Trends in Personal Motor Vehicle Ownership and Use: Evidence from the Nationwide Personal Transportation Survey

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The size, composition, and use of the U.S. motor vehicle fleet are subjects of major interest to analysts and policy-makers concerned with the environmental impacts of passenger transportation. The release of 1995 Nationwide Personal Transportation Survey (NPTS) provides an opportunity to examine recent trends in motor vehicle ownership and usage. This latest NPTS, which follows similar studies conducted in 1969, 1977, 1983, and 1990, also incorporates several refinements that may make it a more useful data source for understanding the causes and implications of these trends.

This paper addresses three related subject areas. The first is the total volume of personal motor vehicle travel, its recent growth, and the sources of its growth. The second subject concerns vehicle ownership, specifically, the number, types, and age distribution of motor vehicles available to households. The third subject is household vehicle utilization patterns; this section also includes a model of the determinants of household demand for private motor vehicle travel. The paper also explores the implications of changes in vehicle ownership and use for air pollutant emissions and energy consumption.

Like its predecessors, the 1995 NPTS permits a variety of useful analyses that together reveal important insights into the patterns of household motor vehicle ownership and use, as well as into the underlying behavior that produces them. The results presented here should be useful to transportation professionals seeking to understand the patterns and determinants of motor vehicle travel, as well as to planners and policy-makers in their efforts to design and implement strategies that reduce the environmental consequences of growing motor vehicle usage.

Estimates of Total Personal Motor Vehicle Travel

The 1995 Nationwide Personal Transportation Survey (NPTS) contains three different items that can be used to produce estimates of total vehicle miles traveled (VMT) in personal motor vehicles: (1) the number and usage of household motor vehicles; (2) the number of drivers and the drivers' estimates of annual mileage; and (3) the number and length of household members' trips using personal motor vehicles. This section describes each of these three types of data, explains how each can be used to construct an estimate of total driving, and compares the levels of total household vehicle travel they imply. Total VMT estimates from the different NPTS sources are reported in Table 1 and Figure 1, which also include VMT estimates from the Federal Highway Administration's *Highway Statistics 1995* for comparison.[1]

[1] Federal Highway Administration. *Highway Statistics 1995*. Washington, DC: U.S. Department of Transportation, 1996.

Table 1 VMT Estimates, 1995 NPTS and *Highway Statistics 1995*

#	Source	Universe	Type of Data	Trillion VMT
1	1995 NPTS	personal vehicles	reported by respondent	2.149
2	1995 NPTS	personal vehicles	odometer reading	2.215
3	1995 NPTS	drivers (including commercial driving)	reported by driver	2.217
4	1995 NPTS	travel period & day	trip diary	2.181
5	1995 NPTS	travel period & day & commercial driving	diary + daily commercial driving	2.279
6	*Highway Statistics 1995*	all light duty vehicles (LDVs)	state traffic counts	2.228
7	*Highway Statistics 1995*	all motor vehicles, including heavy duty	state traffic counts	2.423

Notes

1 "About how many miles was this vehicle driven [in the last 12 months/since (month/year bought or received)]? Include mileage driven by all drivers."

2 Based on comparing odometer readings at least 6 weeks apart and annualizing. Outliers removed (776 cases).

3 "About how many miles did you personally drive during the past 12 months in all licensed motorized vehicles? Include miles driven as a part of work."

4 Includes commercial trips if driver made 10 or fewer commercial trips during the travel day.

5 VMT estimate number 4 plus estimate of total miles of commercial driving for the day for those who made more than 10 commercial trips.

6 Unlike NPTS, includes vehicles not garaged at home.

7 Unlike NPTS, includes vehicles not garaged at home.

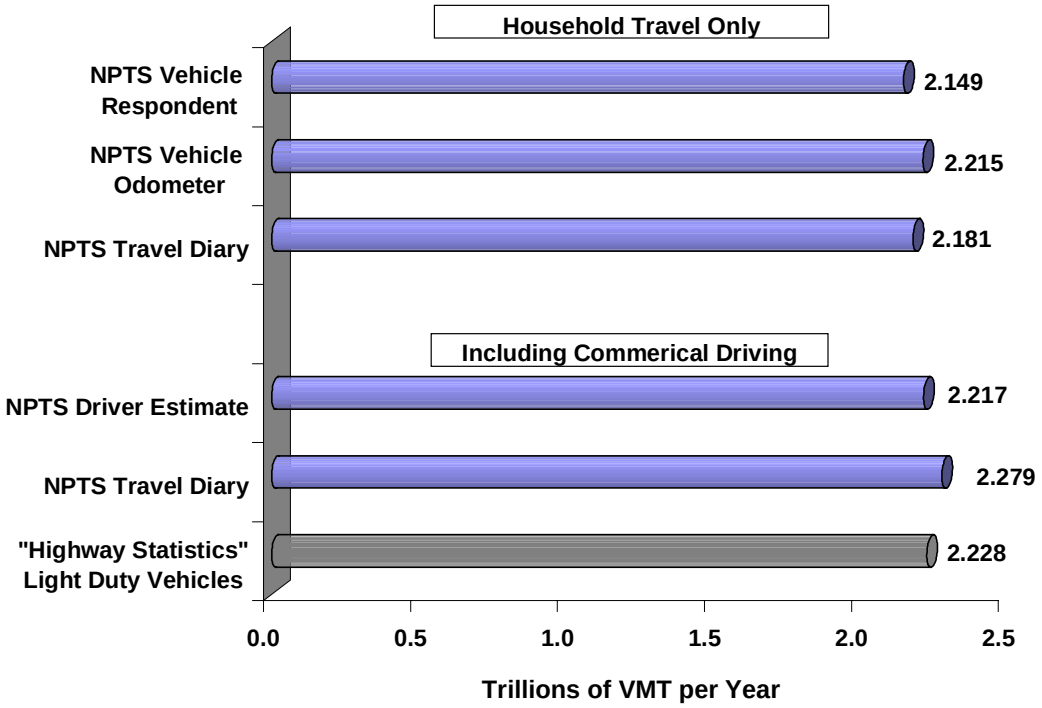
Vehicle-Based VMT Estimates

The first estimate of total VMT is based on the annual mileage driven using all household vehicles that are reported in the survey (defined as "motor vehicles owned or used by the household").[2] In the 1995 NPTS and earlier surveys, respondents were asked to estimate the total number of miles a vehicle was driven in the previous 12 months, including its use by all drivers.[3] The figure was capped at a maximum of 115,000 miles per year. The average of 12,205 miles per vehicle per year in the 1995 survey is multiplied by the 1995 NPTS estimate of the total stock of household motor vehicles (176 million) to produce the owner-reported vehicle-based VMT figure of 2.149 trillion annual VMT reported in Table 1, line 1.

[2] Although the standard errors of statistics reported in this paper were not calculated, they are probably quite small, on the order of 1% or less of the reported means, due to the extremely large sample size of the NPTS (about 40,000 households).

[3] The question asked was, “About how many miles was this vehicle driven [in the last 12 months/since (month/year bought or received)]? Include mileage driven by all drivers.” Mileage estimates for vehicles owned less than 12 months were annualized during post-processing of the data.

Figure 1 Estimates of 1995 Household VMT, with and without Commercial Driving



It is likely that the self-reported VMT is measured with error, since total mileage driven by all drivers residing in a household during an arbitrary 12-month period is probably not a figure that most people keep track of. Moreover, the estimate may be biased if people tend to over- or underestimate the amount of their own driving or the amount of driving by other members of the household. The 1995 survey for the first time included paired odometer readings from which annual mileage estimates can be constructed. Odometer readings for each vehicle owned by a household were obtained for the beginning and end of a several-week period and annualized by extrapolating to their 52-week equivalent. Although usable odometer data were obtained for only about half of all household vehicles, these should provide an unbiased estimate of average vehicle use as long as the missing observations are randomly distributed. Any seasonal variation in vehicle use that might make the annualized estimates of *individual* vehicles' usage unreliable should not significantly affect the estimate of *average* annual vehicle mileage, because the survey was administered over approximately a year-long period and thus included roughly equal numbers of mileage measurements recorded during each season of the year.

Like the self-reported data, odometer readings were capped at 115,000 per year per vehicle.[4] On balance, the odometer-based estimate of annual vehi-

[4] This was accomplished by excluding cases where the "FLAGOUT" variable indicated that the observation was an outlier; virtually all of the outliers were cases where the odometer mileage

cle utilization—the only one in the NPTS based on an instrument rather than respondents' recall—is likely to be more reliable than measures based on survey respondents' recall and approximations. The estimate of annual VMT per vehicle constructed from the odometer data was 12,580, about 3% greater than the self-reported estimate. The total household VMT estimate based on this figure and the previously reported NPTS estimate of 176 million household vehicles is 2.215 trillion annually, reported as line 2 of Table 1. This estimate in principle includes any commercial driving in household vehicles, but not commercial driving involving vehicles not garaged at home.

Driver-Based VMT Estimates

The second source of VMT estimates from the NPTS is derived from asking each driver in the surveyed households to estimate the total number of miles driven (as a driver, not a passenger) in the previous 12 month period.[5] Because respondents were specifically instructed to include commercial driving, i.e., miles driven as a part of work, the total VMT estimate from this source should be higher than the vehicle-based estimates because the question's scope includes *all* commercial driving, not just commercial driving in personal vehicles. The estimate was capped at 200,000 miles annually per driver (only 28 out of 65,718 valid responses exceeded this limit). The 1995 average of 12,540 miles per *driver,* multiplied by the NPTS estimate of 177 million drivers, produces the VMT estimate of 2.217 trillion reported as line 3 of Table 1. This driver-based estimate is probably subject to the same problems of measurement error and possible bias as the self-reported vehicle-based estimate.

Trip-Based VMT Estimates

A third source of VMT estimates can be constructed from the NPTS using the trip-level data recorded in household travel diaries, which are the primary source of NPTS data. The NPTS asked respondents to itemize their trips ending on the previous day (the "travel day") and also trips of 75 miles or more ending in the previous two weeks (the "travel period"). By counting only those trips where the respondent was a driver of a personal motor vehicle, average daily VMT can be estimated. The survey asked respondents who made *more than 10 daily trips* as a part of work (as a truck or taxi driver, for example) to give a separate estimate of their total daily commercial driving. The trips made by commercial drivers who made *10 or fewer trips* on the travel day were included as part of the travel day diary.

A comprehensive estimate of total annual VMT includes the sum of all three of these components: travel day VMT, travel period VMT, and daily commercial VMT. (The 2,900 travel day trips in the sample which were recorded in both the travel day and travel period data were eliminated from the travel day VMT estimate to avoid double-counting.) The resulting annual VMT estimates

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was greater than 115,000.

[5] The question asked was, "About how many miles did you personally drive during the past 12 months in all licensed motorized vehicles? Include miles driven as a part of work."

are 2.181 trillion miles from the travel day and period data, and 2.279 trillion including the commercial VMT estimate; these figures are reported as lines 4 and 5 of Table 1. Table 2 provides a detailed breakdown of the three components of the complete trip-based VMT estimates, and shows the 1990 data for comparison. The 1990 travel day trip mileage estimate reported in Table 2 was adjusted, as described below.

