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An agency staff review of existing Federal regulations performed in compliance with Executive Order 12291 and the agency's regulatory review plan (Regulatory Reform - The Review Process, DOT HS-806-159, March 1982).

16. Abstract One of the principal actions taken by the United States in response to the worldwide energy crisis of the 1970's was to Federally mandate minimum fuel economy standards for new motor vehicles. These standards began with the 1978 Model Year and continue in force today. This study is an assessment of the reduced energy (fuel) consumption for Model Year 1978-1981 vehicles, based on a national, on-road survey. In addition to the Federal standards, rapid rises in fuel costs in that period provided a second incentive for the production of more fuel efficient vehicles. The study found that:

- From 1977 to 1981, on-road fuel economy of cars increased by 41 percent; for light trucks, from 1978 to 1981, the increase was 17-26 percent.
- Fuel efficiency improvements in the 1978-1981 vehicles will reduce fuel consumption by 45.6 billion gallons--a dollar equivalent reduction of $53.8 billion.
- On-road fuel economy is consistently below laboratory (EPA) ratings, ranging from 15-20 percent depending on vehicle type.
- Average annual travel per vehicle is about 6,000 miles; both per vehicle and total fleet travel, based on odometer data, are markedly less than estimated by prior surveys.

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EXECUTIVE SUMMARY

Over a decade has passed since the 1973 Arab oil embargo which presaged a worldwide energy crisis. This initial shock was followed by several years of tight fuel supplies and steadily rising energy prices which had major impact on the U.S. economy as well as the economies of most other world countries.

One of the actions taken in response to this energy problem in the United States was the enactment of the Energy Policy and Conservation Act (EPCA) in 1975 by the Congress. Among other steps taken by this Act, one was aimed at energy conservation in the transportation sector through the establishment of Federal Corporate Average Fuel Economy Standards for new passenger cars and light trucks. Responsibility for administering this motor vehicle fuel economy program was assigned to the Secretary of Transportation who, in turn, delegated it to the Administrator of the National Highway Traffic Safety Administration (NHTSA). Thus motor vehicle fuel economy joined motor vehicle safety and other Federal regulatory programs administered by NHTSA.

Fuel Economy Standards for passenger cars for the first three years (1978-1980) and for 1985 and thereafter were originally set by the Congress in the 1975 Energy Policy and Conservation Act. More recently, NHTSA, by virtue of the statutory authority provided in the 1975 Act, amended the passenger car standard for Model Year 1986. Also a notice of proposed rulemaking (NPRM) has been issued concerning revision of the passenger car standards for Model Years 1987 and 1988. Standards for light trucks have been established for Model Year 1979 through Model Year 1988. All light truck standards have been set by NHTSA. Chapter 1, (Table 1-1) of this report lists the individual fuel economy levels, in terms of miles per gallon, as currently set by the standards.

This study is an assessment of the actual fuel economy levels, and reduction in energy consumption of the new, more fuel-efficient vehicles produced from Model Year 1978 through 1981. It should be noted that, in addition to the fuel economy standards (which took effect for passenger cars in Model Year 1978 and for light trucks in Model Year 1979), consumer demand and other market forces provided incentives for greater fuel economy during that time period. This study does not attempt to determine what portion of the improved fuel economy is attributable to the Federal standards.

A second major portion of this study develops estimates of annual vehicle miles traveled (VMT) by age and type of vehicle (passenger car and light truck) using vehicle odometer readings. It is believed that this is the first time that estimates of VMT have been developed using actual odometer readings from a large-scale national sample of the U.S. vehicle fleet.

The study was conducted to comply both with Executive Order 12291 concerning the review of Federal regulations, and with NHTSA's regulatory review plan published in March 1982 (Regulatory Reform - The Review Process).

As with most of NHTSA's evaluation studies, data reflecting "real-world" or "on-road" experience are used. The data come from a specially conducted survey, using probability sampling methods, of the Nation's fleet of privately owned and operated passenger cars and light trucks. Vehicle owner/drivers provided fuel-mileage logs or diaries for approximately 9,000 vehicles. Each log contained data on fuel purchases and odometer readings for approximately a one-month period. The sample was fielded in twelve monthly replicates throughout an entire one year period in order to account for seasonal effects on fuel economy and on vehicle travel.

This study is not an evaluation or assessment of official compliance with the Federal fuel economy standards. The process by which official compliance is determined was established via statute as part of the Energy Policy and Conservation Act of 1975 which authorized the standards. For each manufacturer, the Environmental Protection Agency (EPA) computes an overall average fuel economy for each model year. This overall average fuel economy (or miles per gallon) is based on laboratory measurements generated by the EPA during its testing of vehicles for emissions levels and for determining compliance with Federal emissions standards. Fuel economy measurements are made for each basic vehicle type for each manufacturer and a harmonically weighted average figure is calculated based on the number of vehicles of each basic type sold by each manufacturer within each model year. This overall fuel economy is thus a sales-weighted average and is commonly referred to as the corporate average fuel economy, or "CAFE." It is this CAFE which determines official compliance with the Federal fuel economy standards.

While the laboratory results generated by the EPA provide a standardized controllable, repeatable, convenient, and economical (i.e., the production of fuel economy data as a byproduct of emissions testing was already in place prior to enactment of the ECPA in 1975) method of assessing manufacturer progress vis-a-vis the Federal standards, it has nonetheless been well established by several prior studies[1] that laboratory tests do not necessarily reflect fuel economy under typical, everyday driving conditions; laboratory results are typically higher than actual on-road fuel economy.[2] Also as has been noted previously, it has been the policy of NHTSA to utilize data reflecting actual "on-road" experience, wherever feasible in its studies of the effects of its programs and motor vehicle regulations.

The general objectives of this study are to:

(1) Estimate the on-road fuel economy improvements for passenger cars and light trucks produced from the beginning of fuel economy standards through Model Year 1981.

(2) Compare the on-road fuel economy with the respective laboratory-based, or corporate average fuel economy (CAFE) levels as computed by the Environmental Protection Agency and as specified in the Energy Policy and Conservation Act of 1975.

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1 These studies have been done both by other Federal agencies and by companies within the motor vehicle industry. The results of these studies are discussed later in this report.

2 Largely as a consequence of this situation, the EPA has recently begun discounting its laboratory data on fuel economy which are displayed on "window stickers" of new motor vehicles and which are published in the EPA annual consumer booklet, "Gas Mileage Guide."

(3) Compare the on-road fuel economy with the levels set by the respective Federal Fuel Economy Standards.

(4) Estimate the reduction in energy (fuel) consumption, and dollar equivalent value, for vehicles produced from Model Year 1978 through Model Year 1981.

(5) Estimate annual vehicle miles traveled by the U.S. fleets of passenger cars and light trucks, by age of the vehicle and overall average per vehicle.

FINDINGS AND CONCLUSIONS

Following are the principal findings and conclusions reached in this study:

(1) On-Road Fuel Economy of Passenger Cars

a. From Model Year 1978 through 1981, the on-road fuel economy of the U.S. fleet of passenger cars increased by 41 percent, rising from 15.2 mpg in Model Year 1977 to 21.4 mpg in Model Year 1981.

b. The greater portion of this gain in fuel economy is attributed to the domestic fleet (39 percent gain) compared to the import fleet (13 percent gain). This is to be expected considering the large differences in the original size and fuel economy of the two fleets prior to promulgation of the standards, and prior to the significant increase in fuel prices following the "second oil shock" of 1979.

c. Among domestic manufacturers, overall fuel economy gains for the four model year period ranged from a low of 25 percent for American Motors to a high of 70 percent for Chrysler, which had a large jump of nearly 6 mpg from Model Year 1980 to Model Year 1981.

d. Gains among foreign manufacturers were modest except for Volkswagen's 30 percent increase, from the 1977 to 1981 models, attributable to a large penetration of diesel vehicles.

(2) On-Road Fuel Economy of Light Trucks

a. From Model Year 1979 through 1981, on-road fuel economy increased by 26 percent (13.4 mpg to 16.9 mpg) for 2-wheel drive vehicles; for 4-wheel drive trucks, the increase was 17 percent (12.3 mpg to 14.4 mpg).

b. As was true for passenger cars, fuel economy gains were greater for domestic vehicles. The relative gains from 1978 to 1981 model fleets were:

2-wheel drive	Change in MPG
domestic trucks:	+21% mpg
import trucks:	+9% mpg
4-wheel drive	
domestic trucks:	+9% mpg
import trucks:	+4% mpg[3]

(3) On-Road Fuel Economy Compared to Laboratory-based (EPA) CAFE[4]

a. For the model years surveyed, on-road fuel economy is consistently below laboratory-based CAFE levels. For passenger cars the difference is 15 percent; for 2-wheel drive trucks, 16 percent; for 4-wheel drive trucks, almost 20 percent.

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[3] 1980 to 1981 increase

[4] It should be noted that the EPA recently issued a final rule (50 FR 27172, July 1, 1985) adjusting its fuel economy measurements for Model Year 1980 and later, to account for test procedure changes. While this information was not available at the time this study was written, the effect of this EPA adjustment is to increase somewhat the differences between EPA CAFE values and on-road fuel economy, as estimated in this study, for Model Years 1980 and 1981.

b. Except for 4-wheel drive trucks, domestic vehicles exhibited a somewhat greater difference than import vehicles.

c. The CAFE to on-road difference among domestic manufacturers was approximately the same with AMC and Chrysler showing slightly less difference than GM and Ford.

d. Among import vehicles, the greatest CAFE to on-road difference was noted for the captive imports of Ford and Chrysler. Only one manufacturer, Volkswagen, had an on-road mpg consistently at or above its CAFE.

e. This finding that on-road fuel economy is consistently below laboratory-based CAFE is not new. It has been shown in several prior studies although the data bases used and the magnitudes of the CAFE to on-road differences found have differed somewhat from those in this study. This study is believed to be the first which develops on-road fuel economy estimates from a nationwide, large-scale probability sample of the total national population of privately-owned vehicles.

(4) On-Road Fuel Economy Compared to Federal Fuel Economy Standards

a. For the three categories of vehicles, passenger cars, two-wheel drive trucks, and four-wheel drive trucks, the on-road fuel economy ranges from 8 to 9 percent below the Federal standard levels for Model Years 1978-1979; for 1980-1981, on-road mpg is much closer to the standard levels and in some instances, slightly above.

b. Domestic vehicle on-road mpg is approximately 10 percent below the Federal standards; import vehicle on-road mpg ranges from 20 to 45 percent above the Federal standards. As stated earlier, this is primarily due to the smaller average size of import vehicles compared to the average size of domestic vehicles. Relative fuel economy gains were greater for domestics than for imports.

(It should be noted, as previously stated, that compliance with the Federal standards is determined through laboratory testing by the Environmental Protection Agency. All vehicles, both import and domestic, complied with the Federal Standards during the study period).

(5) Estimated Reduction in Energy Consumption and Dollar Equivalent Value

a. Estimated, vehicle lifetime, reduction in energy consumption and dollar equivalent value (in 1984 dollars) for all vehicles (cars and trucks) manufactured under the Federal standards through Model Year 1981 are:

	Reduced Fuel Consumption	Dollar Value
Total (All vehicles)	45.6 billion gallons (1.1 billion barrels)	$53.8 billion
Per Vehicle	974 gallons	$1,146

The baseline periods for these estimates are Model Year 1977, for passenger cars, and Model Year 1978, for light trucks.

Costs of implementing the Federal fuel economy standards were not estimated for reasons described in the report.

6. Vehicle Miles Traveled

An analysis of odometer readings for the approximately 9,000 vehicles covered in the survey gave the following estimates concerning vehicle miles of travel by the Nation's population of privately owned vehicles:

a. Average annual miles of travel for passenger cars and light trucks is essentially the same--approximately 6,000 miles per year for the average vehicle.

b. Average annual miles of travel show little differences of a practical nature between classes of vehicle (e.g., small versus large car; 2-wheel drive versus 4-wheel drive truck, etc.).

c. Average annual miles of travel per vehicle shows a sharp decline with vehicle age. First year travel is estimated at 14,000 miles, but by the fifth year of age, travel drops to less than half, or about 6,500 miles.

d. Total miles traveled was found to be considerably higher for diesel vehicles than for conventionally powered gasoline vehicles. This difference was more pronounced for passenger cars than for light trucks. Also, in contrast to the finding for the overall fleet, vehicle size appeared to be an important factor here as well, with small diesel powered vehicles showing a greater increase in miles driven over their gasoline powered counterparts, than large diesel powered vehicles.

e. Average annual travel estimates from the On-Road Survey are similar to estimates of other prior surveys for the <u>initial</u> few years of vehicle life. For later years, however, the On-Road results show a much greater rate of decline in average annual travel than prior surveys.

f. Results from the On-Road Survey indicate that average annual travel per passenger car or light truck, and total travel for all vehicles may be substantially lower than heretofore estimated. Although fleet and business use vehicles were not included in the survey, travel by this class of vehicles does not appear to be of sufficient magnitude to account for the lower VMT (vehicle miles traveled) findings in this study.

This is believed to be the first study to develop VMT estimates from odometer readings of a large national probability sample of the Nation's population of privately owned passenger cars and light trucks.

CHAPTER I

INTRODUCTION

This is one of the continuing series of studies that have been conducted by the National Highway Traffic Safety Administration (NHTSA) to review and evaluate the effects of existing Federal regulations and programs for which the Agency is responsible. Following the issuance of Executive Order 12291 on February 17, 1981, the NHTSA developed and published a regulatory review plan[1] which contained a description of those regulations selected for review together with a schedule for the conduct of the individual reviews. The Automotive Fuel Economy Program was listed in that review plan under the category of "moderate to high" priority.

The purpose of the Automotive Fuel Economy Regulations was to conserve petroleum energy through the production of more fuel efficient motor vehicles. These regulations were authorized under the Energy Policy and Conservation Act of 1975[2] which grew out of the Arab oil embargo of late 1973. The fuel economy regulations, along with other parts of the Energy Policy and Conservation Act, were part of a concerted National effort to reduce energy consumption in the face of suddenly scarce petroleum supplies and skyrocketing prices which grew out of the Arab oil embargo.

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1 "Regulatory Reform - The Review Process," U.S. Department of Transportation, National Highway Traffic Safety Administration, March 1982 (DOT HS-806-159).

2 Public Law 94-163, Title III, "Improving Energy Efficiency." This section of the legislation amended the existing Motor Vehicle Information and Cost Savings Act through the addition of Title V, "Improving Automobile Efficiency. It is this latter portion of legislation which authorized the development and implementation of a multi-year program (i.e., the promulgation of Federal fuel economy standards) to improve the fuel economy of passenger cars and light trucks sold in the United States.

The Energy Policy and Conservation Act assigned the responsibility for administering the fuel economy program to the Secretary of Transportation, who, in turn, delegated this responsibility to the Administrator of the National Highway Traffic Safety Administration on June 22, 1976 (41 F.R. 25015).

NHTSA's responsibilities, under the Act, include:

(1) establishing average fuel economy standards for manufacturers of passenger automobiles and light trucks,

(2) promulgating regulations concerning procedures, definitions, and reports necessary to support the fuel economy standards,

(3) considering petitions for exemption from established fuel economy standards by low-volume manufacturers (e.g., those whose total production is less than 10,000 vehicles annually), and establishing alternative standards for these manufacturers,

(4) reporting annually to Congress on the progress of the fuel economy program,

(5) enforcing the fuel economy standards and regulations, and

(6) responding to petitions concerning domestic production by foreign manufacturers and other matters.

The fuel economy standards that have been established through 1986 appear in Table 1-1.

TABLE 1-1

Fuel Economy Standards for Passenger Cars and Light Trucks for the 1978 through 1987 Model Years (in MPG)

Model Year	Passenger Cars - MPG	Light Trucks[a] MPG		
		Two-Wheel Drive	Four-Wheel Drive	Composite[b]
1978	18.0[c]		-Not Established-	
1979[d]	19.0[c]	17.2	15.8	17.2
1980[e]	20.0[c]	16.0	14.0	----
1981[e]	22.0	16.7	15.0	----
1982	24.0	18.0	16.0	17.5
1983	26.0	19.5	17.5	19.0
1984	27.0	20.3	18.5	20.0
1985	27.5[c]	19.7	18.9	19.5
1986	26.0[f]	20.5	19.5	20.0
1987	27.5[c, g]	21.0	19.5	20.5

a - Standards for 1979 model year light trucks were established for vehicles with a gross vehicle weight rating (GVWR) of 6000 lbs. or less. Standards for MY's 1980 through 1985 are for light trucks with a GVWR of up to 8,500 lbs.

b - For model years 1982-1986 manufacturers may comply with the two-wheel and four-wheel drive standards or may combine their two-wheel and four-wheel drive light trucks and comply with the combined standard.

c - Established by Congress in the Energy Policy and Conservation Act of 1975.

d - For MY 1979, light truck manufacturers may comply separately with standards for four-wheel drive, general utility vehicles and all other light trucks, or combine their trucks into a single fleet and comply with the 17.2 mpg standard.

e - Light trucks manufactured by a manufacturer whose fleet is powered exclusively by basic engines which are not also used in passenger automobiles, must meet standards of 14 mpg and 14.5 mpg in model years 1980 and 1981, respectively.

f - The Energy Policy and Conservation Act of 1975 originally established a standard of 27.5 mpg for 1985 and subsequent years, but also provided the Department of Transportation with authority to amend that standard. In October 1985, NHTSA issued a final rule which changed the 1986 standard to 26.0 mpg.

g - For Model Year 1987 and subsequent years. (Rulemaking action is presently pending which would revise the standards for Model Years 1987 and 1988).

Sources: "Automotive Fuel Economy Program, Seventh Annual Report to Congress," U.S. Department of Transportation, National Highway Traffic Safety Administration, January 1983.

"49 FR 41250," October 22, 1984

It should be noted that the standards began in 1978 for passenger cars and in 1979 for light trucks; also to be noted is that certain standard levels for passenger cars were "pre-established" by the Congress as part of the authorizing legislation of 1975, whereas all remaining standard levels for passenger cars and all standards for light trucks were the responsibility of the Department of Transportation (DOT). Within certain guidelines, the Act also provided the DOT with the authority to revise pre-set standard levels for future model years, should such revision be deemed appropriate.

This study addresses the actual, on-road reduction energy, or fuel, consumption for the U.S. fleet of passenger cars and light trucks produced from the beginning years (1978 for passenger cars; 1979 for light trucks) of the fuel economy standards through 1981. The study deviates, somewhat, from the typical NHTSA evaluation study, or review, of a major regulation or safety program where the primary focus is to estimate the effectiveness, or benefits, attributable to that program and to compare these benefits to the costs of implementing the program. There are two reasons why the conventional approach to program evaluation was not employed in this study.

First, although original plans called for estimation of costs of implementing the Federal fuel economy regulations, subsequent budgetary and program changes precluded the execution of this part of the evaluation effort. In addition, it was recognized that the pervasive scope and complex nature of the changes made within the motor vehicle industry in the drive for greater fuel efficiency would make the estimation of the costs of implementing the regulations difficult indeed. In addition to specific technological developments such as diesel engines and improved transmissions, essentially all major domestic carlines were redesigned and "downsized"; the use of front-wheel drive became widespread. It would have been extremely difficult to attribute, objectively, the cost of such comprehensive changes to the goal of increased fuel economy, vis-a-vis other goals such as styling changes, improvements in vehicle quality and reliability, etc. It is not difficult, therefore, to see that the isolation of the costs of implementing the fuel economy regulations would be a task of emminently greater complexity than the estimation of costs for motor vehicle safety standards such as side door beams, energy absorbing steering assemblies, or fuel system integrity improvements, whose costs have been estimated as parts of prior NHTSA evaluation studies.

A second reason complicating the traditional benefits versus costs[3] approach to this study was that it would be difficult to attribute the reduced fuel consumption of the vehicles produced subsequent to the effective dates of the fuel economy standards to the standards themselves. In addition to the Federal requirements to manufacture vehicles with better fuel economy, there was also a second incentive in the form of increased market or consumer demand for such vehicles, since gasoline prices had increased dramatically during the 1970's and early 1980's.

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[3] While the cost effectiveness of the CAFE standards per se have not been evaluated, NHTSA, as part of its Regulatory Impact Analysis of each CAFE standard promulgated, has analyzed the cost effectiveness of the fuel efficiency improvements available at that time to the manufacturers. The cost effectiveness of fuel efficiency improvements is defined as the estimated retail price increase to consumers, of the vehicle changes, versus the present discounted value of fuel saved over the vehicle's lifetime. These analyses showed that cost-effective fuel efficiency improvements were available.

These analyses were "before the fact" (i.e., conducted prior to the actual production and sale of the vehicle) whereas the analysis in this study is after the fact, covering vehicles that are on the road and that have generated real-world experience.

As is true for most NHTSA evaluation studies, emphasis is placed on assessing the effects of agency regulations, in this case, fuel economy regulations, through the collection and analysis of real-world data. The data for this study was gathered through a nationwide, on-the-road survey of the fuel economy experienced by the U.S. fleet of Model Year 1977 through 1981 passenger cars and light trucks. The target population was also defined as those vehicles manufactured by the four major domestic companies and the four major foreign companies (Datsun/Nissan, Honda, Toyota, and Volkswagen) and was restricted to vehicles owned by private individuals (i.e., fleet vehicles excluded). The survey was based on a national probability sample with the sampling frame being the national vehicle registration files maintained by the R. L. Polk Company. The sample was stratified by model year of vehicle, vehicle type (passenger car, light truck) vehicle size class (subcompact, compact, midsize, etc.), fuel type (gasoline, diesel), and, for light trucks only, the number of drive wheels (two-wheel drive, four-wheel drive). The final sample included 100 strata. Allocation of the sample among strata for each model year and vehicle type was made on a proportional basis with oversampling employed in a few instances for rare strata in order to obtain reasonable subsample sizes in the final sample. Allocation of the sample, within each stratum was also made on a proportional basis among all of the individual vehicle make model combinations comprising each stratum. Over 800 different vehicle make models (i.e., 1981 Oldsmobile Cutlass diesel, 1981 Ford Escort, etc.) appear in the final respondent sample (see Appendix A). The total sample was subdivided into twelve equal replicates with one replicate being fielded for each month of the data collection period, Calendar Year 1983. This distribution over a 12-month period provided control over the seasonal effect on fuel economy and vehicle miles traveled. Each vehicle stratum was distributed equally within each of the 12 replicates.

The methodology for carrying out the survey consisted of mailing a request to owners of sampled vehicles to maintain a record or diary[4], of their fuel purchases and respective odometer readings over a specified, 1-month period. To enhance survey response, the record-keeping request was preceded by an advance notification letter, and accompanied by a small incentive in the form of a log-booklet for the respondents' personal use plus "reminder decals." Two follow-up "reminder" postcards were also sent, one shortly after the mailing of the log-questionnaire and the second at the end of the survey month to remind the respondent to return the completed survey log. A second wave of mailings, including the questionnaire letter and reminder postcards, were sent to all sampled owners who failed to respond to the initial survey wave. Finally, telephone followup samples were taken to investigate the potential effect of nonresponse and to assess the potential for the telephone to enhance basic survey response. A more detailed discussion of the survey methodology is given in Chapter 4.

The data collection and data automation phases of the On-Road Fuel Economy Survey (ORFES) were conducted for NHTSA by a survey contractor.[5] The contractor also provided certain computations and tabulations from the data as well as completing a report on potential effects of survey nonresponse.

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4 See Chapter 4 for a specimen of the survey instrument and Appendix C for other survey materials.

5 "On-the-Road Fuel Economy Survey - Final Data Collection Report", submitted to NHTSA, Office of Program Evaluation, by National Opinion Research Center, October 1984.

The initial total sample of vehicles selected from the "Polk" sampling frame was 46,000. Out of this, a total of 8,914 vehicles were represented on the final survey analysis data file for a conservatively estimated response rate of 21 percent. However, when the results of the two telephone samples are considered together with the definition of eligible respondents as agreed upon by the Council of American Survey Research Organizations[6], the effective response rate is in the vicinity of 35-40 percent. Survey response as well as explanations of the data automation procedures, quality control, etc., are also presented in Chapter 4.

Although the original primary objective of the ORFES was to estimate on-road fuel economy, it was recognized that the survey would provide a large sample of actual vehicle odometer readings from which estimates of vehicle miles traveled could be developed. Data on vehicle miles traveled are also of considerable interest to NHTSA, as well as several other agencies. Thus a second important area covered in this report is the estimation of annual vehicle miles of travel by age of vehicle, by passenger car and light truck, and by vehicle size class. These estimates are compared with vehicle miles traveled estimates from prior known surveys and studies.

This report is presented in the four chapters which follow. Chapter 2 contains the results on fuel economy as measured in the on-road survey. In this chapter, comparisons are also made between the on-road fuel economy and

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6 See Chapter 4, Section 4.4.

respective EPA CAFE[7] numbers and between on-road fuel economy and the Federal standards. Also in Chapter 2, the effect of seasonality and certain vehicle technologies on in-use fuel economy are analyzed. Thirdly, this chapter contains a comparison of the ORFES on-road results with several prior studies of on-road fuel economy. Chapter 2 concludes with an analysis of the reduction in energy (fuel) consumption, and dollar equivalent value for the vehicle fleet produced subsequent to enactment of the Federal standards up through Model Year 1981. Chapter 3 contains the results of the vehicle miles traveled estimates as developed from the survey data on odometers and compares the ORFES estimates with those of prior studies and surveys of vehicle miles traveled. Chapter 4 describes the survey design data collection, data automation, survey response and nonresponse analysis. Chapter 5 summarizes the primary findings and results from an analysis of the survey data as it relates to fuel economy and vehicle miles traveled.

7 CAFE or Corporate Average Fuel Economy as defined in the Energy Policy and Conservation Act of 1975, is that number which is used to determine each manufacturer's compliance, for a given model year, with the Federal fuel economy standard for that year. The CAFE is a number which is the sales-weighted harmonic mean of the fuel economy (mpg) of all individual basic vehicle types produced by a manufacturer in a given model year and is computed by the Environmental Protection Agency based on its laboratory tests of new vehicles for purposes of determining compliance with Federal emissions standards.

CHAPTER 2

ANALYSIS OF SURVEY RESULTS OF FUEL ECONOMY AND ESTIMATION OF REDUCED ENERGY CONSUMPTION AND EQUIVALENT DOLLAR VALUE

2.0 INTRODUCTION

This chapter contains the analysis and summary of the fuel economy results as reported by vehicle owners/drivers in the nationwide On-The-Road Survey. Chapters 1 and 4 contain descriptions of the survey design and methodology, survey instrument and materials, data collection, data automation and quality control, survey response, and nonresponse/noncoverage effects.

All fuel economy estimates presented in this chapter, except where otherwise noted, are harmonically weighted means[1] using, as the weights, actual nationwide counts of vehicles on the road as compiled from national vehicle registration files.[2] These estimates are analogous to the harmonically weighted means using sales data, as specified in the Energy Policy and Conservation Act of 1975, which established the Federal Fuel Economy Standards Program for passenger cars and light trucks.

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1 See Chapter 1, footnote 7.

