILES* PER VEHICLE BY NUMBER OF HOUSEHOLD VEHICLES, HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

		Household Size				
Number of Workers	Vehicles	1	2	3	4+	All
0	1	7,800	9,100	12,500	15,100	8,700
	2	8,500	8,800	10,600	17,400	9,300
	3+	7,100	7,200	7,900	14,400	8,000
1	1	13,600	13,700	15,200	14,100	13,900
	2	11,300	12,200	12,900	14,200	12,900
	3+	10,000	10,600	10,200	11,400	10,700
2	1	—	12,700	15,000	17,000	14,600
	2	—	14,100	14,200	14,000	14,100
	3+	—	12,200	11,500	12,100	12,000
3+	1	—	—	16,500@	12,100@	14,200@
	2	—	—	14,200	13,100	13,400
	3+	—	—	12,700	13,200	13,100
All Households	1	11,300	11,500	14,800	15,100	12,100
	2	10,400	12,400	13,600	14,100	13,100
	3+	9,100	10,900	11,500	12,400	11,700

Source: Adjusted NPTS 1990

* Rounded to closest 100 miles. @ Less than 300,000 households.

Table 9: TOTAL ANNUALIZED MILES* OF ALL VEHICLES IN THE HOUSEHOLD BY HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

	Household Size				
Number of Workers	1	2	3	4+	All Households
0	6,100	12,900	13,100	18,400	9,800
1	14,100	20,600	21,800	25,700	19,800
2	—	28,000	28,700	30,300	29,000
3+	—	—	37,200	41,500	40,100
All Households	10,200	21,300	26,000	30,100	21,700

Source: Adjusted NPTS 1990 * Rounded to closest 100 miles.

As expected, the number of these trips increases with an increasing number of workers, but the trip rate per worker declines with increasing numbers of workers in the household. Two-worker households account for 32.1% of all households but 44.4% of all long trips, thereby being the dominant group (Table 10). One-worker households account for 32.6% of all long trips and they produce relatively fewer trips per household, but they have the highest rate of LDTs per worker.

Quite expectedly, the average trip length is longest for the zero-worker households. Many are retired and have more time; therefore, the average destination distance is 282 miles for this group. The other three groups have lower average destination distances, all ranging from between 207 and 212 miles. Also, the

variation in trip distances (the standard deviation) is considerably higher for zero-worker households.

Table 10: LONG-DISTANCE TRIPS (LDTs) BY NUMBER OF WORKERS PER HOUSEHOLD

Number of Workers	House-holds (mil)	% of HHLDS	LDTs (mil)	% of LDTs	LDTs/ HHLD	LDTs/ Worker
0	23.3	25.0	7.4	12.8	0.32	—
1	33.9	36.3	19.0	32.6	0.56	0.56
2	30.0	32.1	25.6	44.0	0.85	0.43
3+	6.2	6.7	6.2	10.6	1.00	0.31

Source: Adjusted NPTS 1990

Length of Day Trips: Variations by Household Size

From the data discussed up to this point we know that vehicle ownership is largely the result of the number of workers, while the number of miles per vehicle is more related to household size. The length of the average day trip is again related to the number of workers in the household (Table 11). There is a particularly large increase from zero-worker households to all households with workers and a small increase with each additional worker.

Table 11: AVERAGE DAY-TRIP LENGTHS IN MILES AND MINUTES BY HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

Number of Workers		Household Size 1	2	3	4+	All Hhlds
0	Miles	6.2	7.4	7.6	7.0	7.0
	Minutes	13.8	14.7	14.8	16.2	14.7
1	Miles	8.5	8.8	7.8	8.2	8.3
	Minutes	15.7	16.2	15.6	14.5	15.4
2	Miles	—	9.4	9.2	7.7	8.6
	Minutes	—	16.3	16.2	14.5	15.5
3+	Miles	—	—	9.4	9.1	9.1
	Minutes	—	—	16.3	16.3	16.3
All Households	Miles	7.8	8.8	8.7	8.1	8.4
	Minutes	15.1	16.0	15.9	14.9	15.4

Source: Adjusted NPTS 1990; Trips over 75 miles in length are not included.

The pattern regarding the household size is irregular. The two- and three- member households have the longest average trip lengths, while the other two categories (larger and smaller households) are clearly lower (Table 11). This latter pattern is particularly noticeable for zero-worker households, where it peaks at three members per household. This may be related to age, since the small zero-worker households are likely to have retirees whose travel destinations are frequently close to home, and as household size increases, young drivers are more likely to be present.

