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

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ABSTRACT

The size, composition, and use of the nation's household vehicle fleet are subjects of major interest to analysts and policymakers concerned with the economic motivations and enviromental consequences of travel. The 1995 Nationwide Personal Transportation Survey (NPTS), together with similar surveys conducted in 1969, 1977, 1983, and 1990, reveals important insights into the changing patterns of household motor vehicle ownership and use, as well as the underlying behavior that produces them. This paper uses information from the NPTS to address three related subjects: 1) growth in personal motor vehicle travel and its sources; 2) changes in the number, types, and age distribution of household motor vehicles; and 3) the determinants of households' vehicle utilization patterns and demands for private motor vehicle travel. The results presented here can be useful to transportation professionals seeking to understand the patterns and determinants of motor vehicle travel, as well as to planners and policymakers in their efforts to design and implement strategies that reduce the environmental consequences of growing motor vehicle use.

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NATIONWIDE PERSONAL TRANSPORTATION SURVEY

The Nationwide Personal Transportation Survey (NPTS) is a periodic survey of demographic characteristics, motor vehicle ownership, and daily tripmaking by U.S. households. All trips by household members are surveyed for a single "travel day," with interviews conducted so that each of the seven days of the week, including holidays, is represented as a travel day for some households. Trip data collected include the time the trip began and ended, its length, the size and composition of the traveling party, the mode of transportation used, the purpose of the trip, and the specific vehicle that was used (if the trip was made in a household-owned vehicle). In addition, data on all members' trips to destinations more than 75 miles from home during the two-week period ending on the interview day is obtained from a subset of households. Responses to the 1995 survey were supplemented by summary data from the 1990 U.S. Census. This data described the characteristics of the geographic area of each sample household and where each member worked.

The first three surveys (1969, 1977, and 1983) were conducted by the Census Bureau using face-to-face home interviews of a sample of households selected randomly from address files, while the 1990 and 1995 surveys were conducted by the Research Triangle Institute using random digit telephone dialing. The sample sizes of the five surveys varied widely: approximately 15,000 households were interviewed for the 1969 NPTS; 18,000 for 1977; 6,500 during 1983; 22,000 during 1990; and nearly 40,000 in the most recent survey.[1] The 1995 survey was conducted from May 1995 to July 1996.

HOUSEHOLD MOTOR VEHICLE TRAVEL

The 1995 NPTS contains three different types of information that can be used to produce estimates of total vehicle-miles traveled (VMT) in personal motor vehicles: 1) estimates of the number and usage of household motor vehicles, 2) data on the number of drivers and their estimates of how much they drive, and 3) estimates of the number and length of trips by household members using personal motor vehicles. This section explains how each of these types of information can be used to estimate total VMT and compares the results; table 1 reports the various estimates and the data sources used to construct them.

Vehicle-Based Estimates

One estimate of total VMT can be derived from survey respondents' estimates of the total number of miles each household vehicle was driven by all drivers during the previous 12 months.[2] Multiplying their average estimate of vehicle use (12,226 miles per year) by the 1995 NPTS estimate of the total number of household motor vehicles (176.1 million) produces a figure of 2.153 trillion annual VMT (table 1, line 1). The 1995 survey also obtained odometer readings for about 44% of all household vehicles at the beginning and end of a period of several weeks, and these can be extrapolated to their annual equivalents.[3] The estimate of annual vehicle use constructed from these odometer data is 11,801 miles per year, or about 4% less than the self-reported estimate; the total household VMT estimate based on this figure is 2.078 trillion annually (table 1, line 2). Both of these estimates presumably include commercial driving in *household* vehicles but not in vehicles garaged outside the home.

[1] Approximately 24,000 households were included in the national sample drawn for the survey, while the remaining 16,000 were included in order to enrich the sample in a few specific states and urban areas.

[2] The survey asked respondents to estimate use of each vehicle "available to" the household, so presumably some company-provided cars were included in addition to those owned or leased by household members. The specific question it asked was, "About how many miles was this vehicle driven [in the last 12 months] since the date (month/year) it was 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.

[3] 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.

TABLE 1 Estimates of Total Vehicle-Miles Traveled (VMT) During 1995

Line	Source	Basis of estimate	Type of data	Estimate (trillion VMT)
1	NPTS	Household vehicle use	Owner estimates	2.153
2	NPTS	Household vehicle use	Odometer readings	2.078
3	NPTS	Driving for all purposes	Driver estimates	2.383
4	NPTS	Driving for personal travel	Trip diaries	2.181
5	NPTS	Driving for all purposes	Trip diaries	2.279
6	FHWA	Light-duty vehicle travel	State traffic counts	2.228
7	FHWA	All motor vehicle travel	State traffic counts	2.423

Sources: 1995 NPTS; and the U.S. Department of Transportation, Federal Highway Administration (FHWA), *Highway Statistics 1995* (Washington, DC: 1995), table VM-1.

Driver-Based Estimates

A second source of VMT estimates from the NPTS can be derived from surveyed drivers' estimates of the total number of miles they each drove during the previous 12-month period.[4] Because respondents were specifically instructed to include commercial driving ("miles driven as a part of work") in their responses, the total VMT estimate from this source should be *higher* than the vehicle-based estimates, which included only driving in vehicles owned by household by members. The resulting average of 13,478 annual miles per driver multiplied by the NPTS estimate of 176.8 million drivers produces an estimate of 2.383 trillion annual VMT (table 1, line 3), which is indeed considerably larger than the two estimates that include only household vehicle use.

Trip-Based Estimates

A third source of VMT estimates can be constructed using the trip-level data recorded in NPTS household travel diaries, which asked respondents to itemize their trips ending on the previous day, the "travel day," and also all trips of 75 miles or more ending during the previous two weeks, the "travel period." By counting only those trips where the respondent was a driver of a personal motor vehicle, we estimated their average daily miles of travel.[5] The resulting annual VMT estimates from combining the travel day and travel period data are 2.181 trillion miles for personal travel only (table 1, line 4), slightly above the higher of the two vehicle-based estimates, and 2.279 trillion VMT including commercial driving (table 1, line 5), somewhat lower than the driver-based estimate.

Comparing the Estimates

Although they are derived from completely separate sections of the survey, the three VMT estimates that include only driving in household-owned vehicles are reasonably consistent with one another; the range from lowest to highest is only about 5%. Similarly, the difference between the two NPTS estimates that include commercial driving in non-household vehicles is about 5%. For comparison, the Federal Highway Administration (FHWA) reports in its annual *Highway Statistics* publication that 2.228 trillion miles were driven in passenger cars and light trucks during 1995 (USDOT 1995) (table 1, line 6), including both their personal and commercial use; adding heavy-duty vehicle use

[4] 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."

