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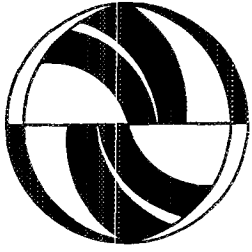
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Author

Lave, Charles

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Working Paper
UCTC No. 231

**The University of California
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**State and National VMT Estimates:
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Charles Lave

Department of Economics
University of California at Irvine
Irvine, CA 92717

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"STATE AND NATIONAL VMT ESTIMATES: IT AIN'T NECESSARILY SO"

Charles Lave
Department of Economics
University of California, Irvine, CA 92717

ABSTRACT

The enormous jump in vehicle miles traveled (VMT) reported by the 1990 U.S. Nationwide Personal Transportation Survey (NPTS) caused a great deal of concern among planners and policy analysts. Such a jump seemed to portend an era of ever increasing travel, pollution and energy consumption.

This paper re-analyses the NPTS data and shows that the VMT jump was a statistical error. The 1990 NPTS oversampled new vehicles and undersampled old ones. Since new vehicles are driven two to three times as much as old ones, the sampling bias will overestimate VMT. And the result may have been intensified by an underestimate of VMT in the 1983 NPTS, thus increasing the apparent jump from 1983 to 1990.

I also calculate alternative VMT estimates using data from two other national surveys and a massive odometer-based California study. The three new estimates are in close agreement with each other. I conclude that VMT per vehicle actually grew at only half the rate estimated by the NPTS.

1. INTRODUCTION

When the preliminary data from the 1990 United States Nationwide Personal Transportation Survey (NPTS) began coming out, transportation planners were shocked by the 41% jump in vehicle miles traveled (VMT), compared to the 1983 NPTS. A number of papers analyzed the implications of this jump and rightly drew the conclusion that there was serious trouble ahead unless we adopted policies to curb VMT growth. (For example, Kenworthy and Newman, 1993; The Energy Foundation, 1993; Dunphy and Fisher, 1994).

There are reasons to be suspicious of the 1990 NPTS results: (A) They are not in line with U.S. historical trends: VMT grew only 17% between the 1969 and 1977 NPTS surveys, and only 10% between the 1977 and 1983 NPTS surveys. (B) The NPTS results are not in line with the state-based VMT figures compiled by the U.S. Federal Highway Administration (FHWA): the NPTS data show VMT per vehicle growing at a rate of 2.7% per year; the FHWA data show a growth of only 1.4% per year for the same period. (C) There are reasons to doubt the reliability of respondents' answers to a subjective question ("How many miles did you drive last year?"), concerning an area of their lives where they do not usually think in quantitative terms. (D) The basic survey methodology of the NPTS changed. Up through 1983, the NPTS used home interviews.

In 1990, because of financial constraints, the NPTS was changed to a telephone survey based on random-digit dialing.

This paper begins by reviewing what is known about the quality of the data in the NPTS and the FHWA data bases. I then introduce evidence from a third survey, the Residential Transportation Energy Consumption Survey administered by the U.S. Department of Energy: a household interview survey that collects actual odometer readings. Finally, I introduce a new VMT data set based on my analysis of odometer readings from the entire population of California vehicles.

I find evidence of sampling bias in the NPTS: it oversampled high-VMT households, and undersampled low-VMT households. I find evidence of inconsistent responses to subjective questions about VMT in the NPTS. And I find that the two data sources which used objective odometer data are in close agreement with each other, and with the FHWA data, while disagreeing with the NPTS estimate of VMT. I conclude that the 1983-90 VMT jump in the NPTS is about double the actual VMT growth rate.

2. QUALITY OF THE NPTS DATA

The Data: The NPTS survey has been run approximately every seven years in the U.S., beginning in 1969. Up through the 1983 survey it used home interviews. Its VMT estimates are based on subjective data. Respondents are asked: How many miles was each vehicle driven last year? There are reasons to be concerned about the accuracy of the responses. The concept "yearly VMT" is not salient to the ordinary decisions of respondents -- it's not a category that normally concerns them -- furthermore the answer is difficult for them to estimate.

If respondents' subjective guesses about yearly VMT were sometimes high and sometimes low, then an average over many respondents would still yield accurate results for the average level of VMT. And even if most respondents were biased in a particular direction, e.g. too high, the data is not a total loss: the VMT level in any one NPTS survey would be too high, but so long as the degree of bias was constant from survey to survey, we could still calculate accurate growth trends.