The DINK households are very mobile. Among all households they and the three-member, three-or-more worker counterparts have the longest average daily trip lengths.

Length of Day Trips: Mode Use by Gender

While trip distances increase with the number of workers, there is less difference by gender (Table 12). On average, males make longer trips by private vehicle but the differences are less than one mile for all categories. There is no consistent pattern for average trip lengths by public transit, except that males make longer trips than females in MWHs (measured in both miles and minutes).

In all households females make a higher percentage of all trips by public transit, but in no category does it exceed more than 2.5% (Table 12). For both males and females, the greatest propensity to use public transit is in the zero-worker households, and in both cases it is only marginally greater than the percentages for three-or-more worker households. While it is logical that as the number of workers in a household increases the likelihood of someone using transit also increases, the difference, for example, between one- and three-or-more worker households is less than half a percentage point.

Length of Day Trips: Trip Purpose

We have seen that trip distances increase with the number of workers, and since the work trip is typically the longest trip, one might logically conclude that the work trip contributes to the household differences in trip lengths. Shopping and social trips, however, account for the differences and work trip length actually shows a slight decline with increasing number of workers in the household, especially for trips by private vehicle (Table 13). Conversely, social trip lengths increase markedly with the number of workers in the households.

Table 12: AVERAGE DAY-TRIP LENGTHS IN MILES AND MINUTES BY GENDER, MODE AND WORKERS PER HOUSEHOLD

Number of Workers	Gender		Private Vehicles	Public Transit	All Trips	% by Public Transit
0	Male	Miles	7.4	6.5	7.1	2.2
		Minutes	14.7	29.8	14.9	
	Female	Miles	7.3	8.9	7.0	2.5
		Minutes	14.1	33.1	14.4	
1	Male	Miles	9.0	8.9	8.7	1.7
		Minutes	15.8	31.7	15.8	
	Female	Miles	8.2	9.4	8.0	2.1
		Minutes	14.8	33.2	15.0	
2	Male	Miles	8.9	11.5	8.7	1.1
		Minutes	15.3	36.8	15.5	
	Female	Miles	8.7	10.7	8.5	1.6
		Minutes	15.2	35.4	15.5	
3+	Male	Miles	9.8	11.3	9.5	2.1
		Minutes	16.3	39.6	16.6	
	Female	Miles	9.1	9.6	8.9	2.3
		Minutes	15.5	38.7	15.9	
All Households		Miles	8.7	9.7	8.4	1.7
		Minutes	15.3	34.5	16.4	

Source: Adjusted NPTS 1990; Trips over 75 miles in length are not included.

Table 13: AVERAGE TRIP LENGTHS IN MILES AND MINUTES BY TRIP PURPOSE, MODE AND WORKERS PER HOUSEHOLD

Number of Workers		Home to Work	Home to Shop	Home to Social	Home to Work Private Vehicle	Home to Work Public Transit	All Trips
0	Miles	—	5.7	9.3	—	—	7.0
	Minutes	—	12.3	18.1	—	—	14.7
1	Miles	11.1	6.5	9.2	11.2	12.3	8.3
	Minutes	19.3	12.0	17.2	18.8	37.7	15.4
2	Miles	11.0	6.1	9.6	11.0	14.9	8.6
	Minutes	19.5	11.2	17.2	19.0	42.4	15.5
3+	Miles	10.7	6.9	10.8	10.8	11.4	9.2
	Minutes	18.9	11.7	17.9	18.2	37.8	16.3
All Households	Miles	11.0	6.2	9.7	11.0	13.2	8.4
	Minutes	19.3	11.7	17.4	18.8	39.7	15.4

Source: Adjusted NPTS 1990; Trips over 75 miles in length are not included.

Single-Occupancy Work Trips

As the number of workers in a household increases, so does the seeming potential for increased car pooling to work. Table 14 illustrates that this holds for both increasing number of workers and household members. The likelihood of driving to work alone is more a factor of household size than the number of workers. Just over 90% of the single-person households drive to work alone. This drops ten percentage points to approximately 80% for four-or-more person households. While there is also a statistically significant decline (95% confidence level) in solo driving with increasing numbers of workers in a household, the drop is only about five percentage points (from approximately 83% to approximately 78%).