[5] The survey asked respondents who made *more than 10 daily trips* as a part of work (e.g., as a truck or taxi driver) 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.)

brings the FHWA estimate of total VMT to 2.423 trillion (table 1, line 7)[6] (USDOT 1995). As would be expected, both of the NPTS-derived VMT estimates that include driving in nonhousehold vehicles (table 1, lines 3 and 5) fall between the two FHWA figures.

Recent Growth in VMT

While several changes between the 1990 and 1995 NPTSs complicate the task of comparing VMT estimates for these two years, the basic survey method (household telephone survey) and the self-reported annual driving and vehicle-use questions remained unchanged between the two surveys, making VMT estimates using these two sources directly comparable for 1990 and 1995. The total VMT estimates derived from responses to these questions show very different changes over the five-year period between the two surveys: the total, based on survey respondents' estimates of household vehicle use, rose 4.4% (about 0.9% annually), while that based on their estimates of annual driving increased 11.4% (2.2% annually). 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.

Comparing the *trip-based* VMT estimates from the 1990 and 1995 surveys is complicated by a major change in methodology: 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 interviewers. Not surprisingly, the 1995 method recorded many more trips than the 1990 procedure and earlier surveys; specifically, many short trips that had apparently been overlooked using the recall method were recorded by the diary method. Although the change in survey method is likely to have greatly improved the accuracy and completeness of trip recording, the 1990 NPTS trip-based estimate of total VMT in retrospect seems likely to have been an underestimate. Comparing the estimate of total household motor vehicle travel reported in the 1990 NPTS almost certainly leads to a substantial overestimate of the 1990 to 1995 growth in VMT.

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 were calculated based on the pretest data (shown in appendix table A-1) and applied to the 1990 trip-based data to produce a VMT estimate more closely comparable to the 1995 figure. The change between the resulting adjusted 1990 trip-based VMT estimate and the 1995 figure, 18.1% over the five-year period or 3.4% per year, is much greater than the corresponding changes in the driver- and vehicle-based VMT estimates 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, because these adjustments do not account for other changes in the survey, such as the inclusion of commercial driving during 1995. 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.

For comparison, the annual growth rates implied by the FHWA *Highway Statistics* data for 1990 to 1995 are 2.3% annually for light-duty vehicles only and 2.5% per year including heavy-duty vehicles. These fall approximately midway between the estimates based on NPTS respondents' reports of household vehicle use (0.9% annually) and the number and lengths of their trips (3.4% per year), but they conform quite closely with the growth rate (2.2% annually) derived from respondents' estimates of their driving activity. On the basis of its close agreement with the growth rates implied by the FHWA data, it appears that the NPTS driving-based estimate of total VMT may provide the most reliable indicator of the pace of recent growth in household travel.

[6] The FHWA definition of light trucks includes all two-axle, four-tire trucks.

Longer Term Growth in VMT

Fortunately, there is somewhat closer agreement about the longer term pattern and average rate of growth in motor vehicle travel, both between the two NPTS methods and between their results and other sources. Figure 1 reports annualized growth rates for the NPTS driver- and vehicle owner-based estimates of total travel in household-owned motor vehicles from 1977 to 1995, as well as for all light-duty vehicles as reported in FHWA's *Highway Statistics.* As the figure indicates, the three sources yield estimates of annual VMT growth over this extended period ranging from 2.8% to 3.6%, not an unreasonably wide interval considering the differences in methods and data used to produce them.

All three sources also show the rate of VMT growth accelerating sharply between 1983 and 1990, from its moderate 1977 to 1983 pace, and then slowing from 1990 to 1995. The most significant disagreement seems to be over *how much* the rate of growth slowed during this latter period. But as figure 1 shows, the FHWA *Highway Statistics* data indicate both a lower average growth rate over the entire 1977 to 1995 period and more stability among the three separate intervals comprising it. The consistency of the procedures used to develop the FHWA estimates throughout most of this period and the continuous annual basis of that data series probably mean that it provides a more reliable picture of both longer term average growth in travel and shorter term variations in the pattern of its growth than can be obtained from an occasionally administered survey such as the NPTS. The primary advantage of the NPTS is the insight it provides into the changing patterns of household vehicle ownership and use and their underlying causes.

SOURCES OF GROWTH IN HOUSEHOLD TRAVEL

As an illustration, total VMT can be divided into several individually meaningful components in order to gain more insight into the forces producing growth in motor vehicle travel. Figure 2 employs the calculation previously used to derive the NPTS driver-based estimate of total annual VMT—average annual miles driven per licensed driver multiplied by the estimated number of licensed drivers—to show how the 1990 to 1995 *change* in total VMT can be broken down into changes in annual miles per driver and in the number of licensed drivers.[7] The NPTS shows that

[7] 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.

FIGURE 1 Comparison of Total VMT Estimates

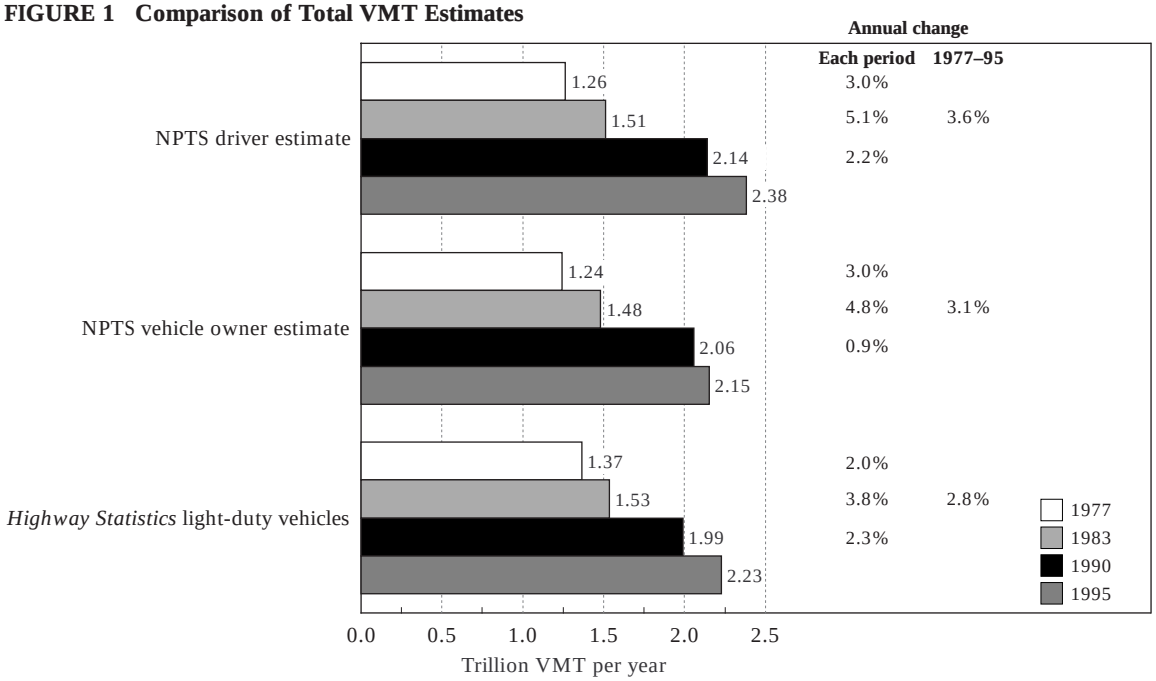
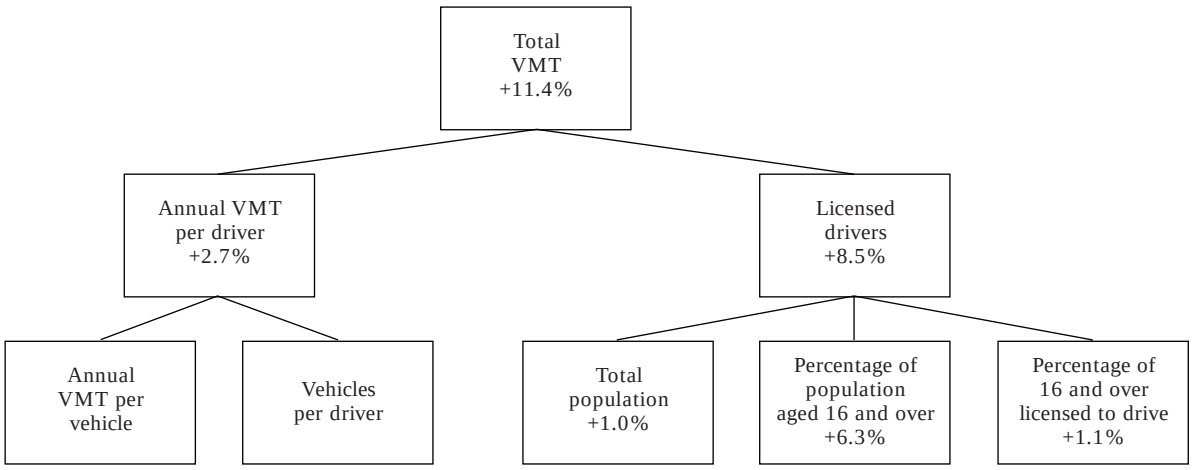