Comparing the NPTS Estimates

All of these VMT estimates—which are derived from completely separate sections of the survey—are surprisingly consistent with one another. As noted previously, the vehicle-based estimates should be somewhat lower than the others in that they exclude driving in non-household (i.e., corporate-owned or fleet) vehicles, some amount of which is incorporated in each of the other estimates.

How do the 1995 NPTS VMT figures compare to estimates from other sources? Probably the most widely-cited estimates are those reported by the Federal Highway Administration (FHWA) in its annual *Highway Statistics* publication. The national totals are based on state VMT estimates built up from local traffic counts reported by state sources, and in some cases cross-checked with state-level fuel sales data. The vehicle-based NPTS estimate is closest conceptually to the FHWA estimate for light-duty vehicles (or "LDVs," which includes passenger cars and 4-wheel, 2-axle trucks). However, the latter includes the small amount of VMT represented by light duty vehicles not garaged at a household. The difference between the NPTS odometer reading-based estimate and the FHWA LDV estimate is less than 1%.

The *Highway Statistics* estimate of nationwide VMT for all motor vehicles (both commercial and household) during 1995 was 2.423 trillion, reported as line 7 of Table 1. This figure is approximately 6% higher than the trip-based NPTS estimate that includes commercial driving (2.279 trillion; line 5). Because the survey was not designed to produce estimates of heavy-duty or commercial vehicle driving, however, it is not surprising that these figures are less closely comparable than the NPTS and FHWA estimates of household and light-duty vehicle use.

Recent Growth in VMT

What is the recent trend in motor vehicle travel as reported by the NPTS? Several changes in the survey between 1990 and 1995 complicate the task of comparing VMT estimates for these two years. The basic survey method (household telephone survey) as well as the self-reported annual driving and vehicle use questions remained unchanged between the two surveys, so VMT estimates using these two sources should be directly comparable for 1990 and 1995. As shown in Table 3, the total VMT estimates based on these questions each show growth of about 4% over the five-year period, which implies an annual growth rate between 0.7% and 0.9% per year. Unfortunately, it is not possible to derive an estimate of VMT *growth* from the odometer-based VMT estimate, because this method was introduced into the NPTS for the first time in 1995.

Table 2 Complete Trip-Based VMT Estimates, 1990 (adjusted) and 1995

	Travel Day Section Adjusted[1]	Adjusted Travel Day Trips[2]	Travel Period Section	Commercial Driving Section	TOTAL
1990	1,275,792	1,289,826	337,332	302,824	1,929,982
	(133,784)				
VMT/driver	7,826	7,912	2,069		11,839
1995	1,988,141	na	192,998	97,784	2,278,923
	(76,190)				
VMT/driver	11,245		1,092		12,890

[1]The numbers in parentheses are the travel estimated for overlap trips. These estimates are excluded from the travel day estimates to avoid double counting. Travel day estimates without overlap trips are referred to as the "Travel Day Section Adjusted."

[2]This figure comes from a comparison of 1990 and 1995 survey methods in a 1994 NPTS pretest; it is based on motor vehicle total distance traveled.

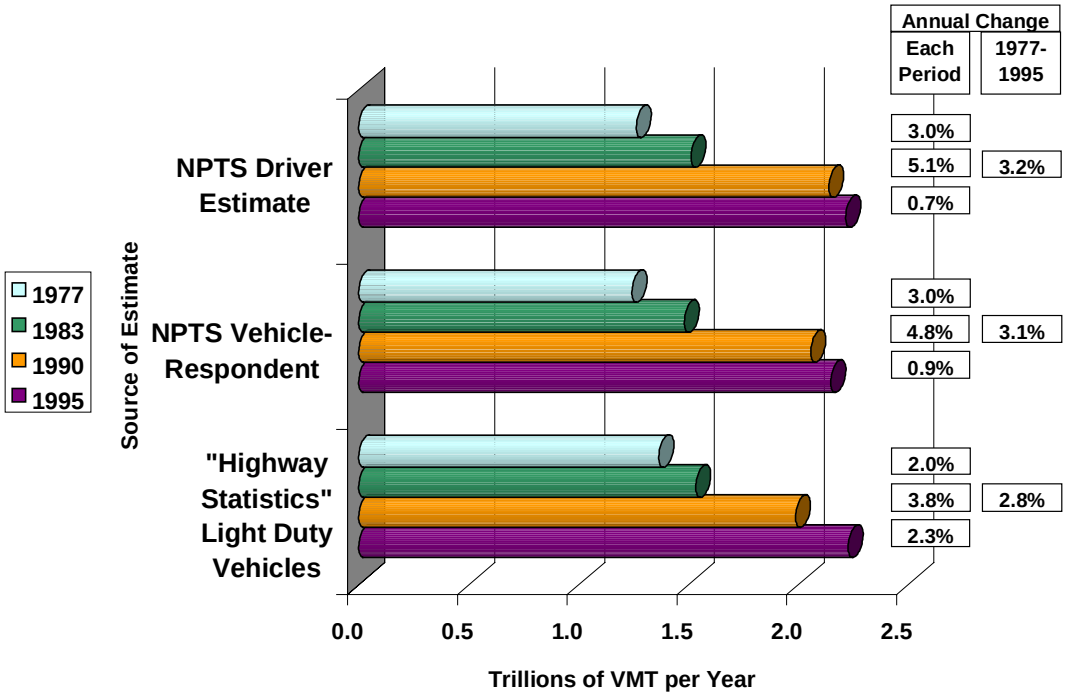
Comparing trip-based VMT estimates from the 1990 and 1995 surveys is complicated by a major change in methodology between the two. While the 1990 survey asked respondents to recall their trips from the previous day, the 1995 survey asked respondents to record all of their trips on a designated "travel day" in travel diaries which were subsequently read to survey collectors. Perhaps not surprisingly, the 1995 method recorded many more trips than the procedure employed in the 1990 and earlier surveys. The new method is likely to have greatly improved the accuracy and completeness of trip recording, since many short trips that were apparently overlooked using the recall method were recorded by the diary method. Comparing the estimate of total household personal motor vehicle travel it implies to that from the 1990 NPTS almost certainly leads to a substantial overestimate of the 1990 to 1995 growth in VMT.

Table 3 Change in VMT, 1990 to 1995: NPTS and Other Sources

			Trillion VMT		% change	
Source	**Universe**	**Type of Data**	**1990**	**1995**	**Total**	**Annual**
NPTS	drivers (including commercial driving)	reported by driver	2.140	2.217	3.6%	0.7%
NPTS	personal vehicles	reported by respondent	2.058	2.149	4.4%	0.9%
NPTS *	travel period & day & commercial driving	diary + daily commercial driving	1.930	2.279	18.1%	3.4%
Highway Statistics	all light duty vehicles (LDVs)	state traffic counts	1.989	2.228	12.0%	2.3%
Highway Statistics	all motor vehicles, including heavy duty	state traffic counts	2.144	2.423	13.0%	2.5%

*The 1990 statistic was increased to account for undercounting of trips (see previous table).

Figure 2 Annual Growth Rate of VMT, 1977-1995



The 1990 NPTS trip-based estimate of total VMT is thus likely to be an underestimate, and should not be compared to the 1995 figure without adjustment to compensate for under-reporting of trips. For the 1994 pretest of the 1995 NPTS, some surveys were completed with the new method (diary) and some with the old (respondent recall), so that the effects of the change in methodology can be compared directly (a full discussion of this issue is presented in the Appendix). Adjustment factors for trips and miles traveled for all trips, motor vehicle trips (driver and passenger), and vehicle trips (driver only) were calculated based on the pretest data (shown in Appendix Table A-1). However, these adjustments do not account for other changes in the survey, such as the treatment of commercial driving; as shown in Table 2, the adjustment was applied only to travel-day trips, not to travel period trips or commercial driving.

The change between the adjusted 1990 trip-based VMT and the 1995 figure (18.1%, or 3.4% per year) is much greater than the driver- and vehicle-based figures reported previously. It is important to emphasize, however, that even the adjusted 1990 trip-based VMT estimate is not completely comparable to the 1995 figure. In contrast, the questions and methods used in the driver and vehicle estimates of VMT did not change between the 1990 and 1995 administrations of the survey, so the estimates of VMT growth they produce should be more reliable. The annual growth rate implied by the *Highway Statistics* figures—2.3% annually for light-duty vehicles and 2.5% for all vehicles (see Table 2)—falls between the two very different NPTS-derived estimates. If the driver- and vehicle-based estimates of VMT growth are taken as the more reliable fig-

ures, the NPTS data suggest that growth in total travel is slowing compared to the rapid increases recorded during the 1980s.

Sources of Growth in Household Travel

The estimates of total VMT discussed in the previous section can be divided into several individually meaningful components, in order to gain a more complete understanding of the forces producing changes in motor vehicle travel. This procedure employs a series of "accounting" identities to subdivide the different estimates of VMT into their individual arithmetic components. As an illustration, the driver-based estimate of annual VMT can be thought of as the average number of annual miles driven per licensed driver multiplied by the number of licensed drivers (second line of Figure 3).[6] Each of these two components, miles per driver and number of drivers, can be further broken down: the former into annual driving per household vehicle multiplied by the number of vehicles per driver in the household, as shown in the third line of Figure 3. The number of drivers is equal to the licensing rate (the fraction of the driving-age population actually holding drivers' licenses), multiplied by the product of the share of the population of driving age and the total population itself.

Figure 3 Components of Change in VMT, 1990 to 1995

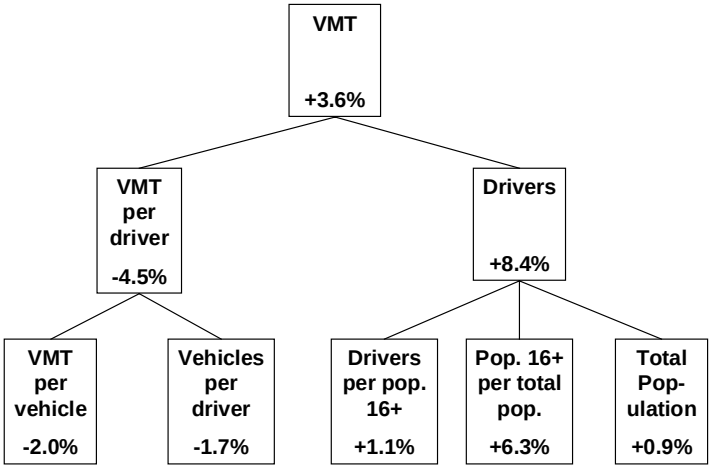


Table 4 shows estimates of each of these components constructed from the 1990 and 1995 NPTSs, as well as their percent changes over the period. Annual miles driven per licensed driver *decreased* 4.5% over this period, while the number of licensed drivers increased 8.4%, resulting in the previously reported total VMT increase of about 4%. Annual miles driven per licensed driver decreased because each of its two components—annual driving per vehicle and the number of household vehicles owned per licensed driver—decreased, as

[6] One potential problem in interpreting the vehicle- and driver-based VMT estimates in this way is that the number of household vehicles and the number of licensed drivers vary throughout the year, and some arbitrary date must be chosen to count them. In effect, the NPTS sets this date individually for each surveyed household, but this is likely to be a very minor problem.

Table 4 reports.[7] The number of licensed drivers increased because all three of its components grew, although Table 4 suggests that most of the change in the number of drivers was contributed by the increased share of the population of driving age.