Females hold a slight margin over males as solo drivers to work but not in all household categories. The most noticeable patterns is with increasing numbers of workers. In one-worker households, the female solo driver percentage is about two percentage points higher than for males, and while they are even in two-worker households, they switch places in three-or-more worker households and males have higher levels by two percentage points.

Table 14: DRIVE ALONE AS A PERCENTAGE OF ALL TRIPS TO AND FROM WORK BY GENDER, HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

		Household Size				
Number of Workers	Gender	1	2	3	4+	All Hhlds
1	Male	90.7	76.4	90.1	76.9	82.5
	Female	90.7	81.7	83.8	83.1	84.7
2	Male	—	85.0	80.7	82.8	83.2
	Female	—	87.9	83.1	79.2	83.4
3+	Male	—	—	78.0	80.1	79.5
	Female	—	—	82.4	76.2	77.6
All Households	Male	90.7	82.7	82.1	80.5	82.4
	Female	90.7	86.4	83.1	79.1	82.8

Source: Adjusted NPTS 1990

Work Trips by Public Transit

There is, however, no evidence of increasing propensity to use public transit with increasing numbers of workers in a household nor with increasing household size. In fact as the household size increases public transit use declines (Table 15). There is no evident relationship between number of workers and public transit use.

Table 15: PUBLIC TRANSIT USE AS A PERCENTAGE OF ALL TRIPS TO AND FROM WORK BY GENDER, HOUSEHOLD SIZE AND WORKERS PER HOUSEHOLD

		Household Size				
Number of Workers	Gender	1	2	3	4+	All Hhlds
1	Male	3.6	2.4	2.6	2.0	2.5
	Female	4.2	2.8	4.0	1.8	3.0
2	Male	—	3.0	1.6	1.4	2.0
	Female	—	2.8	2.1	1.9	2.2
3+	Male	—	—	2.3	3.7	3.3
	Female	—	—	1.4	4.6	3.8
All Households	Male	3.6	2.8	2.0	2.1	2.1
	Female	4.2	2.8	2.6	2.5	2.3

Source: Adjusted NPTS 1990

Implications and Conclusions

This report's conclusions may be summarized in the following list:

Trends in Number of Multiworker Households (MWHs)

- MWHs have been increasing as a proportion of all households since 1960.
- The growth in share is continuing but declining in rate.

Household Characteristics

- Both numbers of drivers and numbers of vehicles increase with number of workers in MWHs, but drivers increase more rapidly than vehicles.
- The percentage of MWHs increases with household income up to the $70,000 annual level.

Location of Multiworker Households (MWHs)

- The greatest concentration of multiworker households is in the New England and East North Central (eastern Midwest). The lowest levels are in the South from Texas to Kentucky, where less than 63% of the females aged 18-64 work out of the home.
- The percentage of MWHs increases with size of the metropolitan area.
- The percentage of MWHs increases with declining ZIP-code density.
- The percentage of MWHs increases with distance from public transportation (up to one mile).

Travel Demand

- There is a positive relationship between number of workers in a household and annualized miles per vehicles, but the relationship is stronger between increase in annualized miles and increase in household size.
- There is a positive relationship between number of workers and the number of long-distance (over 75 miles) trips (LDTs), but expressed in LDTs per worker, the relationship is negative.
- The average distance of day trips increases with the number of workers in a household, but not with household size (there is no apparent relationship).
- The average day-trip distances are higher for males in all MWH categories.
- Average distance to work decreases with increasing number of workers in a household, but not for work trips by public transportation.
- Average distance for home to social and recreational activities increases with number of workers in a household.
- There is no apparent relationship between shopping trip distance and number of workers in the household.
- Solo driving to work declines more with household size than with number of workers.
- Females are more likely to be solo drivers in one-worker households and men are likely to be solo drivers in three-or-more worker households.

The emphasis in public policy over the last several decades has been on job creation. Population and job growth has been more rapid in low density suburban areas where public transit service is generally sparse. This contributes to the need for automobile access to the workplace and as a consequence, vehicles per household have increased even with declining household size.

There is little doubt that employment growth has contributed to the number of workers per household, thereby increasing transportation demand. But the increase in MWHs has begun to slow and it seems to be largely confined to two-worker households, which have increased by 25% from 1983 to 1990. The number of three-or-more worker households has begun to decline.