FIGURE 2 Components of Change in Total VMT: 1990–95



Note: Percentages equal product, rather than sum, of the change in individual components.

annual miles driven per licensed driver increased 2.7% over this period, while the number of licensed drivers increased 8.5%; these changes combine to produce the previously reported increase of 11.4% in the driver-based estimate of total travel.[8]

As figure 2 also shows, the change in the number of licensed drivers can be further broken down into changes in the total population, the share of the population of driving age (16 years and above in most states, but higher in a few states), and the fraction of the driving-age population actually licensed to drive. The number of licensed drivers increased between 1990 and 1995 because all three of its components grew, although most of the growth in licensed drivers was accounted for by the increased share of the population of driving age, which rose 6.3%. In principle, it should also be possible to break down the growth in annual miles per driver into changes in annual miles driven per vehicle and in the number of vehicles per driver, but the instruction to survey respondents to include driving as part of work in vehicles garaged outside the household in their estimates of annual driving (see footnote 2) makes this measure inconsistent with the NPTS estimate of the vehicle population, which is limited to household vehicles.[9]

More detailed analysis reveals that the increase in annual VMT per licensed driver occurred primarily among women and older men. Table 2 reports that VMT for the youngest drivers (16 to 19 years old) declined significantly among both men and women, although the percentage decline among males was twice as large as that among females. In contrast, driving increased significantly and fairly uniformly among women aged 20 to 64 years; only among women 65 and older did it fail to change significantly. Table 2 also shows that changes in annual driving among the most active drivers—men aged 20 to 64 years—were mixed, the 20 to 34 age group showed a slight decline, the men 35 to 54 years showed almost no change, and

[8] The percentage change in total travel is equal to the product, rather than the sum, of the change in the individual components.

[9] Ignoring this inconsistency, which was also present in the 1990 survey, results in calculated changes of 4.5% in annual vehicle use and –1.7% in the number of (household) vehicles per driver from 1990 to 1995, which together produce the 2.7% increase in annual VMT per driver reported in figure 2. The calculated increase in annual vehicle use (4.5%) contrasts with the change in respondents' estimates of annual *household* vehicle use reported in the 1990 and 1995 surveys, which is –2.0%. This suggests that much of the growth in total VMT may have been in the use of commercial and other vehicles garaged outside the household. Unfortunately, no estimate of the vehicle population that includes household vehicles plus those others that NPTS respondents are likely to have reported driving is readily available.

TABLE 2 Changes in Annual VMT per Driver by Age and Sex: 1990–95

	Male			Female		
Age	1990	1995	% change	1990	1995	% change
16–19	9,543	8,203	–14.0%	7,387	6,870	–7.0%
20–34	18,310	17,980	–1.8%	11,174	12,001	7.4%
35–54	18,871	18,859	–0.1%	10,539	11,463	8.8%
55–64	15,224	15,844	4.1%	7,211	7,795	8.1%
65+	9,162	10,320	12.6%	4,750	4,788	0.8%
All ages	16,536	16,553	0.1%	9,528	10,143	6.5%

Source: Tabulated from 1990 and 1995 NPTS household files.

those aged 55 to 64 showed a modest increase. Taken as a single group, however, there was little increase in driving, perhaps suggesting some tendency for motor vehicle use to stabilize among those who are already the most active drivers. Older males showed the largest increase in average annual driving between 1990 and 1995, although by 1995 they still drove considerably less than their younger counterparts.

Travel Mode and Vehicle Occupancy

Because the demand for *vehicle* travel ultimately derives from the demand for *person* travel,[10] growth in VMT can also be related to the underlying demand for person-miles of travel (PMT). Specifically, total PMT can be translated into VMT using the share of trips that are made using motor vehicles and the average occupancy of motor vehicles used for each trip. The 1995 NPTS reveals continuing, though modest, growth in the share of trips made using household-owned motor vehicles: from about 84% in 1977 to slightly above 87% during 1990, and up to more than 89% by 1995. The increase in motor vehicle use has come at the expense of walking, public transit, and school bus travel. While the share of bicycle trips increased between 1977 and 1995, it remains under 1%.

At the same time, the survey shows that vehicle occupancy continued to decline: the fraction of vehicle trips made by a single occupant rose from about 60% during 1977 to 67% by 1990 and to 68% by 1995. A more precise indicator of vehicle occupancy is the average number of person-miles per vehicle-mile, which implicitly weights vehicle occupancy for each trip by its distance; this measure declined from 1.89 persons in 1977 to 1.64 during 1990, and further to 1.59 persons by 1995. The combination of a rising share of trips in personal vehicles and declining occupancy of those vehicles means that an increasing number of vehicle-miles are required to meet the same underlying demand for person-miles, so that even the modest recent growth in total *person* trips and miles of travel has been reflected in the significant increases in *vehicle* trips and vehicle-miles noted previously.