2 Vehicle counts are taken from the files compiled by the R. L. Polk Company as of July 1, 1982, the latest data available when the analyses of data were initiated.

The on-road fuel economy results are presented by type of vehicle (passenger car, light truck); vehicle origin of manufacture (domestic, import); vehicle manufacturer[3]; and vehicle size class (essentially corresponding to EPA size class). Data are also presented to compare fuel economy between gasoline and diesel powered vehicles.

Secondly, comparisons are made between on-road fuel economy and laboratory based (EPA) corporate average fuel economy (CAFE) levels, and between on-road fuel economy and the applicable Federal standard levels.

Third, and lastly, estimates of the total reduction in energy (fuel) consumption are made for the vehicles represented in the survey, both on an overall vehicle lifetime basis, and on a per vehicle (lifetime) basis. Estimated dollar equivalent values of the reduced consumption are also developed.

2.1 PASSENGER CARS: ON-ROAD FUEL ECONOMY

Table 2-1 displays the on-road fuel economy for passenger cars for the 5 model years covered by the survey. Data are shown for both the Domestic Fleet, the Import Fleet and the overall or combined U.S. Fleet. Also presented are the respective EPA CAFE's and the Federal Fuel Economy Standards for the 4 years, 1978 through 1981. Figure 2-1 displays the trend in on-road, EPA CAFE, and standard values by model year.

[3] The survey included all four major domestic manufacturers (including their captive imports, as appropriate), plus the four major foreign manufacturers (Datsun/Nissan, Honda, Toyota and Volkswagen).

TABLE 2-1

PASSENGER CAR ON ROAD FUEL ECONOMY
AND COMPARISON TO EPA CAFE
- DOMESTIC AND IMPORT FLEETS -

FLEET	Miles per Gallon for Model Year: 1977	1978	1979	1980	1981
Domestic					
On-Road	14.5	15.7	16.5	18.6	20.2
EPA CAFE	N/A	18.7	19.3	21.8	23.6
Import					
EPA On-Road	23.7	24.6	25.0	26.7	26.7
CAFE[4]	N/A	28.7	27.2	29.7	31.4
Overall On-Road	15.2	16.6	17.3	20.0	21.4
Overall EPA CAFE[5]	18.6	19.9	20.3	23.4	25.2
Fuel Economy Standard	N/A	18.0	19.0	20.0	22.0

NOTE 1: Sample sizes (i.e., number of vehicles reporting in the national survey) ranged from 109 to 1,527 for each of the ten subgroups in the above table.

NOTE 2: The above EPA CAFE values were correct at the time this study was written. However, it should be noted that the EPA recently issued a final rule (50 FR 27171, July 1, 1985) which adjusted (upward) its fuel economy measurements for Model Year 1980 and later, to account for changes in test procedures. The effect of this EPA revision is to increase, somewhat, the above CAFE's for Model Years 1980 and 1981, and thereby increasing the amounts of CAFE to on-road differences as estimated in this study.

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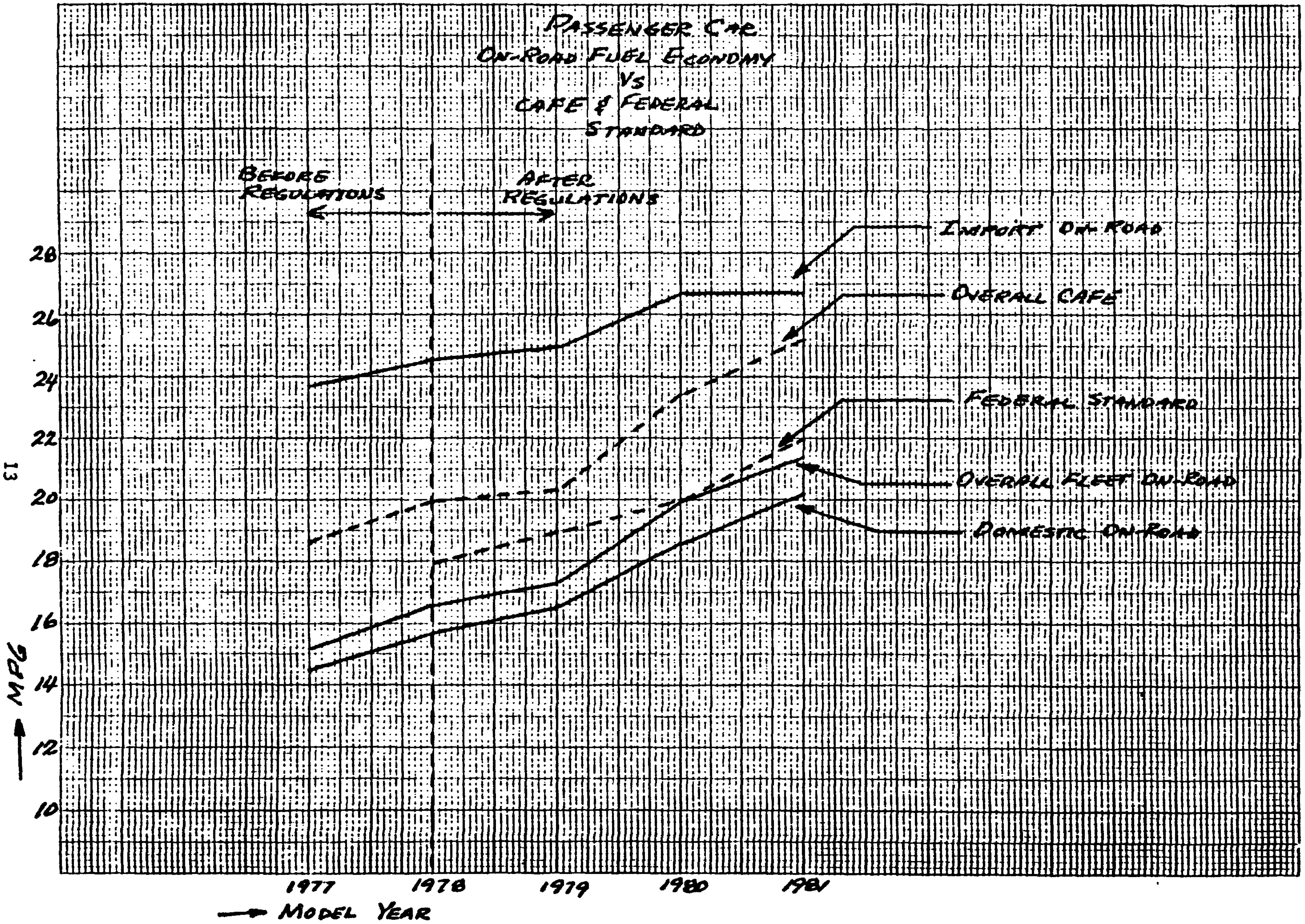
4 CAFE for six import manufacturers included in survey: Datsun/Nissan, Honda, Toyota, Volkswagen, and two captive import groups, Chrysler and Ford.

5 CAFE for all import manufacturers, including captive imports for Chrysler and Ford.

FIGURE 2-1


PASSENGER CAR
ON-ROAD FUEL ECONOMY
VS
CAFE & FEDERAL
STANDARD
BEFORE
REGULATIONS
AFTER
REGULATIONS
IMPORT ON-ROAD
OVERALL CAFE
FEDERAL STANDARD
OVERALL FLEET ON-ROAD
DOMESTIC ON-ROAD
28
26
24
22
20
18
16
14
12
10
MPG
1977
1978
1979
1980
1981
MODEL YEAR

As the table shows, the overall (i.e., total fleet) on-road fuel economy shows a steady improvement over the base 1977 Model Year from 15.2 miles per gallon (mpg), to 21.4 mpg for the 1981 Model Year. This represents a total increase in fuel economy of 6.2 mpg or 41 percent over four model years. The yearly, average increase amounts to approximately 10 percent or 1.55 mpg. The major portion of this increase can be attributed to vehicles produced in the U.S. which saw an overall increase in fuel economy of approximately 40 percent, compared to an increase of 13 percent for the imports. Of course, it must be remembered that prior to enactment of the fuel economy regulations, the mpg was considerably higher for the imports than for domestically manufactured cars; import fleet mpg for the base year was nearly 60 percent higher than domestic fleet mpg. Consequently, the impetus for import manufacturers to raise mpg was less since their base year mpg was already higher than the fuel economy regulations called for, even as late as 1981.

One qualifying comment should be noted in the above discussion of the fuel economy improvements. Nineteen seventy-eight was the initial year of the Federal Fuel Economy Regulations, and therefore, 1977 is taken as the base year on which to compute fuel economy gains. However, the first significant step to increase passenger car fuel efficiency came in the 1977 model year when General Motors downsized its standard-sized cars and standard-sized station wagons. Based on registration data, the GM standard size cars accounted for approximately 20 percent of the U.S. domestic fleet of 1977 passenger cars. Therefore, it may be stated that the above estimates of total fuel efficiency gains are somewhat conservative since they do not include that portion of the gain resulting from the downsizing of the 1977 GM standard size cars. As noted previously, Model Year 1977 was the earliest year covered by the survey and thus the actual incremental savings attributable to the downsized GM standard vehicles cannot be measured with the available data.

2.1.1 RELIABILITY OF ON-ROAD FUEL ECONOMY ESTIMATES

In statistical surveys such as the On-Road Fuel Economy Survey, it is typically of interest to estimate not only the mean values for certain population parameters--in this case, on-road fuel economy or mpg--but also to evaluate the reliability of these estimates. Reliability here is defined as the degree of precision which can be attached to the various mean estimates.

The standard method of measurement of precision in statistical surveys is the standard error which in the simple case is the sample standard deviation, s, divided by the square root of the sample size, or n. Table 2-2 contains standard error estimates for each of the overall model year (e.g., domestic plus import) estimates of on-road mpg as given in Table 2-1. The standard errors for each model year are estimated from the formula:

$$SE(\text{Model Year}) = \left[\sum W_h^2 SE_h^2 \right]^{1/2}$$

where,

$SE_h = s/\sqrt{n}$ = standard error for each stratum in the sample or each vehicle size class within a given model year.

and W_h = weighting factor corresponding to the proportion of the total vehicle population in the stratum/size class relative to the total vehicle population for the given model year.

Also given in the table are the 95 percent confidence intervals for the mean estimates for each model year. The interpretation for each of these intervals is that in repeated sample surveys such as this, 95 percent of intervals so constructed would contain the true population mean or the true on-road mpg for the particular model year.

TABLE 2-2

STANDARD ERROR AND 95 PERCENT CONFIDENCE INTERVALS FOR PASSENGER CAR ON-ROAD MPG

Model Year	Sample Size	On-Road MPG (Mean)	Standard Error (MPG)*	Relative Standard Error (%)	95 Percent Confidence Interval (MPG)*
1977	855	15.2	0.157	1.0	14.9 - 15.5
1978	1,129	16.6	0.145	0.9	16.3 - 16.9
1979	1,380	17.3	0.184	1.1	16.9 - 17.7
1980	1,570	20.0	0.132	0.7	19.7 - 20.3
1981	2,114	21.4	0.120	0.6	21.2 - 21.6

*It will be recalled that the mean mpg has been calculated using the harmonic formula since this was the method specified in the Energy Policy and Conservation Act which established the CAFE standards. The standard errors in the above table however, have been computed on the basis of a regular arithmetic mean due to the general lack of computerized statistical algorithms to handle standard errors for harmonic means. (It has for years been nearly universal in the fields of analytical and survey statistics to utilize the arithmetic mean rather than the harmonic mean as a measure of central tendency.) Since it can be shown that the harmonic mean, in the general case, is slightly less than the arithmetic mean, it follows that an "arithmetic standard error" will be slightly less than a "harmonic standard error." This is due to the fact that the standard error is a function of $\sum_i (x_i - x)^2$, or the sum of squares of the deviations of the sample mean from each individual sample observation. Also confidence intervals constructed from arithmetic standard errors will be slightly more narrow than similar intervals based on harmonic standard errors. However, the magnitude of such differences will be quite small for the data collected in the On-Road Survey and hence the estimates given in the above table will be very close to the values that would be obtained based on "harmonic standard errors."

It can be seen that the magnitude of the standard error does not differ appreciably among the five model years, ranging from 0.12 to 0.18. Relative to the mean however, it is seen that the error does tend to decrease with the later model years.

2.1.2 ON-ROAD FUEL ECONOMY VERSUS EPA CAFE

Table 2-3 compares the results from the On-Road Survey with the CAFE (as based on EPA test data) and with the Federal Fuel Economy Standards for the years 1978-1981.

For the domestic cars, the on-road experience is consistently below respective EPA CAFE levels by about 15 percent. On an absolute, or mpg basis, the difference is somewhat larger in 1981 than in the period 1978-1980, rising to 3.4 mpg from about 3.0 mpg. This is to be expected if the relative difference is essentially constant over the 4 years since both the on-road and EPA CAFE levels show continual increases.

For imported cars, the on-road fuel economy is closer to the EPA CAFE than for the domestic vehicles. No clear trend is evident here, however, since the on-road mpg is 14 to 15 percent lower than the EPA CAFE for Model Years 1978 and 1981, but only 8 to 10 percent, for the intervening years 1979 and 1978. On an absolute basis, import on-road mpg is below the EPA CAFE, ranging from approximately 2 to 5 mpg less. Again no distinct trend is evident.

TABLE 2-3

PASSENGER CARS:
COMPARISON OF ON-ROAD FUEL ECONOMY WITH EPA CAFE
AND WITH FUEL ECONOMY STANDARDS

COMPARISON	1978		1979		1980		1981	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
Domestic vs. EPA CAFE	[3.0]	[16.0]	[2.8]	[14.5]	[3.2]	[14.7]	[3.4]	[14.4]
Import Fleet vs. EPA CAFE	[4.1]	[14.3]	[2.2]	[8.1]	[3.0]	[10.1]	[4.7]	[15.0]
Overall Fleet vs EPA CAFE	[3.3]	[16.6]	[3.0]	[14.8]	[3.4]	[14.5]	[3.8]	[15.1]
Domestic vs. Standard	[2.3]	[12.8]	[2.5]	[13.2]	[1.4]	[7.0]	[1.8]	[8.2]
Import vs. Standard	6.6	36.7	6.0	31.6	6.7	33.5	4.7	21.4
Overall Fleet vs. Standard	[1.4]	[7.8]	[1.7]	[8.9]	0.0	0	[0.6]	[2.7]

NOTE: Bracketed entries represent negative values (i.e., on-road values less than respective EPA CAFE or standard values).

On a relative overall fleet (e.g., both domestic and import vehicles combined) basis, the on-road mpg is below the respective EPA CAFE by about 15 percent or 3-4 mpg. These differences are quite close to the differences noted for the domestic vehicles and, again, are to be expected since domestic vehicles comprise the major portion of the U.S. passenger car fleet.

2.1.3 ON-ROAD FUEL ECONOMY COMPARED TO THE FEDERAL STANDARDS

Table 2-3 also compares the on-road mpg with the Federal Standards for the 4 model years, 1978-1981. As shown, the domestic fleet is below the Standard for each of the 4 years, by an average of 10.3 percent, or 2.0 miles per gallon. There is some indication that this difference may be declining for the later model years (e.g., 1980-1981).

Imports, on the other hand, show an on-road mpg considerably above the Federal standards, ranging from 21 to 37 percent (5-7 mpg) above the standard levels. As pointed out earlier, however, the imports average on-road mpg was originally (i.e., prior to enactment of the Federal standards) at a level considerably above the level required by the standards, as those vehicles have been, and remain, predominately small cars.

On an overall fleet basis, the difference between on-road mpg and the Federal standard levels appears to be narrowing, with the 1980-81 difference being about 1.5 percent compared to 8-9 percent in 1978-79. On an mpg basis, this difference for 1980-81 averages less than one-half mile per gallon, with the on-road average for 1980 exactly equaling the standard level of 20.0 miles per gallon.

2.1.4 ON-ROAD FUEL ECONOMY BY VEHICLE SIZE CLASS

Table 2-4 displays the on-road fuel economy by vehicle size class.[6] From 1977 through 1981, consistent year-to-year gains were made for most size classes. Over the full 4-year period, the average increase in mpg per size class was 35 percent. The largest gain (79 percent) was registered for the compact class, while the mini class had the lowest increase at 7 percent.

2.1.5 ON-ROAD FUEL ECONOMY BY MANUFACTURER

Tables 2-5 and 2-6 display the on-road fuel economy (MPG) by model year for the domestic manufacturers and the import manufacturers, respectively. The import table also includes "Ford" and "Chrysler" which refer to the captive imports for these two manufacturers. These are broken out since captive imports are to be treated separately (i.e., not combined with vehicles manufacturer domestically) in accordance with the legislative

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6 The size classes here essentially correspond to the EPA size classes as defined in the annual "Gas Mileage Guide" publications for the respective model years covered by the survey. One exception is the "mini" class which includes not only vehicles classified as "mini", but also vehicles classified as "two-seaters."

TABLE 2-4

PASSENGER CAR ON-ROAD
FUEL ECONOMY

SIZE CLASS BY MODEL YEAR

Size Class	Miles per Gallon for Model Years: 1977	1978	1979	1980	1981
Mini	22.9	21.0	22.3	23.4	24.5
Sub-Compact	17.4	21.2	21.3	23.3	24.3
Compact	14.5	16.4	16.2	19.1	25.9
Midsize	14.3	15.2	16.0	18.2	19.6
Large	13.6	14.5	15.4	16.4	17.6
Small Station Wagon	19.2	21.0	21.5	24.0	25.4
Midsize Station Wagon	13.9	15.7	16.2	17.2	19.7
Large Station Wagon	13.0	14.3	14.0	15.8	16.5

NOTE: Sample sizes range from 19 to 491 vehicles for each of the 40 Size Class-Model Year categories.

TABLE 2-5

PASSENGER CAR ON-ROAD FUEL ECONOMY BY MANUFACTURER (DOMESTIC) AND MODEL YEAR

- Miles Per Gallon -

MODEL YEAR	GEN. MOTORS	FORD	CHRYSLER	AMC
1977	14.8	13.9	14.0	15.4
1978	15.9 (19.0)	15.1 (18.4)	16.4 (18.4)	15.9 (18.6)
1979	16.4 (19.1)	16.1 (19.1)	17.4 (20.4)	17.8 (19.9)
1980	18.7 (21.8)	18.8 (22.0)	17.9 (21.3)	18.0 (21.5)
1981	19.7 (23.2)	20.3 (23.3)	23.8 (26.4)	19.3 (22.5)

NOTE: Numbers in parentheses are the respective EPA CAFE levels.

Sample sizes range from 15 to 997 vehicles for each of the 20 manufacturer-model year categories.

TABLE 2-6

IMPORT PASSENGER CAR FLEET - ON-ROAD MPG
BY MANUFACTURER AND MODEL YEAR

MODEL YEAR	DATSUN/NISSAN	HONDA	TOYOTA	VW	FORD	CHRYSLER
1977	23.4	28.3	21.4	26.1	--	24.2*
1978	22.6 (26.8)	28.5 (33.7)	22.4 (26.8)	27.4 (27.2)	30.2 (37.3)	24.2 (30.6)
1979	26.8 (26.7)	27.5 (29.8)	21.6 (24.4)	30.4 (28.5)	22.5 (32.2)	22.4* (30.1)
1980	26.9 (31.5)	27.5 (30.0)	24.1 (27.4)	33.8 (30.8)	25.5 (29.9)	25.4 (30.7)
1981	25.7 (30.9)	27.7 (31.0)	25.5 (31.0)	34.0 (33.5)	19.6* (34.8)	29.3 (31.9)

NOTE: Numbers in parentheses are the respective EPA CAFE numbers.

*Sample size (i.e., number of vehicles in survey) less than 10; remaining categories range in sample size from 10 to 215 vehicles.

stipulations for computing CAFE and determining compliance with Federal Standards. Captive imports for years represented in the survey included:

Ford: Fiesta, Capri
Chrysler: Plymouth Arrow, Dodge Colt, Plymouth Champ, Dodge Challenger, Plymouth Sapporo

2.1.5.1 DOMESTIC MANUFACTURERS

For the domestic companies (Table 2-5), the on-road mpg shows a continuous improvement from Model Year 1977 through Model Year 1981. The magnitude of these increases is reasonably consistent for all four manufacturers except for Chrysler in 1981 which showed a much larger than average jump of nearly six mpg. A major contributor to this large increase for Chrysler was the introduction of the "K-cars" (i.e., Plymouth Reliant and Dodge Aries), all new front-wheel drive cars which not only obtained considerably higher mpg than models which they replaced (Volare and Aspen) but also comprised a large portion of Chrysler sales for 1981.

Tables 2-7 and 2-8 summarize comparisons of the domestic manufacturer on-road results with EPA CAFE's and Federal Standard levels, respectively. Overall, on-road mpg remains below the EPA CAFE by a rather consistent margin of 14-15 percent, or about three mpg and while no trends are evident, Chrysler's 1981 mpg comes closest to the EPA CAFE level, being below by less than 10 percent. The comparison against Federal Standard levels yields similar results in that no trends are apparent. On-road mpg

TABLE 2-7

DOMESTIC PASSENGER CAR FLEET - COMPARISON
Of ON-ROAD MPG WITH EPA CAFE
BY
MANUFACTURER

MODEL YEAR	GENERAL MOTORS		FORD		CHRYSLER		AMC	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
1978	[3.1]	[16.3]	[3.3]	[17.9]	[2.0]	[10.9]	[2.7]	[14.5]
1979	[2.7]	[14.1]	[3.0]	[15.7]	[3.0]	[14.7]	[2.1]	[10.1]
1980	[3.1]	[14.2]	[3.2]	[14.5]	[3.4]	[16.0]	[3.5]	[16.3]
1981	[3.5]	[15.1]	[3.0]	[12.9]	[2.6]	[9.8]	[3.2]	[14.2]
AVG.	[3.1]	[14.9]	[3.1]	[15.3]	[2.8]	[12.9]	[2.9]	[13.8]

NOTE: Brackets indicate negative values (i.e., on-road mpg less than EPA CAFE).

TABLE 2-8

DOMESTIC PASSENGER CAR FLEET - COMPARISON
OF ON-ROAD MPG WITH FEDERAL STANDARD
BY
MANUFACTURER

MODEL YEAR	GENERAL MOTORS		FORD		CHRYSLER		AMC	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
1978	[2.1]	[11.7]	[2.9]	[16.1]	[1.6]	[8.9]	[2.1]	[11.7]
1979	[2.6]	[13.7]	[2.9]	[15.3]	[1.6]	[8.4]	[1.2]	[6.3]
1980	[1.3]	[6.5]	[1.2]	[6.0]	[2.1]	[10.5]	[2.0]	[10.0]
1981	[2.3]	[10.5]	[1.7]	[7.7]	1.8	8.2	[2.7]	[12.3]
AVG.	[2.1]	[10.6]	[2.2]	[11.3]	[0.9]	[4.5]	[2.0]	[10.1]

NOTE: Brackets indicate negative values (i.e., on-road mpg less than Federal Standards).

lags the standard levels by about 10 percent or 2.0 mpg for General Motors, Ford, and American Motors. Chrysler's overall decrease is less than 5 percent or approximately 1 mpg with the 1981 on-road figure being the only instance where on-road mpg exceeds the Federal Standard.

2.1.5.2 FOREIGN MANUFACTURERS

The on-road mpg for the foreign manufacturers (or import vehicles) was shown in Table 2-6. As stated earlier, the two domestic companies, Ford and Chrysler, represent captive import categories, which for purposes of EPA CAFE computation are classed as import vehicles. Volkswagen shows the largest increase in on-road mpg among the six manufacturers. This is attributed to the increasingly large penetration of diesel powered vehicles, principally VW Rabbits, which occurred over the 1979-1981 period. Diesel vehicles achieve substantially higher fuel economy than comparable vehicles powered by gasoline engines (see Section 2.5). Among the other manufacturers, Datsun/Nissan and Toyota show modest increases in on-road mpg for the latest two-to-three model years. The other three manufacturers, Honda, Ford, and Chrysler show no trends of mpg increases, with Honda's average on-road mpg remaining essentially constant over the entire 5-year period. It should also be noted in the case of these latter two manufacturers that the sample sizes are rather small for some model years.

Table 2-9 shows the import manufacturers on-road mpg versus EPA CAFE comparison. Overall, no trends are evident. For all except one manufacturer, VW, on-road mpg shows an essentially consistent decrease

TABLE 2-9

IMPORT PASSENGER CAR FLEET - COMPARISON OF ON-ROAD MPG WITH EPA CAFE BY MANUFACTURER

MODEL YEAR	DATSUN/NISSAN		HONDA		TOYOTA		VW		FORD		CHRYSLER	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
1978	[4.2]	[15.7]	[5.2]	[15.4]	[4.4]	[16.4]	0.2	0.7	[7.3]	[19.6]	[6.4]	[20.9]
1979	0.1	0.4	[2.3]	[7.7]	[2.8]	[11.5]	1.9	6.7	[9.7]	[30.1]	[7.7][7]	[25.5]
1980	[4.6]	[14.6]	[2.5]	[8.3]	[2.7]	[9.9]	3.0	9.7	[4.5]	[15.1]	[5.3]	[17.3]
1981	[5.2]	[16.8]	[3.3]	[10.6]	[5.5]	[21.6]	0.5	1.5	[15.2]	[43.7]	[2.6]	[8.2]
AVG	[4.0]	[11.7]	[3.3]	[10.5]	[3.9]	[14.9]	1.4	4.7	[9.2]	[27.1]	[5.5]	[18.0]

NOTE: Brackets indicate negative values (i.e., on-road mpg less than EPA CAFE).

7 Sample size less than 10

relative to EPA CAFE, with Ford showing the greatest disparity (again, small sample sizes in some cases mean individual model year estimates are subject to greater variability). Volkswagen's on-road mpg in all instances is slightly above the EPA CAFE level; this is believed primarily due to its high proportion of diesel powered vehicles.

The comparison of import on-road mpg with the Federal standards is displayed in Table 2-10. As would be expected from the results discussed above, on-road mpg exceeds the Federally required level in nearly every instance. The degree to which the on-road mpg exceeds the Federal levels is typically quite large, ranging from a low of approximately 19 percent (for Toyota) to a high of nearly 60 percent (for VW).

2.2 LIGHT TRUCKS - TWO WHEEL DRIVE: ON-ROAD FUEL ECONOMY

On-road fuel economy for light trucks is shown in Table 2-11 for both domestic and import manufacturers, along with the respective EPA CAFE for each Model Year 1978-1981. The data are divided by two-wheel and four-wheel drive configurations corresponding to the manner in which the Federal Regulations were set for this class of vehicles. Figure 2-2 displays graphically the data in Table 2-11 , showing the trend by model year.

It should be noted that fuel economy regulations for light trucks began in 1979, 1 year later than for passenger cars. Therefore, the base year for estimating fuel economy improvement for light trucks is Model Year 1978.