Unfortunately, there is reason to suspect that any bias in the VMT estimates would not be consistent from 1983 to 1990. Reacting to severe budget pressures, the NPTS changed sampling procedures and began using telephone interviews based on a random-digit dialing methodology. Respondents may react differently to a telephone interview. They may treat the questioners more casually, especially in a situation that seems to require a quick and accurate response to an unexpected and difficult question such as: How much was that car driven last year?¹ I will call this Response Error.

¹Comparing phone interviews to home interviews, Tanur finds that phone answers to open-ended questions tend to be shorter and have fewer multiple responses, and suggests that respondents may have more tendency to omit responses that they consider trivial (Tanur, 1982, p. 309-310). That is, the absence of an interviewer sitting opposite me, allows me to skimp on answers. Comparing phone interviews to home interviews, de Leeuw and van der Zouwen, note there is some tendency for phone respondents to choose the extreme

A further problem is that telephone surveys will contact a disproportionate number of high income households: a household with three phones (teenager, general use, business) is three times as likely to be called as a household with one phone. And to the extent that low income households share a phone, any given low income household is less likely to be contacted. Survey organizations are aware of these biases and use a variety of techniques to compensate for them. If these compensation techniques fail we will have Sampling Bias.

Testing for Response Error in the NPTS Data: I tested for response error first. The NPTS not only asks respondents about their yearly VMT, it also asks detailed questions about travel on the previous day: times, destinations, and distances for each trip. This "diary" data has the advantage of being fresh in memory. It does require a subjective estimate of distances, still it seems likely that respondents will be better at estimating distances between specific destinations (especially if they are frequent destinations) than they will be at estimating the distance driven in an entire year. So I scaled-up the trip diaries into a yearly VMT estimate for each respondent. I then compared the scaled-up diary VMT to each respondent's answer to the yearly VMT question. For the 1977 NPTS, the average of the scaled-up diary estimates was 21% less than the average of the respondents' answers to the yearly VMT question. For the 1983 NPTS, the scaled-up diary estimates were 43% less than the respondents' yearly VMT guess. And for the 1990 NPTS, the scaled-up diary estimates were 23% less than the respondents' yearly VMT guess.

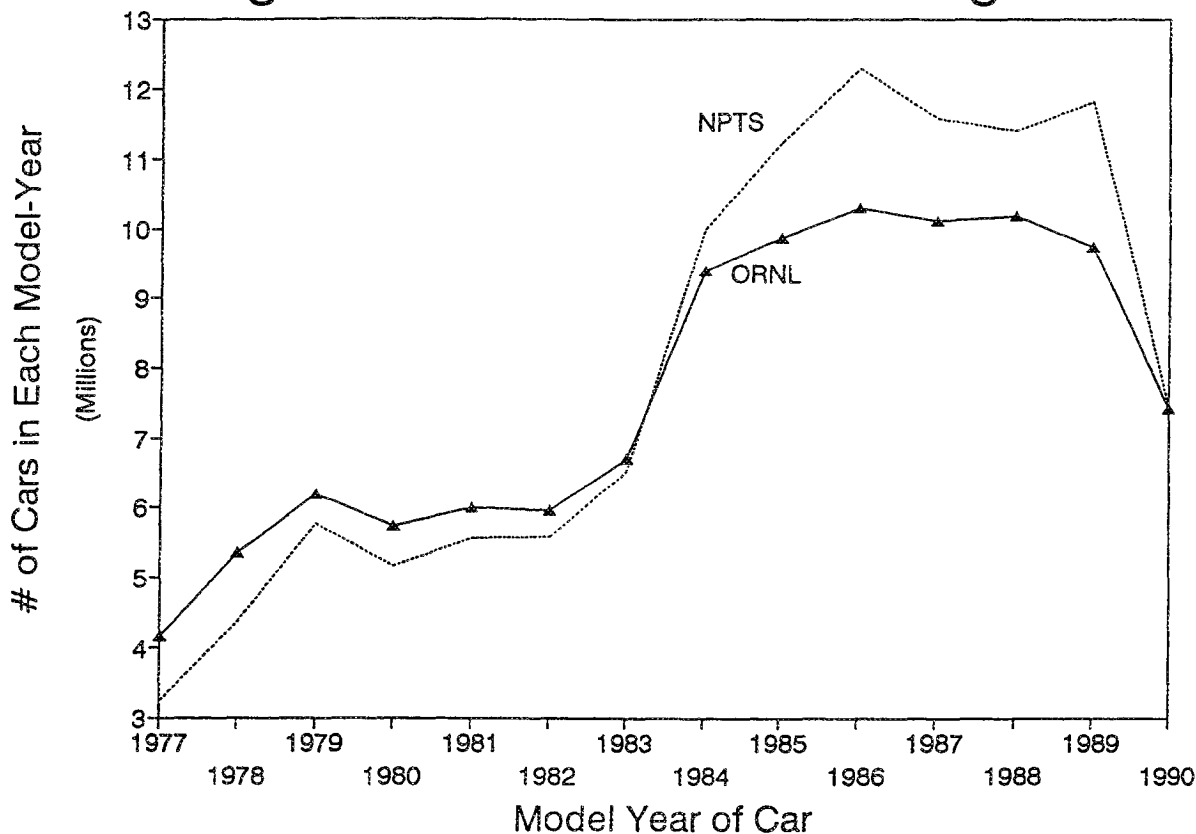
That is, there is not a consistent relationship between respondents' travel diaries and their estimates of yearly VMT. There is not even a consistent trend between the two VMT measures -- convergence or divergence over time. Instead, the evidence suggests that the bias associated with respondents' answers has varied up and down over time. This in turn would imply that we cannot compute accurate growth rates from the change in VMT between NPTS surveys.