HOUSEHOLD VEHICLE OWNERSHIP

The NPTS also provides detailed information about continuing changes in the number, types, and use of motor vehicles owned by U.S. households. The two major developments revealed by the succession of surveys are the trend toward nearly ubiquitous ownership of at least one vehicle among U.S. households, and the rapidly increasing number of households owning multiple vehicles. More recently, the 1990 and 1995 NPTSs highlight the increasing substitution of vehicles classified as light-duty trucks—pickup trucks, passenger and cargo vans, and sport utility vehicles (SUVs)—for automobiles in providing household transportation. While widespread use of pickup trucks as household vehicles significantly predates that of other light trucks (and displays a markedly different geographic pattern), recent purchases of vans

[10] Person travel refers to all trips outside the home by household members made by any means, including on foot and by motorized or nonmotorized vehicles of all types. As employed in the NPTS, vehicle travel includes only household members' trips that are made using personal motorized vehicles owned by that or another household.

and SUVs have substantially increased the share of household vehicles and mileage accounted for by light trucks.

Increasing Vehicle Ownership

Table 3 summarizes changes in the distribution of vehicle ownership among U.S. households from 1977 through 1995. It also shows accompanying changes in the average number of vehicles owned and in the number of household members of driving age.[11] Although the percentage of households without vehicles was not large even at the outset of this period, it declined sharply, while the proportions 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 households with three or more vehicles was more than *twice* as large as the number without vehicles.

Interestingly, however, these seemingly large changes in the distribution of households among vehicle ownership categories were translated into comparatively modest growth in average vehicle ownership. As table 3 shows, 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. But the average number of household members of license-eligible age *fell* slightly, as the effect of continuing declines in household size offset that of the aging of the "baby boom" generation. Thus, as table 3 shows, the number of vehicles per household member of driving age increased from 0.76 in 1977 to 0.89 (17%) in 1990, but remained unchanged in the 1995 survey.

The Increasing Importance of Light Trucks

As indicated previously, a major change in the composition of the household vehicle fleet (i.e., the increasing substitution of light-duty trucks for automobiles) has taken place during the period spanned by the NPTS. Table 4 reports the distribution of household vehicles during 1990 and 1995 by type; it indicates that passenger automobiles represented only about 65% of household vehicles in 1995, a significantly lower share than the more than 71% they accounted for only five years earlier.[12] In contrast, SUVs accounted for 7% of household vehicles by 1995, exactly double their representation in 1990, while the share of passenger vans also increased rapidly, from 5.4% to 7.9% of household vehicles. Table 4 shows that the representation of pickup trucks, the earliest light truck models to be purchased on a widespread basis for passenger transportation, rose only slightly between 1990 and 1995, although the share of pickups, nearly 18%, still exceeds that of all other light trucks.

Because the nation's household vehicle fleet grew rapidly during the period covered by table 4, what may seem like relatively modest changes in

TABLE 3 Changes in Household Motor Vehicle Ownership: 1977–95

Variable	1977	1983	1990	1995
% of households owning:				
0 vehicles	15%	14%	9%	8%
1 vehicle	35%	34%	33%	32%
2 vehicles	34%	34%	38%	40%
3 or more vehicles	16%	19%	20%	19%
Vehicles/household	1.59	1.68	1.77	1.78
Household members 16 or older	2.10	2.06	1.98	2.01
Vehicles/household member 16 or older	0.76	0.82	0.89	0.89

Source: 1990 NPTS, *Summary of Travel Trends*, tables 1, 2, and 4; and 1995 NPTS.

[11] 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.

[12] Unlike the 1995 NPTS, the 1990 survey did not include a category for sport utility vehicles 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. Unfortunately, we were unable to tabulate the distribution of vehicles among the same type classes shown in table 4 for previous survey years, although the passenger van and SUV categories were probably quite small before 1990.

TABLE 4 Household Vehicles by Type: 1990 and 1995

Vehicle type	1990 Number (millions)	1990 Percentage of total	1995 Number (millions)	1995 Percentage of total	Percentage change 1990–95
Passenger car	117.5	71.2%	113.3	65.2%	–3.6%
Light truck:					
Sport utility[1]	5.9	3.5%	12.2	7.0%	107.6%
Van	9.0	5.4%	13.8	7.9%	53.8%
Pickup	28.4	17.2%	31.1	17.9%	9.6%
Subtotal, light truck	43.2	26.2%	57.1	32.8%	32.1%
Other truck	1.0	0.6%	0.7	0.4%	–27.9%
Recreational vehicle	0.9	0.5%	0.9	0.5%	6.0%
Motorcycle	2.2	1.3%	1.7	1.0%	–24.2%
Other	0.4	0.2%	0.1	0.1%	–57.6%
Subtotal, type known	165.1	100.0%	173.8	100.0%	5.3%
Unknown	0.1		2.3		[2]
TOTAL	165.2		176.1		6.6%

[1] 1990 data retabulated using 1995 definition of sport utility vehicles.
[2] Computed percentage change is extremely large.

Source: Tabulated from 1990 and 1995 NPTS vehicle files.

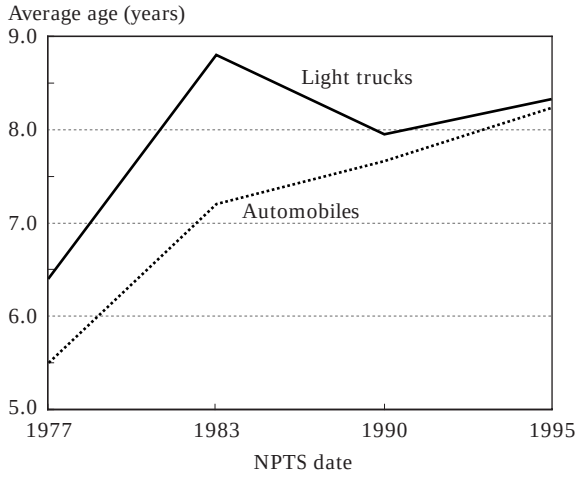
the proportions of vans, SUVs, and pickup trucks obscures significant increases in their *numbers*. The number of vans owned by households increased by nearly 5 million between 1990 and 1995, while the number of SUVs grew by more than 6 million and the number of pickups by nearly 3 million. Thus, in total, the number of light trucks owned by households grew by almost one-third from 1990 to 1995; as a result, they accounted for more than one-third of the household vehicle fleet for the first time in 1995. In contrast, table 4 shows that the number of passenger cars actually declined during this period, suggesting that households were replacing older automobiles with new SUVs and vans. Recent sales figures suggest that the effect of this shift from conventional automobiles to trucks on the composition of the household vehicle fleet has not yet peaked, since truck models currently represent nearly half of all light-duty vehicles sold, with SUVs continuing to exhibit the strongest sales growth of any passenger vehicle category (Another Month 1999).