TABLE 2-10

IMPORT PASSENGER CAR FLEET - COMPARISON OF ON-ROAD MPG WITH FEDERAL STANDARD LEVELS

MODEL YEAR	DATSUN/NISSAN		HONDA		TOYOTA		VW		FORD		CHRYSLER	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
1978	4.6	25.5	10.5	58.3	4.4	24.4	9.4	52.2	12.2	67.8	6.2	34.4
1979	7.8	41.1	8.5	44.7	2.6	13.7	11.4	60.0	3.5	18.4	3.4*	17.9
1980	6.9	34.5	7.5	37.5	4.1	20.5	13.8	69.0	5.5	27.5	5.4	27.0
1981	3.7	16.8	5.7	25.9	3.5	15.9	12.0	54.5	[2.4*]	[10.9]	7.3	33.2
AVG	5.8	29.5	10.6	41.6	3.7	18.6	11.7	58.9	5.9	28.1	5.6	28.1

NOTE: Brackets indicate negative values

* Sample size less than 10

TABLE 2-11

LIGHT TRUCK ON-ROAD FUEL ECONOMY, AND
COMPARISONS TO EPA CAFE
- DOMESTIC AND IMPORT FLEETS -

Miles Per Gallon

	Two-Wheel Drive				Four-Wheel Drive			
FLEET	1978	1979	1980	1981	1978	1979	1980	1981
Domestic								
On-Road	12.3[8]	15.2	14.7	14.9	12.3	12.9	12.9	13.4
EPA CAFE	(N/A)	17.9	17.5	18.6	(N/A)	16.5	15.2	17.1
Import								
On-Road	22.3[9]	20.5	21.3	24.3	--	--	18.5	19.3
EPA CAFE	(N/A)	20.9	25.0	28.0	(N/A)	25.6	21.8	24.3
Overall On-Road	13.4[10]	15.7	16.4	16.9	12.3[11]	12.9	13.6	14.4
Overall EPA CAFE	(N/A)	18.4	19.3	20.7	(N/A)	16.6	16.1	18.6
Fuel Economy Standard	(N/A)	17.2	16.0	16.7	(N/A)	15.8	14.0	15.0

NOTE 1: For Model Year 1979, the light truck fuel economy standards applied only to those light trucks having a gross vehicle weight rating (GVWR) of 6,000 pounds or less. In Model Year 1980, the standards were broadened to apply to all light trucks having a GVWR of 8,500 pounds or less.

NOTE 2: For 1979, domestic manufacturers were permitted to include captive import trucks in their overall EPA CAFE figures, whereas beginning with Model Year 1980, captive imports had to be separated as a special class.

NOTE 3: Sample sizes for each of the 16 base categories range from 27 to 244 vehicles.

NOTE 4: While the above EPA CAFE's are correct as of this writing, rulemaking action in process may adjust upward the above CAFE's for Model Year 1980 and later (see Note 2, Table 2-1).

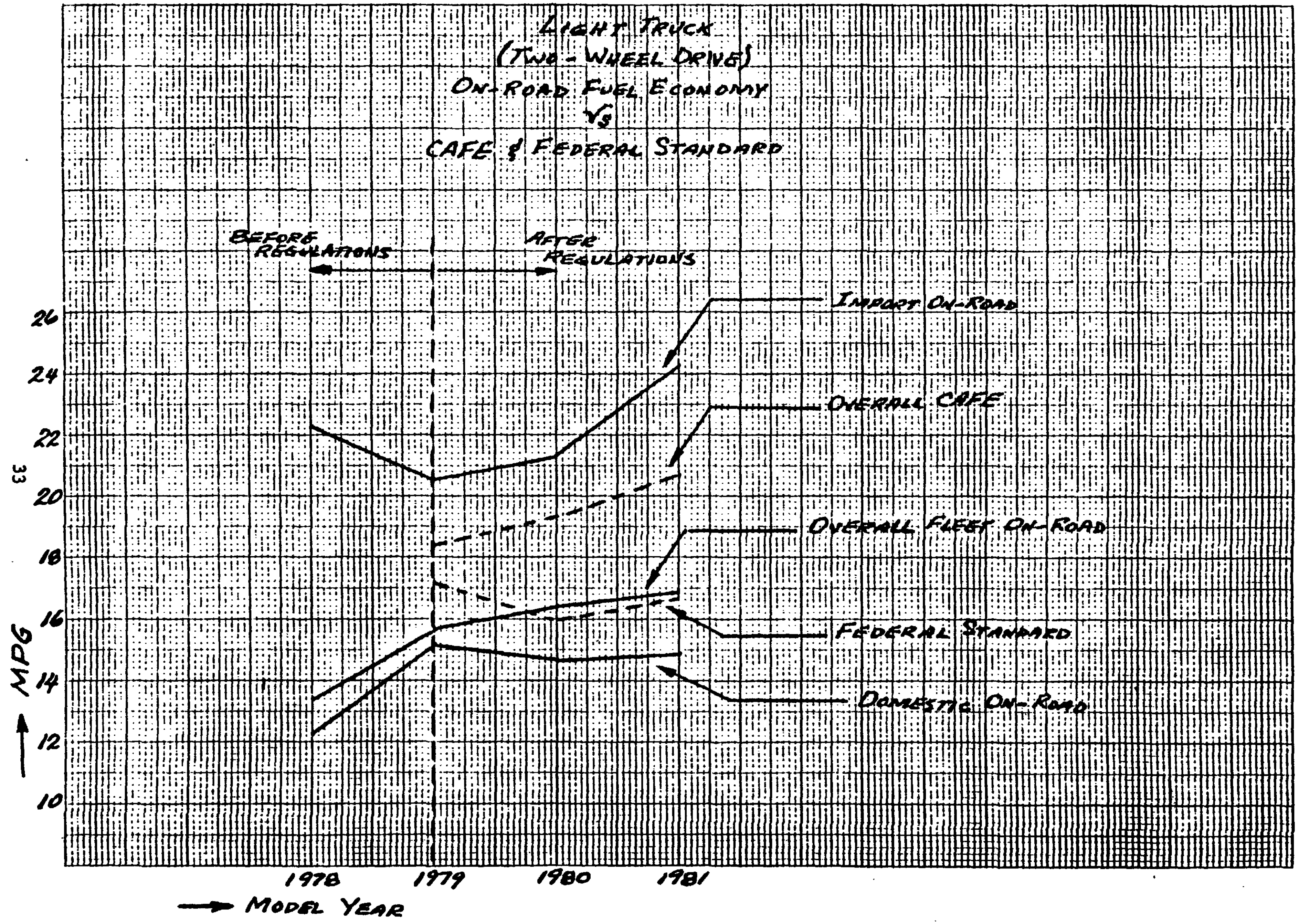
8 Includes vehicles with GVWR ≤ 8,500 lbs.; excluding vehicles ≥ 6,000 lbs., but less than 8,500 lbs., GVWR, and including captive imports, the figure is 14.1 mpg..

9 Includes captive imports.

10 Excluding vehicles > 6,000 lbs., figure is 15.2 mpg.

11 Excluding vehicles > 6,000 lbs., figure is 13.7 mpg.

FIGURE 2-2


LIGHT TRUCK
(TWO-WHEEL DRIVE)
ON-ROAD FUEL ECONOMY
VS
CAFE & FEDERAL STANDARD
BEFORE REGULATIONS
AFTER REGULATIONS
IMPORT ON-ROAD
OVERALL CAFE
OVERALL FLEET ON-ROAD
FEDERAL STANDARD
DOMESTIC ON-ROAD
MPG
26
24
22
20
18
16
14
12
10
1978
1979
1980
1981
MODEL YEAR

Standards for trucks began a year later (Model Year 1979 instead of Model Year 1978) than for passenger cars, and the year-to-year progression in standard levels was less than for passenger cars. It should be noted that beginning with 1980, the light trucks regulations included vehicles up to 8,500 lbs. Gross Vehicle Weight Rating (GVWR), whereas the 1979 standard only included vehicles up to 6,000 lbs. GVWR. Also for 1979, the domestic manufacturers were permitted to include captive import trucks in the overall EPA CAFE computation, whereas in 1980 and later captive import trucks had to be excluded as a separate segment for the domestic companies.

2.2.1 ON-ROAD FUEL ECONOMY COMPARED TO EPA CAFE

Comparing on-road fuel economy for two-wheel drive light trucks with CAFE levels (as computed from EPA laboratory tests), the following observations are made (see Table 2-12):

(1) The on-road mpg for the overall fleet is below the EPA CAFE mpg by an average of 16 percent per each year, 1979 through 1981. On a miles per gallon basis, this difference increases from 2.7 in 1979 to 3.8 in 1981.

(2) For domestic vehicles, there is a slight trend that the difference between on-road mpg and the EPA CAFE may be increasing, on both a relative, or percent, and an absolute, or mpg basis.

TABLE 2-12

LIGHT TRUCK: TWO-WHEEL DRIVE -
COMPARISON OF ON-ROAD FUEL ECONOMY
WITH
EPA CAFE AND WITH FUEL ECONOMY STANDARDS

COMPARISON	1979		1980		1981	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
Domestic with EPA CAFE	[2.8]	[15.6]	[2.8]	[16.0]	[3.7]	[19.9]
Import with EPA CAFE	[0.4]	[1.9]	[3.7]	[14.8]	[3.7]	[13.2]
Overall Fleet With EPA CAFE	[2.7]	[14.7]	[2.9]	[15.0]	[3.8]	[18.4]
Domestic with Standard	[2.1]	[13.2]	[1.3]	[8.1]	[1.8]	[10.8]
Import with Standard	3.3	19.2	5.3	33.1	7.6	45.5
Overall Fleet with Standard	[1.5]	[8.7]	0.4	2.5	0.2	1.2

(Column heading: -MODEL YEAR-)

NOTE: Brackets indicate negative values, i.e., on-road values less than standard values.

(3) For import trucks, the on-road fuel economy remains below the EPA CAFE values for 1980 and 1981 by approximately 14 percent or 3.7 mile per gallon. This contrasts with 1979 which saw import trucks on-road mpg only slightly less (1.9 percent) than the EPA CAFE.

(4) Overall, the EPA CAFE figures for light trucks exceed on-road experience by amounts similar to those noted for passenger cars--approximately 16 percent per year, or from 3 to 4 miles per gallon.

2.2.2 ON-ROAD FUEL ECONOMY COMPARED TO FEDERAL STANDARD

Comparing on-road experience of two-wheel drive light trucks with the Federal Standard levels yields the following observations:

(1) On an overall (fleet) basis, the on-road results are quite close to the standard levels. In fact for the latest 2 years, 1980 and 1981, the on-road mpg actually exceeds the standards slightly (by 1 to 2 percent).

(2) The primary reason for this close correspondence between overall fleet mpg and the Federal Standards is the wide margin by which the import trucks exceed the respective standards. For the 3 model years 1979 to 1981, import trucks increasingly exceed the standards, ranging from 19.2 percent

in 1979, to 45.5 percent in 1981. Conversely, the on-road mpg of domestic trucks is below the standards for each of the 3 model years by an average of 10.7 percent. Again, however, as was the case for passenger cars, import trucks had a much higher on-road mpg prior to enactment of the Federal Standards than did domestic trucks. The original (Model Year 1978) mpg for the imports was even higher than the ultimate standard level for 1981. Therefore the impetus for fuel economy improvement was much greater for the manufacturers of domestic trucks than for the manufacturers of import trucks and, as was the case for passenger cars, the relative increase in on-road mpg was greater for domestic trucks than for import trucks.

2.3 LIGHT TRUCKS - FOUR-WHEEL DRIVE: ON-ROAD FUEL ECONOMY

Survey data for four-wheel drive trucks were not as complete as for two-wheel drive vehicles. The survey results for these vehicles along with respective EPA CAFE's and Federal Standards are shown in Table 2-13.

For domestic trucks with respect to EPA CAFE, it is seen that the on-road experience again falls below EPA CAFE levels by an amount ranging from 15 to 22 percent. Compared to the Fuel Economy Standards, the on-road decrease is not as large, ranging from 18 percent in 1979 to 11 percent in 1981.

TABLE 2-13

LIGHT TRUCK: FOUR-WHEEL DRIVE -
COMPARISON OF ON-ROAD FUEL ECONOMY
WITH
EPA CAFE AND WITH FEDERAL STANDARDS

	- MODEL YEAR -					
COMPARISON	1979		1980		1981	
	MPG	PERCENT	MPG	PERCENT	MPG	PERCENT
Domestic with EPA CAFE	[3.6]	[21.8]	[2.3]	[15.1]	[3.7]	[21.6]
Import with EPA CAFE	--	--	[3.3]	[15.1]	[5.0]	[20.6]
Overall Fleet with EPA CAFE	--	--	[2.5]	[15.5]	[4.2]	[22.6]
Domestic with Standard	[2.9]	[18.4]	[1.1]	[7.9]	[1.6]	[10.7]
Import with Standard	--	--	4.5	32.1	4.3	28.7
Overall Fleet with Standard	--	--	[0.4]	[2.9]	[0.6]	[4.0]

NOTE: Brackets indicate negative values (i.e., on-road values less than the Standard.

For the 2 years for which comparisons may be made for import trucks, Table 2-13 shows that on-road mpg is lower than EPA CAFE levels by 15-21 percent, differences similar to those noted for the domestic two-wheel drive trucks. With respect to the Fuel Economy Standards, as was the case for passenger cars, there is a marked difference in the opposite direction--on-road mpg exceeds the Federal Standards by a considerable margin. For 1980, on-road mpg exceeds the Federal Standard of 14.0 mpg by 32 percent; for 1981, on-road mpg is 29 percent higher.

For the overall fleet of four-wheel drive trucks, the 1980 and 1981 on-road fuel economy is lower than the EPA CAFE by 15 to 23 percent. Relative to the Federal Standards, the on-road mpg is quite close, trailing by only 3 to 4 percent. Once again, this close agreement is primarily due to the import trucks which, although representing a minor portion of the total truck fleet, exhibit a much higher on-road fuel economy level.

Figure 2-3 is a graphic display of the data for four-wheel drive trucks, taken from Table 2-11.

2.4 LIGHT TRUCK ON-ROAD FUEL ECONOMY BY SIZE CLASS

Table 2-14 summarizes the light truck on-road results by vehicle size class. It shows that the gains made by light trucks over the 3-year period of the standards were generally small, compared to the gains made in the passenger car sector. In a few instances, certain size classes show an on-road reversal (e.g., decrease in mpg), rather than an increase.

FIGURE 2-3

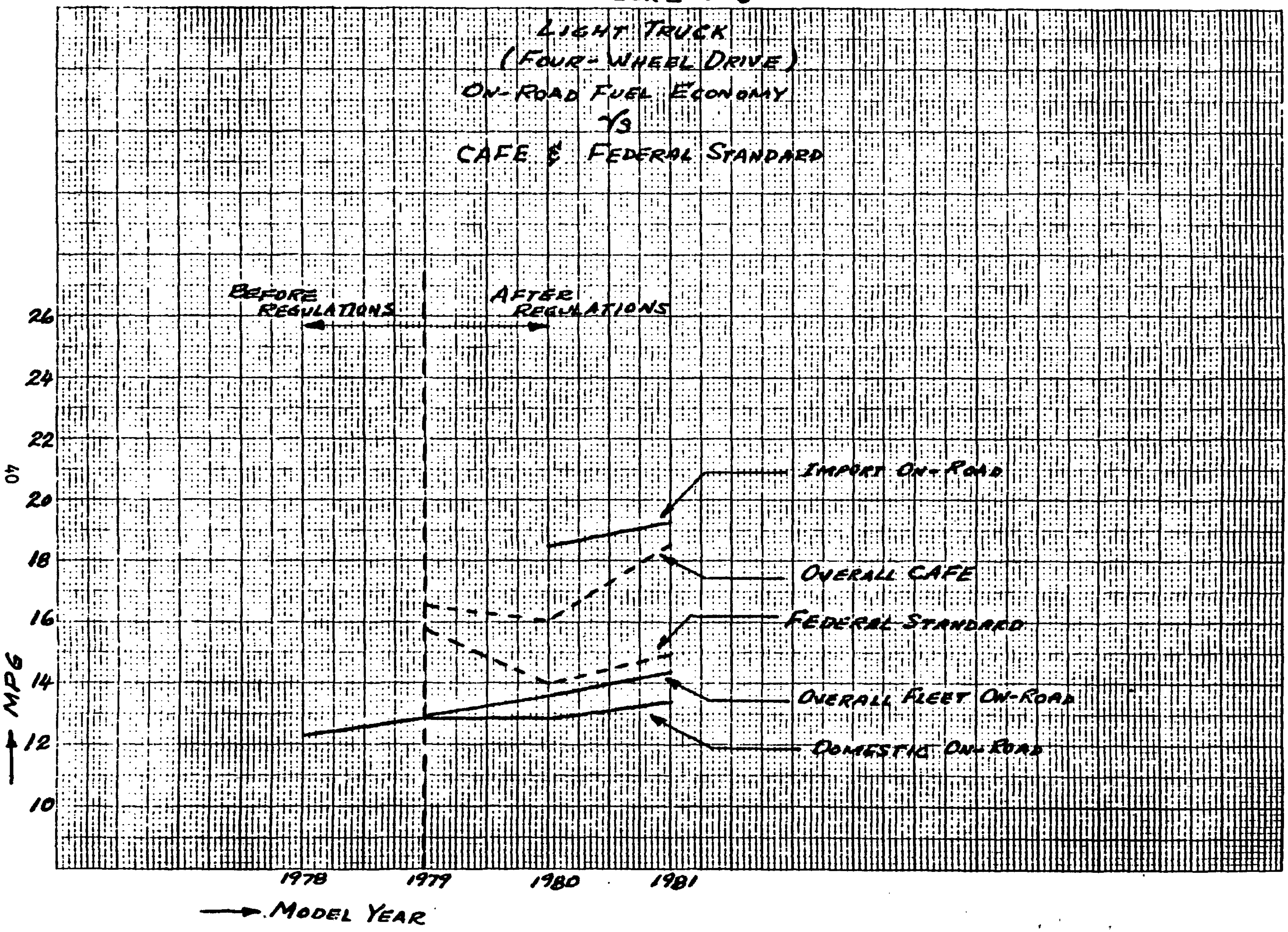

LIGHT TRUCK
(FOUR-WHEEL DRIVE)
ON-ROAD FUEL ECONOMY
VS
CAFE & FEDERAL STANDARD
BEFORE REGULATIONS
AFTER REGULATIONS
IMPORT ON-ROAD
OVERALL CAFE
FEDERAL STANDARD
OVERALL FLEET ON-ROAD
DOMESTIC ON-ROAD
26
24
22
20
18
16
14
12
10
MPG
1978
1979
1980
1981
MODEL YEAR

TABLE 2-14

LIGHT TRUCK ON-ROAD
FUEL ECONOMY -

SIZE CLASS BY MODEL YEAR

SIZE CLASS	----MODEL YEAR---- 1978	1979	1980	1981
2WD				
Small Pickup	22.8	20.8	21.5	24.6
Standard Pickup	11.9	13.0	15.7	15.4
Vans	13.3	13.1	13.4	13.7
Special Purpose	13.0	13.9	10.1	12.9*
4WD				
Small Pickup	--	--	18.5	19.4
Standard Pickup	--	--	12.1	13.9
Special Purpose	12.3	11.5	14.0	14.1

*Sample size less than 10 vehicles.

Sample sizes for remaining cagetories vary from 18 to 170 vehicles.

2.5 DIESELIZATION

One of the primary technological developments made in the drive for better fuel economy was the diesel engine. For the Model Year period covered in the survey, the two manufacturers with significant numbers of diesel powered vehicles were Volkswagen (VW) and General Motors (GM). During the 1980-1981 period, diesel Rabbits comprised a major share of that carline for VW and diesel engines were also offered in VW's small pickup truck. Although GM's diesel penetration never grew to a significant proportion of its total yearly sales, it nevertheless sold considerable numbers of diesel vehicles. These diesel vehicles were confined to certain makes of GM's midsize and large (or standard) size carlines with a high concentration in the Oldsmobile Division (Cutlass Supreme, Cutlass Cruiser, Delta 88, 98, and Custom Cruiser). GM also offered the diesel option in its standard size pickup trucks (Chevrolet and GM). Since diesel vehicles were a very small proportion of the total number of fleet vehicles registered for each year, they were oversampled in order to assure that reasonable numbers appeared in the final survey sample.

2.5.1 EFFECT OF DIESELIZATION ON FUEL ECONOMY

While it is generally well known that diesel vehicles obtain better fuel economy than comparable vehicles with gasoline engines, the survey provides a basis for estimating the extent of the diesel's fuel economy advantage in typical, everyday driving throughout the Nation. Table 2-15 summarizes the results of this comparison for the 6 vehicle classes discussed above. The data indicate a substantial fuel economy advantage for

TABLE 2-15

COMPARISON OF FUEL ECONOMY (MPG) BETWEEN DIESEL AND GASOLINE POWERED VEHICLES

Vehicle Class/ Fuel Type	-- MODEL YEAR -- 1978	1979	1980	1981
Subcompact (VW Rabbit)				
Gasoline	25.60	28.56	26.39	27.64
Diesel	44.99	41.94	42.35	42.07
Diesel Pct. Increase	75.7%	46.8%	60.5%	52.2%
Midsize Sdn (GM)				
Gasoline		16.26	16.33	17.42
Diesel	N/A	23.45	22.11	23.96
Diesel Pct. Increase		44.2%	35.4%	37.5%
Midsize St. Wgn. (GM)				
Gasoline		16.89	15.45	17.65
Diesel	N/A	22.09	21.44	24.39
Diesel Pct. Increase		30.8%	38.8%	38.2%
Large Sdn (GM)				
Gasoline	14.34	15.58	15.92	16.74
Diesel	21.18	21.71	21.81	23.49
Diesel Pct. Increase	47.7%	39.3%	37.0%	40.3%

TABLE 2-15 (Continued)

Vehicle Class/ Fuel Type	-- MODEL YEAR -- 1978	1979	1980	1981
Large St. Wgn. (GM)				
Gasoline	14.61	14.51	14.35	15.42
Diesel	20.45	20.18	21.11	20.86
Diesel Pct. Increase	40.0%	39.1%	32.0%	35.3%
Small Pickup (VW)				
Gasoline			26.76	28.72
Diesel	N/A	N/A	37.23	38.34
Diesel Pct. Increase			39.1%	33.5%
Standard Pickup (GM)				
Gasoline	12.74	14.25	14.79	16.69
Diesel	17.54	19.33	18.30	18.28
Diesel Pct. Increase	37.7%	35.6%	23.7%	9.5%

the diesel engine over a generically similar vehicle equipped with a gasoline engine. While little difference is noted among model years within vehicle classes or between sedans and station wagons within the same size class, the extent of the advantage for diesel vehicles does appear to be related to vehicle size/weight and also to vehicle type (car or truck). The average increase, per model year, in fuel economy for diesels is highest at almost 59 percent for the subcompact class (VW) compared to an average advantage of 38 percent for the combined midsize/large class, both sedans and station wagons (GM). For trucks the same trend holds, but with a smaller advantage for the diesel and a smaller advantage than for passenger cars. The average increase for diesels in small trucks (VW) is 36 percent compared to about 27 percent for standard size pickups (GM). Two probable reasons for the lower diesel advantage in trucks versus cars are the higher gearing/axle ratios for trucks and the heavier usage environment experienced by trucks (e.g., heavier loads, less highway driving, etc.).

2.5.2 DIESEL ON-ROAD FUEL ECONOMY VERSUS EPA LABORATORY ESTIMATES

In addition to the fuel economy advantage over gasoline engines, a second topic of interest relative to the diesel engine is whether diesels exhibit the same relationship between on-road fuel economy and laboratory (or EPA) fuel economy as do gasoline engines. In Section 2.1.2 of this chapter it was found that for all model years studied, and for all passenger cars, the on-road fuel economy was approximately 15 percent less than the laboratory tests (or EPA CAFE) for generically similar vehicles.

In order to evaluate the laboratory to on-road relationship for diesel engines, the on-road results for the sample of diesel powered passenger cars for the 1981 model year was compared with the respective EPA figure, or rating. The 1981 models represent the most recent model year available in the survey and a total of 286 vehicles were available representing the two major manufacturers of diesel power passenger cars for that period, General Motors and Volkswagen. General Motors vehicles in the sample were comprised of midsize passenger cars and midsize station wagons; and standard or large size passenger cars and large station wagons. All GM cars were powered by the eight-cylinder, 350 cubic inch diesel engine manufactured by Oldsmobile. The Rabbit represented Volkswagen's diesel car in the sample and all had the standard four cylinder engine displacing 97 cubic inches.

Table 2-16 contains the data for the nine make models in the sample. The EPA MPG figures are the EPA "combined" numbers which are harmonically weighted averages of "city" and "highway" numbers in the ratio of 55 percent city and 45 percent highway. The "percent decrease" column is the amount by which the on-road MPG falls below the EPA combined MPG.

TABLE 2-16

DIESEL ON-ROAD FUEL ECONOMY VERSUS EPA LABORATORY ESTIMATES; 1981 PASSENGER CARS

Vehicle Make/Model	No. Vehicles in Samples	On-Road MPG (Avg.)	EPA MPG	Avg. Percent Decrease - EPA to On-Road
VW Rabbit	74	42.07	46	8.6
Oldsmobile Cutlass Supreme	34	24.66	27	8.7
Oldsmobile 88	46	23.92	26	8.0
Pontiac Bonneville	21	23.94	26	8.0
Oldsmobile 98	15	23.13	26	11.0
Oldsmobile Cutlass	21	24.64	27	8.7
Oldsmobile Cutlass Cruiser	21	24.39	27	8.7
Oldsmobile Custom Cruiser	27	21.79	23	5.5
Chevrolet Caprice Wagon	27	20.89	23	9.2

Average pct. decrease, EPA - to on-road (weighted) = 8.4

As the table shows, on-road mpg is consistently lower than laboratory tested mpg with the overall weighted average showing on-road mpg for diesel cars being 8.4 percent lower. This is only slightly more than one-half the decrease of approximately 15 percent noted earlier for the entire fleet of cars, the large majority of which are gasoline powered. Thus it appears that laboratory results more accurately reflect the fuel economy achieved by owners of diesel cars than it does the fuel economy achieved by owners of typical gasoline powered cars.

2.6 SEASONAL EFFECT ON FUEL ECONOMY

Several factors influence the fuel economy of a vehicle in the real world driving environment. In addition to the characteristics peculiar to the vehicle itself (size/weight of vehicle, engine size, type of transmission, type of fuel, axle ratio, aerodynamics, air conditioning, etc.), other factors pertaining to the driver, the way in which the vehicle is used (load/cargo carried, highway versus "off-road" usage, etc.), and the environment in which the vehicle operates, all can have an impact on on-road fuel economy.

Under the area of environment, one of the primary factors affecting fuel economy is the "seasonal" effect. This seasonal effect might also be referred to as the "winter-summer" effect, and is, in turn, composed of two principal subfactors, the ambient temperature of the environment in which the vehicle operates, and the way in which the vehicle is used. Under cold temperature conditions, as opposed to warm/hot temperatures, the engine must operate on a richer fuel-air mixture (e.g., choke engaged) until the engine reaches a certain operating temperature. Additionally, "winter" driving typically involves more short trip driving than "summer" driving due to most vacation/recreation travel being in the warmer seasons of the year. Short trip driving typically results in poorer fuel economy since engine temperatures often fail to reach maximum operating levels where best fuel economy is obtained.