Place of Residence and Household Characteristics

Across the country, there are only subtle regional differences in the proportion of the households with more than one worker. It is higher in the East and lower in the West and South. More significant is the variation by metropolitan area size and the neighborhood population density. As the metropolitan population increases, MWHs increase; however, these households are disproportionately found in low density areas within these metropolitan areas. Therein lies a key to an increasing travel demand scenario. By having the resources that MWHs tend to have, they can opt to live in large living quarters, in low density areas, increasing the dependence on private vehicles for travel.

Trip Length

Long-distance trips (over 75 miles) are also more prevalent in MWHs but if they are expressed in trips per worker, then the production is greatest in single worker households. Effectively, this indicates that workers have less time to make such trips. Zero-worker households make relatively few long trips but their trip-length average is about a third higher than for households with workers.

Day-trip lengths are more a factor of the number of workers in a household than household size, but not only because of the larger number of relatively long work trips. Work trip lengths decline with the increasing number of workers in a household but social trips increase dramatically, thereby accounting for longer total trip lengths. Social trips are more likely to be made by males and most trips by males are longer regardless of purpose, but in both cases the differences are small. In general, there are few notable gender differences in travel behavior.

Principal Conclusion

The principal finding is that the increase in the number of MWHs contributes to a low density urban life style, which relies on the private vehicle to access jobs, stores, and friends. The number of workers, more than household size, contributes to automobile ownership and therefore travel demand. There is little gender difference in travel behavior, although some of the traditional patterns remain, such as slightly shorter trips and marginally more public transit for females. MWHs as a category are different enough in their travel patterns from other household types to warrant the inclusion of household structure as an element in transportation planning studies.

Other Research

Traffic management, congestion and pollution mitigation policies in the past have treated the commute to work as the cause of congestion and pollution. Several studies have indicated that the structure of the household, including the number of workers, affects the makeup, length and duration of the work trip, turning it into a linked, multi-destination, multi-purpose journey (6,7,8). With this in mind, traffic management policies that reduce peak congestion, such as congestion pricing, may increase travel in off-peak hours.

These complex trip chains that are formed by MWHs can, however, be highly resistant to managed attempts at peak spreading. Management policies that try to increase the number of occupants per vehicle have the potential to send two or more drivers out in separate vehicles after the home commute to attend to personal trip requirements. If MWHs do indeed link more trips around the work commute, the extra time that they spend at these stops is time not spent on the highway, thereby lengthening the "peak" hours but reducing the number of cars at any one time.

For these reasons, more analysis of MWHs is needed and future models of congestion and pollution must include this variation from the traditional commuting pattern (home-work-home). The importance of household composition in explaining differences in trip chaining has pollution and congestion management policy and travel demand implications.

MWHs are likely to continue to be part of our social structure. While married couples with children continue to decline as a percent of all households, it is more and more likely that both adults in these households will have jobs outside the home. Job growth in our economy has facilitated what will probably be long-lasting structural changes in our households. Understanding the process of these changes will provide a more fundamental understanding of the changes in the spatial and temporal dimensions of travel demand.

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Adjustment of Weights to Compensate for Deletion of Households with Incomplete Person-level Data

Technical Appendix to

Multiworker Household Travel Demand

Introduction

There are two places in the NPTS data files in which the number of workers per household may be found but in neither place is this a complete count. In the Household File there is a variable, WRKRCNT, which reports the "number of workers in the household." In reality, this is the number of individuals in the household who were interviewed and identified themselves as workers. Those workers in the household who could not be interviewed were not included in this tally and therefore it does not report all workers in the household.

The other file that includes information on number of workers is the Person File. In this file the variable WORKER is coded as a one if the respondent is in the workforce. By summing the number of workers in a household the same tally is achieved as in the Household File. If all eligible individuals in the household (essentially all those over the age of 5) were interviewed, then this would be an accurate tally of the number of workers. Since households in which not all members were interviewed need to be discarded from all data files, the method described in the next section was devised to compensate for the deleted data.

Steps in the Adjustment Process

Step One in the adjustment of the weights included determining whether all eligible persons in the household were interviewed. This was accomplished by comparing the HHELGCNT variable ("# of eligible persons in HH"—page C-2 in the User's Guide for the Public Use Tapes) with the RESP_CNT variable ("Number of respondents in household"—page C-5) in the Household File. If the two variables match then we know that there is information on all eligible individuals and the household record is complete. If the two do not match then some household members were not interviewed, resulting in incomplete household information. These households records were discarded as were all the records which pertain to these households in the other five files, e.g., Travel Day File. This reduced the number of households from 22,317 to 17,690.