AGING OF THE FLEET

The 1995 NPTS reveals continued aging of the household vehicle fleet.[13] As figure 3 shows, the average age of household automobiles increased sharply from 5.5 to 7.2 years between the 1977 and 1983 surveys and then more slowly, reaching 8.3 years through 1995. The average age of household-owned light-duty trucks followed a slightly

[13] There is no unambiguously "correct" way to translate the distribution of vehicle model years recorded by the NPTS into a fleet-average vehicle age, partly because the NPTS surveys households over a period that typically includes more than one calendar year. In addition, the difference between the calendar year and most vehicles' model years means that it is not obvious how to code vehicle ages. This paper uses the average ages for 1977, 1983, and 1990 reported as part of the 1990 NPTS (USDOT 1993, 3–40). The 1995 figures were then 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 one, as were one-year-old vehicles (those with a model year of 1995); model year 1994 vehicles were assigned an age of two, model year 1993 vehicles were given an age of three, and so forth.

FIGURE 3 Trends in Vehicle Age by Type: 1977–95



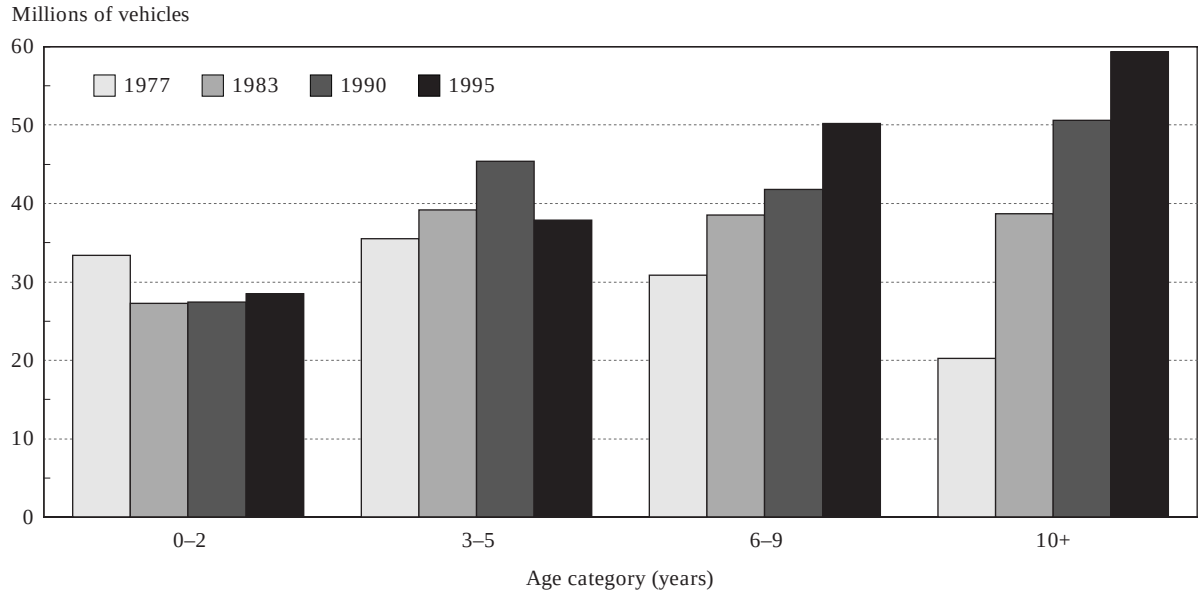
different pattern, as the figure shows: like that of automobiles, it rose sharply between the 1977 and 1983 surveys, but then declined significantly between 1983 and 1990 before increasing again by 1995. The gradual convergence of the average ages of autos and light trucks shown in figure 3 again probably reflects the increasing substitution of light trucks, particularly the more recently marketed models such as minivans and SUVs, for household automobiles.

Because the timing of new vehicle purchases (both to replace aging ones and to expand vehicle availability) is sensitive to macroeconomic conditions, the patterns of vehicle aging shown in figure 3, particularly the sharp increase in average ages of both cars and light trucks between 1977 and 1983, may be partly attributable to the severe recession of the early 1980s, the rapid recovery that followed, and the subsequent slowdown during the early 1990s. Superimposed on this pattern, however, appears to be a gradual longer term increase in the average age of household-owned vehicles that must be explained by other factors. The accompanying changes in the age *distribution* of household vehicles provides some useful suggestions about the underlying causes of fleet aging.

Changes in the Age Distribution of Household Vehicles

Figure 4 displays the age distribution of the nation's household vehicle fleet for each of the four NPTS years. As it shows, the number of U.S. household-owned new vehicles that were up to two years old in 1995 was only slightly greater than the comparable figures for 1983 and 1990 and was well *below* the 1977 number, despite rapid expansion of the total household vehicle fleet throughout this period. After rising steadily from 1977 through 1990, the number of three- to-five-year-old vehicles also declined significantly in the 1995 survey. At the other end of the age distribution, however, the number of six- to nine-year-old vehicles, which had risen only modestly between

FIGURE 4 Distribution of Household Vehicles by Age: 1977–95



1983 and 1990, 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, almost exactly double the 17% share they represented in 1977.

PATTERNS OF VEHICLE USE

The implications of the continued aging of household vehicles for transportation safety, urban air pollution, and energy consumption depend not only on their age distribution but also on 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 quickly noticeable. However, if older vehicles are used nearly as intensively as newer ones, the effects of these measures will require many years after they are adopted to be widely felt. The gradual retirement of vehicles of different "vintages" 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 NPTS reveals important information about each of these effects.

A Note on the NPTS Measures of Vehicle Use

As the earlier discussion of total VMT estimates indicated, the NPTS includes two measures of vehicle usage. Households responding to the survey were first asked to estimate the number of miles each of the vehicles available to them were driven during the previous 12 months; respondents provided usable estimates of annual mileage for more than 80% of the 75,000 household vehicles identified in the survey. In addition, odometer readings were obtained for each household's vehicles at the time of the interview, and surveyors subsequently attempted to obtain odometer readings for each of these same vehicles several weeks after the initial interview. The difference in odometer readings between these two dates was then adjusted for normal seasonal variation in household driving activity (the survey period spanned more than a year) and extrapolated to an estimate of each vehicle's annual usage. The paired odometer readings necessary to construct these estimates of annual usage were obtained for about 44% of all household vehicles identified in the 1995 NPTS.