Since the On-Road Survey was conducted throughout an entire 12-month period, it provides a method of estimating the seasonal effect on fuel economy. Table 2-17 summarizes the fuel economy results by the four seasons in which the data were collected. The winter period is defined as January 1983 through March 1983, the summer period as April 1983 through June 1983, etc. The data have been combined for all vehicles in the survey, including passenger cars as well as light trucks, in order to obtain more stable statistical estimates of the seasonal effect. The data, as well as the plot in Figure 2-4, show a very consistent seasonal effect, for both the individual model years represented in the survey and for the overall results of the five model years. If we define "winter" as January through March plus October through December, and "summer" as April through September, the overall seasonal effect on fuel economy is estimated to be 18.90 -17.83 = 1.07 mile per gallon, or approximately one mile per gallon. This result is similar to that found in other studies.[12]

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12 "Passenger Car Fuel Economy: EPA and Road," J. D. Murrell, EPA460/3-80-010, January 1980.

"In-Use Fuel Economy of 1980 Passenger Cars." R. W. Schneider, B. W. Lipka, and F. K. Miller, General Motors Corporation, SAE Paper #810384, February 23-27, 1981, meeting in Detroit, Michigan.

TABLE 2-17

ON-ROAD FUEL ECONOMY BY SEASON OF YEAR
(PASSENGER CARS PLUS LIGHT TRUCKS)

MODEL YEAR	WINTER (Jan.-Mar.)		SPRING (Apr.-June)		SUMMER (July-Sept)		FALL (Oct.-Dec.)	
	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$	n	$\bar{X}$
1977	250	15.19	291	16.33	267	15.91	253	14.66
1978	362	16.46	419	17.95	333	17.31	331	16.27
1979	424	17.34	468	18.27	405	18.55	396	17.25
1980	493	19.97	507	20.96	461	21.27	475	20.10
1981	635	21.46	721	22.53	636	22.34	602	21.40
OVERALL	2164	17.93	2406	18.95	2102	18.84	2057	17.72

WINTER/FALL: n = 4221, X = 17.83

SPRING/SUMMER n = 4508, $\bar{X}$ = 18.90

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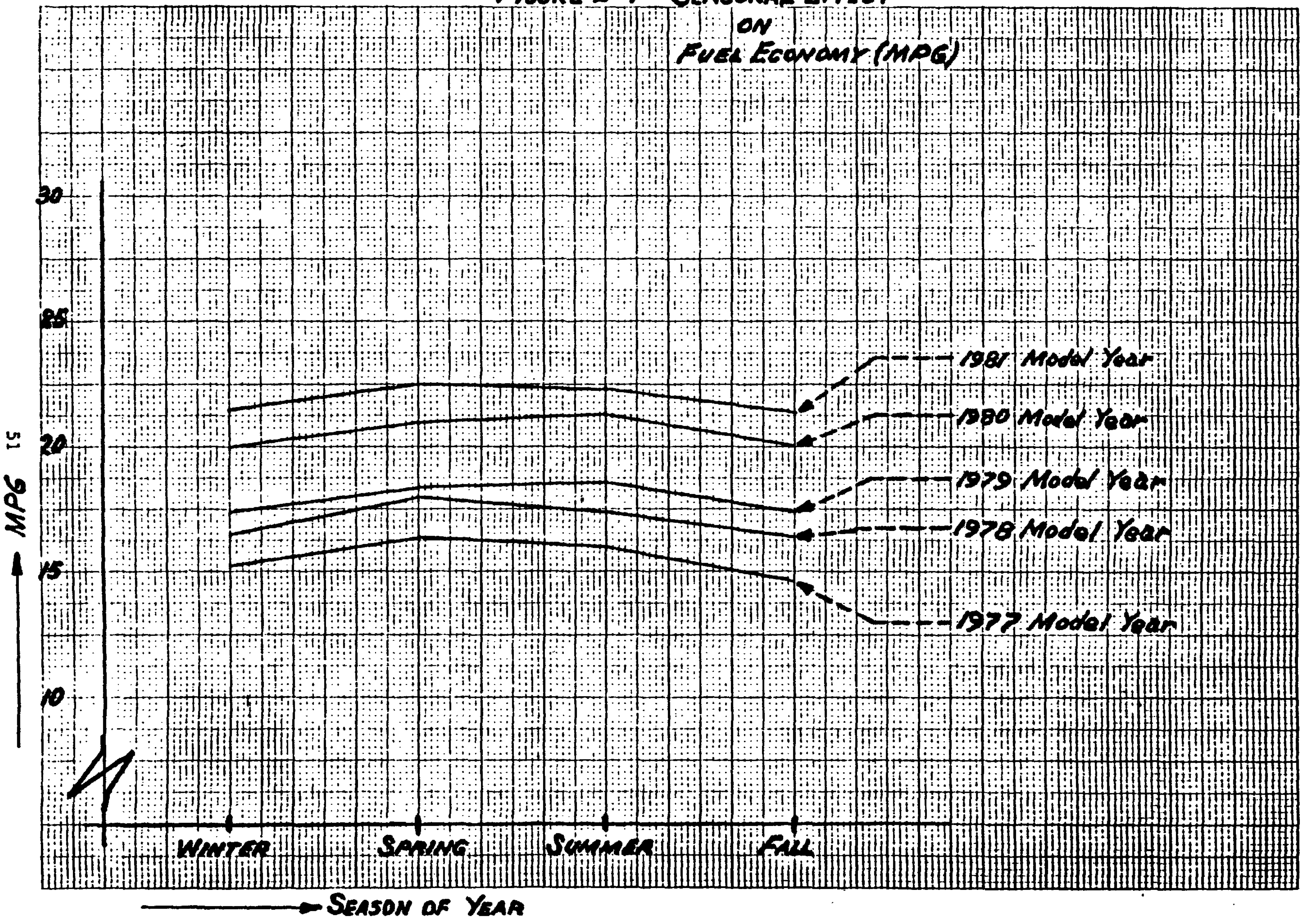
n = no. vehicles in sample

X = mean fuel economy

NOTE: estimates are weighted arithmetic means

Figure 2-4 Seasonal Effect on Fuel Economy (MPG)



2.7 COMPARISON OF ORFES RESULTS WITH PRIOR STUDIES OF ON-ROAD FUEL ECONOMY

As has been stated earlier in this report, several prior studies of on-road fuel economy have been made together with comparisons and analyses of on-road results with laboratory fuel economy measurements as developed by the Environmental Protection Agency. This section compares the results of these earlier studies with the results obtained in the ORFES. Four primary studies have been selected representing efforts by the Department of Energy, the Environmental Protection Agency, General Motors, and Ford Motor Company.

2.7.1 DEPARTMENT OF ENERGY STUDIES

Some of the earliest studies of on-road fuel economy were made by the Department of Energy (DOE). Studies[13] by McNutt et. al., were among the first to document the existence of a decrease between laboratory (EPA) fuel economy and on-road fuel economy. These earlier studies were based on passenger car Model Years through 1978 and used on-road data primarily from fleet operated, domestically produced (i.e., data on import vehicles was essentially absent) vehicles. In addition to the lower on-road finding, these DOE studies also concluded that the magnitude of this difference was increasing with later Model Year vehicles and with higher-mpg vehicles. The

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[13] "A Comparison of Fuel Economy Results from EPA Tests and Actual In-use Experience, 1974-1977 Model Year Cars", by Barry D.Mc Nutt, Diane Pirkey, U.S. Dept. of Energy and Robert Dulla, Craig Miller, Energy and Environmental Analysis, Inc., February 1978.

"On-Road Fuel Economy Trends and Impacts" by Barry D. McNutt, U.S. Dept. of Energy and Robert Dulla, Energy and Environmental Analysis, Inc., February 1979.

"Statement of Barry D. McNutt, Senior Technical Advisor, Office of Conservation Policy and Evaluation, U.S. Dept. of Energy before the Sub-committee on Environment, Energy, and Natural Resources of the Committee on Government Operations", January 29,1980.

EPA to on-road decrease was estimated at 21 percent for Model Year 1978. In contrast to these findings, the ORFES data show a decrease in the EPA to on-road difference from Model Year 1977 to Model Year 1978 (18.3 percent to 16.6 percent). Additionally, ORFES estimates of on-road fuel economy are consistently higher than those found in the DOE studies. It is believed that the difference between the ORFES and DOE findings could largely be due to the representativeness of the data bases used. Use of primarily fleet data by DOE together with the absence of data on import cars could well produce lower fuel economy estimates than ORFES, which was a national probability sample of the entire population of privately owned vehicles, including both domestic and import vehicle. It is also arguable that fleet vehicles, by nature of the environment in which they are operated and maintained, could achieve lower fuel economy than privately owned vehicles.

A later study[14] by DOE covering vehicles through Model Year 1981 and incorporating additional data on private vehicles(from "postcard" surveys by General Motors and Ford) showed a reversal in the earlier trend of increasing gap--the 1979-1980 Models showed less difference between EPA and on-road than 1978 and earlier years. This reversal was attributed to changes in 1979 test procedures by the EPA and to new vehicle technologies (i.e., diesels, front-wheel drive, fuel injection, and manual transmissions) which were concluded to show a lower EPA to on-road gap than conventional technology vehicles (gasoline engine, rear wheel drive, carburetted,

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14 "Comparison of EPA and On-Road Fuel Economy for 1975-1980 Cars," by B. McNutt, Dept. of Energy; R. Dulla and R. Crawford, Energy and Environmental Analysis, Inc., and H.T. McAdams, Falcon Research and Development Co., February 1981 (Copies of slides from Society of Automotive Engineers presentation).

automatic transmission). The ORFES results showed a similar drop in the EPA to on-road mpg for 1979-1980 vehicles (14.5 to 14.8 percent) over 1977-1978 vehicles (16.6 to 18.3 percent).

Still a third DOE study[15] compared on-road fuel economy and EPA measured fuel economy for the (then) relatively new diesel power passenger cars. This study concluded that: (1) diesel vehicles average 45 percent better on-road fuel economy than comparable gasoline vehicles, and (2) diesel vehicles exhibit significantly less EPA-to-on-road difference than do gasoline vehicles, from 5 percent to 11 percent, at 20 (EPA) mpg and 40 (EPA) mpg, respectively. The ORFES results (Section 2.5.1 and 2.5.2) showed: (1) diesel on-road advantage was 38 percent to 59 percent, depending on car/engine size, and (2) diesel decrease, EPA to on-road, of only 8.4 percent or only slightly more than one-half the decrease noted for the fleet as a whole. Thus the ORFES and DOE findings regarding diesel vehicles are generally similar.

2.7.2 ENVIRONMENTAL PROTECTION AGENCY STUDY

As a consequence of the emerging concern over differences in EPA fuel economy and consumer-achieved fuel economy, the Congress authorized the EPA to conduct a special study to evaluate this issue and to prepare a detailed report on the degree to which laboratory fuel economy data provide realistic estimates of the fuel economy likely to be achieved by the driving

15 "Comparison of Gasoline and Diesel Automobile Fuel Economy as Seen by the Consumer," by Barry D. McNutt, U.S. Dept of Energy, paper for SAE Annual Meeting, December 1980 (meeting February 1981).

public. The EPA study[16] often referred to as the "404 Study," responding to this statutory action produced on-road fuel economy estimates which were lower and EPA to on-road estimates which were higher than those found in ORFES. For the years 1977 through 1979, the 404 study estimated on-road fuel economy to range from 14.7 mpg to 16.9 mpg compared to 15.2 mpg to 17.3 mpg for ORFES. Estimates of EPA to on-road decrease ranged from 19.7 percent to 15.9 for the same years, compared to a range of 18.3 percent to 14.8 percent for ORFES. Much of the data used in the 404 study was the same data used in the DOE studies, discussed above, and hence the reasons for the divergence from the ORFES data are believed to be the same as previously cited, namely, the predominance of fleet data and lack of data on import vehicles for the 404 Study, thereby likely biasing the data insofar as national representativeness was concerned. The EPA did acknowledge in the 404 Report these two shortcomings of the data which could hinder representativeness and therefore introduce a potential bias into the subsequent analysis and conclusions reached in the study.

2.7.3 GENERAL MOTORS STUDY

Schneider[17] et.al., in 1980-1981 conducted an on-road survey utilizing a methodology which closely paralleled the methodology used in NHTSA's ORFES. The survey was confined to 1980 passenger cars, but used a stratified random sample from the R.L. Polk registration files, the same frame used for ORFES. Sample allocation in the GM survey was on a quota

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16 "Passenger Car Fuel Economy: EPA and Road, A Report to the Congress," in Response to the National Energy Conservation Policy Act of 1978, Public Law 95-619, Title IV, Part I, Section 404, Environmental Protection Agency, September 1980.

17 "In-Use Fuel Economy of 1980 Passenger Cars", R.W. Schneider, B.W. Lipka, and F.K. Miller, General Motors Corporation, SAE Paper #810384, February 23-27, 1981 meeting in Detroit, Michigan.

basis relative to each car line (make-model), whereas ORFES used basically a proportional allocation within model years. Both surveys sampled domestic as well as import cars. The GM survey did not cover light trucks. The data collection instrument was also similar to that used in ORFES, consisting of a diary record of fuel purchases and odometer readings. One principal area where the GM survey differed from ORFES was the collection period. The GM data represented only 6 months, August 1980 through January 1981, with over 90 percent of the returns representing only a 3-month driving period, October 1980 through December 1980. ORFES, as previously stated, was conducted throughout an entire 12-month period, January through December of 1983. The response rate was much lower in the GM survey with the diaries constituting the final data base representing only 9.2 percent of the total number (52,770) of diaries originally mailed.

The GM survey found the average on-road fuel economy for the 1980 Model Year passenger fleet to be 19.9 mpg, which is surprisingly close to the ORFES estimate of 20.0 mpg. However, closer inspection reveals that the true GM estimate is probably higher than the ORFES estimate. Since the GM survey was heavily concentrated in 3-month period (over 90 percent in October - December 1980), the seasonal effect on fuel economy was not accounted for. The ORFES survey (Section 2.6 of this chapter) indicates that for the October-December period, overall average fuel economy is lower by approximately one mile per gallon than for the "summer" months (April - September). Therefore, approximately 0.5 mpg would have to be added to the GM, October - December estimates in order to compensate for the seasonal effect on fuel economy. This gives 19.9 + 0.5 = 24.4[18] mpg as the seasonally

[18] This adjustment assumes that there was no significant difference between the seasonal effect of comparable periods of 1980, when the GM survey was conducted, and 1983, when ORFES was conducted.

adjusted GM estimate which is still reasonably close to the ORFES estimate of 20.0 mpg. It should be noted that Schneider et al did recognize this seasonal bias in their data and discussed adjustment factors which were of the same general magnitude as those discussed above, drawn from the NHTSA survey.

2.7.4 FORD MOTOR COMPANY STUDY

The fourth and final study to be compared with the ORFES study was one done by South[19] of Ford Motor Company. This study utilized data from only Ford vehicles operated under lease fleet conditions by Ford employees. Passenger car data for 1978 through 1980 models were presented together with limited results for 1980 light trucks.

The Ford study estimated the (Ford) on-road fuel economy for passenger cars at 14.7 mpg, 16.6 mpg, and 18.7 mpg, for Model Years 1978, 1979 and 1980 respectively. These corresponded to EPA to on-road decreases of 20%, 13%, and 15%, respectively. Corresponding ORFES results for Ford cars (Table 2-5) were 15.1mpg, 16.1 mpg, and 18.8 mpg. These are higher than the South estimates except for 1979, which is lower. For EPA to on-road decrease, ORFES estimates are 17.9%, 15.7%, and 14.5%. ORFES data show lower EPA to on-road difference for 1978 and 1980, and greater EPA on-road difference for 1979.

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19 "1978 to 1980 Ford On-Road Fuel Economy," Neil South, draft of SAE Paper No. 810383 for presentation at 1981 SAE International Congress and Exposition on February 26,1981.

For 1980 light trucks, the limited data of the Ford study estimated on-road fuel economy at 13.9 mpg and 11.6 mpg for two-wheel and four-wheel drive trucks respectively. These corresponded to EPA to on-road differences of 20% for each type (i.e., drive) of truck. Due to smaller sample sizes for light trucks relative to passenger cars, this report does not break out estimates by manufacturer for light trucks. However, for 1980 domestically-produced light trucks, ORFES estimates for on-road fuel economy are:

Two-wheel drive: 14.7 mpg

Four-wheel drive 12.9 mpg

Corresponding ORFES estimates for EPA to on-road differences are:

Two-wheel drive: 16%

Four-wheel drive: 15.1%

For trucks, ORFES on-road estimates are higher than the Ford Fleet estimates and therefore the decreases, EPA to on-road, for ORFES are lower than the Ford fleet estimates.

Summarily, ORFES estimates, for both cars and trucks, generally show higher on-road fuel economy and lower EPA to on-road difference than the Ford study. As with the earlier studies discussed in this Section, the reason for these differences is believed likely due to the difference in representativeness of the data sources employed. It should be noted, however, that the Ford study did find that the amount of EPA to on-road difference remained essentially constant over the model years estimated--a finding which is in agreement with the ORFES study.

2.7.5 SUMMARY OF ORFES COMPARISON WITH OTHER ON-ROAD FUEL ECONOMY STUDIES

It is concluded, from the above comparison of ORFES with other in-use fuel economy studies that the representativeness of the data is the primary factor affecting the on-road fuel economy estimates. Use of primarily fleet data and data which excludes smaller (import) vehicles generally produces lower on-road estimates, and correspondingly, greater laboratory to on-road differences than data representing the general population of American drivers of all vehicles, of all size classes and of both domestic and import manufacture. The General Motors study, which used a sampling methodology most closely approximating that used in ORFES gave on-road estimates closest to those results obtained in ORFES. Aside from these issues, however, several of the other findings and trends were reasonably similar between the prior studies and ORFES.

2.8 ESTIMATED REDUCTION IN FUEL CONSUMPTION AND EQUIVALENT DOLLAR VALUE

This Section estimates the reduced energy consumption and equivalent market value of that reduction resulting from the more fuel efficient vehicles introduced following promulgation of the Federal Fuel Economy Standards. The following paragraphs derive the reductions in energy consumption and dollar equivalents for passenger cars and for light trucks based on the on-road fuel economy achieved by the Nation's motorists and as measured in the On-Road Survey. Estimates are made for the total fleet for the model years studied, and also on a per vehicle basis. For passenger cars, reduced fuel consumption and dollar value estimates are extended to cover Model Years 1982 through 1985.

2.8.1 REDUCED FUEL CONSUMPTION FOR PASSENGER CARS

Federal fuel economy standards for passenger cars began with the 1978 Model Year. Therefore Model Year 1977 is taken as the base year on which to compute estimates of reduced fuel usage.[19a] For purposes of estimating these reductions, the following criteria and simplifying assumptions are used:

(1) The mean total miles traveled (i.e., lifetime vehicle miles) per passenger car is 85,730; this includes mileage of fleet and business use vehicles which were not sampled in the ORFES survey. The lifetime mileage is also a function of the average vehicle miles traveled for a given vehicle age, x, times the probability of survival of the vehicle to age x. (This incorporates the "scrappage rate" of vehicles over time). The basis for this lifetime estimate of per vehicle miles traveled is given in Appendix D.[20]

[19a] As previously stated in this report, fuel economy increases may result from market forces as well as from CAFE standards.

[20] The estimate of 85,730 miles, per average passenger car, lifetime, is considerably less than most all prior studies and surveys have assumed. The primary basis for this lower estimate is the odometer data collected in the ORFES survey and as analyzed in Chapter 3 and Appendix D.

(2) The age distribution of the passenger car fleet ranges from zero to twenty years, with the survival probability for a given vehicle being a decreasing function of its age.[21]

(3) The total U.S. sales of passenger cars (including both domestic and import vehicles) for a given model year is approximately equal to the total U.S. sales of passenger cars for that same calendar year.[22]

Using these assumptions and the data from Table 2-1, the reduction in energy (fuel) consumption is computed as follows:

For Model Year 1978, the reduction in fuel use per vehicle, compared to the 1977 Model Year, is merely the decrease in fuel consumption rate per mile (the reciprocal of mpg) for the newer vehicle times the miles the average vehicle will travel in its lifetime, or:

$$\frac{\text{gal.}}{15.2\text{ mi.}} - \frac{\text{gal.}}{16.6\text{ mi.}} \times \frac{25{,}730\text{ mi.}}{\text{vehicle}} = 475\ \frac{\text{gal.}}{\text{vehicle}}$$

The total reduction in fuel consumed for Model Year 1978 is then the product of the per vehicle reduction and the total number of vehicles in the original (i.e., new) Model Year 1978 fleet. This is:

$$11{,}261{,}569\text{ vehicles} \times 475\ \frac{\text{gal.}}{\text{vehicle}} = 5.346 \times 10^9\text{ gallons}$$

$$= 5.35\text{ billion gallons}$$

21 See Appendix D.

22 Sales by calendar year have been used. Sales figures used are taken from "Wards Automotive Yearbook," 1978 through 1982 editions. Total U.S. passenger car sales, domestic and import, for the five Model Years 1977-1981, respectively, are: 11,168,708; 11,261,569; 10,647,442; 9,976,535; 8,504,686.

Similar computations for Model Years 1979, 1980, and 1981 yield the following estimates of reduced energy consumption. All estimates are based on Model Year 1977 as the base year:

1979 Model Year: total reduction = 7.29 billion gallons
per vehicle reduction = 685 gallons

1980 Model Year: total reduction = 13.51 billion gallons
per vehicle reduction = 1354 gallons

1981 Model Year: total reduction = 13.81 billion gallons
per vehicle reduction = 1624 gallons

The cumulative reduction in fuel consumption, both fleet total and per vehicle average, for the four model years covered by the on-road survey are:

Total reduction for four model years = 39.96 billion gallons

Average per vehicle reduction = 989 gallons

The cost equivalent of the above reductions in fuel use can be estimated by assigning an average cost per gallon of fuel conserved and aggregating these costs over the average lifetime vehicle miles. Since annual vehicle miles traveled vary with vehicle age (more specifically the odometer data in Chapter 3 show that yearly vehicle miles decrease rather markedly with vehicle age, especially after the first few years of vehicle life) and since the real price of gasoline is projected to increase over time, it is therefore necessary to estimate reduced fuel costs per each year of vehicle life. Finally since a portion of the reduced fuel consumption will occur in the future, it is customary to discount such costs to arrive at their present value.

For each vehicle of a given model year, the following formula was used to determine the estimated, lifetime dollar equivalent value of the reduction in fuel used:

$$\text{Dollar value (per vehicle)} = \sum_{i=1}^{20} (VMT)_i \, P(S)_i \, FS \, C_i \, D_i \qquad (1)$$

Where,

$(VMT)_i$ = average annual vehicle miles traveled for a vehicle of age i, where 20 years is considered the maximum age that a vehicle can attain

$P(S)_i$ = probability that a vehicle will survive to age i

FS = per vehicle reduced fuel consumption in gallons per mile driven

C_i = estimated cost, in dollars, per gallon of fuel for year i

D_i = discount factor for year i

The total dollar equivalent for a given model year (j) is then merely the per vehicle dollar value, as estimated from the above equation, times the total number vehicles sold in that model year or

$$\text{Dollar value (Model Year)} = N_j \sum_{i=1}^{20} (VMT)_i \, P(S)_i \, FS \, C_i \, D_i \qquad (2)$$

Where,

N_j = total number of vehicles sold in Model Year j and the remaining factors are as defined in (1) above.

A 10 percent discount rate[23] has been used and all estimates are expressed in terms of 1984 dollars. Appendix D contains further data and information on the computation of the dollar equivalent estimates, including references for pertinent data sources such as the Department of Energy for price projections of gasoline, and the Department of Commerce for data on fleet trucks.

[23] OMB Circular No. A-94, March 27, 1972.

Applying the above methodology for estimating the dollar value of reduced fuel consumption yields the following estimates for each of the four model years for the reduced fuel consumption values computed in the preceding section:

1978 Model Year:	total dollar value = $6.83 billion per vehicle dollar value = $606
1979 Model Year:	total dollar value = $9.33 billion per vehicle dollar value = $876
1980 Model Year:	total dollar value = $16.30 billion per vehicle dollar value = $1,634
1981 Model Year:	total dollar value = $15.30 billion per vehicle dollar value = $1,799

Aggregating the above estimates, the total dollar value due to increased fuel efficiency for the four model years is:

$47.76 billion, or $1,182 per vehicle

Estimates of reduced fuel consumption and dollar equivalents to this point are lifetime vehicle estimates for the first four model years of passenger cars subject to the Federal fuel economy regulations. Estimates have been restricted to this portion of the fleet since the survey only included Model Year 1977 through 1981 vehicles. However, since the present fuel economy standards extend to 1985 and beyond, and the standard levels for each remaining year are known, the present survey provides complementary information (in the form of on-road fuel economy vis-a-vis CAFE levels) which can be used to project similar estimates beyond the Model Year 1978-1981 fleet.

The following calculations project reduced fuel consumption and dollar equivalent through model year 1985. Assumptions used in these projections are the same as those used in the preceding calculations, plus the following additional assumptions:

(1) An average annual sales volume of 10 million vehicles.

(2) The total U.S. passenger car fleet (both domestic and import vehicles) CAFE will average 26.0 mpg for each Model Year, 1982 through 1985.[24]

(3) Actual on-road fuel economy will continue to remain below CAFE levels by approximately 15 percent, the same as the average noted in the Model Year 1978 through Model Year 1981 vehicles covered in this survey.

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[24] The rationale for this assumption is as follows: The overall fleet CAFE, for Model Year 1982 was 26.1 mpg. For Model Year 1983, it fell slightly to 25.9. Certain large manufacturers have had to rely on carry-forward/carry-back credits in order to meet 1983 CAFE standard levels. Without these credits manufacturer CAFE's would have been low by as much as 2.2-2.5 mpg. More recent trends are for customers to purchase increasing numbers of larger vehicles which are less fuel efficient. NHTSA has recently (October 1985) amended the level of the 1986 model year standard for passenger cars from 27.5 mpg to 26.0 mpg. Sales of diesel-powered vehicles (which show marked improvement in fuel economy over generically similar gasoline engine vehicles) have greatly diminished from their peak sales period in 1981. General Motors recently dropped the diesel engine option from essentially all of its passenger car lines. Petroleum supplies continue to remain abundant with prices also remaining relatively stable. Collectively, these factors are believed to offer strong support that overall fleet CAFE levels will not exceed 26.0 mpg, average, per year, 1982 through 1985.

Using these assumptions, the reduction in fuel consumption, per each year, 1982-1985, is computed as follows:

1977 fleet fuel consumption, per mile per vehicle = .065789 gal. (from earlier calculations).