Table 4 Components of VMT, 1990 and 1995

component	unit	1990	1995	% change
Population	*millions*	239.4	241.7	0.9%
Population 16+	*millions*	185.1	198.6	7.3%
Vehicles	*millions*	165.2	176.1	6.6%
Drivers	*millions*	163.0	176.8	8.4%
VMT/driver	*miles*	13,125	12,540	-4.5%
VMT/vehicle	*miles*	12,458	12,205	-2.0%
Vehicles/Driver	*miles*	1.01	1.00	-1.7%
Drivers/Pop16+	*na*	0.88	0.89	1.1%
Pop16+/Pop	*na*	0.77	0.82	6.3%

More detailed analysis reveals that the decline in annual VMT per licensed driver was not the result of demographic changes such as continued aging of the nation's population, since it occurred among both men and women and among most age groups.

Table 5 reports that VMT per driver declined for most age and sex categories, with greater declines for the youngest drivers and for men compared to women (with the exception of women 65 and older).

Table 5 VMT per Driver by Age and Sex

	Male			Female		
Age	1990	1995	% change	1990	1995	% change
16-19	9,543	7,543	-21%	7,387	5,985	-19%
20-34	18,310	16,921	-8%	11,174	11,074	-1%
35-54	18,871	18,029	-4%	10,539	10,637	1%
55-64	15,224	14,951	-2%	7,211	7,049	-2%
65+	9,162	9,830	7%	4,750	4,152	-13%
ALL (1)	16,536	15,685	-5%	9,528	9,257	-3%

(1) Includes drivers with unreported age.

The 1990 and 1995 NPTS results reveal that the use of household vehicles (measured by annual VMT *per driver*) has not contributed to recent growth in VMT but has actually declined, both because household vehicle ownership per licensed driver and the intensity of vehicle use (annual VMT *per vehicle*) fell slightly. Instead, the primary source of the modest growth in total VMT between

[7] The 2.0% decline in VMT per vehicle shown in Table 4 is taken from the NPTS question concerning miles driven for each household vehicle. An alternative approach, taking the NPTS estimates of VMT per driver and vehicles per driver and solving for VMT per vehicle produces a decrease in use per vehicle of 2.7%.

the two most recent surveys has been the aging of the U.S. population and the resulting increase in the number of persons of driving age. At the same time, slight increases in licensing and total population have each made small contributions to the increased number of drivers and therefore to the growth in total VMT.

Mode of Travel and Vehicle Occupancy

The demand for vehicle miles traveled ultimately derives from the demand for *person* travel. Person travel is the distance traveled regardless of mode and regardless of the number of vehicles used. Translating person miles traveled (PMT) into VMT requires knowing, first, the share of trips that are in motor vehicles, and, second, the average occupancy rate of those motor vehicle trips.

The 1995 NPTS reveals continuing slow growth in the share of trips in personal motor vehicles, considering the travel day data (not including the longer travel period trips). Table 6 shows that the share of trips in personal motor vehicles has grown from an already high 84% in 1977 to 89% in 1995. (The slight dip in the personal motor vehicle share in 1983 may be a result of differences in the definition of "other" mode trips.) The increase in the motor vehicle share has come at the expense of walking, public transit, and school bus trips. The share of bicycle trips increased noticeably from 1990 to 1995, although starting from a very small base.

Table 6 Person Trips by Mode, 1977-1995 NPTS

	1977	1983	1990	1995	% change, 1990-95
Personal Motor Vehicle	83.9%	82.0%	87.1%	89.3%	3%
Walk	9.3%	8.5%	7.2%	5.5%	-23%
School Bus	2.8%	2.6%	2.4%	1.8%	-25%
Public Transit	2.4%	2.2%	2.0%	1.8%	-10%
Bicycle	0.6%	0.8%	0.7%	0.9%	30%
Other (1)	1.0%	3.9%	0.6%	0.6%	3%
TOTAL	100.0%	100.0%	100.0%	100.0%	

(1) Amtrak, airplane, taxi, and other. It is unclear why the figure for 1983 is higher than that of the other years. Judging from the other survey years, it seems likely that at least 3% of the 3.9% of other trips recorded are actually personal motor vehicle trips.

The person miles accounted for by the nearly 90% of all trips that are personal motor vehicle trips can be translated into VMT by dividing by average trip occupancy. The trends in vehicle occupancy are shown in Table 7. Part A of the table reveals that the number of occupants *per trip* has continued to decline. The number of single occupant trips—which since 1990 have accounted for more than two-thirds of all personal motor vehicle trips—continued to increase, albeit at a slower rate than that found between earlier surveys. The

number of trips with two and four or more persons continued to decline, but in a reversal of the prevailing trend, the number of three person trips increased slightly.

Another way of measuring vehicle occupancy is to consider the number of person miles per vehicle mile. This gives an average occupancy rate weighted by trip distance. Part B of Table 7 shows the average occupancy by trip purpose calculated from each NPTS since 1977. The latest survey reveals that the trend toward lower average vehicle occupancy has slowed, but not disappeared. Declining occupancy rates and a higher share of trips in personal vehicles both indicate that more personal motor *vehicle* miles are required to meet the same underlying demand for *person* miles. Viewed another way, these trends imply that person miles have grown at even slower rates than the modest growth in vehicle miles noted previously.

Table 7 Vehicle Occupancy, 1977-1995 NPTS

A. Percent of Vehicle Trips by Number of Occupants

	Number of Occupants				
	1	2	3	4 or more	TOTAL
1977	59.6%	24.7%	8.3%	7.4%	100.0%
1983	65.7%	21.5%	7.4%	5.4%	100.0%
1990	67.1%	21.6%	6.5%	4.8%	100.0%
1995	68.4%	20.2%	6.9%	4.5%	100.0%

B. Vehicle Occupancy by Trip Purpose (Person Miles/Vehicle Mile)

	Trip Purpose					
Survey Year	Work or Work-Related	Family or Personal Business	School or Religious	Social or Recreational	TOTAL (1)	Annual % change
1977	1.32	2.02	1.95	2.44	1.89	
1983	1.32	1.80	2.08	2.12	1.75	-1.3%
1990	1.16	1.78	1.67	2.08	1.64	-0.9%
1995	1.15	1.76	1.68	2.05	1.59	-0.6%

(1) Includes other and unknown purposes.

Trip Length and Trip Frequency

The “travel day” data permit the calculation of trip making rates (trips per capita) and average trip length. The product of these two factors is, of course, total distance traveled. As shown in Part A of Table 8, the travel day data produce a *vehicle* trip rate in 1995 of 2.6 trips per person per day and an average vehicle trip length of 8.99 miles. For person trips (all modes, including passengers), the rate was 4.4 trips per person per day and the average length was 8.78 miles. Multiplying trips per day by the average trip length gives an estimate of travel distance per person per day.

As a check of the consistency of the data, one can convert vehicle miles traveled (PMT) into person miles traveled (PMT), as shown in Part B of Table 8. Vehicle miles per day are multiplied by average vehicle occupancy to produce

person miles in motor vehicles. The result is then divided by the share of mileage in personal motor vehicles to produce an estimate of VMT. The result, about 40 miles per day, is very consistent with the estimate taken directly from the travel day data.

Table 8 Person and Vehicle Trips and Mileage

A. Trip Rates and Trip Length

Type of Trips	Mean Number per Day	Mean Length	Mean Total Miles per Day
Person	4.4	8.99	39.6
Vehicle	2.6	8.78	22.8

B. Converting VMT to PMT

I	Vehicle miles per day	22.8
II	Occupancy (vehicle miles/person miles)	1.54
III	Person miles in motor vehicles (I x II)	35.2
IV	Share of person miles in motor vehicles	88.1%
V	Person miles (III / IV)	39.9

The introduction of the travel diary method in the 1995 survey increased the completeness of trip reporting. However, this change in methods means that trip rates cannot be compared between the 1995 and earlier surveys. Adjustment factors can be estimated from the previously-discussed 1994 pretest of the 1995 NPTS (see Appendix). However, these adjustment factors do not appear to fully account for all of the changes in survey methods introduced in 1995. For example, in 1995 commercial travel was included in the travel day count if the respondent made fewer than 10 commercial trips per day, while the 1990 figures exclude commercial driving. Because of the lack of data comparability, the trends in trip rates and trip distance are not discussed here, and, in fact, cannot adequately be measured using the 1995 NPTS.

Household Vehicle Ownership

The 1995 NPTS also reveals continuing changes in the number and types of vehicles owned by U.S. households. Two major developments identified by the survey—both of which have been visible for at least two decades—are the trend toward nearly ubiquitous vehicle ownership among U.S. households, and the increasing number of households owning multiple vehicles. A more recent development highlighted by the 1995 NPTS is the increasing substitution of vehicles classified as light-duty trucks—pickup trucks, vans, and sport/utility vehicles (SUVs)—for automobiles in providing household transportation, although the substitution of pickup trucks for automobiles both significantly predates that of other types of light trucks and displays a markedly different geographic pattern.

Changing Vehicle Ownership Levels

Table 9 reports changes in the distribution of U.S. households among vehicle ownership categories as reported by the 1977, 1983, 1990, and 1995 NPTSs. It also reports changes in the average number of vehicles owned by all households and in the average number of household members of drivers' license-eligible age (16 and older).[8] As the table indicates, the fraction of households owning no vehicles declined sharply over this period, while the proportion of households owning only one vehicle fell slightly; in contrast, the percentages of households owning two and three or more vehicles rose significantly. Thus during 1977, the number of carless households almost exactly equaled the number owning three or more vehicles, yet by 1995 the number of three-plus vehicle households was more than *twice* as large as the number without vehicles.

Table 9 Household Motor Vehicle Ownership

Statistic	1977	1983	1990	1995
% of households owning:				
0 vehicles	15.3%	13.5%	9.2%	8.1%
1 vehicles	34.6%	33.7%	32.8%	32.4%
2 vehicles	34.4%	33.5%	38.4%	40.4%
3+ vehicles	15.7%	19.2%	19.5%	19.1%
Average number of vehicles owned per household	1.59	1.68	1.77	1.78
Average number of household members 16 years or older	2.10	2.06	1.98	2.01
Vehicles per household member 16 years or older	0.76	0.82	0.89	0.89

Interestingly, these seemingly large changes in the distribution of households among vehicle ownership categories were translated into only modest growth in average household vehicle ownership. As Table 9 reports, the average number of vehicles per household rose from 1.59 during 1977 to 1.78 in 1995, an increase of only about 12% over a period spanning nearly two decades. At the same time, however, the average number of household members of license-eligible age fell by about 4%, as the effect of continuing declines in household size offset that of the aging of the "baby-boom" generation. Thus as Table 9 also shows, the number of vehicles per household member of driving age increased from 0.76 in 1977 to 0.89 (or by 17%) during 1990, where it remained in the 1995 survey.

[8] The number of license-eligible household members is used in this analysis because the number of licensed drivers per household is so closely related to the average number of household vehicles. This suggests that the decision by a household member to obtain a driver's license is not separable from the household's decision to acquire an additional vehicle.

The Increasing Role of Light Trucks

As indicated previously, a major change in the composition of the household vehicle fleet has been the increasing substitution of light-duty trucks for automobiles. Table 10 reports the distribution of household vehicles by type.[9] As it indicates, passenger automobiles represented only about 65% of household vehicles during 1995, a significantly lower share than the more than 71% they represented only five years earlier.