While it might appear that the odometer-based estimates provide a more reliable measure of vehicle use, two considerations complicate the choice between the odometer-based and respondent-reported estimates. First, while there are almost certainly errors in household members' estimates of how much each vehicle was used, there may also be important, if less obvious, sources of measurement error in the odometer-based estimates. Errors could have arisen in reporting a vehicle's odometer readings either during the initial telephone interview or at the time of the followup call. Errors also could have been introduced during the complex process used to convert differences in odometer readings to estimates of annual driving.[14]

Second, the estimates of average vehicle use, and the relationships of vehicle use to other variables that can be inferred from the subsample of vehicles for which the two usage measures are available, are both subject to potential bias. In part because the owner-reported estimates of vehicle use were obtained for such a large fraction of all household vehicles identified by the survey, the typical characteristics of both the vehicles for which these estimates were available and the households who owned them closely mirror those characteristics of all households and vehicles included in the NPTS. In contrast, the vehicles for which odometer-based estimates of annual usage were obtained are significantly newer on average, tend to include a higher percentage of automobiles, and are more commonly owned by households with only one or two vehicles than is the case for all household vehicles identified in the survey.

Thus, it is difficult to choose between the respondent-reported and odometer-based usage estimates, and the two measures do not agree closely. Their simple correlation among the more

[14] See USDOT 1997, appendix K, for a detailed discussion of the procedure for annualizing the odometer reading data.

than 25,000 vehicles for which both were obtained is only 0.64. While the odometer-based estimates seem likely to be inherently more reliable, they may still contain significant measurement errors because of the characteristics of this subsample. Estimates of average usage and of the relationships of use to other variables might be sources of bias for the subsample. Because of the difficulty of choosing between them, this section employs *both* the owner-reported and odometer-based estimates of vehicle use in each of the analyses it reports.

Annual Utilization by Vehicle Age

Figure 5 shows the 1995 patterns of estimated annual usage of different aged household vehicles calculated from the two vehicle-use measures. Both measures indicate that the five newest model years in the household vehicle fleet are driven quite intensively, averaging nearly 14,000 miles annually, according to the owner-reported use estimates, and about 13,000 miles annually, according to the odometer data. Surprisingly, vehicles between 6 and 10 years old seem to be driven nearly as much, averaging 11,000 to 12,000 miles annually, depending on the measure used. Figure 5 shows that according to both measures, it is not until approximately age 12 (model year 1983 in the 1995 NPTS) that annual utilization drops consistently below the 10,000-mile threshold.[15] While the small samples of vehicles older than 15 years from which odometer readings were obtained in both surveys produces considerable variation in the average utilization of individual age cohorts, it appears that usage reaches a "floor" of approximately 6,000 miles annually, even among the oldest vehicles remaining in the household fleet.

The Distribution of Household VMT by Vehicle Age

Figure 6 shows the pattern of usage of household vehicles by age during 1995 derived from the

[15] 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 may be misleading, or at least incomplete. Lave (1994) 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 purchase new vehicles infrequently and retain them for longer periods. Assuming some distribution of household travel demands, this process would produce exactly the same fleet age and mileage accumulation patterns revealed by the 1995 NPTS and its predecessors. In fact, both of these models are probably simultaneously at work within the household vehicle fleet, 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.

FIGURE 5 Vehicle Age and Annual Miles Driven: 1995 NPTS

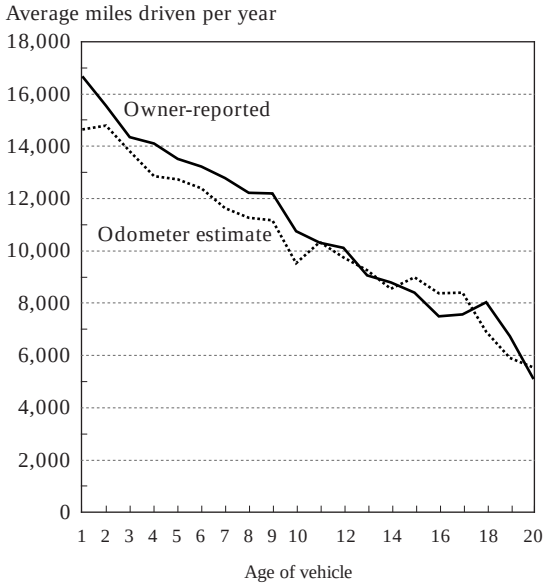
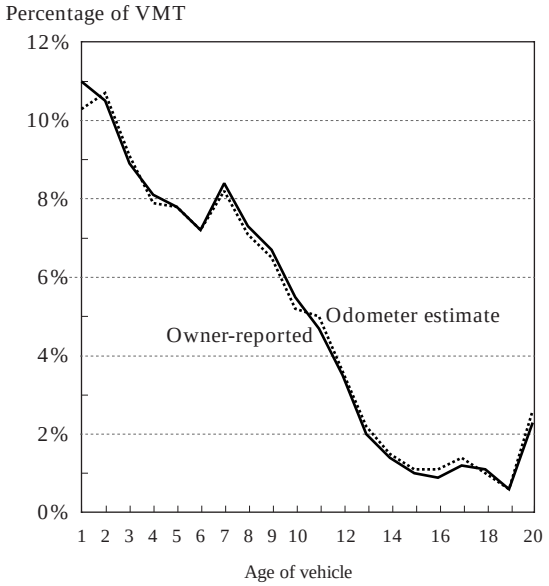


FIGURE 6 Vehicle Age and Percentage of Total VMT: 1995



NPTS to produce the distribution of total household VMT. As it indicates, the effect of declining usage with increasing vehicle age offsets the larger number of older vehicles, so that a higher fraction of total VMT is accounted for by relatively new vehicles than their representation in the fleet would suggest. Thus, according to the NPTS, nearly 50% of all household VMT in 1995 was driven by vehicles that were five years of age or newer, with most of the remainder distributed among vehicles of ages 6 through 15 years.

Annual Utilization by Vehicle Type

Table 5 compares average annual miles driven in different types of household vehicles, again computed from both the owner-reported and odometer-based estimates of vehicle use. The two measures disagree about exactly how much automobiles are typically driven. The odometer figure is about 6% less than owners' estimates, but both indicate that automobiles tend to be less intensively used than other types of household vehicles. Vans are the most heavily used household vehicles, while other light trucks—sport utility vehicles and pickups—fall between automobiles and vans. Since older vehicles of all types tend to be used less than newer models, however, some of the less intensive use of pickups may simply be associated with their much higher average age. The annual use estimates for all household vehicles, which are about 11,800 miles from the odometer-based data and 12,200 miles from owners' estimates, are generally consistent with those reported by other sources.[16]

TABLE 5 Mean Age and Annual Usage, by Vehicle Type

Vehicle type	Mean age (years)	Average annual miles driven	
		Reported[1]	Odometer[2]
Automobile	8.2	11,988	11,318
Van	6.7	14,256	14,389
Sport utility	6.6	13,853	13,436
Pickup	9.6	12,064	11,826
All household vehicles[3]	8.3	12,226	11,801

[1]Average of vehicle owners' estimates of annual usage.
[2]Average of estimated annual usage for vehicles from which odometer readings were obtained.
[3]Includes other trucks, motorcycles,and recreational vehicles.

Source: Tabulated from 1995 NPTS vehicle file.