1982-1985 fleet fuel consumption, per mile per

$$\text{vehicle} = \frac{1}{26.0\ \frac{\text{mi.}}{\text{gal.}} \times .85}$$

$$= .0452488\ \text{gal./mi.}$$

Per vehicle reduction, 1982-1985 fleet over 1977 fleet =

$$.065789\ \frac{\text{gal.}}{\text{mi.}} - .0452488\ \frac{\text{gal.}}{\text{mi.}}$$

$$= .0205402\ \text{gal./mi.}$$

Reduction in fuel usage, lifetime, 1982-1985 vehicle =

$$.0205402\ \frac{\text{gal.}}{\text{mi.}} \times \frac{85{,}730\ \text{mi.}}{\text{vehicle}}$$

$$= 1{,}761\ \frac{\text{gal.}}{\text{vehicle}}$$

Reduction in fuel usage, lifetime, Model Year 1982-1985 fleet =

$$\frac{1{,}761\ \text{gal.}}{\text{vehicle}} \times 4 \times 10^{7}\ \text{vehicles}$$

$$= 7044 \times 10^{7}\ \text{gallons}$$

$$= 70.44\ \text{billion gallons}$$

The cost equivalents of these reductions in fuel consumed, computed as before for 1978-1981 models are:

1982 Model Year: total dollar value = $17.84 billion
per vehicle dollar value = $1,784

1983 Model Year: total dollar value = $16.21 billion
per vehicle dollar value = $1,621

1984 Model Year: total dollar value = $14.61 billion
per vehicle dollar value = $1,461

1985 Model Year: total dollar value = $13.48 billion
per vehicle dollar value = $1,348

Total dollar value, total 1982-1985 fleet = $62.14 billion

Finally, by adding to these totals the reductions in fuel consumption and dollar equivalents previously computed for the 1978-1981 fleets, it can be stated that the estimated reductions in fuel consumption and dollar equivalents, lifetime, for all Model Years 1978-1985 of passenger cars, subject to Federal Fuel Economy Standards are:

Per Vehicle:

Reduced fuel consumption = 1,373 gal.

Dollar value = $1,367

Total Fleet (Model Years 1978-1985):

Reduced fuel consumption = 110.40 billion gallons

Dollar value = $109.90 billion

2.8.2 REDUCED FUEL CONSUMPTION FOR LIGHT TRUCKS

Federal standards for light trucks took effect in 1979, one year later than for passenger cars. Therefore, Model Year 1978 is taken as the base year from which to compute estimated reductions in fuel use. The same criteria and assumptions used for passenger cars are used here for light trucks with one minor exception, the average lifetime miles for trucks (see Appendix D) is slightly less at 85,427. Calendar year vehicle sales were taken from Wards Automotive Yearbooks.[25] The sales data on trucks were not as detailed as those for passenger cars. Therefore, certain minor adjustments had to be made. The resulting numbers are shown in Table 2-18.

TABLE 2-18

CALENDAR YEAR SALES OF LIGHT TRUCKS, MODEL YEARS 1979-1981

	MODEL YEAR		
Drive Configuration	1979	1980	1981
Two-Wheel Drive	1,484,802	1,994,363	1,823,977
Four-Wheel Drive	255,934	450,267	369,495

For Model Year 1979, the sales figures are for trucks with GVWR of 6,000 pounds or less, while for 1980-1981, the figures are for trucks with GVWR up to 8,500 pounds.

25 Footnote 26, Op. Cit.

Using data from Tables 2-11 and 2-18, the fuel reductions and dollar equivalents are estimated in the following computations. Estimates are made separately for two-wheel drive and four-wheel drive configurations, with computation procedures similar to those used for passenger car fuel reductions and dollar equivalent estimates.

2.8.2.1 REDUCED CONSUMPTION FOR TWO-WHEEL DRIVE TRUCKS

For Model Year 1979, the reduced fuel consumption per vehicle, compared to the 1978 base year, is given by:

$$\frac{\text{gal.}}{15.2\text{ mi.}} - \frac{\text{gal.}}{15.7\text{ mi.}} \times \frac{85{,}427\text{ mi.}}{\text{vehicle}} = 179\ \frac{\text{gal.}}{\text{vehicle}}$$

The total reduction for the 1979 fleet over the 1978 fleet is therefore:

$$1{,}484{,}802\text{ vehicles} \times 179\ \frac{\text{gal.}}{\text{vehicle}} = 0.2658 \times 10^9\text{ gallons}$$

$$= 0.27\text{ billion gallons}$$

Similar computations for Model Years 1980 and 1981 yield the following estimates of energy reduction, based on Model Year 1978 as the base year.

1980 Model Year: total reduction = 2.31 billion gallons
per vehicle reduction = 1,159 gallons

1981 Model Year: total reduction = 2.41 billion gallons
per vehicle reduction = 1,321 gallons

Aggregating the above estimates, the lifetime reduction in fuel consumption for two-wheel drive light trucks for Model Years 1979 through 1981 is found to be:

Total fleet reduction = 4.99 billion gallons

Per vehicle fuel reduction = 940 gallons

Converting the above two estimates to dollar equivalents, using the same criteria and assumptions as for passenger car yields:

Total fleet value = $5.41 billion

Per vehicle average value = $1,020

2.8.2.2 REDUCED CONSUMPTION FOR FOUR-WHEEL DRIVE TRUCKS

For Model Year 1979, the fuel reduction per vehicle compared to the 1978 base year, is given by:

$$\frac{\text{gal.}}{13.7\text{ mi.}} - \frac{\text{gal.}}{12.9\text{ mi.}} \times \frac{85{,}427\text{ mi.}}{\text{vehicle}} = -387\ \frac{\text{gal.}}{\text{vehicle}}$$

Since the estimate for the 1979 fleet is negative, relative to the 1978 fleet, no reduction is estimated for the 1979 four-wheel drive light truck fleet. Rather there is an estimated decrement of:

$$(255{,}934 \text{ vehicles} \times (-387 \frac{\text{gal.}}{\text{vehicle}}) = -0.10 \text{ billion gallons}$$

Using the same procedures, fuel reductions for the 1980 Model and the 1981 Model Year four-wheel drive light truck fleets are computed to be:

1980 Model Year: total reduction = 0.30 billion gallons

per vehicle reduction = 664 gallons

1981 Model Year: total reduction = 0.41 billion gallons

per vehicle reduction = 1,108 gal.

Accumulating the above model year estimates the total reduction in fuel use for four-wheel drive light trucks for Model Years 1979 through 1981 is:

Total reduction = 0.61 billion gallons

Per vehicle reduction = 566 gal.

In dollar equivalent values, the estimates are:

Total dollar value = $0.66 billion[26]

Per vehicle value = $610

2.8.3 REDUCED FUEL CONSUMPTION, LIGHT VEHICLE FLEET

By aggregating results from the previous sections on passenger cars and light trucks, total estimates for the entire light vehicle fleet are obtained. These are the total estimated reductions in energy consumption and dollar equivalent values (vehicle lifetime) resulting from the more energy-efficient passenger cars and light trucks produced from the beginning of the Federal Fuel Economy Standards (Model Year 1978 for passenger cars; Model Year 1979 for light trucks) through the 1981 Model Year. The base year for these estimates is Model Year 1977. These estimates are summarized in the following tables:

[26] These estimates may be conservative since the on-road survey did not produce estimates for import four-wheel drive trucks for Model Year 1979. These vehicles due to their considerably higher fuel economy would raise the overall (domestic plus import) fleet average above that of the domestic vehicles used in the estimate. On the other hand, the estimates are likely overstated for 1980-81 due to the fact that the baseline period is representative of only domestic vehicles, whereas the 1980-81 periods include both domestic and import vehicles.

TABLE 2-19 (a)

TOTAL REDUCTION IN FUEL CONSUMPTION AND EQUIVALENT DOLLAR VALUE--PASSENGER CARS AND LIGHT TRUCKS

VEHICLE TYPE	REDUCED FUEL CONSUMPTION (billion gals.)	DOLLAR VALUE (billions)
Passenger Car	39.96	$47.76
Light Trucks:		
Two-wheel Driv	4.99	5.41
Four-wheel Drve	0.61	.66
TOTAL SAVINGS	45.56	$53.83

TABLE 2-19 (b)

PER VEHICLE REDUCTION IN FUEL CONSUMPTION AND EQUIVALENT DOLLAR VALUE - PASSENGER CARS AND LIGHT TRUCKS

VEHICLE TYPE	REDUCED FUEL CONSUMPTION (gals)	DOLLAR VALUE (dollars)
Passenger Cars	989	$1,182
Light Trucks:		
Two-wheel Drive	940	1,020
Four-wheel Drive	566	610
Overall Average	974	$1,146

2.8.4 DISCUSSION OF REDUCED FUEL CONSUMPTION AND DOLLAR EQUIVALENT ESTIMATES

It is customary in the Agency's typical evaluation studies of its major regulations to estimate the benefits attributable to such regulations together with the costs of implementing the regulations. This provides a basis for comparing the costs and benefits or a basis for assessing cost-effectiveness of the given regulation.

Due to the pervasive scope and complex nature of the motor vehicle changes made in the drive for greater fuel efficiency, cost estimates of these changes were not made. In addition to technological changes such as diesel engines and improved transmissions, essentially all major domestic carlines were redesigned and "downsized". While specific cost estimates have not been made, the impact and effect of the changes can be said to be large indeed, perhaps one of the greatest changes in the history of the automotive industry and one whose costs have variously been said to be in the several billions of dollars.

As to the crediting of the reduced fuel consumption (i.e., benefits) estimated in this report to the Federal fuel economy regulations, this is also not a straightforward exercise. The fuel economy regulations took effect in Model Year 1978 (calendar year 1977) for cars and Model Year 1979 (calendar year 1978) for light trucks. During the mid-1970's, however, following the Arab oil embargo, a shift in market demand for more fuel-efficient vehicles emerged. The "second oil shock" of 1979 increased the importance of this factor.

The following statements are quoted from the Secretary of Commerce's annual report[27] to Congress on the Chrysler Corporation Loan Guarantee Act of 1979 (Section 126, P.L. 96-185):

> "These trends (i.e., a fundamental shift in consumer demand toward smaller, more fuel-efficient vehicles, etc.) emerged in the mid 1970s, but did not present serious challenges to U.S. auto manufacturers until a second round of oil price shocks in 1979 fundamentally altered the competitive environment in the world motor vehicle industry."

> "In the United States in particular, gasoline prices rose sharply from 1979 to 1981 and led to a dramatic shift in consumer demand in favor of smaller, more fuel-efficient automobiles......."

> "Virtually overnight, the small car share of the U.S. market jumped from 27 percent in 1979 and increased to 61.5 percent in 1981."

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[27] "The U.S. Automobile Industry, 1983, Report to the Congress from the Secretary of Commerce, December 1984.

While no meaningful cost versus benefit comparison[28] can be made of the CAFE Standards per se, the estimates of the reduction in energy consumed and dollar equivalent value derived in this study (45.6 billion gallons of fuel; $53.8 billion) are considered conservative for the following reasons: (1) The estimates only include vehicle model years through 1981; design and technological changes implemented through 1981 have been carried forward in many instances to subsequent years which means that additional benefits will accrue as a result of those changes. (2) The estimates begin with the 1978 model year; they, therefore, exclude the 1977 full-sized GM cars which represented the first portion of the fleet to be "downsized" in the drive for greater fuel economy.

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[28] While the usual cost versus benefits comparisons for the CAFE standards per se cannot be made, NHTSA, as part of its Regulatory Impact Analysis of each CAFE standard promulgated, has analyzed the cost effectiveness of fuel efficiency improvements available at that time to the manufacturers. The cost effectiveness of fuel efficiency improvements is defined as the estimated retail price increase to consumers, of the vehicle modifications, versus the present discounted value of fuel saved over the vehicle's lifetime. These analyses showed that cost-effective fuel efficiency improvements were available.

These analyses were "before the fact" (i.e., conducted prior to the actual production and sale of the vehicle) whereas the analysis in the study is "after the fact," covering vehicles after they have been introduced into the Nation's fleet and have accumulated real-world experience.

CHAPTER 3

ANALYSIS OF SURVEY RESULTS OF VEHICLE MILES TRAVELED

3.0 INTRODUCTION

The original design of the On-Road Fuel Economy Survey (ORFES) did not have as one of its primary objectives the estimation of vehicle miles traveled (VMT). The major emphasis was on the estimation of on-road fuel economy. However, it was recognized early in the project that the collection of actual odometer readings on a large, national probability sample of vehicles would also provide a basis for estimating vehicle miles of travel, and that such information could be a second important use of the survey data. Travel data are also of considerable interest to NHTSA as well as to several other agencies. While there have been prior studies and surveys of the average and yearly travel of motor vehicles, as far as is known, none have been based on actual vehicle odometer readings. These former studies have relied primarily on data in the form of subjective estimates by vehicle owner/drivers as to the total miles a given vehicle was driven in a particular period, typically a year.

It will be recalled that the questionnaire design, a fuel-mileage log, requested respondent reporting for a one-month period, of not only the amounts of fuel purchased and other data, but also the actual odometer readings, for the sampled vehicle, at each such fuel purchase. These odometer readings, which were necessary to accurately develop fuel economy estimates, are used in this chapter to estimate vehicle miles of travel, both on an annual basis, by the age of the vehicle, and on a total, or overall, vehicle lifetime basis, for the given model year (or vehicle age) groups represented in the on-road survey.

3.1 METHODOLOGY FOR ESTIMATING VEHICLE MILES TRAVELED

The methodology used to develop the VMT estimates was as follows:

(1) The respondent-reported odometer readings of each vehicle were assumed to represent the total accumulated (i.e., lifetime) miles traveled for that vehicle as of the dates the vehicle was sampled in the survey. The specific odometer reading used for each vehicle in estimating VMT was the average odometer reading for the one-month (nominal) period during which the fuel-mileage diary record was kept for that vehicle. The average here was defined as the arithmetic mean of the lowest and highest odometer readings for the reporting, or diary period for each vehicle. Symbolically,

$$O_i = \frac{O_1 + O_f}{2} \qquad (1)$$

where,

O_i = average odometer reading for ith vehicle in survey

O_1 = initial odometer reading for sample period (typically one month) for ith vehicle

O_f = final odometer reading for sample period for ith vehicle

(2) For each model year, or age group of vehicles, the overall average odometer reading was simply the weighted arithmetic mean of the odometer readings as defined in (1) above, using as weights the actual numbers of registered vehicles[1] in the population as described in the previous chapter on fuel economy.

The formula for computing the average odometer reading for a given model year (or age group) stratum is given by:

$$O\ age\ (j) = \sum_{h=1}^{K} W_h\, O_h \qquad (2)$$

[1] As previously stated in the Chapter on Fuel Economy, the number of vehicles in the national fleet, or populations, were taken from the annual registration files maintained by R. L. Polk Company.

where,

O age (j) = overall average odometer reading for j<u>th</u> model year group,

O_h = average odometer reading for h<u>th</u> stratum

W_h = proportion of vehicles in stratum h, relative to the total number of vehicles in the overall (j<u>th</u>) group.

In the above formula (2), O_h is given by:

$$O_h = \sum_{j=1}^{1} W_j \left(\frac{\sum_{i=1}^{n} O_i}{n} \right)$$

where O_i is given by (1) and n is the number of sample vehicles in substratum j. The W_j are weights corresponding to the proportion of vehicles in each substratum relative to the total number of vehicles in stratum h.

(3) Since the vehicles were sampled throughout the entire twelve months (January through December) of Calendar Year 1983, the average odometer reading for each model year group, as defined in formula (2), above, was assumed to represent total lifetime vehicle miles traveled as of July 1, 1983, or the midpoint of the calendar year in which the data were collected.

(4) The average age of a given model year group of vehicles is estimated by assuming that sales of vehicles of each model year begin on October 1 of the previous calendar year and continue for approximately 14 months. Sales typically extend over more than a 1 year or 12-month period due to year-end

sales of "left-over" or previous model year vehicles at the beginning of a new model year. Sales data indicate that vehicle sales per month over this 14-month period are distributed somewhat unevenly. The method of estimating average vehicle age as of the July 1, 1983, mid-point of the survey was to compute a weighted average age using monthly vehicle sales data. Model year 1977 sales were chosen as typical and data together with computation methods are shown in Appendix B.

Using the above assumptions, average odometer readings were computed for each of the 5 model year/age groups of vehicles. Computations were made by vehicle type (car, truck), size class, fuel type (gasoline, diesel), and number of drive wheels (trucks only). All computations are weighted arithmetic means using actual counts of registered vehicles as described in the above paragraphs. As stated above, the odometer reading of each vehicle at the point at which the vehicle is sampled in the survey is assumed to represent the total miles traveled by that vehicle at that point in the life of the vehicle. Therefore, the computations of odometer readings presented and discussed in the following sections of this chapter will be referred to as vehicle miles traveled or simply VMT.It should be remembered that the survey only included privately-owned vehicles, and did not include passenger car fleets, i.e., rental, business, etc. Odometer readings from approximately 9,000 total vehicles were analyzed. Sample sizes for each of the five model years (including both cars and trucks) ranged from 1,084 for 1977 models to 2,662 for 1981 models.

3.2 VEHICLE MILES TRAVELED ESTIMATES

3.2.1 OVERALL ESTIMATES BY MODEL YEAR AND VEHICLE TYPE

Table 3-1 displays the average (i.e., per vehicle) total vehicle miles traveled, as of the July 1, 1983, midyear point of the survey as discussed above. Estimates are shown for passenger cars and for light trucks for each of the 5 model years represented in the survey.

Of special interest is the extremely close correspondence in miles traveled between the 2 vehicle types. So close is this agreement that the question of whether any statistically significant difference exists between the VMT for cars and light trucks is essentially a moot point. Certainly, no practical significance exists. The two vehicle types can be considered as one general class and overall estimates for this combined group are shown in the third column of the table.

TABLE 3-1

TOTAL VEHICLE MILES TRAVELED, AS OF JULY 1, 1983, BY TYPE OF VEHICLE AND MODEL YEAR

Model Year	Passenger Cars	Light Trucks	Overall
1981	28,776	28,573	28,739
1980	38,579	39,607	38,759
1979	46,838	48,050	47,080
1978	53,212	54,073	53,378
1977	59,034	57,689	58,782

3.2.1.1 VARIABILITY OF OVERALL VMT ESTIMATES

The estimates of VMT given in Table 3-1 are means, or averages. In a statistical survey of this type, it is also of interest to know something about the reliability of the (mean) estimates, or something about the variability of the data. Variability estimates can be developed for surveys such as ORFES which are carried out according to probability sampling methods.

Two generally accepted measures of variability are the sample standard deviation and the standard error. The standard deviation is a measure of the variability of all the individual observations that comprise the sample, or, in this case, an indication of the vehicle-to-vehicle variability in VMT. The standard error, on the other hand, is an indication of the reliability, or precision, of the sample mean, or the average VMT.

Table 3-2 lists the sample standard deviation and the standard error for each of the five Model Years for the combined (cars plus trucks) vehicle classes of Table 3-1. Looking first at the standard deviation column, it is seen that there is considerable variation in VMT among the individual vehicles comprising each Model Year group. This variation ranges from 14,109 miles for the 1981 vehicles to 23,784 miles for the 1977, or oldest vehicles. In terms of differences in miles driven, these numbers appear quite large, indeed.

TABLE 3-2

STANDARD DEVIATION AND STANDARD ERRORS FOR VMT
ESTIMATES BY VEHICLE MODEL YEAR

Model Year	Sample Size (n)	Mean VMT ($\bar{x}$)	Standard*/ Deviation (s)	Standard**/ Error (S.E.)	Coefficient of Variation (c.o.v.)	Relative Std. Error (R.S.E.) %
1977	1,084	58,782	23,894	841	.405	1.43
1978	1,471	53,378	23,116	631	.433	1.18
1979	1,722	47,080	19,487	549	.414	1.17
1980	1,975	38,759	18,379	430	.474	2.34
1981	2,662	28,739	14,109	301	.491	2.13

* Weighted, pooled standard deviation from individual stratum variances.
** Weighted standard error from individual stratum standard errors.

A second way of viewing the variation among samples is via the coefficient of variation (c.o.v.), which is defined as ($s/\bar{X}$), and therefore is a measure of the degree of variation in VMT among the individual vehicles relative to the mean VMT for that age group. Column 5 of Table 3-2 lists the c.o.v.'s. Again, it is observed that the variation and VMT is quite large, ranging from approximately 40 percent to nearly 50 percent, relative to the mean VMT. While the actual magnitude of the variation in VMT appears to increase with vehicle age, the opposite is true for the relative variation, with the youngest vehicles showing the greatest variation, relative to the mean VMT.

The standard errors for the mean VMT estimates of the five Model Year groups are also shown in Table 3-2, column 7. The standard error gives an indication of the variability of the sample mean. As the table shows, the standard errors are quite small; relative to the mean, the standard errors range from approximately 1 to 2 percent. Similar to the trends noted for the standard deviation, it is seen that the magnitude of the standard error increases for older vehicles whereas on a relative basis, the error is larger for the newer vehicles. Since the standard error is inversely related to the square root of the sample size, part of the reason for the smaller standard errors for later model years is that larger sample sizes were taken for newer vehicles.

Using data from Table 3-2, two additional statistics are presented which provide additional information on the variability of the ORFES VMT estimates. These statistics are: (1) the 95 percent confidence interval on the mean VMT, and (2) the 95 percent x 95 percent tolerance limits on VMT for individual vehicles in each of the model year groups. Both of these statistics assume a normal distribution for the population VMT parameter, and are shown in Table 3-3.

The 95 percent confidence limits from column 3 of the table indicate that the mean estimates for VMT are quite precise. The width of the intervals ranges from a low of approximately 1,200 miles (for 1981 vehicles) to a high of approximately 3,300 miles (for 1977 vehicles). The interpretation of these intervals is that, in repeated samplings of vehicles, such as conducted in ORFES, 95 percent of the intervals constructed from the sample data would contain the true mean VMT for the entire fleet population represented (e.g., 1978 vehicle fleet, 1979 vehicle fleet, etc.).

TABLE 3-3

NINETY-FIVE PERCENT CONFIDENCE LIMITS AND TOLERANCE LIMITS ON VMT BY VEHICLE MODEL YEAR

Model Year	Mean VMT (X)	95% Confidence Interval	95% x 95% Tolerance Limits
1977	58,782	57,134-60,430	10,263-107,301
1978	53,378	52,141-54,615	6,221-100,535
1979	47,080	46,004-48,156	7,327-86,833
1980	38,759	37,536-39,602	1,266-76,252
1981	28,739	28,149-29,329	-43*-57,521

* Considered a minor anomaly (VMT can't be negative)

Ninety-five x ninety-five percent tolerance limits on individual vehicle VMT are listed in the last column of Table 3-3. Tolerance limits refer to the VMT for each individual vehicle in the population as contrasted with the confidence limits which refer to the mean VMT for all vehicles in the population. The interpretation of tolerance intervals is that in repeated survey samples of vehicles, such as conducted in ORFES, the 95 percent of the intervals constructed from the sample data would encompass the VMT for 95 percent of the total vehicles in the population.

Once again, the great variation in VMT among vehicles within the same age group is apparent. For example, the VMT among individual 1977 model year vehicles is seen to range over nearly 100,000 miles! Nineteen seventy-seven vehicles were approximately 6.2 years old at the time of the on-road survey. The other model year groups show similar wide ranges for the VMT among individual vehicles. These data indicate that within each vehicle age group there are a small percentage of vehicles which have accumulated very high VMT, and also a small percentage which have been driven very few miles.

The principal point that stands out in the above statistics is that for each age group, the variability in VMT per vehicle is very large. VMT per vehicle does not cluster around the mean VMT for a given age group, but rather exhibits wide dispersion around the mean. The method used in allocating the sample among strata (i.e., oversampling a few small strata in order to increase the precision of the estimates for these strata) has the effect of increasing the magnitude of the variance estimates. However this effect is considered minor relative to the magnitude of the variance estimates for VMT, as shown above.

3.2.2 ESTIMATES BY SIZE CLASS

Estimates of total miles traveled by vehicle size class are shown in Tables 3-4 and 3-5 for passenger cars and light trucks respectively. A general perusal of these tables indicates that little difference of a practical nature exists due to vehicle size class for either cars or trucks. Furthermore, this finding is true between two-wheel drive and four-wheel drive trucks. For trucks, there is some indication of slightly higher travel by vans, but the magnitude is not considered of practical significance. For passenger cars, large station wagons appear to accumulate somewhat higher mileage than other car classes, while compacts and midsize cars seem to have been driven the least.

For the passenger car size classes an average rank order for the five model years was computed. A "1" was assigned to the highest VMT within each model year and an "8" to the lowest VMT. The average ranks appear in Table 3-6.

TABLE 3-4

TOTAL VEHICLE MILES TRAVELED
PASSENGER CARS BY SIZE CLASS

Size Class	1981	1980	-MODEL YEAR- 1979	1978	1977
Mini	31,805	45,271	47,201	50,212	65,748
Subcompact	30,114	38,784	50,449	57,641	59,330
Compact	29,832	35,530	45,976	49,336	56,981
Midsize	26,558	37,394	44,004	50,419	55,693
Large	29,082	37,825	46,069	54,323	61,254
Small St. Wagon	29,725	45,635	46,008	60,677	62,417
Midsize St. Wagon	30,157	39,138	49,620	56,442	60,124
Large St. Wagon	31,847	45,651	49,265	59,847	66,616

NOTE: Sample sizes range from 24 to 569 for each of the above year-size class categories.

TABLE 3-5

TOTAL VEHICLE MILES TRAVELED
LIGHT TRUCKS BY SIZE CLASS

Size Class	MODEL YEAR 1981	1980	1979	1978	1977
2-Wheel Drive					
Small Pickup	31,469	34,766	47,418	54,169	61,477
Standard Pickup	26,069	41,475	47,809	51,997	55,750
Van	31,045	43,953	51,857	59,322	61,014
Special Purpose	29,483*	55,702*	53,062*	40,243*	67,435*
Overall 2-Wheel Drive	28,393	40,197	48,767	54,380	58,242
4-Wheel Drive					
Small Pickup	33,128	40,225	**	**	**
Standard Pickup	28,648	35,969	**	**	57,788*
Special Purpose	27,127	38,981	43,592	51,952	52,102
Overall 4-Wheel Drive	29,362	37,862	43,592	51,952	52,535

Sample size for each of the individual year-size class groups ranges from 20 to 170.

*Very small sample size (< 10)

**Not sampled

TABLE 3-6

AVERAGE VMT RANK BY SIZE CLASS, PASSENGER CARS

Size Class	Average Rank (All Model Years
Mini	3.6
Subcompact	3.8
Compact	7.0
Midsize	7.4
Large	5.4
Small Station Wagon	3.6
Midsize Station Wagon	3.6
Large Station Wagon	1.6

This table does indicate, as previously stated, that large station wagons tend to accumulate higher mileage while compacts and midsize cars accumulate lower mileage. Statistical tests on the data for the 1977 Model Year indicate that the only significant differences in VMT are between the large station wagon/mini classes and the compact/midsize classes. Practically speaking, however, it is doubtful whether such differences are meaningful. The difference noted for the 1977 vehicles are for the total VMT accumulated over the life of the vehicles which are slightly more than six years old on the average. On a per year basis, the difference in VMT would be much less.