Testing for Sampling Bias in the NPTS Data: Was the NPTS sample biased against low-income low-travel households? I cannot test this directly, but there is a powerful indirect test. Does the NPTS sample contain too few old cars? To test this, I classify the cars in the NPTS by their model year, then compare them to the correct population distribution of cars obtained from Oak Ridge National Laboratory (ORNL). ORNL's model-year distributions are based on the actual vehicle registration tapes from the individual states. Figure 1 shows the comparisons. The dark line with the triangles shows the ORNL figures for model-year distributions. The lighter line shows the

response on scale questions, and suggests that the absence of visual contact between respondent and interviewer can lead to two problems: since the interviewer cannot pick up and respond to visual cues indicating the respondent's confusion, the respondent's task becomes more cognitively complex; since there is less chance to develop rapport between interviewer and respondent, the respondent may have less motivation to answer (de Leeuw and van der Zouwen, 1988, pp. 293-294).

distribution of the cars sampled by the NPTS. Clearly, the NPTS sample includes too many young cars and too few old ones.²

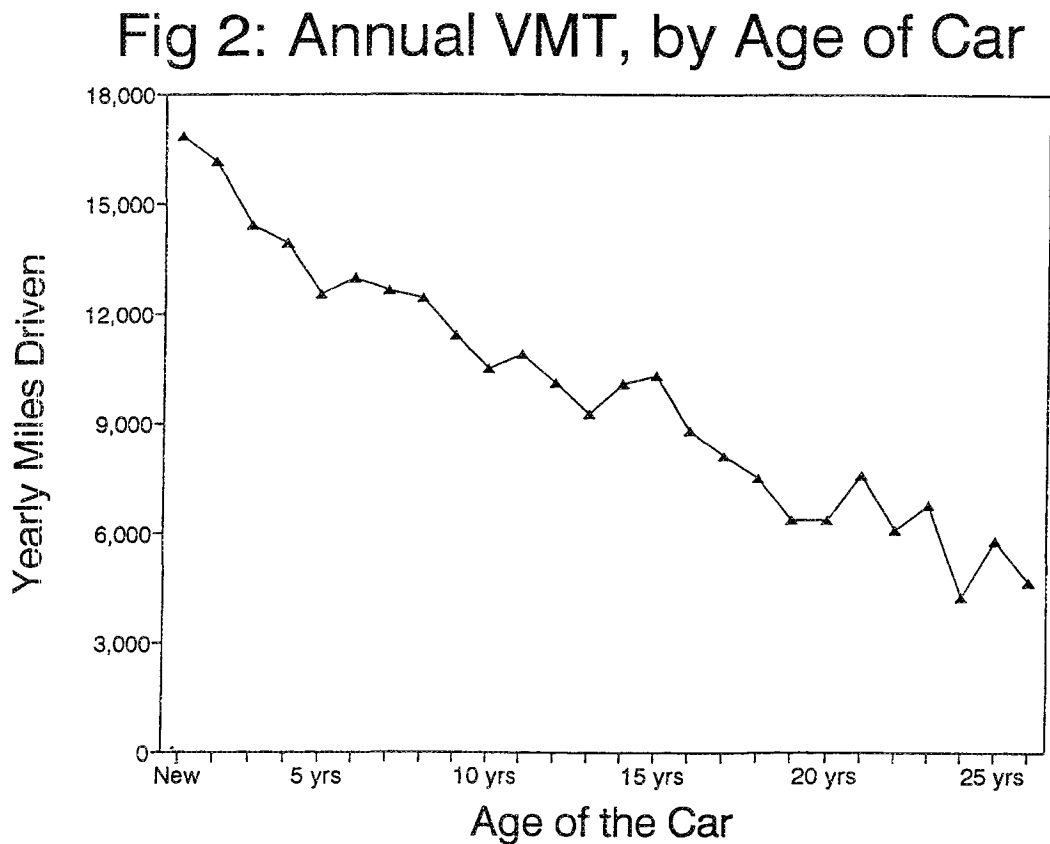
Fig. 1: NPTS vs ORNL Auto Registrations



²Details: The ORNL data cover 123.3 million cars. The NPTS data cover 123.4 million cars -- this is the scaled-up auto population: sampled vehicles multiplied by the NPTS sampling weights. When I remove those vehicles that have no model year data, the NPTS sample drops to 119.9 million. When I also exclude those that have no yearly VMT data, the sample drops to 100.8 million. Figure 1 is based on the 100.8 million subgroup; NPTS cars whose owners gave VMT estimates. This is the subgroup where the NPTS had the necessary data to compute its VMT per car figures. But to cross-check the results, I also ran a version of Figure 1 based on the full 119.9 million subgroup. It had the same shape as Figure 1 -- apparently there was little relationship between vehicle age and the owner's willingness to estimate yearly VMT. Since the ORNL figures are for 123.3 million and the NPTS subgroup is 100.8 million, it would be hard to see the difference in model-year profiles in a simple plot. So I multiplied each of the NPTS points by the ratio 123.3/100.8.