A MODEL OF VEHICLE USE

Table 6 shows the results of an analysis designed to clarify the independent effects of age and vehicle type, as well as to explore the influence of household demographic and economic characteristics on vehicle use. The table reports least-squares regression estimates of the parameters of a model relating annual utilization of vehicles to characteristics of the households that own them, their locations, and the vehicles themselves. Changes in vehicle usage can be thought of as a short-run adjustment to changes in factors influencing households' demands for private vehicle travel, such as their demographic composition or the price of fuel, which allows households to respond to such changes without altering their vehicle ownership levels. Households are likely to adjust to permanent changes in these factors by varying their levels of automobile ownership, thereby producing a tendency for average vehicle use to return to some "target" or equilibrium level. Over the longer run, however, this target level may itself rise or fall in response to factors such as additional household members reaching driving age, changing costs of vehicle ownership and use, or improvements in vehicle performance and durability.

[16] For example, the Federal Highway Administration (USDOT 1995, table VM-1, p. V-92) reports average annual mileage of 11,489 for automobiles plus two-axle, four-tire trucks, which corresponds roughly to the definition of household vehicles employed in the NPTS. This number is somewhat below the odometer-based estimate of average household vehicle use reported in table 5. However, the FHWA figure is derived by dividing its estimate of total VMT driven in those vehicles by the number of them registered during the year. The latter measure overstates the actual number of those vehicles in use, because the state registration data used by FHWA to compile it double count vehicles that are sold or moved between states and thus registered twice during the same year. Compared with survey data on the number of vehicles in use reported by R.L. Polk (AAMA 1996), the FHWA vehicle stock estimate appears to be approximately 10% too large. Adjusting to compensate for the double counting of vehicles in state registration data produces an estimate of 12,638 miles per vehicle in 1995, somewhat above the figure derived from NPTS respondents' estimates of vehicles use that is reported in table 5.

TABLE 6 Vehicle Usage Model: Regression Results

Independent variable	Estimated coefficients and t-statistics[1]						Estimated coefficients and t-statistics[2]					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	ß	t	ß	t	ß	t	ß	t	ß	t	ß	t
constant	9.27	27.91	8.45	25.19	8.44	25.17	10.01	21.72	8.84	18.94	8.77	18.81
numadlt	0.10	12.66	0.11	14.00	0.11	13.97	0.17	14.11	0.18	15.12	0.18	15.13
numchild	0.04	8.95	0.04	8.18	0.04	8.36	0.14	21.31	0.14	20.87	0.14	21.03
age	–0.06	–72.51	–0.06	–72.88	–0.06	–59.98	–0.08	–58.16	–0.08	–58.14	–0.07	–45.41
hhvehcnt	–0.15	–24.83	–0.16	–27.44	–0.16	–27.56	–0.09	–9.48	–0.11	–11.78	–0.11	–11.85
linc	0.15	19.27	0.17	20.95	0.17	21.25	0.08	7.12	0.10	8.60	0.10	8.85
lpgas	–0.29	–4.18	–0.08	–1.20	–0.08	–1.21	–0.34	–3.59	–0.05	–0.45	–0.04	–0.41
lbgden		–0.04	–15.44	–0.04	–15.43		–0.06	–13.96	–0.06	–14.16		
van	0.14	7.20	0.13	6.87	0.02	0.59	0.13	5.28	0.13	5.10	0.03	0.83
suv	0.11	5.58	0.10	4.90	0.00	–0.06	0.12	4.43	0.10	3.85	0.16	3.78
pickup	0.09	6.73	0.06	4.08	0.07	3.09	0.04	2.34	0.00	0.11	0.12	3.94
truck	0.16	1.87	0.12	1.37	0.80	4.71	0.06	0.39	0.03	0.21	0.10	0.32
rv	–0.56	–7.98	–0.56	–8.06	–1.09	–7.29	–1.15	–9.41	–1.13	–9.27	–2.24	–8.13
*age*van*					0.016	4.34					0.016	3.12
*age*suv*					0.014	4.12					–0.009	–1.68
*age*pickup*					–0.001	–0.63					–0.015	–4.86
*age*truck*					–0.043	–4.57					–0.006	–0.31
*age*rv*					0.041	4.04					0.083	4.43
Adj. R sq.	0.145		0.149		0.150		0.181		0.187		0.189	

[1] Dependent variable: Natural logarithm of annualized miles driven, derived from vehicle owner estimates (mean = 8.92).
[2] Dependent variable: Natural logarithm of annualized miles driven, derived from vehicle odometer readings (mean = 8.92).

Because the coefficient estimates reported in table 6 are derived from a large cross-section of households and individual vehicles, they theoretically represent the effects of the variables on households' long-run target or desired levels of vehicle use. The coefficient estimates for the categorical or "count" variables included in the model (e.g., *numadult* or number of adults in the household) indicate the proportional or percentage increase in the annual number of miles driven in each of the household's vehicles that is associated with an increase of one in the value of that variable (e.g., the presence of another adult in the household). Because the continuous explanatory variables included in the model are in logarithmic form (e.g., *linc* or the natural logarithm of the household's annual income), their estimated coefficients indicate the percentage change in annual vehicle use associated with a 1% change in the value of each variable.

Demographic and Economic Effects on Vehicle Use

The coefficient estimates reported in table 6 suggest that the presence of another adult member of the household increases vehicle use by 10% to 18%, depending on whether the owner-reported or odometer-based estimates of vehicle use are used. Interestingly, the owner-reported use data suggest that this effect is more than twice as large as that of an additional child in the household, while the odometer-based data indicate that the effect of an additional child is nearly as large as than of another adult. Increasing vehicle ownership, as measured by the variable *hhvehcnt*, reduces the utilization of each vehicle, although there is some disagreement about the size of this effect: the owner-reported data suggest that average use declines 15% to 16% with the presence of each additional vehicle, while the odometer data suggest a 9% to 11% decline. The larger effect implied by the owner-reported use data appears to be more consistent with previous estimates, which indicate that a household's ownership

of additional vehicles substantially reduces their average use.[17] One possibility is that the explicit controls for the ages and types of household vehicles included in this model capture some effects of increasing vehicle specialization and the matching of vehicles to specific household trip demands that have previously been attributed to a simple count of the number of vehicles a household owns.

The estimated values of the coefficient on the household income variable shown in table 6 indicate that increases in a household's income have only a slight effect on utilization of the vehicles owned. Since there is considerable evidence that rising household income significantly increases members' motor vehicle travel, this result suggests that most of that increase occurs through the mechanism of higher vehicle ownership.[18] In contrast, the estimated coefficient on gasoline prices (*lpgas*) provides some suggestion that the per mile cost of driving may influence households' target levels of vehicle use, although collinearity between this variable and the residential density of the neighborhoods where surveyed households reside (*lbgden*) makes it difficult to tell which of these two variables independently affects vehicle use.[19]

Effects of Vehicle Type and Age

The regression results shown in table 6 also confirm that vans are particularly intensively utilized, but they suggest that much of this greater utilization is explained by a less rapid decline in van usage with age than occurs with other vehicle types. This is evidenced by the fact that when the *age*van* variable is added to the regression, its positive coefficient reduces the negative effect on usage of the *age* variable itself, and the magnitude of the coefficient on the *van* variable declines sharply. The intensive van usage result may be partly an artifact of the different transportation functions served by older passenger and cargo vans (i.e., commercial purposes as well as household travel), and the more recently marketed mini-vans, which more clearly substitute for automobiles and thus tend to serve more limited travel purposes. However, both data sources suggest a tendency for vans of both types to be used more intensively than other types of household vehicles throughout their lifetimes.