3.2.3 ESTIMATES BY TYPE OF FUEL

Since fuel costs vary appreciably between gasoline and diesel vehicles, it was considered of interest to investigate whether type of fuel was associated with the amount of miles traveled. Tables 3-7 and 3-8 summarize a comparison of total VMT for the common vehicle classes (e.g., classes where both diesel and gasoline engines were represented) and for both cars and trucks. This comparison reveals that, indeed, a difference exists due to fuel type. Diesel vehicles show consistently higher mileage than vehicles powered by conventional gasoline engines and this difference is considerably greater for passenger cars than for light trucks. It also appears that within cars, size class may be a factor as well with small subcompact cars showing greater excess of travel diesel versus gasoline, than for midsize and large cars. The reason(s) for the higher travel for diesel vehicles is believed most likely due to the lower fuel cost per mile driven for diesel vehicles, although other factors such as purpose /type of driving could also be involved. Chapter 2.0, Section 2.5 showed estimates of the on-road advantage in fuel efficiency for diesel vehicles over gasoline vehicles.

TABLE 3-7

VEHICLE MILES TRAVELED - PASSENGER CARS
GASOLINE VERSUS DIESEL

SIZE CLASS	- MODEL YEAR - 1981	1980	1979	1978
Diesel-Subcompact	41,390	55,707	64,073	*
Gas-Subcompact	29,543	37,962	50,117	*
Diesel (Midsize, Large Midsize/Large Station Wagon)	34,998	45,298	54,863	62,682
Gas (Midsize, Large, Midsize/ Large Station Wagon	26,941	37,385	45,239	54,899

*Insufficient sample size

TABLE 3-8

TOTAL VEHICLE MILES TRAVELED
GASOLINE VERSUS DIESEL
LIGHT TRUCKS

SIZE CLASS	MODEL YEAR 1981	1980	1979	1978
Diesel Small Pickup	34,445	53,043*	No Diesels Available	
Gas Small Pickup	30,911	34,117	--	--
Diesel Standard Pickup	33,625	43,383	48,446	56,327
Gas Standard Pickup	25,930	41,360	47,789	51,195

Sample sizes range from 21 to 146 for each year-size class group

*Sample size < 10

3.2.4 ANNUAL VMT ESTIMATES

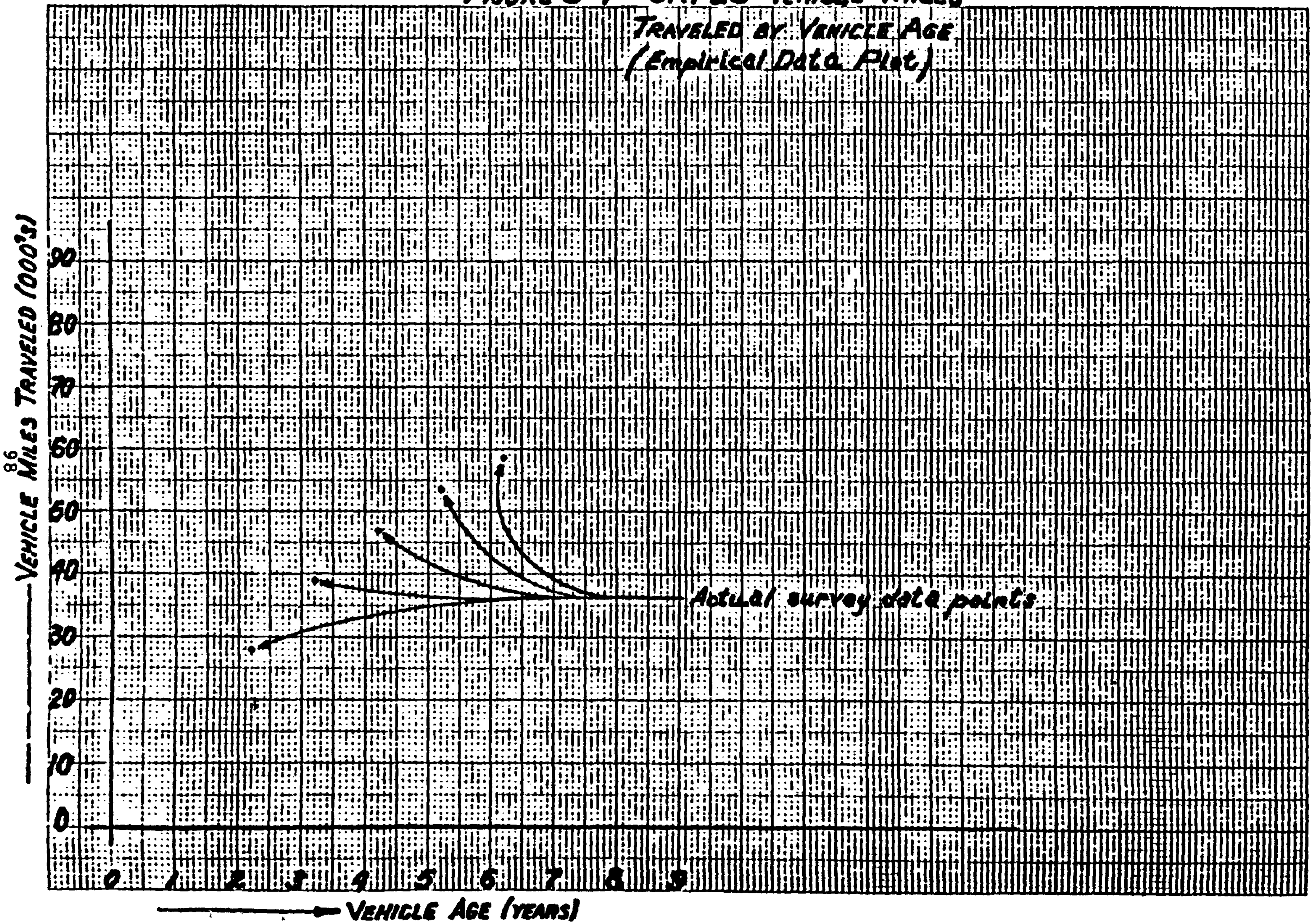
Using the survey estimates of vehicle travel given in the previous sections, estimates can be made of the annual VMT as a function of the age of the vehicle. The overall estimates (i.e., Column 4) given in Table 3-1 are chosen as the basis for estimation of annual VMT. These data are selected since the individual estimates for passenger cars and trucks are extremely similar, and also since the total sample size for each age category will be the largest, thereby decreasing the statistical variability of the estimates. The annual VMT estimates thus developed will apply to the total U.S. Fleet of light vehicles including both passenger cars and light trucks.

As a first step in the estimation process, the data from Table 3-1 were plotted to give a visual picture of the relationship between VMT and vehicle age. This is done in Figure 3-1 with VMT as the ordinate and vehicle age as the abscissa. The average ages of the model year groups of vehicles at the July 1, 1983, mid-year point (the point for which the average model year odometer readings are computed are:

Model Year	Average Vehicle Age on July 1, 1983
1981	2.2 years
1980	3.2 years
1979	4.2 years
1978	5.2 years
1977	6.2 years

(NOTE: see Appendix B for explanation of average age computation)

FIGURE 3-1 ORFES VEHICLE MILES TRAVELED BY VEHICLE AGE (Empirical Data Plot)



Note from Figure 3-1 that the five average odometer readings as computed from the survey data form a very smooth function. A curve can be drawn through the five points with essentially no discernable dispersion, or scatter, of any point from the curve. The function is definitely curvilinear with a declining slope which indicates a decline in annual VMT with the age of the vehicle.

The curvilinear plot of the data suggest that a logarithmic function might fit the points reasonably well (i. e., be used to explain the relationship between VMT and vehicle age). The following function was fitted:

$$y = a + b \log x$$

where y represents VMT in miles as indicated by the vehicle odometer readings),

x represents vehicle age in years, and a and b are constants to be determined.

Resulting computations showed that indeed, the logarithmic function fits the data quite well. Figure 3-2 displays the fitted function which is:

$$y \text{ (miles)} = 5{,}445 + 66{,}996 \log x \text{ (age)}$$

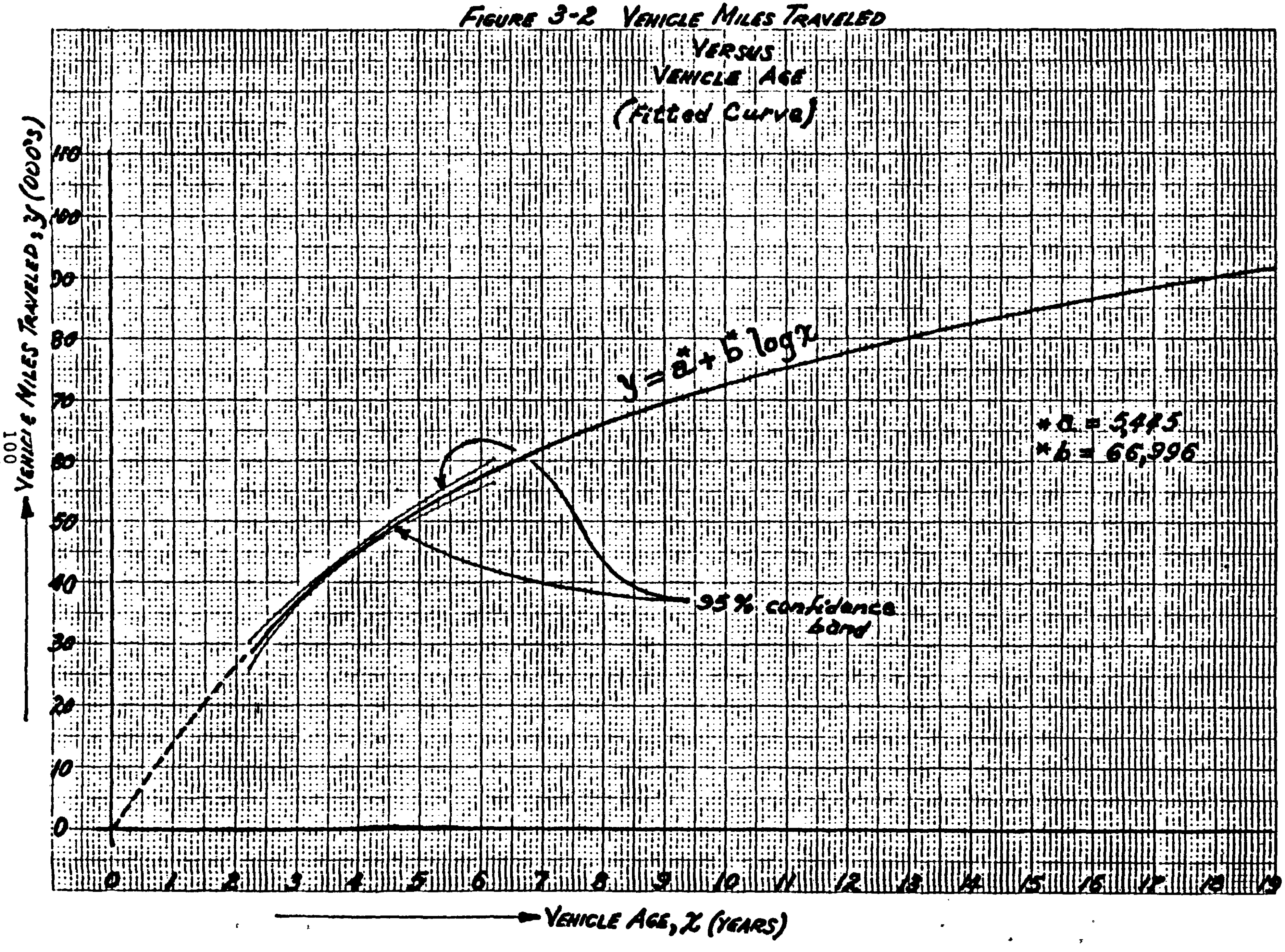


Figure 3-2 Vehicle Miles Traveled
Versus
Vehicle Age
(Fitted Curve)
y = a* + b* log x
95% confidence band
* a = 5415
* b = 66,996
Vehicle Miles Traveled, y (000's)
Vehicle Age, x (Years)
0
10
20
30
40
50
60
70
80
90
100
110
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

The fitted curve is plotted in Figure 3-2 for the vehicle age range 2.2 years through 19 years. The coefficient of determination (r^2_{xy}) and the standard error of the estimate (Sy.x) for the fitted equation are:

$$r^2_{xy} = .99945,$$

$$Sy.x = 302.25 \text{ miles}$$

These statistics indicate a very close fit for the VMT curve. Over 99.9 percent of the variation in the dependent variable, y, or VMT, is explained by the function. Computing 2-standard error limits (equivalent to 95 percent confidence limits) for y give $\pm$ 590.45 miles, a very small range of error.

A second view of the close fit of the equation is afforded by Table 3-9 which compares the dispersion between the observed and predicted values of VMT.

TABLE 3-9

COMPARISON OF OBSERVED AND PREDICTED VMT

x (yrs.)	VMT Observed	VMT Predicted	Difference (Obs.-Pred.)	Percent Difference
2.2	28,739	28,386	353	1.2
3.2	38,759	39,288	-529	-1.4
4.2	47,080	47,200	-120	-0.3
5.2	53,378	53,414	- 36	-0.07
6.2	58,782	58,532	250	0.4

Again, the high degree of fit is demonstrated with the relative difference between the observed VMT and predicted VMT from less than 1/10 of one percent to 1.4 percent. The actual data points were not plotted on Figure 3-2 (as is often done in typical curve-fitting analyses) because they would be virtually indistinguishable from the line itself.

Finally, 95 percent confidence intervals for VMT were computed for each of the five sampled vehicle age points. These are shown on Figure 3-2. The width for each of these intervals, from vehicle age 2.2 years to 6.2 years respectively, are: 2,136 miles, 802 miles, 349 miles, 1,041 miles, and 1,664 miles.

NOTE: The very good fit of the above function may, in some respect, be due to the fact that the five VMT data points represented means of reasonably large samples rather than individual VMT readings. Nevertheless, the near-collinearity of the observed points apart from the fitted equation is considered surprising, if not remarkable.

The logarithmic function in Figure 3-2 is plotted over the vehicle age range of 2.2 years (the newest vehicles covered in ORFES) to a vehicle age of 19 years. While the survey only included vehicles up to 6.2 years of age, it is considered reasonable to extend the curve[2] for the following reasons:

(1) The statistical fit of the curve is very good, as confirmed by the above measures of goodness of fit.

(2) The actual data points, apart from a curve-fit, are so well defined that a curve can be simply hand-fitted through them with essentially no discernable dispersion, or scatter (see Figure 3-1).

(3) The form of the VMT-age function appears to be definitely curvilinear, with a continuously declining slope. This implies that VMT decreases as the age of the vehicle increases. This decreasing rate of VMT with vehicle age is reasonable, and in accord with intuition. Vehicles wear out--not only due to mileage, but also simply due to environmental degradation and decay (i.e., rust, corrosion, hardening/cracking of rubberized and plastic components) which in general affects all systems and

---

2 Extension of the VMT-Age curve is made with full recognition of the long-standing general statistical caution against extrapolation beyond the bounds of the sample data. One of the reasons for this caution is that typically little or no a priori information is available concerning the relationship of the fitted variables, beyond the range of the empirical data. We have considerable a priori knowledge here about the nature of the underlying process operating to define the function, namely, that VMT decreases, in general, with vehicle age.

components of the vehicle. Thus, as vehicles age, it seems quite logical that they are driven less due to decreased vehicle reliability and increased cost of operation.

That vehicles are driven less as they become older is generally supported by other VMT surveys which are discussed later in this chapter.

Therefore, there is strong support for a VMT-vehicle age function which has a declining slope.

An extension of the logarithmic function vehicles newer than 2.2 years does not fit well, since at a vehicle age of slightly less than one year, the curve would intersect the x-axis. This indicates a VMT of zero, and realistically for an average vehicle, zero mileage should coincide with zero age. A visual review of Figure 3-2 indicates that the form of the true function between age 2.2 years and zero years should be essentially linear, since the extension of the function from 2.2 years must pass through the origin. In keeping with the curvilinear relationship of the statistically fitted function, it is considered reasonable to hand-fit the remaining portion of the function over this short (zero-to-2.2 years) span such that a slight degree of curvature is maintained. This has been done and appears as the "dotted" portion in Figure 3-2.

3.2.4.1. CUMULATIVE AND ANNUAL VMT ESTIMATES BY VEHICLE AGE

Table 3-10 displays cumulative and annual VMT estimates based on the fitted curve in Figure 3-2. The cumulative miles are computed directly from the logarithmic equation for x = 2.2 years and greater, while for x < 2.2 years, the cumulative miles are read directly from the graph. The annual estimates are merely the result of subtraction (i.e., annual VMT for year "x" = cumulative VMT for year "x" minus cumulative VMT for year "x-1".) To be noted is the continuous decrease in annual VMT with vehicle age. The average 15-year-old vehicle has been driven approximately 85,000 miles.

TABLE 3-10

CUMULATIVE AND ANNUAL VMT ESTIMATES BASED ON FITTED LOGARITHMIC CURVE

Age in Years	CUMULATIVE VMT	ANNUAL VMT
0	0	--
1	14,000	14,000
2	26,000	12,000
3	37,410	11,410
4	45,781	8,371
5	52,273	6,492
6	57,578	5,305
7	62,063	4,485
8	65,948	3,885
9	69,375	3,427
10	72,441	3,066
11	75,214	2,773
12	77,746	2,532
13	80,075	2,329
14	82,231	2,156
15	84,238	2,007
16	86,116	1,878
17	87,880	1,764
18	89,543	1,663
19	91,116	1,573

3.2.4.2 AVERAGE ANNUAL VMT ESTIMATE FOR TOTAL VEHICLE FLEET (ALL AGES

Table 3-11 contains the data for estimating the average annual VMT for the total vehicle fleet, all age groups of vehicles. The estimates are derived from a weighted average (arithmetic) of the annual miles traveled, by vehicle age as shown in column 4 of the table with the weights being the number of total vehicles registered nationally, for each age group, as of July 1, 1982, and as compiled by the R. L. Polk Company. The age groups have been changed slightly to conform to the date on which the Polk figures are compiled and to incorporate all vehicles in the U.S. fleet which are less than 2 years of age. Again, the estimates are for all light vehicles which includes both cars and light trucks. The estimated average annual miles traveled for all vehicles (i.e., all vehicle age groups) appears at the bottom of column 4 and is:

average annual VMT (all vehicles on-road) = 6,025 miles

This estimate as well as the marked decline in VMT with vehicle age shown in Table 3-11 and Figure 3-2 differ considerably from prior estimates of VMT as developed in various surveys and studies. A discussion of these differences is given in the following section.

TABLE 3-11

DATA FOR COMPUTATION OF AVERAGE ANNUAL VMT, ENTIRE U.S. FLEET OF PASSENGER CARS AND LIGHT TRUCKS

Age in Years	No. of Vehs.[a] Registered	Pct. Total[a] Registered	Annual VMT
.2	5,494,680	.0397	1,500
1.2	9,989,001	.0720	13,500
2.2	10,621,006	.0767	13,386
3.2	13,380,754	.0967	10,902
4.2	13,294,218	.0960	7,912
5.2	12,520,031	.0904	6,214
6.2	10,809,647	.0781	5,118
7.2	8,264,068	.0597	4,351
8.2	10,560,859	.0763	3,784
9.2	9,605,962	.0694	3,348
10.2	7,587,798	.0548	3,002
11.2	5,357,835	.0387	2,721
12.2	4,583,669	.0331	2,489
13.2	3,841,661	.0277	2,292
14.2 and older*	13,393,061	.0967	2,125
OVERALL TOTALS	138,440,546	1.0060	6,025

*Includes small number of unknown ages

[a] Source: R. L. Polk and Company, NVPP File, July 1, 1982, FURTHER REPRODUCTION PROHIBITED

3.2.5 COMPARISON OF ORFES VMT ESTIMATES WITH OTHER SURVEY ESTIMATED

Table 3-12 is a comparison of the VMT estimates from the On-Road Fuel Economy Survey with VMT estimates from other past surveys. Note that for the first two-to-three years, the surveys do not differ greatly as to the VMT by age. However, beginning with the fourth year, the ORFES estimates begin to show considerable departure from the other survey estimates, and generally show a marked decrease in annual VMT compared to the other surveys, together with a much more pronounced rate of VMT decline with vehicle age. Additionally, the average annual VMT for all vehicles for ORFES is considerably lower at 6,025 miles, than the other surveys which range from 10,000 to 11,000 miles.

As to possible reasons for this difference between ORFES and the other surveys, perhaps the most likely candidate is the method of estimating travel for each individual vehicle in the survey. As far as is known, the method used in all prior surveys was to ask individual members of a sampled household, "About how many miles did your household drive vehicle "A" in the last year?" ORFES estimates, on the other hand, are based on the actual odometer readings as recorded by survey respondents over a 1-month period during which they kept a log of their fuel purchases. In the former case, we have data which must be considered subjective, the degree of accuracy of which is unknown. Odometer readings, in contrast, must be considered objective in nature and, as far as is known, ORFES is the first instance where odometer readings have been sampled on a nationally representative basis. ORFES also used the national population of <u>vehicles</u> (privately owned) as a sampling frame whereas the other surveys are based on a sample from the Nation's households. The target population for both ORFES and the

TABLE 3-12

COMPARATIVE ESTIMATES OF AVERAGE ANNUAL MILES PER AUTOMOBILE[a] BY AGE OF AUTOMOBILE

Age in years	1969 NPTS	1975 WCMS	1977 NPTS	1978 Cambridge Systematics	1983 NHTSA CRFES[b]
1	17,600	13,565	11,794	10,360	14,000
2	16,200	14,805	13,396	12,910	12,000
3	13,200	11,115	13,380	12,720	11,410
4	11,500	11,030	12,107	9,910	8,371
5	11,700	11,054	11,307	12,530	6,492
6	10,000	9,869	10,694	9,390	5,305
7	10,400	9,570	10,517	10,230	4,485
8	8,700	8,862	9,532	9,300	3,885
9	10,900	9,361	8,658	8,570	3,427
10	8,000	7,305[c]	8,812	8,670	3,066
11	6,600[d]		7,132[d]	6,770[d]	2,773
12					2,532
12					2,329
14					2,156
15					2,007
16					1,878
All, miles	11,600	10,626	10,307	10,100	6,025

[a]Household autos only.
[b]Includes light trucks
[c]Includes vehicles 10 years old and older.
[d]Includes vehicles 11 years old and older.

Secondary Source: Transportation Energy Data Book, Sixth Edition
U.S. Department of Energy

Original Sources: 1969 - U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Study: Annual Miles of Automobile Travel, Report No. 2, Washington, D.C., April 1972, p. 14.

1975 - Washington Center for Metropolitan Studies, Lifestyles and Household Energy Data, Washington, D.C., 1977.

1978 - Cambridge Systematics Inc., Cambridge, Mass., National Travel Survey 1978, magnetic tape, prepared by the National Science Foundation, 1979.

1977 - J. R. Kuzmyak, COMSIS Corp., 1977 Nationwide Personal Transportation Study, Report 5: Household Vehicle Utilization, U. S. Department of Transportation, Federal Highway Administration, Washington, D.C., April 1981.

other surveys shown in Table 3-12 was the same--all privately-owned vehicles. This fact perhaps accentuates even more the question of why the results are so different.

One area that could cause travel estimates based on odometer readings to be biased low is where odometer readings have been turned back or otherwise tampered with. While available information does not allow an estimate of the magnitude of bias due to this phenomenon, it is believed that it would not be sufficient to explain a signficant amount of the difference in VMT estimates between ORFES and the prior surveys.

In terms of comparisons of ORFES results with other data, one other area is to be noted. As a part of its many highway-related statistics, the Federal Highway Administration (FHWA) annually publishes estimates of VMT. For 1983, the FHWA gives the following estimates[3] for passenger cars and light trucks:

passenger cars - 9,641 miles

light (single unit) trucks - 9,705 miles

The definition of light trucks differs between FHWA and the light trucks samples in ORFES, so that a meaningful comparison is not possible. However, for passenger cars, a comparison can be made.

3 "Highway Statistics", 1983, published by Federal Highway Administration, U.S. Department of Transportation.

In making this comparison, it must be remembered that the ORFES sampling frame included only privately-owned vehicles, thereby excluding fleet vehicles (business, rental, police, government, taxi, etc.). The FHWA estimate is for all passenger cars, fleets included. The impact on VMT of fleet vehicles, it seems, would have to be large, indeed, in order to offset the large difference in the two estimates, of 6,025 miles for ORFES and 9,641 miles for FHWA.

One way to investigate the impact of fleets on average annual VMT is to calculate the average annual VMT necessary for fleet vehicles in order to have the overall U.S. fleet (e.g., both private and fleet) VMT equal to the FHWA estimate, or 9,641 miles per annum.

In order to do this, the simplifying assumption is made that all fleet vehicles are 6.2 years of age, or younger. We next construct the following equation:

$$.5496\ (x) + .4504\ (2{,}552 \text{ miles}) = 9{,}641 \text{ miles}$$

Here x is the average annual VMT for all U.S. fleet vehicles 6.2 years of age and younger. The proportion of total fleet vehicles in this age bracket is .5496 as computed from column 3 of Table 3-11; .4504 is the remaining portion of the total fleet or that portion over 6.2 years of age, and 2,552 is the average annual VMT for this latter portion of vehicles as computed from columns 3 and 4 of Table 3-11 (e.g., the population weighted average VMT).

Solving the above equation gives:

$$x = 15,450 \text{ miles}$$

Comparing 15,450 with the On-Road Survey estimate of 8,780[4] implies that the non-privately owned vehicles, assuming they comprise 17 percent[5] of all vehicles aged 6.2 years and younger, would have an average annual VMT, y, given by:

$$.17y + (1 - .17)\ 8,780 \text{ miles} = 15,450 \text{ miles}$$

or

$$y = 48,015$$

---

4 The population weighted average annual VMT for vehicles aged 6.2 years and younger, computed from columns 3 and 4 of Table 3-11.

5 Per Transportation Energy Data Book, Edition 7, Oak Ridge National Laboratory, ORNL-6050, issued June 1984, total fleet vehicles in 1982 numbered approximately 10 million vehicles. This is approximately 17 percent of total U.S. registered passenger cars aged 6.2 years and younger, based on R. L. Polk data. Passenger cars are subsetted from all vehicles in column 2 of Table 3-11 in order to compute this fraction.

Thus, under the assumptions made above, fleet vehicle annual travel would have to be 48,015 miles in order for the FHWA estimate of 9,641 miles annually for all vehicles to hold. This is five to six times the average VMT (8,780) for privately owned vehicles of the same age as estimated from the On-Road Survey. It is also twice the average annual travel of 24,000 miles per fleet/business vehicle as given by Shonka[6]. The estimate of 48,015 miles further implies that all fleet vehicles would have to travel a total of 48,015 x 6.2 or nearly 300,000 miles average, during their fleet lifetime! This would appear to be quite unrealistic.