Figure 1 only plots the distributions for automobiles. We know that households also purchase large numbers of light trucks and use them in much the same way they would use cars. Did the NPTS also over-sample young trucks? I cannot compute this for national data because the ORNL data base does not have model-year distributions for light trucks. But I do have official registration data for California's light trucks. So I plotted a version of Figure 1 for registered California light trucks versus the light trucks in the NPTS sample. It shows that new trucks were over-sampled in the NPTS.

Why Does It Matter? What are the consequences of over-sampling new vehicles in the NPTS? Figure 2 shows the relationship between vehicle age and yearly VMT: as vehicles age they are driven significantly less. (Data from other sources shows this same VMT-decay.) Since the average car in the 1990 NPTS is newer than it ought to be, the 1990 NPTS will overestimate VMT per vehicle.



The consequence of overestimating 1990 VMT may have been compounded by problems with the 1983 NPTS. In personal communications, the NPTS staff have said that the 1983 VMT figures may have been erroneously low because of the small sample size and the effects of the economic recession. If true, the combination of underestimate in 1983 plus overestimate in 1990 would substantially overstate the growth rate of travel.

Summary: The 1983 NPTS estimated that the average household-based vehicle (cars and trucks) traveled 10,315 miles per year; the 1990 NPTS estimated 12,458 miles per year --

a growth rate of 2.7% per year. These VMT estimates are based on answers to the subjective question: How much was that vehicle driven last year? There is evidence that the bias in respondents' answers to this question has varied up and down over time, and hence one may not infer VMT growth rates from the change in average VMT between NPTS samples. There is evidence that the VMT estimates in the 1990 NPTS are too high: the change to a random digit dialing phone survey caused an over-sampling of high income households, and this in turn produced an upward bias in the VMT estimates. There is also the possibility that the 1983 NPTS underestimated VMT: if so, the combination of a low estimate in 1983 with a high estimate in 1990 would further overstate the growth of VMT.