Table 10 Household Vehicles by Vehicle Type, 1990 and 1995 NPTS

	1990		1995		% change
Vehicle Type	**Frequency**	**Percent**	**Frequency**	**Percent**	**1990-95**
Passenger Car	117,521,164	71.2%	113,284,291	65.2%	-4%
Sport/Utility (1)	5,853,590	3.5%	12,154,709	7.0%	108%
Van	8,978,441	5.4%	13,810,102	7.9%	54%
Pickup	28,373,539	17.2%	31,110,105	17.9%	10%
Other Truck	965,717	0.6%	695,829	0.4%	-28%
RV	871,478	0.5%	924,122	0.5%	6%
Motorcycle	2,188,659	1.3%	1,658,514	1.0%	-24%
Other	350,958	0.2%	148,884	0.1%	-58%
Total, Type Known	165,103,546	100.0%	173,786,555	100.0%	5%
Unknown (2)	117,280		2,280,102		
TOTAL VEHICLES	165,220,826		176,066,657		7%
Total Light Trucks	44,171,288	26.7%	57,770,744	32.8%	31%

(1) 1990 NPTS retabulated using 1995 definition of sport/utility vehicles (SUV).

(2) "Don't know" and "refused."

In contrast, SUVs represented 7% of household vehicles in 1995, exactly double their representation among household vehicles during 1990, reflecting the particularly rapid growth in SUV purchases during recent years. The role of passenger vans also increased during this period, as the table shows, while that of pickup trucks—the earliest light truck models to be purchased on a widespread basis for passenger transportation—remained approximately stable.

Because the nation's household vehicle fleet grew during the period covered by Table 10, these relatively modest changes in the *proportions* of vans, SUVs, and pickup trucks obscured significant increases in their absolute *numbers*. The number of vans owned by households increased by nearly 5 million over the five-year period between administrations of the NPTS, the number of SUVs by more than 6 million, and the number of pickups by nearly 3 million. In contrast, the number of passenger cars actually *declined* during this period, suggesting that households were replacing older automobiles with new SUVs and

[9] Unlike the 1995 NPTS, the 1990 version did not include a category for sport/utility vehicles (SUVs) in its vehicle type classification. The SUV category was recreated for this paper by using the SUV vehicle make and model codes from the 1995 survey to identify SUVs in the 1990 sample.

vans. Thus in total, the number of light trucks owned by households grew by a third from 1990 to 1995.

Growth in the newest styles of light trucks—SUVs and minivans—was considerably greater than that of pickups, but even the latter was more rapid than that of passenger cars. These differential growth rates meant that light duty trucks accounted for more than one-third of the fleet for the first time in 1995. Recent sales figures suggest that the effect of this shift from conventional automobiles to trucks on the composition of the household vehicle fleet may not yet have peaked, since trucks represent almost 45% of all light-duty vehicles being sold as of this writing. Among the various classes of light trucks, sport-utilities have recently exhibited the strongest sales growth: compared to a year earlier, September 1997 sales were *down* 2.5% for pickups, but up 1.3% for vans and 13.7% for sport/utility vehicles.[10] However, some of the new SUV buyers are former truck owners rather than former car owners, implying that the substitution of trucks for cars may be slowing.

Geographic Patterns of Vehicle Ownership

Differences in household vehicle ownership patterns by Census Bureau regions (shown in Figure 4) and by metropolitan area size reveals some variation in the relative importance of these different vehicle types. As Part A of Table 11 reports, automobiles represent more than 70% of household vehicles in the Northeast, but only about 61% in the West, with the figures for the North Central and South between these extremes but closer to the lower West value.

[10] Figures from Automotive News Data Center, reported in John Couretas, "Sport-Ute Stampede." *Automotive News*. 10/13/97, p. 1i.

Figure 4 U.S. Census Regions

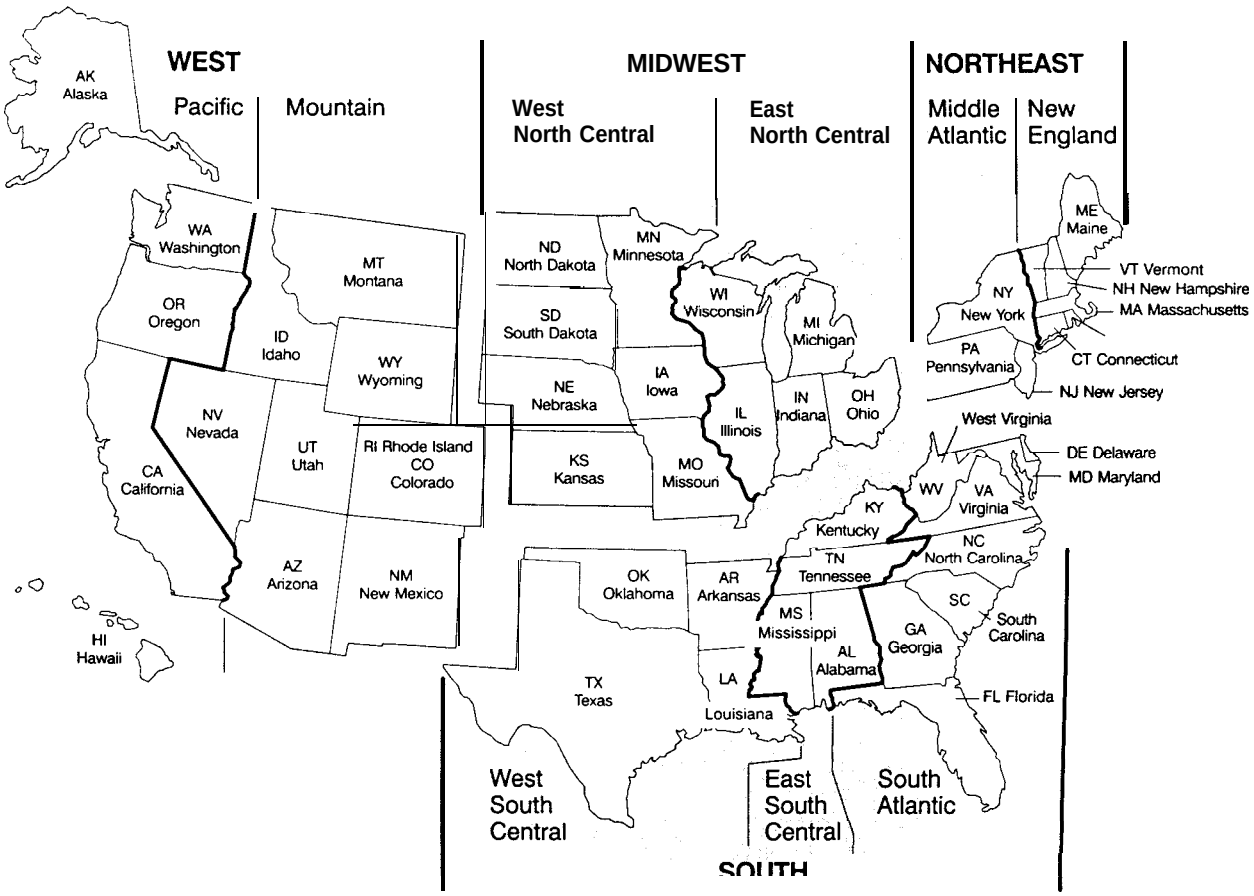


Table 11 Type of Vehicle by Census Region and MSA Size

A. Percent Distribution of Fleet by Census Region

	Northeast	North Central	South	West	USA
Auto	70.8	64.8	62.8	61.3	64.3
Van	7.6	9.1	7.6	7.0	7.8
Sport Utility	7.6	5.9	6.6	8.0	6.9
Pickup	11.2	16.9	20.2	19.5	17.7
Other*	2.8	3.3	2.8	4.2	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0

B. Percent Distribution of Fleet by MSA Size

	Not in MSA	<0.25 mil	.25 -.50 mil	.5 - 1 mil	1-3 mil	3 mil +	USA
Auto	54.8	61.4	62.7	65.6	66.2	70.0	64.3
Van	6.9	7.3	8.5	8.1	8.1	8.2	7.8
Sport Utility	6.6	6.9	7.0	6.8	6.9	7.1	6.9
Pickup	27.9	21.5	18.4	16.8	15.6	11.6	17.7
Other*	3.8	2.9	3.4	2.7	3.2	3.1	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*Includes other trucks, motorcycles, RVs, and other.

The mix of other vehicle types owned by households varies in a relatively complex pattern among regions: the proportion of household vehicles that are passenger vans varies significantly from its national figure (7.8%) only in the North Central region (where it exceeds 9%), while the fraction of SUVs exceeds its national norm (although only modestly) in both the Northeast and West. In contrast, the role of pickup trucks in household vehicle holdings varies substantially among regions: pickups represent slightly more than one in ten household vehicles in the Northeast, but account for one in six vehicles in the North Central region and as many as one in *five* vehicles in both the South and West.

As Part B of Table 11 reveals, the distribution of household vehicle types varies far more among city sizes and between urban and rural areas than among geographic regions. In fact, it seems likely that much of the regional variation shown in Part A of the table is "explained" by different degrees of urbanization and varying city size distributions among the nation's different regions. As is the case among regions, however, most of the variation in different vehicle types' representation reflects substitution between automobiles and pickup trucks, since there is relatively little variation in the shares of vans and SUVs about their national proportion among urban area sizes and between urban and non-urbanized areas.

Part B shows that in the nation's largest metropolitan areas, automobiles represent 70% of household vehicles, with pickups accounting for less than 12%, and the remainder divided roughly equally between vans and SUVs. In small urban areas (those under 250,000 population), however, the automobile share falls to about 61%, while that of pickups rises to more than 21%. This pattern continues outside metropolitan areas, where automobiles decline to only

about 55% of household vehicles, and where the van and SUV shares also decline slightly compared to even the smallest urban areas. In non-urban areas, pickups increase to nearly 28% of household vehicles, presumably reflecting their adaptability to the various non-passenger transportation functions that household vehicles are more commonly required to perform in rural areas.

Aging of the Vehicle Fleet

The 1995 NPTS reveals a pronounced acceleration of the aging of the household vehicle fleet that first became apparent with the 1983 NPTS.[11] As Table 12 reports, the average age of all vehicles owned by U.S. households increased sharply—from 5.6 to 7.6 years—between the 1977 and 1983 surveys but remained nearly constant (rising only to 7.7 years) until 1990, before rising to 8.3 years by 1995. Not surprisingly, the pattern was similar for automobiles (since they represent the bulk of household vehicles): their average age increased markedly between 1977 and 1983, only slightly between 1983 and 1990, and again rapidly through 1995. The average age of household light-duty trucks showed a slightly different pattern, declining significantly between 1983 and 1990 before increasing again by 1995.

Table 12 Vehicle Age by Type

	1977	1983	1990	1995	% change, 1977-1995
Passenger Car	5.5	7.2	7.66	8.23	50%
Truck/Van (1)	6.4	8.8	7.95	8.33	30%
Van	na	na	5.88	6.68	
Sport Utility	na	na	6.42	6.58	
Pickup	na	na	8.41	9.62	
Total Fleet (2)	5.6	7.6	7.70	8.32	49%

	Annual Percentage Change		
	1977-1983	1983-1990	1990-1995
Passenger Car	4.6%	0.9%	1.4%
Truck/Van (1)	5.5%	-1.4%	0.9%
Total Fleet (2)	5.2%	0.2%	1.6%

(1) Van, SUV, pickup, and other trucks available to the household.