Furthermore, available data on fleet vehicles also indicate that the average age of fleet cars at time of trade-in or replacement by fleet owners is only 2 to 2 1/2 years.[7] At an average annual VMT of nearly 48,015 miles, as computed above, the average fleet vehicle at time of trade-in would have been driven 120,000 miles! Again this is considered highly unlikely due to the low remaining useful life and low resale value such vehicles would possess. In all likelihood such vehicles have considerably lower mileage at the time they are traded in.

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6 Transportation Energy Data Book, Edition 7, cited in footnote 5/ to this chapter. Secondary source: Annual Travel and Size of Fleet - D.B. Shonka, "Characteristics of Automotive Fleets in the United States, 1966-1977," ORNL/TM-6449.

7 "Characteristics of Automobile Fleets in the United States, 1966-1977," D.B. Shonka, ORNL/TM-6449, September, 1978.

"The Use of Weighted Vehicle Miles Traveled in Estimates of Corporate Average Fuel Economy", Internal Report by J. Thornton, NHTSA, July 1981. (Data on vehicle age obtained from National Association of Fleet Administrators, 1980).

Collectively, the above numbers offer rather strong support that annual VMT for the U.S. fleet of passenger cars and light trucks both on a per vehicle and overall fleet basis, are considerably lower than previously indicated by existing prior surveys and studies.

CHAPTER 4

SURVEY METHODOLOGY AND DATA COLLECTION

4.0 INTRODUCTION

This chapter describes the methodology and data collection aspects of the national survey which provided the data to support this evaluation. study. As stated earlier in this report, the original primary objective of the survey was to produce valid *national estimates* of the actual on-road fuel economy for motor vehicles produced under the early years of the Federal Fuel Economy Standards. Early in the survey implementation period, the purpose of the survey was broadened to also include the estimation of annual vehicle miles traveled (VMT). Survey issues discussed in the following sections include: (1) The design of the survey, (2) The survey instrument (questionnaire), (3) Data collection, (4) Data reduction and data processing, and (5) Survey response and nonresponse topics, and (6) Potential sources of error.

Actual implementation of the survey, including final design aspects, sample selection, development of mean miles per gallon estimates including weighting, and data reduction and processing was performed by a national survey firm under contract to the National Highway Traffic Safety Administration. The contractor also conducted an analysis of potential nonresponse effects. The results of the survey implementation are documented in a contractor final report to NHTSA.[1]

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1 "On-the-Road Fuel Economy Survey: FINAL DATA COLLECTION REPORT," Submitted to: National Highway Traffic Safety Administration, Office of Program Evaluation by the National Opinion Research Center, 6030 South Ellis Avenue, Chicago, IL 60637, University of Chicago, October 1984.

4.1 SURVEY DESIGN

The design of the survey was based primarily on the results of an in-house pilot test conducted by NHTSA in 1979 which evaluated the questionnaire format and the effect of various other factors on the enhancement of survey response. Prior to arriving at the final design, reviews were made of two other major surveys designed to collect similar information on the fuel consumption of motor vehicles.[2] These reviews included both documentation concerning the two surveys, plus on-site discussions with officials of the two sponsoring agencies. Minor modifications were made in the final survey design as a result of recommendations of the winning proposal to the competitive bidding action to obtain a survey contractor.

4.1.1 TARGET POPULATION AND SAMPLING FRAME

The vehicle population for which on-road fuel economy inferences were desired was defined as all privately-owned passenger cars and light trucks of the 5 Model Years 1977 through 1981 in the United States. The vehicle population was further defined as those vehicles produced by the 4 major domestic and 4 major foreign manufacturers: American Motors, Chrysler, Ford, General Motors, Datsun/Nissan, Honda, Toyota and Volkswagen. The population of interest excluded vehicles in fleets because it was deemed operationally infeasible to obtain nationally representative fuel economy data on these vehicles at the level of detail desired. This assessment was

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2 "The Fuel Consumption Survey," Statistics Canada, Special Surveys Division, 3C-3 Jean Talon Bldg., Ottawa, Ontario.

"Residential Energy Consumption Survey," Energy Information Administration, Office of Energy Markets and End Use, U.S. Department of Energy, Washington, D.C.

made upon review of prior attempts to survey fleets for fuel economy. The sub-population of import vehicles was confined to the four major companies to simplify the sample selection and allocation and since these four companies represent the large majority (approximately 75 percent) of the total import vehicle fleets for the model years of interest.

The sampling frame chosen for the On-Road Survey was the U.S. vehicle registration files maintained by the R. L. Polk Company. The choice of a sampling frame for most large scale national probability surveys is often one of the major decisions that must be made in carrying out the survey. Factors such as completeness (e.g., extent to which the frame coincides with or covers, the target population), availability, ease of access, cost, type of sampling identifier information contained, currentness, and accuracy of information are some of the typical items which must be weighed in choosing a frame. A consideration of these factors together with the major objectives of the survey led to the choice of the Polk files as the sampling frame for the On-Road Survey. The primary advantages of the Polk data were: (1) its reasonable availability[3] (2) it was a national file of vehicles, (3) it contained good vehicle identifier information for stratification of the sample according to desired characteristics, (5) the fact that vehicle owner name and address were available along with specific vehicle identifiers, and (6) reasonable cost to access.

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[3] The prime contractor for the survey had to enter into a subcontract with the R. L. Polk Company to furnish a specific sample of vehicles for the survey.

The primary disadvantages of the Polk frame were that it excluded vehicles registered in 14 States,[4] or approximately 25 percent of the vehicle population of interest, and that it would not always provide current or up-to-date information. This latter problem would arise due to vehicle resale/owner residence changes as continuous functions over time together with the elapsed time required for Polk to merge registration files from individual States into a national file, given that States differ as to the frequency of updating their own registration files and as to the dates they provide their respective files to R. L. Polk. This issue of out of date information was heightened somewhat in implementing the sample for the On-Road Survey due to a 6 to 8 month period between selection of the sample from the Polk files and the beginning of actual survey reporting. Some additional "aging" of the sample, once selected, occurred due to the implementation of the survey over a 1-year period.

Of the two disadvantages of using the Polk files as the frame, currentness is judged to be of greater impact since survey experience showed very little success in following sold vehicles or in following owners who had moved from their original address (e.g., the one listed on Polk's

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4 These States were excluded because the States themselves had placed restrictions on the use of their vehicle data for surveys such as the On-Road Survey. Although NHTSA could have pursued release of files for these 14 States, on an individual appeal basis, such action was not considered worthwhile in view of the effort required, the potential time delay in survey implementation that might ensue, and the judgment that exclusion of the States would, in all likelihood, not cause serious bias.

files). Generally this meant that sampled vehicle/owners were not contacted. Relative to the "excluded States" issue, their omission is not believed to have significant impact on survey estimates. Table 4-1 lists the excluded States and Figure 4-1 gives a geographical view of their distribution, along with those 36 States which were represented in the survey sample. Since the excluded States are distributed rather evenly throughout the U.S., and since there is no reason to suspect that the basic vehicle (year, type, make/model, etc.) distribution differs significantly between these 14 States and the 36 which were sampled, omission of the 14 States from the sample frame (i.e., a "noncoverage" issue in statistical sample survey terms) is not believed to constitute a significant concern insofar as it might cause a bias in the survey estimates.

TABLE 4-1

STATES NOT SURVEYED
(EXCLUDED FROM SAMPLING FRAME)

1.	Alaska	8.	New Mexico
2.	Arkansas	9.	Oklahoma
3.	Connecticut	10.	Pennsylvania
4.	Hawaii	11.	South Dakota
5.	Indiana	12.	Virginia
6.	Nevada	13.	Washington
7.	New Jersey	14.	Wyoming

These States represent approximately 25 percent of the total U.S. population of passenger cars and light trucks, per the R. L. Polk Co.

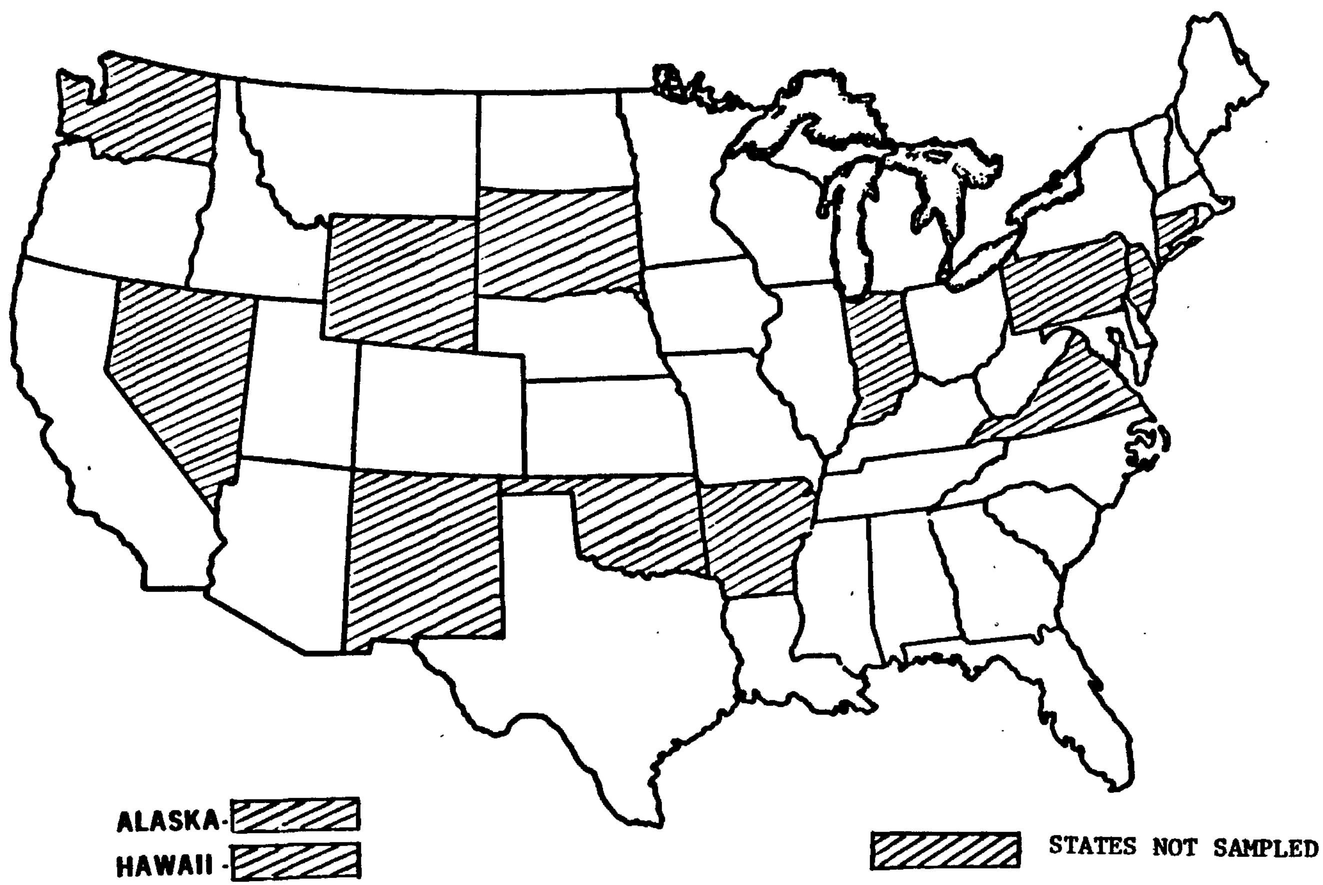
4.1.2 SAMPLE SELECTION, STRATIFICATION, AND DIVISION INTO REPLICATES

Sample sizes were originally derived to provide estimates of specified precision for the two major vehicle classes (passenger cars and light trucks) and five model years of interest. The total sample size was 46,000 vehicles--33,500 passenger cars and 12,500 light trucks. Subsequent

FIGURE 4-1

GEOGRAPHICAL DISTRIBUTION OF STATES
NOT SAMPLED

(EXCLUDED FROM SAMPLING FRAME)



sample sizes for these 10 vehicle classes, or strata, were altered somewhat to provide more precise estimates for newer vehicles (e.g., newer model years were oversampled) keeping the total sample sizes constant at 46,000 total, 33,500 for cars, and 12,500 for trucks.

In order to increase the efficiency of the estimates and to provide estimates for certain vehicle classes of interest, the vehicle type/model year strata were further stratified by number of drive wheels (2-wheel drive, 4-wheel drive) for light trucks, by vehicle size class, and by type of fuel used, gasoline or diesel. The vehicle size classes essentially corresponded to those classifications employed, for each model year, by the Environmental Protection Agency in its laboratory testing of new vehicles for compliance with Federal emissions standards and for estimation of vehicle fuel economy or miles per gallon. Within each vehicle type and year, the sample was allocated proportionately among size classes except for a few instances where oversampling was employed in order to obtain reasonable sample sizes for certain rare substrata of interest which included station wagons, vans, special purpose vehicles, and diesel powered vehicles.

Tables 4-2 and 4-3 present the allocation scheme of the total sample among the various strata for passenger cars and trucks, respectively. In selecting the actual sample of vehicles from the Polk registration files, one further allocation scheme was employed. The total sample size for each size class within each higher order stratum was allocated proportionately among all the make model combinations shown on the Polk files for that particular size class. This assured representation of each make model on a basis portional to that make model's representation in the total population of vehicles in that size class.

The final sample for which data were received and input to the final data analysis file contained more than 800 different make model combinations (Examples: 1980 Chevrolet Chevette, 1980 GMC G25 van, 1981 Honda Civic, 1980 Oldsmobile Cutlass Supreme diesel, 1981 Ford Escort, 1979 Ford Bronco 4WD, 1978 Dodge Diplomat, 1977 Toyota Corolla Wagon, etc.)

Prior to implementing the selected sample of 46,000 vehicles, it was distributed equally among 12 subsamples, or replicates, so that 1/12 of the total sample could be implemented over each month of a consecutive 12-month period. This step was taken in order to account, or control for, the seasonal effect on fuel economy. Distribution of the sample was made so that each vehicle stratum and substratum were equally represented among the 12 replicates.

TABLE 4-2

SAMPLE ALLOCATION SCHEME
Cars and Station Wagons, N = 33,500

	MODEL YEAR				
STRATUM	1977	1978	1979	1980	1981
Gas					
Cars	4,100	4,379	4,684	5,551	6,079
Station Wagons	925	1,048	1,011	713	1,040
Diesel					
Cars	N/A	479	845	794	931
Station Wagons	N/A	124	160	312	325
Total N =	5,025	6,030	6,700	7,370	8,375

Source: Survey contractor final report, previously cited

TABLE 4-3

SAMPLE ALLOCATION SCHEME
Trucks, N = 12,500

STRATUM	MODEL YEAR 1977	1978	1979	1980	1981
Gas					
Two-Wheel Drive					
Pickups	600	750	772	856	1,122
Vans	952	824	818	298	399
Special Purpose	21	20	17	28	38
Four-Wheel Drive					
Pickups	15	0	0	85	799
Vans	N/A	N/A	N/A	N/A	N/A
Special Purpose	287	431	518	340	298
Diesel					
Two-Wheel Drive					
Pickups	N/A	225	375	413	469
Vans	N/A	N/A	N/A	N/A	N/A
Special Purpose	N/A	N/A	N/A	N/A	N/A
Four-Wheel Drive					
Pickups	N/A	N/A	N/A	N/A	N/A
Vans	N/A	N/A	N/A	N/A	N/A
Special Purpose	N/A	N/A	N/A	N/A	N/A
TOTAL	1,875	2,250	2,500	2,750	3,125

Source: Survey contractor Final Report, previously cited.

4.2 QUESTIONNAIRE DESIGN AND DATA COLLECTION METHODOLOGY

As stated earlier, the survey instrument and method of data collection were based primarily on the results of a NHTSA pilot test. The survey was conducted by mail. The initial step in the data collection method was to mail a "prenotification" letter to the owner of each vehicle selected in the sample. Actually, the prenotification mailing contained 2 letters, one from NHTSA, and one from the survey contractor. This was followed in approximately 2 weeks by the survey questionnaire which was accompanied by a brief letter of instruction, a small incentive in the form of a personal fuel mileage booklet, and two decals, one to serve as an in-vehicle reminder to fill in the log at each fuel purchase, and the second for use in sealing the completed log for mailing. The log-questionnaire (see Figure 4-2a) was preprinted with the vehicle make, model, and model year information: the owner's name, address, and survey identification number; and, on the opposite side, with address and franking data for returning the questionnaire (see Figure 4-2b). The questionnaire requested a few items characterizing the sampled vehicle (Section A) and brief information at each fuel purchase during a specified 1-month period (Section B). The format of the questionnaire was designed to permit data reduction of returns via optical scan equipment.

Three-to-four days after the questionnaire was mailed, a reminder card was sent. A second card was sent shortly before the end of the survey month as a reminder to send in the log. A second wave of mailings, exclusive of the prenotification letter were sent to all sampled vehicle owners who did not respond to the initial wave. Samples of all the materials used to supplement the survey questionnaire are included in Appendix B.

The impact on survey response of the prenotification letter, the personal log-booklet (incentive), and reminder postcards were evaluated in the NHTSA pilot test, as mentioned before, and each of these items was shown to have a positive effect on survey response. The use of more valuable gift

FIGURE 4-2a

U.S. Department of Transportation

National Highway Traffic Safety Administration

ON THE ROAD FUEL MILEAGE LOG

FORM APPROVED THRU 9/30/84
O.M.B. NO. 2127-0037

PLEASE KEEP YOUR ANSWERS IN THE BOXES

SECTION A — VEHICLE INFORMATION

1. The vehicle we want information about is your: MAKE MODEL MODEL YEAR

2. BODY STYLE:
(a) CAR: 2-Door 4-Door Station Wagon
TRUCK: Pick-up Van Jeep, Blazer, Bronco, etc. Truck-based Station Wagon *(e.g., Suburban, etc.)*
(b) TYPE DRIVE: 2-Wheel Drive 4-Wheel Drive

3. AIR CONDITIONED Yes No 4. RADIAL TIRES Yes No

FOLD HERE

5. ENGINE: a- No. of Cylinders 8 6 4 b- Turbo Charged Yes No
c- Fuel Gasoline Diesel d- Fuel System Carburetor Fuel Injection
e- Size/Displacement (Fill in only one) Cubic Inches Cubic Centimeters Liters

6. TRANSMISSION: MANUAL 3-Speed 4-Speed 5-Speed AUTOMATIC 3-Speed 4-Speed

VEHICLE MAINTENANCE:
7. Within the last 3 months has the vehicle had (check all that apply) Tune-up Wheel Alignment Tire Pressure Check

8. VEHICLE OWNERSHIP Owned Leased Company Car

FOLD HERE

SECTION B — GAS MILEAGE LOG

Please complete one line below each time you FILL UP/BUY GAS next month for the vehicle listed above.

GAS PURCHASES												
DATE OF PURCHASE			ODOMETER READING		FUEL AMOUNT				FILLTANK		TYPE DRIVING EACH PERIOD			
MO	DAY	YR	WHOLE MILES	10th	GALS	10th	LITERS	10th	Yes	No	* MOSTLY City	Hwy	** HEAVY USAGE Yes	No

001

THANK YOU. Please fasten completed card with tape or decal and mail, (no stamp needed).

*MOSTLY CITY 20-45 MPH, short trips
*MOSTLY Hwy 50-55 MPH

**HEAVY USAGE Towing, snow, off-road use, heavy loads

FIGURE 4-2b

(Reverse side of questionnaire)

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

400 Seventh St., S.W.
Washington, D.C. 20590

Official Business
Penalty for Private Use $300

NO POSTAG
NECESSAR
IF MAILED
IN THE
UNITED STAT

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 73173 WASHINGTON, D.C.

POSTAGE WILL BE PAID BY NATL. HWY. TRAFFIC SAFETY ADMIN.

U.S. Department of Transportation
National Highway Traffic Safety Administration
c/o National Opinion Research Center
6030 South Ellis
Chicago, IL 60637

NORC 4349

items or direct monetary payments as further inducements for survey participation were not considered since these were generally against agency policy and also since an evaluation of the impact of monetary incentives used or tested in other surveys did not provide convincing evidence that the use of such incentives would be at all cost-effective.

Use of the telephone, however, was evaluated as to its effect on increasing survey response. The original design methodology called for a telephone followup to a random sample of nonrespondents to the first and seventh replicates of the main survey. The basic objective of these telephone followups was to investigate potential nonresponse effects on the primary variable to be measured in the survey--fuel economy. The plan called for converting a sufficient number of nonrespondents, through telephone contact, and persuading them to complete the 1-month fuel-mileage log. The data on fuel economy thus obtained would then be compared with the fuel economy data obtained from the main (mail) survey to see if any significant nonrespondent effect existed.

The results of the telephone followup for Replicate 1 did not provide sufficient data for making a direct comparison of fuel economy, but did provide supplementary data from the nonrespondents which was used, together with other survey return information, to conduct an analysis of potential nonresponse bias effects on the primary survey objective--the measurement of on-road fuel economy. Since the telephone followup results for Replicate 1 did not result in a sufficient number of completed logs the telephone followup originally planned for Replicate 7 was not performed. The telephone was further evaluated, however, as to its potential for enhancing response to the basic mail survey. For Replicate 5, instead of sending the mail followup wave to all nonrespondents, a portion were contacted via telephone. Once again, however, use of the phone did not prove significant in increasing response over that obtained solely from the mail contracts.

One additional significant finding from the telephone followup experiments was that the rate of vehicle/owner noncontacts was appreciably higher than that computed merely from mail returns themselves. This information was used to adjust the survey response/nonresponse rates, which are discussed in the last section of this chapter.

4.3 DATA COLLECTION, PROCESSING, AND STATISTICAL ESTIMATION

4.3.1 RECEIPT CONTROL

To maintain control over the large volumes of mailings and receipts in the On-Road Survey, the survey contractor utilized two automated receipt control files. One file, called the "locator file," was used to track the location of sampled vehicle owners and the status of their vehicles. Table 4-4 is a summary of the different designators, or disposition codes, used to maintain control over the 46,000 vehicles sampled during the 1-year period of the survey. The second control file used throughout the survey was to maintain an accounting of the survey questionnaires, or logs, as to the disposition of each one. Table 4-5 summarizes the codes used by this tracking system.

TABLE 4-4

LOCATOR FILE DISPOSITION CODES

(Used for Replicates 1-6)	(Collapsed categories used for Replicates 7-12)
01 Same Owner, new address 02 New owner, same address	01 Post Office will forward
03 New owner, new address 22 Other remail	03 Remail
04 New owner is dealer, address given 05 New owner is dealer, no address given 06 Sold, new name given, no address 07 Sold, no new name or address given 09 Owner deceased -- no further information	07 Unpursuable
08 "Owner" had no knowledge of vehicle 21 Make/model/year wrong	08 Out of Scope (1)
10 Fleet car 11 Fuel not measurable 12 Vehicle not driven in assigned month 19 Vehicle junked or stolen 20 Vehicle repossessed	10 Out of Scope (2)
	13 Refusal
14 Envelope or postcard returned with addressee unknown 15 Bad address/no such address 16 No forwarding address, forwarding expired 17 Returned to sender, not deliverable	14 Undeliverable

Source: Survey contractor Final Report, Op. Cit.

TABLE 4-5

DISPOSITION CODES FOR RETURNED QUESTIONNAIRES

32 (Second Wave)/42 (First Wave)
Complete (Usable) Log (Section B of log has specified amount of information)

31 (Second Wave)/41 (First Wave)
Incomplete Log (Vehicle owner attempted to complete the log, but the information was insufficient)

33 (Second Wave)/43 (First Wave)
Wrong Month (Log filled in for out-of-scope month. Out of scope falls outside: prior to two months to record-keeping month, and/or two months after record-keeping month)

38 (Second Wave)/48 (First Wave) .
Inadequate Information (Information not usable because of format; e.g., owner writes in "10 miles per gallon; what a lemon!")

Source: Survey contractor final report, previously cited.

4.3.2 DATA PROCESSING

The data reduction and processing function for all returned questionnaires included a manual review, or edit, keypunching[5] the data reported on the questionnaires, and subjecting the keypunched information to a machine edit. The manual review served to separate good or complete logs from incomplete ones and to correct any obvious ambiquities in respondent reported information.[6] Keypunching of questionnaires which passed the manual edit was performed under subcontract to the survey firm. Data entry specifications included 100 percent verification of key items such as odometer reading, fuel amount and certain administrative identification

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5 It was not possible to use optical scan equipment, as originally planned, to capture the data reported on the questionnaires; hence, the questionnaires were keypunched.

6 The survey contractor final report, previously cited, contains additional detail on the manual edit of returned questionnaires.

items. A periodic random check was made of the keypunched data by the survey contractor who reported the average error rate at less than one-tenth of one percent.

The third stage of the data processing function was a machine edit or "cleaning" program which had as its overall objective the preservation of a maximum number of completed survey logs subject to certain quality control specifications. Among the functions carried out by the machine edit are the following steps:[7]

(1) verification of individual case/questionnaire identification number

(2) selection and printing of a random sample of each batch of keypunched logs for purposes of checking keypunch accuracy

(3) conversion of certain reported data to standard categories used for processing and data analysis

(4) overriding certain illegal respondent answers with a single response according to predetermined rules

(5) sorting/merging of survey logs with corresponding data from the Polk sampling frame data for purposes of inputing certain information if missing on survey log

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7 Survey contractor report, previously cited.

(6) imposing range checks on certain data items:

(a) MPG range for gasoline vehicle: 5-40

MPG range for diesel vehicle: 15-50

(b) Engine displacement: 40-500 cu. in.

(c) Period for which log kept:

waves 1 and 2: ± 2 mo. from target mo.

wave 3: ± 4 mo. from target mo.

(wave 3 applies only to Replicates 1 and 5 and refer to telephone experiments)

(d) Odometer reading: > 1,000 miles

(e) Fuel purchase amount: < 40 gal.

(f) Miles driven between successive log entries: < 500 miles

These ranges provide a check on respondent reported errors concerning the vehicle, the fuel purchase or odometer (such as reporting trip odometer readings). The range of months serves to retain some "early" or "late" logs while still preserving a general seasonality factor in the data. The ranges also serve to check on possible omission of fuel purchase amounts during the recordkeeping period.

(7) to calculate MPG according to an algorithm based on "valid segments." (see following section on Statistical Estimation).

(8) to produce an error listing of the data by type of error (e.g., suspected trip odometer, out-of-range date, backwards odometer, invalid fuel type, etc.

4.3.3 STATISTICAL ESTIMATION

In order to have reliable estimates of fuel economy, a method of computation was developed by the sample survey contractor which computes miles per gallon for each surveyed vehicle based on the concept of "valid segments." This concept was developed in order to salvage as much data as possible from each survey log, considering that respondents might occasionally fail to complete each line of Section B of the log correctly at each and every fuel purchase during the survey period (e.g., a fuel purchase might be omitted, numbers transposed/recorded incorrectly, etc.).