3. QUALITY OF THE FEDERAL HIGHWAY ADMINISTRATION DATA

The Federal Highway Administration (FHWA) collects the VMT statistical data produced by the 50 states, compiles them, and publishes them in Highway Statistics. Thus the quality of the FHWA data is strictly a function of the quality of the state data. In 1979, the U.S. Department of Energy commissioned a survey to learn how the states estimated VMT (Greene and Loebel, 1979). The basic conclusion was that most states took accurate data on motor fuel consumption from their fuel tax records and multiplied it by estimates of average miles per gallon. The states have tried to improve the quality of the VMT data. They make more use of traffic counts, though these cover only a portion of the highways, and some states now use elaborate models to estimate VMT.³

Summary: For 1983, the FHWA estimated that the average VMT for cars and light trucks was 9,655 miles per year; for 1990 the estimate was 10,633 miles. This is a growth rate of 1.4% per year, compared to the NPTS' 2.7% per year. The FHWA's estimate is based on state level data. This data is produced by combining objective fuel-consumption data with estimated fuel-efficiency data, modified by traffic counts in selected areas.

4. OTHER DATA SOURCES -- RTECS

The U.S. Department of Energy has been conducting its Residential Transportation Energy Consumption Survey (RTECS) approximately every three years since 1978. It is a household interview survey of about 3,000 households. Its unique feature is that it collects actual odometer readings for each household vehicle, and does so at two different times approximately a year apart. Thus it is an objective source of VMT data.

The RTECS survey begins with a personal interview at each household to gather basic demographic information and the characteristics of the household's vehicles. This is followed by a telephone interview half a year later to ask about changes in the household's vehicle fleet, and then another telephone interview at the end of the year. The respondent is asked to fill out a postcard at the end of the year to record the odometer reading of each household vehicle. With two odometer readings, and their associated dates, each vehicle's VMT is calculated.

³ In two years of discussing these issues at transportation meetings, no one had heard of an instance where states were trying to use objective odometer data.

For 26% of the RTECS vehicles there was only one odometer reading available: for these vehicles the VMT was imputed from a regression based on the respondent's answer to the question: How many miles was it driven last year? On another 19% there were no odometer readings available: for these vehicles, the VMT was estimated from a regression where the independent variables were number of drivers, household income, age of household head, type of vehicle, and use of vehicle on the job. That is, 55% of the RTECS VMT data is fully based on odometer data, 26% is based on a combination of odometer and subjective data, and 19% is based on household and vehicle characteristics.

Summary: The 1983 RTECS survey estimated that the average household-based vehicle traveled 9,399 miles; the 1991 RTECS survey estimated 10,600 miles -- a growth rate of 1.5% per year. For purposes of VMT estimation, the RTECS data ought to have several advantages over the NPTS: the household sample comes from a national multistage probability survey, rather than from random digit dialing; the initial interview is a personal interview in the household; and the great majority of the VMT data are based on odometer readings. Its major disadvantage is its small size, 3,045 households.

5. OTHER DATA SOURCES -- CALIFORNIA SMOG-CHECK DATA

All gasoline powered vehicles in California are subject to a smog-check inspection every two years (or upon transfer to another owner) to assure that their emission control systems are working properly. The inspector notes the emission readings of each vehicle, along with the date, license plate number, and the odometer reading. This data is sent to Sacramento, where it is stored on magnetic tape. Thus, by matching cars across two inspections, one would have two odometer readings and two dates, and it would be straightforward to compute an objective VMT measure.

We obtained complete data for four years: 1985, 6.3 million vehicles; 1987, 7.6 million vehicles; 1989, 8.3 million vehicles; and 1991, 10.9 million vehicles. The increase in number of records is the result of better data processing in Sacramento, and somewhat better coverage by the smog-check program; 1985 was the earliest available data. Though simple in principle, the actual matching process involved considerable effort. To assure accuracy, we used only those matches where the license plate, model year, and make of the car were identical across the time period. Instances of broken odometers (0 VMT) were discarded. Some inspectors were sloppy in recording odometer numbers and shifted readings to the right or left in the columns. We detected or eliminated these by using screening criteria recommended by the California Bureau of Automotive Repairs, the agency that collects this data: an upper bound of 60,000 miles per year during a vehicle's first two years of operation, 50,000 miles per year during the next two years, and 40,000 miles per year thereafter. Identical screening procedures were applied to all years, thus any bias created by our screening is constant over time and will not affect estimates of growth rates.