Since 4,627 households were discarded, the weights in the household file had to be adjusted upward. This was Step Two and consisted of selecting adjustment variables which we felt would minimize the bias created by discarding households. Based on our experience with the data, the documentation regarding the data, and in consultation with several persons familiar with the data, two variables were selected: household size and household income.

Household size (HHSIZE) was divided into six categories. The first five included one-person to five-person households and the last consisted of households with six or more members. For household income (HHFAMINC), seventeen categories were used plus the two unreported classes (98 = not ascertained and 99 = refused). This yielded a 6 X 19 adjustment matrix with 114 cells; all cells contained at least six households (only five had less than ten households). The list of number of households in these 114 adjustment cells and the adjustment factors is shown in Table 1.

As an illustration there were 244 single-person households in the lowest income category and three of these were discarded because there was no information in the Person File. *Consequently the weights for each of the remaining 241 households (WTHHFIN) were increased by a*

Table 1: NUMBER OF WORKERS PER HOUSEHOLD, 1983-1990

Number of Workers	1983	1990	1983	1990
	(in millions)		(percent)	
0	22.6	23.3	26.5%	24.9%
1	33.0	33.9	38.6%	36.3%
2	23.3	30.0	27.3%	32.1%
3+	6.5	6.2	7.6%	6.7%
Total Households	85.3	93.5	100.0%	100.0%
2+ (multiworker)	29.8	36.2	34.9%	38.8%

Source: NPTS 1983, 1990

factor of 1.01245. Similarly, the two-person households in income category one had their weights increased by a factor of 1.25 (Table 1). Continuing this for all households, the data were adjusted to total 93,347,000 households. This was Step 3. While the total for other variables such as the number of adults should be similar to the original data set, we do not anticipate them to be exactly the same. Step Three yields a file of 17,690 households with new weights (old weights multiplied by the corresponding adjustment factors).

The weighting procedure for the Household File was then completed. These weights also applied to the Vehicle File as was the case with the original weights.

In the original data, the Person File contained a set of weights different from the household weights, because some persons were not interviewed. Since households with these "missing persons" were discarded and new weights were calculated with these deletions in mind, the new household weights were also used for the person file. Applying the new household weights to the Person File was Step Four.

Step Five consisted of applying new weights to the Travel Day File. These were derived by multiplying the new Household (or Person) File weights by 365. In Step Six these same weights were applied to the Segmented Travel File.

Step 7 - the last step - included multiplying the new household weights by 365 (days) and dividing by 14 (days—the duration of the travel period) and applying these to the Travel Period File. This completed the adjustment of the weights for all six files.

Conclusion

It should be noted that a more elaborate design could have been implemented but it was the decision of the research team that this particular procedure was one that could be completed in a timely fashion (since no additional resources were allocated for this task) while accounting for two potentially serious sources of bias. The resulting data now report 114 million workers, closer to the U.S. Bureau of the Census figure of 115 million workers than the original NPTS data. Simple factoring could also have been performed, but given the sizes of the data files, this by itself would not have been a trivial task and surely would have yielded biased data.

Table A.1: HOUSEHOLD FILE ADJUSTMENT FACTORS AND NUMBERS OF HOUSEHOLDS BEFORE AND AFTER DELETION OF INCOMPLETE HOUSEHOLDS

Cell	HHFAMINC	HHSize	Factor	Before	After
1	1	1	1.01245	244	241
2	1	2	1.25	140	112
3	1	3	1.26667	76	60
4	1	4	1.3125	42	32
5	1	5	1.21429	17	14
6	1	6	1.625	13	8
7	2	1	1.01656	614	604
8	2	2	1.16718	377	323
9	2	3	1.25564	167	133
10	2	4	1.25352	89	71
11	2	5	1.29412	44	34
12	2	6	1.36364	30	22
13	3	1	1.01171	432	427
...					
102	17	6	1.56757	58	37
103	98	1	1.16776	355	304
104	98	2	1.35039	686	508
105	98	3	1.69903	525	309
106	98	4	1.72803	413	239
107	98	5	1.7047	254	149
108	98	6	1.69767	146	86
109	99	1	1.05758	900	851
110	99	2	1.38286	1517	1097
111	99	3	1.51096	689	456
112	99	4	1.62162	540	333
113	99	5	1.41401	222	157
114	99	6	1.5	90	60
TOTAL				22317	17690