(2) Includes recreational vehicles.

While average ages for individual light truck classes (vans, SUVs, and

[11] There is no unambiguously "correct" way to translate the distribution of vehicle model years recorded by the NPTS into a fleet average vehicle age. The NPTS surveys households over a period of several months which typically includes more than one calendar year. Because of the difference between calendar year and model year, it is not obvious how to code vehicle ages. This paper uses the average ages shown in the *1990 NPTS Databook, Volume 1*, p. 3-40 (US DOT, Federal Highway Administration, 1993) for the 1977 to 1990 data. The 1995 figures were calculated in a manner consistent with the 1990 data. The most recent model year vehicles (1996, and a very few 1997 vehicles) were assigned an age of 1. One-year old vehicles (model year 1995) were also coded with an age of 1. Model year 1994 vehicles were given an age of 2, model year 1993 vehicles were given an age of 3, and so forth.

pickups) are not available for the 1977 and 1983 surveys, their aging patterns seem likely to differ markedly over the period covered by Table 12. Pickups probably showed continuing increases in average age from 1977 through 1990, while vans—which increased rapidly in popularity during the late 1980s—were probably slightly "newer" on average during 1990 than 1983, but have aged slightly since then. SUVs, which were first introduced in the late 1970s but became widely popular only during the 1990s, probably aged the least rapidly during this period. These differing patterns of variation in average age among vehicle classes appear to reflect the increasing substitution of first mini-vans and subsequently SUVs for conventional passenger automobiles.

Changes in the Age Distribution of Household Vehicles

The aging of the fleet is more readily apparent in Figure 5, which displays the age distribution of the nation's household vehicle fleet for each of the four NPTS years. As it shows, the number of new vehicles (those up to two years old) owned by U.S. households during 1995—approximately 28.5 million—was only slightly greater than the comparable figures for 1983 and 1990, and sharply *below* its number during 1977, despite continued expansion of the total household vehicle fleet throughout this period. The number of 3-5 year-old vehicles declined significantly in the 1995 survey, after rising steadily from 1977 through 1990.

At the other end of the age distribution, the number of 6-9 year-old vehicles—which had declined for the first time during the 1990 survey—increased significantly by 1995, while the size of the oldest vehicle age cohort (those 10 or more years old) continued the rapid growth revealed by previous surveys. Thus by 1995, vehicles that were 10 or more years old accounted for more than one-third of all household vehicles.

Figure 5 U.S. Household Vehicle Fleet by Age Category, 1977-1995

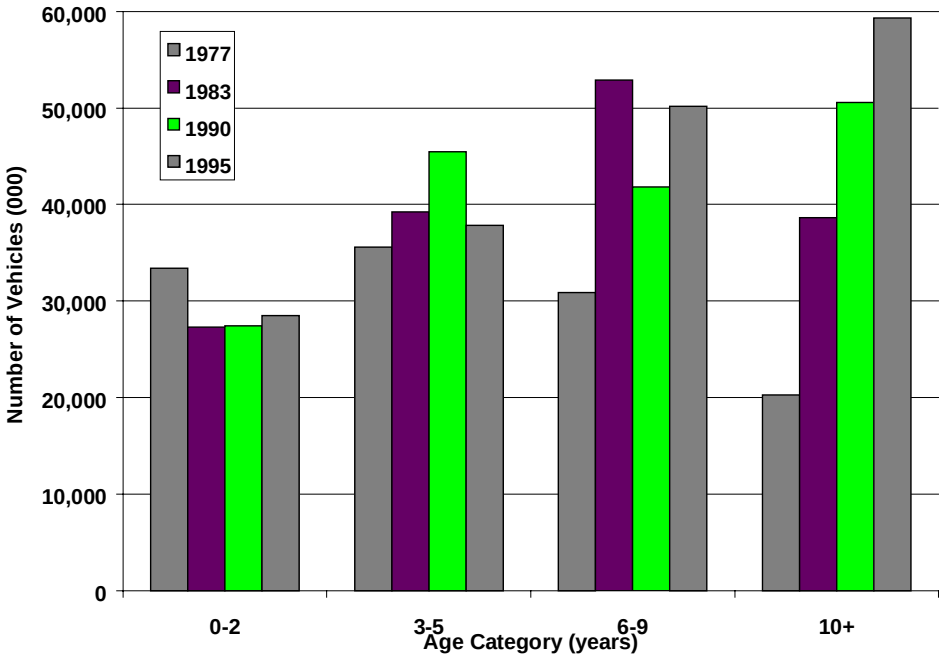
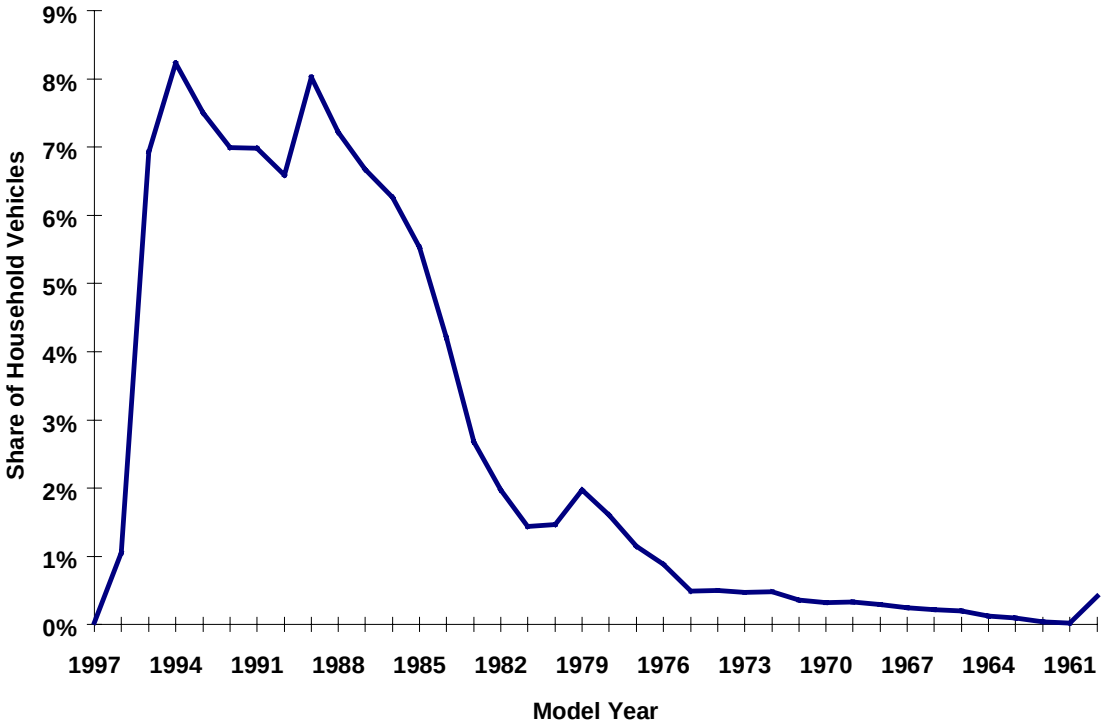


Figure 6 displays the distribution of household vehicles by model year derived from the 1995 NPTS. At the time of the survey, some model-year 1996 (and a very few model-year 1997) vehicles had already entered the fleet, reflecting manufacturers' custom of offering vehicles of a given model-year designation for sale during the latter months of the previous calendar year, while the 1995 model year was probably not yet fully absorbed into the fleet. The irregularities in Figure 6 show the effects of variation in new-vehicle sales patterns during the recessions of 1980-82 and 1990-92 and the ensuing economic recoveries.

Figure 6 Distribution of Household Vehicles by Model Year



However, these relatively minor variations are superimposed on a pattern composed of approximately equal representation—between 6% and 8% of total household vehicles—of the ten most recent model years, followed by rapidly declining presence of preceding model years. The few vehicles remaining in the fleet at age twenty—at the time of the 1995 survey, those manufactured in model years 1976 and earlier—appear to remain in the fleet and be retired only very slowly, as the extremely long "tail" of the model year distribution in Figure 6 shows.

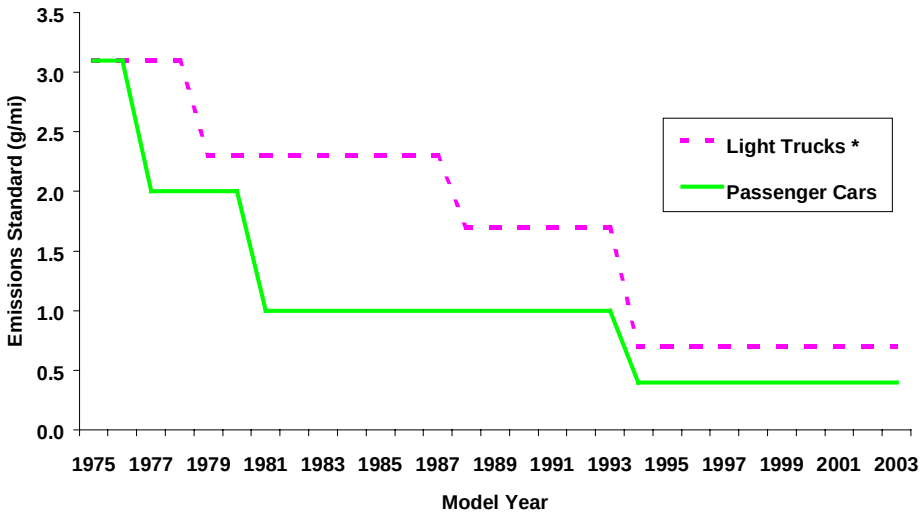
The Underlying Causes of Fleet Aging

The continued aging of household vehicles is undoubtedly a complex phenomenon, but a few of its contributing factors seem readily apparent. The most commonly emphasized of these is the increasing durability of new vehicles manufactured in more recent model years, which has raised the "life expectancy" of vehicles recently entering the household fleet and improved the quality of transportation services they provide when older. Less frequently noted, but perhaps more important, has been the combined effect of rising household demand for personal motor vehicle travel—itself a product of factors including rising incomes, declining household sizes, increasing participation in the labor force by women, and continuing decentralization of metropolitan areas—with sharply increasing prices for new vehicles relative to those for used models.

This combination of factors has led households to expand their vehicle ownership levels, as revealed previously by Table 9, but increasingly to do so by

retaining older vehicles as a substitute for purchasing newer ones. As a result, the progressively tighter safety, fuel economy, and emissions standards that passenger vehicles are required to meet have—by raising prices for new vehicles—slowed "turnover" of households' vehicle holdings and thus been incorporated into the nation's vehicle fleet more slowly than originally anticipated. Since these standards have typically been more stringent for automobiles than for light trucks, this mechanism may also have contributed to the increasing substitution of vans and SUVs for conventional automobiles in households' vehicle-purchasing decisions.