The higher average utilization of both SUVs and pickups, as shown by the mostly positive coefficients on the *suv* and *pickup* variables in table 6, may also reflect frequent use of these vehicles for recreational travel, joint household and business use, or other nonpassenger transportation uses. Interestingly, the odometer-based data suggest that the decline in usage of pickups with increasing age is slightly *more* pronounced than for conventional automobiles; since the average age of pickups is significantly higher than other vehicle types, their more intensive utilization seems difficult to explain in light of this result. While it may simply mean that pickups are more readily adaptable to various commercial and nonpassenger household transportation functions than are other vehicles, the effect of introducing the neighborhood density

[17] Using 1990 NPTS data, Walls et al. (1993, 22) estimate that a household's acquisition of each additional vehicle reduces its average annual driving per vehicle by as much as 40%.

[18] For example, Schimek (1997, 88) reports that estimates of the income elasticity of total motor vehicle travel range from 1.2 to 1.4, but that income elasticities of average vehicle use are typically in the range of 0.2 to 0.3.

[19] This collinearity may arise from the procedure used to develop the gasoline price variable, which is the average of monthly retail prices including all taxes over the 15-month survey period, May 1995 through July 1996, in the state where the household or vehicle is located. Most of the variation in this measure among locations is due to differences in state fuel taxes rather than to geographic variation in the pretax price of gasoline. More urbanized states appear to have higher fuel tax rates. As a consequence, households facing higher fuel prices are apparently more likely to reside in higher density neighborhoods, thus making it difficult to disentangle the separate effects of fuel prices and residential density on vehicle use. 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 significant variation in its price. As a result, using monthly gasoline prices does not allow the specific response we are attempting to measure—movement along the demand curve in response to gasoline price changes—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 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.

measure on the coefficient of the *pickup* variable suggests that their more intensive use stems partly from their more frequent ownership by households outside urban areas, where longer trip distances increase vehicle use significantly.

CONCLUSIONS

Analysis of the 1995 Nationwide Personal Transportation Survey and its predecessors reveals continuing growth in household vehicle ownership and use, although at somewhat slower rates than prevailed during the 1980s. The 1995 survey reveals only modest growth in annual VMT per licensed driver since 1990, indicating that the growth rate in total driving may ultimately decline toward the rate of increase in the number of licensed drivers. However, rapid increase in the driving-age population provided a significant boost to VMT growth during this period and may continue to do so for some time. In addition, the modest overall increase in VMT per driver obscured rapid growth in driving among women across a broad age spectrum (20 to 64 years) and among older men, developments that may continue to offset the apparent stabilization of driving among young adult and middle-aged men.

The most recent NPTS also shows that vehicle ownership, both per household and per person of driving age, remained virtually unchanged between 1990 and 1995, as did the fraction of households owning multiple vehicles. These developments provide some suggestion that vehicle ownership may be stabilizing, although at levels only slightly below one vehicle per household member of driving age level. Further, the historical decline in average vehicle occupancy slowed markedly during this same period, suggesting that it may also be approaching some floor as vehicle availability becomes virtually ubiquitous among the population of driving age. Combined with a continuing increase in the fraction of household members' trips made by private motor vehicles, the decline in vehicle occupancy meant that even modest growth in *person* travel continued to generate significantly increased *vehicle* travel.

In contrast to the apparent stabilization of these variables, the aging of household motor vehicles accelerated sharply from its historic pace in recent years, primarily as the result of declining retirement rates for vehicles over 10 years of age. The 1995 NPTS also shows that the usage of older vehicles is considerably greater than is generally assumed in the modeling of fleetwide air pollutant emissions and energy consumption levels, raising the possibility that the contribution of older vehicles to these undesirable byproducts of automobile use may be significantly understated. The survey also clearly documents the increasing substitution of light trucks, particularly vans and sport utility vehicles, for passenger automobiles and shows that household-owned light trucks tend to be more intensively utilized than automobiles. While light trucks grew from about one-quarter to nearly one-third of all household vehicles between 1990 and 1995 alone, they continue to represent a still larger fraction of new vehicle sales, so this figure will undoubtedly continue to rise over the foreseeable future.

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APPENDIX

Comparing Survey Methods Using the 1994 NPTS Pretest

The 1995 NPTS uses a different survey method from earlier editions of the survey, making comparisons with earlier NPTS statistics difficult. In order to anticipate the various consequences of this change in survey methods, a 1994 pretest of the 1995 NPTS employed both the 1990 survey method, retrospective recall, and the 1995 survey method, a diary mailed in advance of the travel day; households were randomly assigned to be surveyed using the two different methods.[20] The difference in average measures from each of the two survey methods in the pretest can be used to approximate the difference due to the change in sampling technique alone.

Table A-1 shows average trip length, the number of trips, and their product, total travel, estimated using the two survey methods. 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 VMT. The diary method recorded more short motor vehicle trips: the number of vehicle trips was nearly 10% higher using this method, although their 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 also recorded when the diary method was used, but 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 on average; thus the retrospective method appears to understate the number of PMT 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. Other inconsistencies between the two survey methods were not accounted for, however, such as the treatment of commercial driving. Therefore even the adjusted 1990 data are not completely comparable to the corresponding measures obtained from the 1995 survey.

[20] The 1994 pretest also used a third technique, a memory jogger, which is essentially a simpler form of the travel diary. Since this method was not chosen for subsequent use in the 1995 survey, it is not discussed here.

TABLE A-1 Estimates of Person Trips, Average Trip Length, and Total Person Travel Using Different Survey Methods: 1995 NPTS Pretest

	Retrospective method			Trip diary method			% difference between methods		
Statistic	Average length (miles)	Number of trips (billions)	Person-miles (billions)	Average length (miles)	Number of trips (billions)	Person-miles (billions)	Average length (miles)	Number of trips (billions)	Person-miles (billions)
All person trips[1]	7.77	80.4	625	7.89	91.7	723	1.5%	14.1%	15.7%
Person trips by motor vehicle	8.51	69.9	595	8.75	79.7	698	2.8%	14.0%	17.3%
Motor vehicle trips[2]	8.65	48.6	420	7.97	53.3	425	–7.9%	9.7%	1.2%

[1] Excluding airplane trips.
[2] Trips by drivers only.