The end result of the computations is yearly VMT for each model-year, where the VMT is the average over all California cars of that particular model-year. The data has the familiar shape: new cars drive about 14,000 miles per year, old cars drive about 5,000-7,000 miles per year. To compare to the NPTS, I want to know the VMT of an average California car in a given NPTS-survey-year. To compute this I multiply each of the

model-year-VMT figures by the proportion of California vehicles in that model-year category. To minimize the effects of any sampling bias in the smog check data, the model-year distribution data is taken from the Department of Motor Vehicles registration data for the entire California fleet, rather than from the model-year distributions in the smog check data. (All of the California calculations are done separately for cars and trucks, then combined as appropriate.)

Although the law requires that all gasoline powered vehicles be smog-checked, owners of large fleets are allowed to apply for certification to do their own testing. Most large fleets, e.g., Hertz, Avis, Yellow Cab, do this, and so data from their testing will not appear in the California smog check tapes. In addition, since almost all large trucks are diesel powered, we have no data on their VMT either.

Both the NPTS and RTECS are household based samples, and so their VMT estimates apply to household behavior. Thus the exclusion of fleet vehicles and large trucks from our California odometer data is a bonus, it makes the California sample correspond more closely to the NPTS and RTECS sample. To the extent that the California data contain commercial gasoline powered trucks, the estimated VMT will be biased upwards.⁴

Summary: For the 1985-1987 period, the average California vehicle (cars and trucks) traveled 9,925 miles per year; for the 1989-1991 period, the average California vehicle traveled 10,585 miles -- a growth rate of 1.6% per year. For purposes of VMT estimation, the California data ought to have several advantages over the NPTS: it is objective odometer data and is a nearly complete enumeration, not a small sample. Furthermore, California has 12% of the nation's vehicles and to the extent that California is atypical, most observers believe that its VMT growing atypically fast.

6. CONCLUSIONS

Table 1 summarizes the VMT estimates from the four data sets. On the left-hand side of the table are the VMT per year estimates and the year to which they apply. On the right-hand side of the table are the growth rates for the longest period applicable to each data set. Where intermediate points were available for a data set, they are shown and the intermediate growth rates are also calculated.

The FHWA data, the RTECS data, and the California data are in close agreement on VMT per year: 10,633 miles/year, 10,600 miles/year, and 10,585 miles/year, respectively. These VMT estimates are well below the NPTS estimate of 12,458 miles/year. The FHWA, RTECS, and California data are also in close agreement on overall VMT growth rates: 1.4%, 1.5%, and 1.6%, respectively. These growth rate estimate are about half the NPTS estimate.

But truth is not just a question of a three to one vote. On VMT questions, the RTECS and California data sets are inherently more credible because they collect objective

⁴On a national basis, 90% of all trucks are light trucks, and the 1988 federal Truck Inventory and Use Survey shows that 67% of light trucks are used for personal travel.

Table 1: Summary of the VMT and Growth Estimates

	Vehicle-Miles Per Year, For An Average Vehicle									Annual Growth Rate	What Period
	1983	1984	1985	1986	1987	1988	1989	1990	1991		
NPTS Data (U.S.)											
VMT per Year	10,315							12,458			
Annual Growth Rate 2.7% per year									2.7%	<-'83 -'90
FHWA Data (U.S.)											
VMT per Year	9,655			9,995				10,633			
Annual Growth Rate 1.2% / year 1.6% / year									1.4%	<-'83 -'90
RTECS Data (U.S.)											
VMT per Year	9,399		9,855			10,246		10,600			
Annual Growth Rate	.. 2.4% / year 1.3% / year 1.1% / year									1.5%	<-'83 -'91
CALIFORNIA Data											
VMT per Year				9,925		10,238		10,585			
Annual Growth Rate	.. 1.6% / year 1.6% / year ..									1.6%	<-'86 -'90

odometer data. The NPTS is based on subjective VMT estimates, and internal evidence seems to indicate that the bias in these data has varied up and down between the 1976, 1983, and 1990 surveys. Furthermore, there was a critical change in NPTS sampling methods between 1983 and 1990. The 1990 NPTS survey used random digit dialing, instead of a home interview, and the end result was a significant over-sampling of late-model, high-VMT vehicles. (The resultant biases only influence the aggregate VMT estimates, not the disaggregate comparisons of VMT, travel patterns, travel destinations, or travel characteristics between well specified subgroups.)

Thus there are a number of strong reasons to reject the VMT jump in the 1990 NPTS. The best estimate of VMT growth for households in the 1983-1990 period is 1.4%-1.6% per year.

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