Figure 7 EPA NOx Emissions Standards for Passenger Cars and Light Trucks

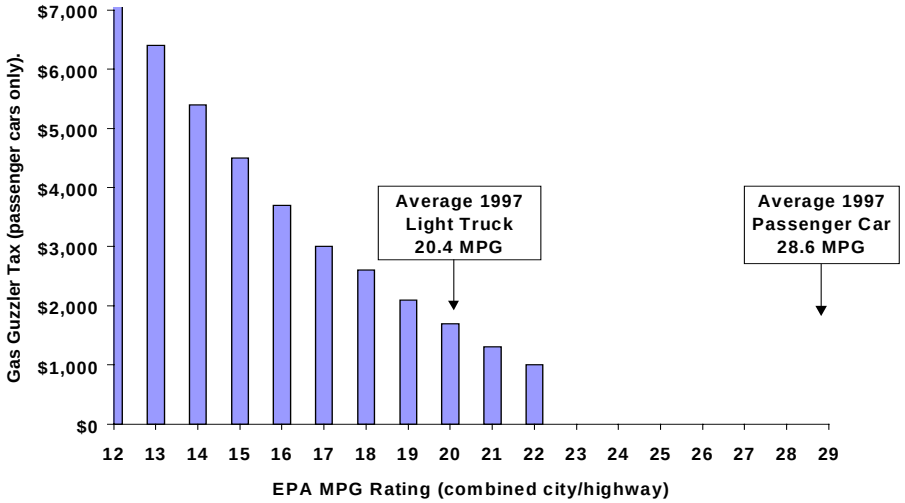


*From 1994 onwards, standards shown are for best-selling weight class of light trucks.

Only the smallest of the four categories of light trucks is now required to meet the same air pollutant emission standards as are automobiles, with larger light trucks subject to progressively less stringent standards. Prior to the 1994 model year, permissible emissions rates for NOx, for example, were consistently higher for light trucks than for passenger cars, and are still more lenient for the best-selling categories of light trucks (see Figure 7). In a similar vein, vehicle manufacturers are required to meet Corporate Average Fuel Economy (CAFE) standards of 27.5 MPG for automobiles, but only 20.7 MPG for their light truck models. Light trucks are also exempt from the federal "gas guzzler" tax imposed on automobiles that fail to meet minimum fuel efficiency levels. The actual sales-weighted fleet average fuel efficiency for passenger cars and light trucks of the 1997 model year are shown in Figure 8. This figure also shows the schedule of gas guzzler taxes. The average 1997 light truck would owe a gas guzzler tax of $1,700 if it were considered a passenger car. These differences in regulatory standards allow manufacturers to meet vehicle buyers' demands for comfort and performance at lower costs for light trucks than for automobiles, while

restricting their ability to offer automobiles with interior volumes and carrying capacities comparable to light truck models. Thus the more lenient regulatory treatment of light trucks may itself have contributed to their growing popularity as automobile substitutes.

Figure 8 Gas Guzzler Tax Schedule and Fleet Average MPG for Passenger Cars and Light Trucks



Ownership of Pre-1981 Vehicles

Because federal standards for air pollutant emissions by automobiles were tightened dramatically over the 1980 and 1981 vehicle model years, the number of pre-1981 vehicles remaining in the nation's fleet has important implications for efforts to comply with federal air quality standards. Policies that seek to reduce the number of pre-1981 vehicles in service or to curtail their use may have beneficial air quality impacts. However, there is concern over the potential impact of such policies on low-income households, who are more likely to own older vehicles. The 1995 NPTS indicates that approximately 8.6% of household vehicles—or some 6.7 million vehicles in total—were manufactured before model year 1981. As Table 13 reports, households with annual incomes under $25,000 own nearly a third of the remaining pre-1981 vehicles, while those with moderate incomes (between $25,000 and $50,000 annually) own another 37% of model year 1981 and older vehicles.

Table 13 Pre-1981 Vehicles and Household Income

Household Income	% of Pre-1981 Vehicles Owned by Income Class	% of Vehicles Owned by Income Class that are Pre-1981
< $25,000	32.2%	15.1%
$25,000 to $50,000	37.3%	9.0%
$50,000 to $75,000	12.4%	6.1%
$75,000 and more	5.9%	3.6%
refused	12.2%	7.2%
TOTAL	100.0%	8.6%

However, Table 13 reveals that pre-1981 vehicles represent only 15% of all vehicles owned even among households in the lowest income category. This proportion declines to 9% in the moderate-income category, and to only 4-6% for households with annual incomes above $50,000. Thus while older vehicles may play a critical role in meeting the transportation demands of some *individual* households, their overall importance in the vehicle ownership patterns of even the nation's lowest-income households is limited. Since nearly 85% of vehicles owned by low-income households are from 1981 or more recent model years, measures aimed at retiring or limiting the use of pre-1981 vehicles may thus have an impact on fewer low-income households than is commonly supposed.

Patterns of Vehicle Utilization

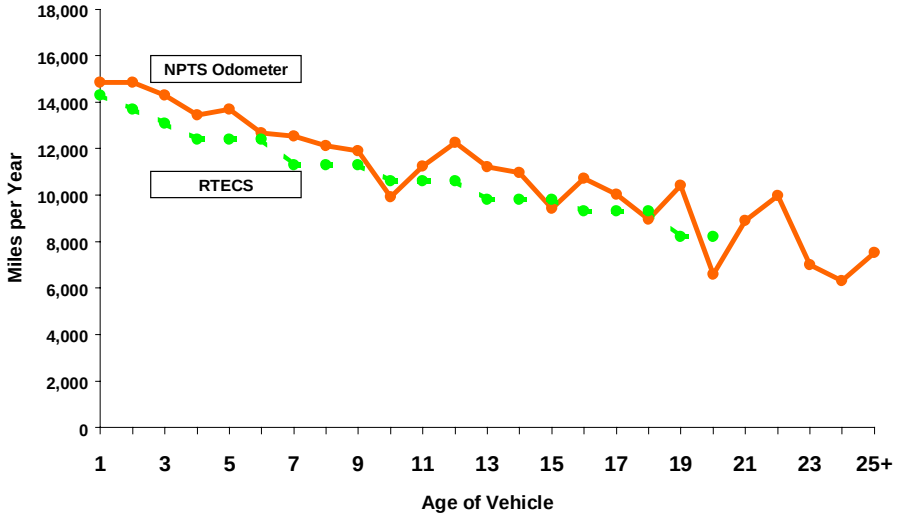
The implications of continued aging of the household vehicle fleet for transportation safety, urban air pollution, and energy consumption depend not only on its age distribution, but also on the pattern of households' utilization of vehicles of different ages. Specifically, if utilization declines rapidly with vehicle age, then the effects of progressively tighter safety, emissions, and fuel efficiency standards for new vehicles will be felt rapidly, while if older vehicles are used nearly as intensively as newer ones, the effects of these measures will require many more years after they are adopted to be felt. The gradual retirement of vehicles of each model year entering the fleet as they age and the changing rates at which vehicles accumulate mileage with increasing age interact to determine the distribution of total household VMT across vehicles of different ages, and the 1995 NPTS—like its predecessors—reveals important information about each of these effects.[12]

[12] Lave has suggested that the customary "model" of individual vehicles' gradually declining utilization with increasing age that is suggested by cross-sectional analysis of the vehicle age distribution and mileage accumulation rates may be misleading, or at least incomplete (see Charles A. Lave, "State and National VMT Estimates: It Ain't Necessarily So," unpublished paper, Department of Economics, University of California, Irvine, January 1994). He argues that an entirely different process may be at work, wherein households with high travel demands purchase new vehicles frequently and "wear them out" quickly, while households with low travel demands satisfy them by purchasing new vehicles infrequently and retaining them for longer periods. Assuming some distribution of household travel demands, this process would produce exactly the

Annual Utilization by Vehicle Age

Figure 9 shows the pattern of estimated annual usage of household vehicles of different vintages derived from the 1995 NPTS, calculated from the sub-sample of vehicles for which odometer readings were obtained. Similar figures from the U.S. Department of Energy's Residential Transportation Energy Consumption Survey (RTECS), last conducted in 1994, are shown in the figure for comparison purposes.[13] As it reveals, the four newest model years (1992-95 at the time of the 1995 NPTS) in the household vehicle fleet are utilized extremely intensively, averaging approximately 15,000 miles annually. Surprisingly, vehicles from ages five to ten years (model years 1991-1986 in the 1995 NPTS) are driven nearly as much, averaging 12,000-13,000 miles annually, and it is not until approximately age 15 and beyond (model years 1981 and previous) that annual utilization drops consistently below the 10,000-mile annual threshold.

Figure 9 Annual Utilization by Age from the 1995 NPTS and the 1994 RTECS



While the small samples of vehicles older than 15 years from which odometer readings were obtained produces considerable variation in the average utilization of individual age cohorts, it appears that annual usage reaches a "floor" of approximately 8,000 miles annually even among the oldest vehicles remaining in the household fleet. The 1994 RTECS data show slightly lower travel overall, but in a pattern that is very consistent with the 1995 NPTS figures. The distribution in Figure 5 implies an average annual utilization of slightly less

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same fleet age and mileage accumulation patterns revealed by the 1995 NPTS and its predecessors. In fact, both of these models are probably at work within the household vehicle fleet simultaneously, although their relative contributions to the patterns revealed in the data are difficult to assess. In any case, they have similar implications for the effects of fleet turnover on the age distribution of VMT and on problems such as safety, air pollution, and energy consumption.

[13] The data are from the Energy Information Administration, U.S. Department of Energy. *Household Vehicles Energy Consumption 1994*. US DOE, August 1997. DOE/EIA-0464(94).

than 12,600 miles for household vehicles of all ages and types, a figure generally consistent with those reported by other sources.[14]

The Distribution of Household VMT by Vehicle Age

Figure 10 combines the age distribution of household vehicles (Figure 6) with the pattern of usage by vehicle age (Figure 9) to produce the distribution of total household VMT driven by vehicles of different model years (and thus ages) during 1995. As it indicates, the effect of declining average utilization with increasing vehicle age accentuates the "newness" of the fleet age distribution—that is, the tendency for the newest model years account for the bulk of household vehicles—thereby causing an even larger share of total VMT to be driven in new vehicles than their representation in the fleet would suggest. Thus nearly 50% of all household VMT during 1995 and 1996[15] was driven by vehicles manufactured during model years 1990 to 1996 (described as vehicles of ages 0 to 6), with the remainder accounted for by vehicles of model years 1989 and earlier.

NPTS compared to MOBILE

State and local transportation and air quality agencies are required to use the U.S. Environmental Protection Agency's MOBILE5.1 vehicle emissions model in estimating the effectiveness of locally-adopted measures to reduce motor vehicles' air pollutant emissions. Since vehicles manufactured during different model years were required to meet different emission standards, one of the critical assumptions affecting MOBILE's estimates of average emissions per vehicle-mile is the relationship of average annual utilization to vehicle age. Figure 10 shows that according to the 1995 NPTS, a significantly larger fraction of light-duty VMT is accounted for by older vehicles (particularly those manufactured before model year 1981) than MOBILE assumes.[16] This difference arises primarily because the "mileage accumulation" curve suggested by the 1995 NPTS (Figure 9) is considerably "flatter" than that employed by MOBILE5.1, which assumes that average annual utilization of light-duty vehicles declines to less than 5,000 miles by the time they reach age 10.

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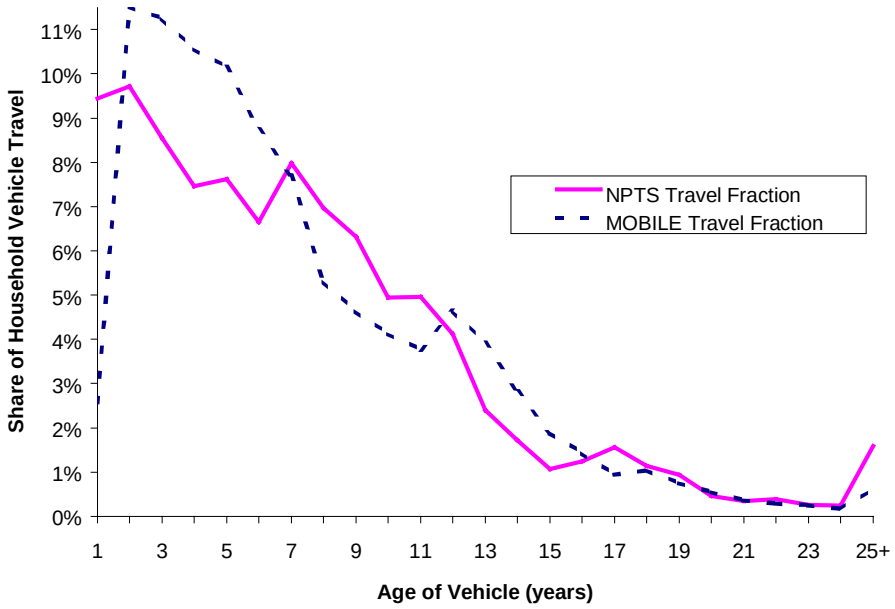
[14] For example, FHWA's *Highway Statistics 1995* reports average annual mileage of 11,489 for automobiles plus two-axle, four tire trucks, a group that corresponds roughly to the definition of household vehicles employed in the NPTS; see Table VM-1, p. V-92. However, this estimate is based on total VMT divided by the size of the vehicle fleet. The latter tends to be overestimated in the state registration data used by FHWA because it double-counts vehicles that are sold or moved between states and thus registered twice during the same year. Compared with survey data produced by R.L. Polk, the FHWA vehicle stock estimate appears to be too large by approximately 10%. Adjusting VMT per vehicle by this amount produces an estimate – 12,638 miles per vehicle during 1995 – which is extremely close to the 1995 NPTS estimate reported here.

[15] The survey was administered between May of 1995 and July of 1996.

[16] MOBILE's data on vehicle utilization by age are based on the 1984 National Vehicle Purchase Diary, updated to reflect changes in average vehicle utilization between 1984 and 1990 reported in FHWA's Highway Statistics.

Figure 10 NPTS and MOBILE Travel Fractions Compared



As a result, using the model may be leading transportation and air quality planners to overestimate the effectiveness of measures that reduce new vehicles' per-mile emissions rates, while underestimating the effectiveness of strategies designed to reduce those of the entire in-use fleet or of older vehicles in particular.[17] Since the MOBILE-based estimates of such measures' effectiveness are used both to select emissions control measures and to assess' localities progress in meeting the emission reduction targets that are necessary for them to comply with federal air quality standards, this difference may have important policy implications. EPA is currently revising the MOBILE model. The new version will incorporate more recent data on the composition and usage of the vehicle fleet.

Annual Utilization by Vehicle Type

Table 14 compares average annual vehicle-miles driven in different types of household vehicles, again computed from the sub-sample of household vehicles from which odometer readings were obtained as part of the 1995 NPTS. As it indicates, automobiles tend to be driven slightly less than the overall average for all household vehicle types—about 12,000 miles annually, or roughly 5% less than the 12,600 figure for all vehicle types. In contrast, light-duty trucks are typically driven considerably more than the conventional automobiles for which they increasingly substitute, as Table 14 shows: vans average nearly 15,000 miles annually, SUVs almost 14,000, and pickup trucks over 13,000 miles per year.

[17] For a detailed analysis of one such measure, see Elizabeth Deysher and Don Pickrell, "Estimating Emissions Reductions from Vehicle Retirement Programs," *Transportation Research Record*, forthcoming.

Table 14 Mean Vehicle Age and Mean VMT by Vehicle Type

Vehicle Type	Age	Annual VMT*	Predicted VMT**
Auto	8.23	11,994	12,121
Van	6.68	14,934	12,519
Sport/Utility	6.58	13,927	12,519
Pickup	9.62	13,154	9,934
Total Fleet* **	8.32	12,580	12,121

*Based on odometer readings.

**Based on average age of vehicle (rounded to nearest whole year).

***Includes other trucks, motorcycles, RVs, and other.

Some—although apparently only a small part—of the more intensive utilization of light trucks appears to result simply from the fact that vans and SUVs are newer on average than automobiles (as Table 12 showed previously). This can be seen by comparing the actual utilization of the individual vehicles types to the "predicted" utilization of household vehicles with the same average age, drawn from the relationship of usage to vehicle age shown previously in Figure 9. As these comparisons reveal, part of the more intensive utilization of both vans and SUVs—although only about 4% for vans and 7% for SUVs—is "explained" by the fact that they are newer on average than the household vehicle fleet as a whole. The higher average age of pickup trucks compared to the household fleet as a whole would be expected to lead to their less intensive use, but Table 14 shows that they are driven about 5% *more* than the fleet-wide average.

Vehicle Use Model

These comparisons suggest that light-duty trucks tend to substitute for automobiles in the vehicle holdings of households with above-average travel demands, probably including many that employ household-based vehicles to serve a combination of personal and work- or business-related travel demands (vanpool operators or small business owners, for example). Tables 15 and 16 present the results of an analysis designed to explore this hypothesis further; Table 15 reports the definitions of the variables used in the analysis, while Table 16 reports the results of regressions of annual utilization on household and vehicle characteristics.[18]

[18] As indicated in Table 15, the gasoline price variable is the average of monthly prices (including all taxes) for the fifteen-month survey period (5/95 to 7/96) in the state where the household or vehicle is located. While it might seem desirable to use gasoline price data for the exact month in which the household was surveyed, the effect of seasonal fluctuations in gasoline demand is to cause significant seasonal variation in its price. As a result, using monthly gasoline prices does not allow movements along the demand curve in response to gasoline price changes—which are the response of interest—to be separated from the effects of seasonal shifts in the gasoline demand curve itself. In the absence of a structural model of gasoline supply to

Table 15 Variable Names and Descriptions

Variable	Description
age	Age of vehicle (MY1996 and MY1997 =1)
hhvehcnt	Number of vehicles per household.
numadlt	Number of adults in the household.
numchild	Number of children in the household.
linc	Natural log of household income.
lpgas	Natural log of gasoline price (1).
van	Indicator: vehicle is a van.
suv	Indicator: vehicle is a sport-utility vehicle.
pickup	Indicator: vehicle is a pickup truck.
truck	Indicator: vehicle is another kind of truck.
rv	Indicator: vehicle is a recreational vehicle.
lbgden	Natural log of block group population density.
age*van	Interaction: age and van.
age*suv	Interaction: age and suv.
age*pickup	Interaction: age and pickup
age*truck	Interaction: age and other truck.
age*rv	Interaction: age and rv.
notinMSA	Indicator: household not in a metropolitan statistical area.
bus	Indicator: transit bus stop within 1/2 mile of residence.
Sunday	Indicator: travel day of week.
Monday	Indicator: travel day of week.
Tuesday	Indicator: travel day of week.
Thursday	Indicator: travel day of week.
Friday	Indicator: travel day of week.
Saturday	Indicator: travel day of week.

(1) Average state price, including all taxes, during the survey period (5/95 to 7/96), adjusted for inflation using the CPI-U.

The regression results show that much of the higher average utilization of vans is explained by the less steep decline in their usage with age in comparison to that for all household vehicles shown earlier in Figure 9. (This is evidenced by the positive coefficient on the **age*van** variable in the regression results, which reduces the magnitude of the negative value of the **age** variable itself.) However, this result may be partly a product of the different transportation functions served by older passenger vans—which often serve commercial purposes as well as household travel, and are thus used particularly intensively—and the more recently-produced mini-vans, which more clearly substitute for automobiles and thus tend to serve more limited travel purposes. The higher average utilization of both SUVs and pickups (as shown by the positive coefficients on the **suv** and **pickup** variables in Table 13) appears to be largely accounted for by their ownership by households with unusually high travel demands, as evidenced by the their higher annual usage even after controlling for household size, income, and other obvious influences on travel demand. This result may reflect the common use of these vehicles for recreational travel, joint household and business use, and various non-passenger transportation uses.

The decline in usage of both SUVs and pickups with increasing age actu-

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be estimated simultaneously with the models of vehicle usage and household travel demand, the resulting "identification problem" can be minimized by using average gasoline prices over the entire survey period, since these can more properly be considered exogenous from the standpoint of households' travel demands and vehicle utilization decisions.

ally appears to be slightly *more* pronounced than for conventional automobiles (as shown by the negative coefficients on the **age*suv** and **age*pickup** variables, which accentuate the negative value of the **age** coefficient), although the reliability of this finding is not extremely high for SUVs. Thus the newer average age of SUVs may explain somewhat more of their increased utilization than the rough calculation accompanying Table 14 above suggested, but this conclusion is again somewhat uncertain. Since the average age of pickups is significantly higher than other vehicle types, their more intensive utilization is even more difficult to explain in light of the regression model results, although it may simply mean that they are more heavily used by households to serve various commercial and non-passenger household transportation functions than are other vehicle types.

Table 16 Vehicle Usage Model, Regression Results

Dependent Variable: Natural Log of Annualized Vehicle Miles
derived from Vehicle Odometer Readings (mean=8.96)

	Estimated Coefficients and T-Statistics							
independent	Model 1		Model 2		Model 3		Model 4	
variable	β	t	β	t	β	t	β	t
constant	9.75	22.09	8.94	21.12	9.72	22.03	8.90	20.03
age	-0.07	-52.42	-0.07	-52.42	-0.06	-41.32	-0.06	-41.12
hhvehcnt	-0.06	-6.51	-0.08	-8.75	-0.06	-6.51	-0.08	-8.77
numadlt	0.14	12.22	0.15	13.19	0.14	12.22	0.15	13.20
numchild	0.13	20.06	0.12	19.52	0.13	20.13	0.12	19.59
linc	0.05	4.85	0.07	6.44	0.05	4.98	0.07	6.59
lpgas	-0.24	-2.57	-0.03	-0.35	-0.24	-2.56	-0.03	-0.32
van	0.14	5.71	0.13	5.54	0.07	1.80	0.07	1.70
suv	0.12	4.55	0.10	4.01	0.17	4.24	0.16	4.02
pickup	0.06	3.27	0.02	1.12	0.13	4.28	0.09	3.25
truck	0.14	0.94	0.13	0.85	0.08	0.26	0.04	0.15
rv	-0.87	-7.51	-0.86	-7.41	-2.22	-8.67	-2.20	-8.64
lbgden			-0.05	-13.17			-0.05	-13.28
age*van					0.012	2.31	0.012	2.31
age*suv					-0.009	-1.74	-0.010	-1.89
age*pickup					-0.008	-2.84	-0.009	-3.19
age*truck					0.004	0.21	0.005	0.28
age*rv					0.099	5.85	0.099	5.86
Adj. R sq.	0.134		0.139		0.136		0.141	

The Determinants of Household Travel Demand

In addition to producing much revealing information about patterns of household travel and vehicle ownership, the 1995 NPTS—again like its predecessors—en-

ables analyses that can provide important insights into the underlying determinants of household travel demand and their individual influences on travel behavior. This section presents the results of a regression analysis of vehicle miles reported by individual households for the NPTS "travel day" based on a simplified model of travel behavior. The model hypothesizes that the household is the appropriate decision-making unit for travel demand analysis, and that the variables influencing motor vehicle travel demand include household demographics and income, gasoline prices, and characteristics of the neighborhood and urban area where the household resides.[19]

While these variables collectively explain only 15% of the total variation in daily household motor vehicle travel, their individual effects on travel demand can be estimated quite reliably from the large sample of households included in the analysis (Table 17). Not surprisingly, the regression results show that the number of members in a household has a significant effect on the level of motor vehicle travel it generates. The relative magnitude of the coefficients on the **numadlt** and **numchild** variables in all of the model specifications tested consistently suggest that the effect of an additional adult household member on travel day VMT is three times as large as that of an additional child.

Table 17 Household VMT Model, Regression Results

Dependent Variable: Natural Log of Vehicle Miles per Travel Day per Household (mean=3.57)

	Estimated Coefficients and T-Statistics											
independent	**Model 1**		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
variable	β	**t**	β	**t**	β	**t**	β	**t**	β	**t**	β	**t**
constant	3.25	7.52	1.32	3.07	1.49	3.46	0.72	1.64	0.87	1.98	1.17	2.73
numadlt	0.31	32.40	0.30	31.54	0.30	31.53	0.30	31.33	0.30	31.31	0.30	31.79
numchild	0.11	17.20	0.10	15.89	0.10	15.90	0.10	15.77	0.10	15.77	0.10	15.95
linc	0.35	37.89	0.37	40.04	0.36	38.69	0.36	39.62	0.35	38.08	0.37	40.35
lpgas	-0.85	-9.40	-0.32	-3.59	-0.32	-3.58	-0.20	-2.19	-0.19	-2.07	-0.31	-3.41
lbgden			-0.10	-29.37	-0.11	-28.42	-0.08	-21.11	-0.09	-21.96	-0.10	-29.44
notinMSA					-0.10	-5.60			-0.12	-6.43		
bus							-0.13	-8.02	-0.14	-8.62		
Sunday											-0.17	-6.87
Monday											0.03	1.08
Tuesday											0.10	4.17
Thursday											0.08	3.37
Friday											0.11	4.41
Saturday											0.19	7.90
Adj. R sq.	0.121		0.147		0.148		0.149		0.150		0.154	

[19] For a detailed discussion of the theoretical influence of household demographic, economic, and locational characteristics on the demand for private motor vehicle travel, as well as of alternative modeling structures for identifying the empirical importance of these determinants, see Paul Schimek, "Household Motor Vehicle Ownership and Use: How Much Does Residential Density Matter?" *Transportation Research Record*, Number 1552 (1996), pp. 120-125.

The Influence of Economic Factors

Turning to the effect of economic characteristics on household demand for motor vehicle travel, the estimated income elasticity of daily VMT in the several models reported in Table 17 ranges from 0.35 to 0.37; thus for example a 10% increase in household income increases daily VMT by 3.5-3.7%. As the regression results also show, the elasticity of household VMT with respect to gasoline prices ranges from -0.19 to -0.32 (so that for example, a 10% increase in gasoline prices *reduces* gasoline consumption by 1.9-3.2%) once neighborhood density is properly accounted for. Because these results are based on a cross-sectional analysis of household behavior, they theoretically capture the *long-run* responses of travel demand to income and gasoline price variation; both results are in close agreement with previous studies of long-run income and gasoline price elasticities.

Location Characteristics and Travel Behavior

Characteristics of households' residential locations also exert important influences on their demands for private motor vehicle travel, according to the results summarized in Table 17. Greater neighborhood residential density is associated with lower household vehicle travel, although this effect seems to be smaller than some other studies have claimed once the roles of income and household size are properly accounted for (the estimated elasticity of daily VMT with respect to residential density in models 2-6 ranges from -0.08 to -0.11).[20] Households located outside metropolitan areas travel 10-12% less by private motor vehicles than those with identical demographic and economic characteristics residing within urban areas, as shown by the magnitude of the coefficient on the variable **notinMSA** in models 3 and 5.

This result seems at first to contrast with the widespread hypothesis that the longer separations between trip origins and destinations that result from the low development densities of rural areas lead to higher household VMT. Because density is already controlled for in the models that produce this result, however, this result reflects the effect of non-urban locations *per se* on household travel and may not contradict the conventional hypothesis. Finally, the availability of public bus transit service within a half-mile distance reduces a household's daily travel by 13-14% compared to that of identical households located farther from a bus route, as shown by the coefficients on the **bus** variable included in models 4 and 6.

Daily Variation in Household Vehicle Travel

The regression results indicate that there is considerable variation in household VMT by day of the week, even after controlling for households' demographic and economic characteristics and for residential location factors. Mondays and Wednesdays (the "reserved" case not included in Model 6) appear to represent

[20] Using the census-tract-level density measure instead of the variable calculated at the block group level produced substantially the same results.

"typical" travel days, in comparison to which travel by otherwise identical households ranges from 8% (Thursdays) to 11% (Fridays) higher on other weekdays. Not surprisingly, Saturday travel is considerably higher (19%) than during the mid-week, while average household VMT recorded on Sundays is lower than its typical mid-week value by an almost equal percentage (-17%).

Concluding Remarks

This analysis of the 1995 Nationwide Personal Transportation Survey shows that the several separate estimates of personal motor vehicle travel it can be used to produce are remarkably consistent (resulting in an estimate of some 2.2 trillion miles per year). However, the growth rate in motor vehicle travel since 1990 is less certain, in part because of changes in survey methods since the previous NPTS. The most directly comparable estimates that can be constructed from the 1990 and 1995 surveys, those derived from asking respondents about their driving and the use of their vehicles during the previous 12 month period, imply very modest growth in vehicle travel. For the first time since the original NPTS was conducted in 1969, the 1995 survey showed a *decline* in driving per licensed driver. The modest increase in total driving between 1990 and 1995 was thus completely explained by the increase in the number of drivers, which in turn was accounted for by an increasing number of people of driving age (rather than by an increase in their licensing rate).

Again for the first time since the survey has been conducted, the level of vehicle ownership (vehicles per driver) remained constant between the 1990 and 1995 surveys. This result suggests that vehicle ownership may have reached the long-anticipated "saturation" level. Nevertheless, the share of carless households continued to decline through 1995.

Person travel grew even more slowly than vehicle travel because a higher percentage of person travel demand was accommodated in motor vehicle trips, and because the average occupancy of those trips declined. The decline in occupancy rate continued a trend that has been apparent with each subsequent NPTS. However, the decline in occupancy slowed markedly in the most recent period, suggesting that occupancy may be approaching a floor which parallels the ceiling in auto ownership and use levels previously suggested.

The composition and age of the vehicle fleet has implications for air quality and fuel consumption. The aging of household motor vehicles accelerated dramatically between 1990 and 1995, compared to the relatively slow aging that occurred in the period between previous surveys. Pre-1981 cars, which have considerably elevated air pollutant emissions rates compared to newer models, remain a small but significant portion of the fleet. Moreover, the NPTS estimate of annual use of these and other vehicles above approximately five years of age is considerably greater than that assumed in EPA's emissions model, so the contribution of older vehicles to current light-duty vehicle fleet emissions may be significantly understated.

The 1995 NPTS clearly documents the increasing proportion of the

household vehicle fleet comprised of light-duty trucks. Vans and sport/utility vehicles seem to be directly substituting for automobiles, particularly for households that prefer newer vehicles and have higher than average driving demands. Pickup trucks, on the other hand, seem to be a distinct class of vehicles with different ownership and utilization patterns from automobiles and other light trucks. Pickups tend to be older than other vehicles on average, and tend to be found in lower-income households, in rural areas, and in the southern and western parts of the Nation.

Multivariate regression models of average vehicle usage and total household VMT using the 1995 NPTS suggest that household size and income are the primary determinants of vehicle use per vehicle and total driving, moderated by fuel price and by neighborhood characteristics. Significant portions of both average vehicle and total household vehicle travel are not explained by the available explanatory variables, but this is not surprising given the degree of random fluctuation of individual travel behavior. Fuel price also has a significant effect on household vehicle use in the long run. In addition, neighborhood characteristics such as population density and the presence of transit service have smaller but statistically significant effects on household travel demand, as does location of the household within versus outside an urbanized area.

APPENDIX

Comparing Survey Methods using the 1994 NPTS Pretest

The 1995 NPTS uses a different survey method than earlier editions of the survey, making comparisons with earlier NPTS statistics difficult. The 1994 pretest of the NPTS used both the 1990 survey method (retrospective recall) and the 1995 survey method (a diary mailed in advance of the travel day).[21] Households were randomly selected with respect to the survey method. The difference in average measures from each of the two survey methods in the pretest approximate the difference due to the sampling technique alone.

Table A-1 Trips, Trip Length, and Travel by Survey Method, 1995 NPTS Pretest

	Retrospective Method			Diary Method			% Difference by Method		
Statistic	Length	Trips	Travel	Length	Trips	Travel	Length	Trips	Travel
All Person Trips (1)	7.77	8.04E+10	6.25E+11	7.89	9.17E+10	7.23E+11	1.5%	14.05%	15.81%
Person Trips in Motor Vehicles	8.51	6.99E+10	5.95E+11	8.75	7.97E+10	6.98E+11	2.8%	14.04%	17.26%
Motor Vehicle Trips (drivers only)	8.65	4.86E+10	4.20E+11	7.97	5.33E+10	4.25E+11	-7.9%	9.76%	1.13%

(1) Excluding airplane trips.

Table A-1 shows average trip length, the number of trips, and their product (total travel) by survey method (retrospective or diary). These three statistics are shown for all person trips (excluding airplane trips), personal motor vehicle trips (driver and passenger), and motor vehicle trips (using the trip data for drivers only). This third statistic produces an estimate of vehicle miles traveled (VMT). For motor vehicle trips, the diary method recorded more short trips, with the result that the number of vehicle trips was nearly 10% higher using this method but the average trip length was nearly 8% *shorter*. The net result is that the diary method revealed only 1.1% more VMT than the retrospective method.

Many more *person* trips were recorded when the diary method was used, and these trips were *longer* on average than those already counted using the retrospective method. About 14% more trips in total were counted under the diary method, and these trips were 1.5% longer. Thus in terms of person miles traveled (PMT), the retrospective method appears to understate travel by nearly 16%. These differences due to survey method for PMT, VMT, and their components were used in this paper to adjust the 1990 NPTS data to make them more comparable with the 1995 data. However, other inconsistencies between the two survey methods were not accounted for, such as the treatment of commercial driving.

[21] The 1994 pretest also used a third technique, a memory jogger, which is essentially a simpler form of the diary. Since this method was not chosen, it is not discussed here.