A valid segment is defined as the minimum distance over which fuel economy estimates can be computed. It consists of a minimum of two rows of information on fuel purchases, from Section B of the questionnaire, in ascending order, which satisfy the following criteria[8]:

(1) valid segments are bounded by fuel purchases amounts designated as "fillups"

(2) valid segments cannot begin or end with an odometer reading less than 1,000 miles (such as a trip odometer reading), an out-of-range date, a descending odometer reading and/or a descending date. Rows of data <u>within</u> segments, on the other hand, may have these problems if they have in-range fuel amounts, since the number of miles driven comes from the difference between the two segment boundary odometer readings and because the total fuel used during the segment is the sum of fuel purchases during the segment. Valid segments do not have to begin with an in-range fuel amount, since the fuel amount recorded at the start of the segment does not constitute fuel consumed during the segment, but rather reflects consumption during the prior segment, a period of driving.

(3) segments must finally pass machine edit specifications in order to be considered valid. These include a specified range for computed miles per gallon (see preceding section).

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8 Survey contractor final report, previously cited.

Vehicle estimates of mpg are the averages of the more detailed segment estimates and both are subjected to the mpg range check described in the preceding section. The formula for calculating mpg for a given vehicle is the ratio of the total miles driven for all valid segments to the total fuel purchased for all valid segments, or,

$$MPG_{\substack{\text{sample}\\\text{vehicle}}} = \frac{\text{total miles driven for all valid segments}}{\text{total fuel purchased for all valid segments}}$$

The average mpg for a given stratum (e.g. such as the model year--vehicle type--fuel type--make model group) is a weighted mean across all vehicles in that particular stratum or,

$$\text{Mean mpg}_{\text{stratum}_i} = \frac{\sum_j W_i \, MPG_{ij}}{\sum_j W_i}$$

where MPG_{ij} is the miles per gallon for vehicle j in stratum i, and W_i is the population based weighting factor given by:

$$W_i = \frac{N_i}{n_i}$$

where N_i is the number of vehicles in the population of stratum i and n_i is the number of sample vehicles in stratum i. The population weights are the actual counts of U.S. registered vehicles as provided from the national files of the R. L. Polk Company, as discussed earlier in this report. Population-based weighting procedures improve the accuracy of survey estimates by correcting for departures of the sample distribution from the population distribution by stratum. Such departures arise because of oversampling, used for certain strata and because of differences across strata in the response rates.

4.4 SURVEY RESPONSE AND NONRESPONSE ISSUES

Of the total sample of 46,000 vehicles (actually 46,001 vehicles were selected for the On-Road Survey), returned logs were received for 10,871 or 23.6 percent of the original sample. Approximately 9.6 percent of the returned cases or 1,039 logs were not sufficiently complete to keypunch (i.e., insufficient lines completed for log section of the questionnaire, log completed for the wrong vehicle, etc.). Of the remaining 9,832 logs which were keypunched, 918 or 9.3 percent did not meet the criteria set forth in the machine edit program, and as described in Section 4.3.3, above. This left 8,914 cases which met all editing/cleaning criteria and are included on the final survey analysis file. The following table (Table 4-6) gives the final breakdown, or disposition of the total sample as reported by the survey contractor.

TABLE 4-6

FINAL DISPOSITIONS FOR TOTAL SAMPLE
(Based on Mail Returns Only)

	Number	Number	Percent
Fielded Cases (Gross Sample)	46,001		
Returned Ineligibles (Out of Scope)	1,921		
Net Sample		44,080	100.0%
Completed Cases (Logs passing machine edit)		8,914	20.2%
Completed Cases (Logs failing machine edit)		918	2.1%
Completed Cases (Not Keypunched)		1,039	2.4%
Refused		600	1.4%
Pursuable		2,409	5.5%
Not-pursuable		3,728	8.5%
Undeliverable		6,592	15.0%
Not Returned		19,880	45.1%

Source: Survey contractor final report, previously cited.

In most surveys, the response rate is defined as the ratio of completed questionnaires to the number of "eligible" units in the total, fielded sample, or

$$\text{Response rate} = \frac{\text{Completed Cases}}{\text{Total Fielded Cases - Ineligible Cases}}$$

Ineligible cases, as defined in Table 4-6 are defined as: (1) owner had no knowledge of vehicle, (2) make, model, model year incorrect, (3) fleet car,[9] (4) fuel not measurable, (5) vehicle not driven in assigned month, (6) vehicle junked or stolen, (7) vehicle repossessed. Furthermore, these designations of ineligibility are based solely on mail returns. If this basis is accepted for computing survey response rate, and "completed cases" are defined as only those passing final machine edit, the response rate for the On-Road Survey is 20.2 percent, as shown in Table 4-6.

However, the above method of computing survey response is considered overly conservative in view of additional usable information obtained in the two telephone experiments mentioned earlier in this chapter, and also in view of alternate ways to define ineligible cases. In the On-Road Survey a sizeable proportion of the cases resulted in failure to locate the sample vehicle, either because the owner had moved (with no forwarding address), the vehicle had been sold (with new owner address unavailable), or through other problems such as incorrect information from the sample frame (vehicle registration files). The category "not-pursuable" in Table 4-6 includes cases of no forwarding addresses and also cases where

[9] The sample was designed to exclude fleet vehicles, as previously stated. However, a handful of returns were classed as fleet vehicles. These, of course, were considered extraneous and ineligible for the survey.

vehicles were sold to car dealers. It was not possible to follow vehicles that had been sold to dealers. According to a report of a special task force authorized by the Council of American Survey Research Organizations (CASRO) in May 1983, for the expressed purpose of developing standardized definitions of survey response rates, the above cases of noncontact can be considered as ineligible. The following quote is taken from the Task Force's report:

> "For mail surveys where the frame is not up to date, nonresponse may occur because the intended recipient of the questionnaire is no longer at the given address. These cannot be considered as non-eligible cases unless definite proof is available through Post Office returns, through personal visits to the address, or through information from some other source."

In the On-Road Survey, proof that the intended recipient (owner of sampled vehicle) was no longer at the given address was available through Post Office returns. All survey mailings were imprinted with "Address Correction Requested" to assure more thorough treatment of incorrect addresses, movers, etc., and to improve identification/disposition of the implemented sample. Cases of "sold vehicles" (unknown, unfollowable address) fall into the same category because the "intended recipient" (i.e., the current vehicle owner) is not at the address to which the questionnaire was mailed. Again, there is "proof through survey returns."

The second element of information for computing an alternate survey response rate comes from the two telephone experiments. These experiments were conducted at two different times during the main survey and utilized random samples of sample vehicles unaccounted for after both waves of mailing (first telephone test), and vehicles unaccounted for after the first wave of mailing (second telephone test). These two telephone efforts were based on reasonably large sample sizes of 1,000 and 776 vehicles, respectively, for the first and second experiment. The results of these two telephone efforts showed that an additional 33 percent of the original sample fell into the categories of "sold vehicle", "no knowledge of vehicle", "junked/stolen", etc., - all cases that can be considered as ineligible according to the CASRO study.[10]

If the additional information obtained from the telephone tests is utilized along with the definition of ineligibility as developed by the CASRO Task Force, the following estimates are obtained for response rates to the On-Road Survey:

Response Rate
(logs passing machine edit) = 33.7 percent

Response Rate
(all completed logs returned) = 41.1 percent

[10] It is believed that this finding indicates that many people who had "unavailable vehicles," for whatever reason, did not make the effort to convey the vehicle status by mail, whereas, such information was obtained when these individuals were contacted by phone. It takes extra effort to reply by mail and, no doubt, many people felt a reply was not necessary since the requested vehicle would not be available for the survey anyway.

It is felt that these rates are a more realistic indication of the response to the On-Road Survey. Considering the fact that the survey instrument was a diary-type questionnaire of unusually long duration (one month), and the fact that the survey was conducted essentially by mail, these response rates are considered to be quite high indeed, compared to response rates for typical mail surveys.

4.5 POTENTIAL SOURCES OF ERROR IN THE ORFES STATISTICS

Sample surveys such as ORFES are subject to various sources of error which can effect the statistics derived and hence the inferences or conclusions drawn from the survey. This section discusses some of the more common sources of error and gives an assessment of each relative to the ORFES statistics. Two major sources of error exist--those due to sampling, or sampling error and those due to sources other than sampling, or nonsampling error.

4.5.1 SAMPLING ERROR

Sampling error arises due to the fact that samples (i.e., portions) are drawn from populations, as opposed to the populations being subjected to complete enumeration. Sampling error is based on the theory of mathematical probability and specific values for these errors can be computed from surveys conducted according to probability sampling procedures. Sampling errors cannot be computed for samples selected according to other methods such as subjective or purposive sampling (i.e., quota samples are typically of this type). Sampling errors can assist in the interpretation of survey statistics, such as means, by providing a measure of how closely the sample statistic estimates the true population statistic and with what degree of confidence or assurance. Sampling errors are included in this report along with the mean estimates relating to the two primary population parameters of interest, on-road fuel economy and VMT.

4.5.2 NONSAMPLING ERROR

The second type of error which can occur in surveys consists of several subcategories, usually referred to as (1) data collection, (2) noncoverage, and (3) nonresponse.

4.5.2.1 DATA COLLECTION

Data collection errors are those that can occur anywhere in the actual data collection or data automation process. This includes errors made by respondents on the original questionnaire; errors made in the process of editing, coding, and preparing the data for machine processing; and errors made in the process of transferring original or intermediate source document information to a machine readable medium such as card, tape, or disk. Extensive procedures (described earlier in this chapter) as applied to large scale surveys were taken to assure the quality of the ORFES data, including both manual and machine edit, with documented steps and definitions, and 100 percent verification of key data items. The keypunch error rate was less than 1/10 of one percent, based on periodic random checks of this data automation task by an independent observer.

4.5.2.2 NONCOVERAGE

Noncoverage refers to the failure to include in the sampling frame all elements in the target population (i.e., the population or universe about which inferences are desired based on the sample results). Approximately 25 percent of the target population of vehicles were excluded from the ORFES frame due to restrictions imposed by certain of the States on the use of their vehicle registration files.

Noncoverage effects generally have less effect on sample means than on simple totals[11]. In this report, we are concerned exclusively with mean estimates as opposed to totals. Additionally, weighting of sample data with population totals, where available, can reduce the effect of noncoverage. Such population data are often unavailable for large-scale surveys, but for ORFES, they were available in the form of national vehicle registration counts and have been used to weight the survey data, as described at various points throughout the report. Finally, the noncoverage proportion of approximately 25 percent could introduce a bias if there were reason to believe that the vehicles in the 14 restricted States differed significantly, or were driven differently, or in an environment different from those vehicles in the 36 included States. Since the 14 States were rather evenly distributed, geographically, there is little reason to suspect

11 "Survey Sampling", Leslie Kish, John Wiley and Sons, Inc., Copyright 1965.

that these States represent a general driving/vehicle usage environment different from the 36 States comprising the sampling frame. Neither is there reason to suspect that the vehicle population itself (i.e., the distribution of vehicles by type, size class, engine size, etc.) in the restricted States is significantly different from the vehicle population in the surveyed States. Even if slight differences did exist in these vehicle characteristics, they would be compensated for by the inclusion of the population weights in the formulae used for computing the various statistical estimates.

4.5.2.3 NONRESPONSE EFFECTS

Nonresponse effects in surveys can arise if the characteristics of the target population being sampled differ between that group which reports in the sample (respondents) and that group for which no reports are received (nonrespondents). Statistically the nonresponse effect can be shown to be proportional to the magnitude of the nonresponse and the magnitude of the difference between the means of the characteristic being measured in the two groups. Symbolically, this can be represented by:

$$RB\ (\bar{X}_1) = P_2 \frac{(\bar{X}_1 - \bar{X}_2)}{\bar{X}}$$ [12]

[12] "Kish", Op. Cit.

where PB $(\overline{X}_1)$ denotes the relative bias in the mean estimate $(\overline{X}_1)$ as fuel economy; P_2 is the proportion of nonrespondents in the original sample; $\overline{X}_2$ is the mean estimate for the nonrespondent group; and $\overline{X}$ is the true, or overall population mean. In order for the nonresponse bias to be important, the above equation implies that a large nonresponse must be accompanied by a large difference between the two subpopulation means.

In order to gain insight into whether nonresponse may induce bias into survey statistics, some method to obtain this information on the nonrespondents must be developed. Two ways of estimating the effect of nonresponse are to: (1) obtain additional information, preferably on the direct variable of interest, via intensive followup with a subsample of the nonrespondents; or (2) use other, a priori information or analysis. In ORFES which was conducted basically by mail, telephone followup tasks were an integral part of the original survey design in order to seek such nonresponse information. Unfortunately, while the telephone followup did provide information to better define sample disposition and response/nonresponse rates, and on vehicle and driver characteristics (see Section 4.4), an insufficient number of nonrespondents were converted to provide a reliable estimate of fuel economy for that group.

As an alternate method of estimating any nonresponse effect, an analysis was performed which evaluated certain vehicle and driver characteristics between the respondent and nonrespondent group as to their possible effect on the mean variable of interest, fuel economy. A first part of this analysis looked at differences between responders and nonresponders for vehicle factors known to be associated with fuel economy (i.e., engine size, transmission, presence of air conditioning, etc.). Also, differences in response rates were evaluated for other vehicle factors such as size class, type of fuel, and number of drive wheels (trucks). Overall, few differences of a practical nature were noted for these vehicle factors between the respondents and nonrespondents. Furthermore, even where certain small, statistically significant differences were found, these should be compensated for by the population weighting scheme employed (i.e., actual population counts by size class, type of fuel, and make model which should also be highly correlated with finer vehicle characteristics such as engine size, transmission type, etc.)

The analysis of driver related factors between the respondent and nonrespondent groups covered five additional items obtained on the original questionnaire or in the telephone followup. These were:

(1) Tune-up in last 3 months? (Yes/No)

(2) Wheel alignment in last 3 months? (Yes/No)

(3) Tire pressure check in last 3 months? (Yes/No)

(4) Proportion of city-highway driving

(5) Heavy usage? (off-road, snow, etc.) (Yes/No)

Only one of the five factors, tire pressure check, was found to be significantly different between respondents and nonrespondents. Seventy-three percent of nonrespondents reported a pressure check within the last 3 months compared to 85 percent for the respondent group. Although this difference was statistically significant, the small relative magnitude of the difference together with the small fuel economy effect expected due to more frequent tire pressure checks imply that the difference is not of practical significance.

The overall finding from the nonresponse analysis was that the effect of any bias on the estimates of on-road fuel economy appeared small. Although the nonresponse portion of the sample was near 60 percent, little evidence was found to indicate that the mean fuel economy differed between the respondent and nonrespondent groups. If any bias did exist, it would likely be positive (i.e., survey estimates would tend to overstate slightly, true on-road fuel economy). Based on an examination of all information available, any bias effect due to nonresponse in the survey is believed to be negligible.

Since the original primary objective of the survey was to estimate on-road fuel economy, the nonresponse analysis was focused on this parameter. No separate analyses were attempted with respect to VMT. Considering the two components of nonresponse bias discussed above, the primary concern relative to possible bias in VMT centers on the question, "Is there reason to suspect that nonrespondent vehicles tend to have higher or lower VMT than respondent vehicles?"

To the extent that vehicle characteristics such as size class, fuel type, etc., are related to VMT, these have essentially been taken care of in the sample stratifications and allocations and in the weighting of the statistical estimates. To the extent that any of the driver characteristics discussed above (tune-up frequency, frequency of checking tire measure, proportion city versus highway driving, etc.) are related to VMT, there was little difference found for these factors between the respondent group and the nonrespondent group. The sample, being nationally representative, gave equal probability of selection of all vehicles, be they low VMT, high VMT, or whatever characteristics they possessed.

Perhaps the issue can only be evaluated further on a subjective or speculative basis. It is possible to postulate that high mileage drivers might be less apt to participate in a survey such as ORFES due to the time/effort required to complete the log since these drivers would be more occupied with the driving task and other purposes relative to their reasons for driving.[13] On the other hand, it is possible to speculate that those who drive very little (such as elderly drivers) would be less apt to participate in ORFES since the primary objective was to measure fuel economy and such drivers could assume that their experience would not be sufficient to give a reliable estimate of mpg.

From the standpoint of estimates of VMT from prior surveys and studies, which are characteristically higher than the ORFES estimates (see Chapter 3.0), greater interest would lie in showing whether there might be a low bias. However, from an objective standpoint, the possibility of a bias in the other (high) direction must be given equal emphasis. In summary, at this juncture at least, no plausible argument is apparent that could indicate a nonresponse bias in the VMT estimates, either low or high.

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13 To the extent that "high mileage" could be associated with "vacation period driving", one might look for lower response rates in the summer months relative to the other months. Response rates for these months did not evidence any unusual patterns in ORFES.

CHAPTER 5

PRINCIPAL SURVEY FINDINGS AND RESULTS

This Chapter summarizes the primary findings and results of the On-Road Fuel Economy Survey. These findings are based on analyses of the data collected in the survey as it relates to two primary topics: (1) the actual fuel economy achieved in normal, everyday driving by the Nation's late model vehicle owners, and (2) the average annual vehicles miles traveled by age of the vehicle. The findings are presented under the following subtopics: (1) on-road fuel economy for passenger cars, (2) on-road fuel economy for light trucks, (3) comparison of on-road fuel economy with corporate average fuel economy, (4) comparison of on-road fuel economy with Federal standards, (5) estimated reduction in energy consumption and equivalent dollar value of more fuel-efficient vehicles, and (6) annual vehicle miles traveled.

5.1 ON-ROAD FUEL ECONOMY RESULTS - PASSENGER CARS

(1) During the first 4 years of the Federal fuel economy regulations (i.e., Model Years 1978 through 1981), the on-road fuel economy of the U.S. passenger car fleet increased by 41 percent compared to the fuel economy of the 1977 Model Year fleet, the year immediately prior to commencement of the regulations.[1] In terms of miles per gallon (mpg), the fleet average rose from 15.2 in 1977 to 21.4 in 1981.

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[1] As stated previously in this study, fuel economy increases may result from market forces as well as from CAFE standards.

(2) The greater portion of this gain in fuel economy is attributed to the domestic fleet (e.g., vehicles manufactured by domestic manufacturers) which saw its national average mpg climb from 14.5 in 1977 to 20.2 in 1981, a gain of 39 percent. That portion of the U.S. passenger car fleet comprised of import vehicles experienced an increase from 23.7 mpg to 26.7 mpg, or about 13 percent. (It should be noted that the domestic passenger car fleet was originally composed of predominately larger vehicles, relative to the import fleet, and therefore the incentive to improve fuel efficiency was much greater on the part of domestic manufacturers than foreign manufacturers).

(3) Fuel economy gains of 25 percent to 40 percent were noted for most size classes of passenger cars, with the highest gain for compacts at almost 80 percent and the lowest gain for the mini class at only 6.5 percent.

(4) Among domestic manufacturers, fuel economy gains over the 4-year period ranged from a low of 25 percent for American Motors to a high of 70 percent for Chrysler which in the last year (1980-1981) showed a much larger than average jump of nearly 6 mpg.

(5) Among foreign manufacturers, fuel economy gains were modest except for a 30 percent increase (1977 to 1981) for Volkswagen resulting from a large penetration of diesel sales in the 1979-1981 period.

5.2 ON-ROAD FUEL ECONOMY RESULTS - LIGHT TRUCKS

(1) During the 3-year period from 1978 to 1981, the on-road fuel economy for the U.S. fleet of 2-wheel drive light trucks increased by 26 percent (from 13.4 mpg to 16.9 mpg). The fuel economy for 4-wheel drive light trucks increased by slightly less, 17 percent (from 12.3 mpg to 14.4 mpg). Fuel economy improvements for light trucks, measured by percentage improvement, were less than those for passenger cars.[2]

(2) As was the case for passenger cars, greater fuel economy improvement was made for domestic light trucks than for import light trucks. The relative increases for the two groups were:

2-wheel drive

- domestic trucks, +21% mpg
- import trucks, +9% mpg

4-wheel drive

- domestic trucks, +9% mpg
- import trucks, +4% mpg[3]

Again, as was true for passenger cars, the domestic light truck fleet was composed of mainly larger vehicles than the import fleet and hence the greater incentive for domestic manufacturers to increase mpg.

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[2] As stated previously in this study, fuel economy increases may result from market prices as well as from CAFE standards.

[3] 1980 to 1981 increase only.

5.3 ON-ROAD FUEL ECONOMY COMPARED TO CAFE[4]

(1) On-road fuel economy consistently fell below corresponding corporate average fuel economy (CAFE) levels for the 4 model years of vehicles studied in the survey. For passenger cars, this difference remained essentially constant with on-road mpg being approximately 15 percent below the respective CAFE level for each year. For 2-wheel drive light trucks, the EPA to on-road difference was slightly greater than for cars at an average of about 16 percent per year, and, there was also some indication that this difference could be increasing with the 1981 vehicles showing a difference greater than 18 percent.

That laboratory testing overstates actual, on-road fuel economy has been known for several years. However, some prior studies have indicated that this difference was increasing whereas other studies have indicated a decrease in this difference for passenger cars. This study shows no trend in either direction, but rather that the difference has remained essentially constant, particularly since 1979.

(2) For 4-wheel drive trucks, on-road difference relative to CAFE was highest of all vehicle classes, averaging nearly 20 percent for the period 1979-1981 with the difference being nearly 23 percent for 1981.

[4] Recent rulemaking action (50 FR 27172, July 1, 1985) by the EPA, adjusted upward the EPA CAFE values used in this study for Model Year 1980 and 1981 due to test procedure changes. While this information was not available at the time this study was written, thee effect of this EPA revision is to increase somewhat, the amounts of the EPA CAFE to on-road differences for Model Years' 1980 and 1981, as found in this study.

(3) Except for 4-wheel drive trucks, domestic vehicles showed somewhat greater CAFE to on-road difference than did import vehicles.

(4) Among domestic manufacturers of passenger cars, the difference between CAFE and on-road experience was reasonably consistent with Chrysler and AMC showing slightly less difference than Ford and GM.

(5) For import passenger cars, the greatest CAFE to on-road decrease was noted for the captive imports of Ford and Chrysler. Among the 6 foreign manufacturers represented in the survey, Volkswagen was the only one whose on-road mpg consistently (i.e., for all model years) equalled or exceeded its respective CAFE numbers. Although not specifically investigated in this study, one reason for Volkswagen's equaling or exceeding CAFE levels is believed to be its large proportion of diesel-powered vehicles for the years studied together with the finding that diesel-powered vehicles exhibit less mpg difference, laboratory tests versus on-road, than conventional gasoline fueled vehicles.

5.4 ON-ROAD FUEL ECONOMY COMPARED TO FEDERAL STANDARDS

(1) For all 3 categories of vehicles, passenger cars, 2-wheel drive light trucks, and 4-wheel drive light trucks, the on-road fuel economy ranges from 8-9 percent below the Federal standard levels for Model Years 1978-1979; for 1980-1981, on-road mpg is much closer to the standard levels. Although the differences are small, on-road mpg is above the standard levels in several instances.

(2) A comparison of domestic and import manufacturers shows that domestic vehicles are below the Federal standard levels by about 10 percent for each model year while import vehicles considerably exceed the standard levels with the on-road mpg ranging from 20 percent to 45 percent above the respective standard. As has been noted previously, the fuel economy of the import fleet, being composed of small vehicles, was not only considerably higher than the fuel economy of the larger and heavier domestic fleet, prior to enactment by the first Federal standards, but in most cases, exceeded the standard levels, even as late as 1981.

5.5 ESTIMATED REDUCTION IN ENERGY CONSUMPTION AND EQUIVALENT DOLLAR VALUE OF MORE FUEL-EFFICIENT VEHICLES

(1) Based on the actual fuel economy as estimated from the On-Road Fuel Economy Survey and compared with the fleet of Model Year 1977 vehicles, it is estimated that the total U.S. fleet of passenger cars and light trucks manufactured from the beginning of the Federal Fuel Economy Standards through Model Year 1981 will consume a total of 45.6 billion gallons (1 billion, 86 million barrels) less fuel over their expected lifespan. This is equivalent to 974 fewer gallons per each vehicle. These energy reductions translate to a dollar value, in 1984 dollars, of $53.8 billion total, or $1,146 per vehicle.

5.6 ESTIMATES OF VEHICLE MILES TRAVELED

An analysis of vehicle odometer readings for the approximately 9,000 vehicles reporting in the On-Road Survey resulted in the following findings concerning vehicle miles of travel:

(1) The average annual miles traveled, per vehicle, is essentially the same for both passenger cars and light trucks--about 6,000 miles per year. This finding is believed to indicate that the usage environments (length of trip, trip purpose, etc.) are similar for cars and light trucks.

(2) Average annual miles traveled shows little practical variation among size classes of vehicles for both cars and trucks, or between 2-wheel drive and 4-wheel drive light trucks.

(3) Average annual miles per vehicle shows a distinct decline with vehicle age. In the first year of vehicle life, average miles traveled is estimated at 14,000. However, by the 5th year by age, average travel per vehicle drops to 6,500 miles, or less than half the travel during the first year. The data strongly indicate that this declining trend of travel with vehicle age continues throughout the life of the vehicle.

(4) Vehicle travel was found to be considerably higher for diesel vehicles than for vehicles powered by conventional gasoline engines. This difference was larger for passenger cars than for light trucks. Additionally and in contrast to the finding for the overall fleet, vehicle size appeared to be a significant factor as well, with small diesel vehicles showing a greater increase in miles driven over their gasoline counterparts, than large diesel vehicles.

Although other factors may be involved, it is believed that the most likely reason behind the greater travel by diesel vehicles is the lower fuel cost per mile for diesel vehicles over gasoline-powered vehicles.

(5) The findings for average annual vehicle travel from the On-Road Fuel Economy Survey are in general agreement with those of most earlier travel surveys for the first few years of a vehicle's life. However, beginning with the 5th to 6th years of vehicle life, the On-Road Survey shows a markedly greater rate of decline in average annual travel than all earlier known surveys.

(6) Average annual travel per vehicle, both passenger cars and light trucks, for all age vehicles (e.g., for the total U.S. fleet of cars and light trucks) on the road is estimated at 6,025 miles. This contrasts with estimates of 9,000 to 11,000 miles based on other known travel surveys or studies.

(7) The implications of the findings on vehicle miles of travel from the On-Road Survey are that both per vehicle and total (all vehicles) annual miles traveled for passenger cars and light trucks are substantially lower than heretofore generally believed, based on prior known travel surveys, or on other estimates of vehicle miles of travel. Fleet vehicles were not included in the survey. However, travel by fleet vehicles does not appear to be of sufficient magnitude to account for the lower VMT findings found in this study.

(8) While average and total annual travel per vehicle is lower than most prior studies have found, the variation travel among vehicles of the same age is very large indeed. For example, for 1977 vehicles, which had been driven an average of 59,000 miles at the time of the survey, it is estimated that in the total population of 1977 models, the total, per

vehicle mileage could range as low as 10,000 or as high as 107,000! Other model year vehicles showed similar large variations in mileage. This is believed to primarily reflect the vehicle owner/usage characteristics. A few owners (such as certain elderly persons, for example) may drive only a few hundred miles per year. On the other hand, certain persons, due to the occupation, avocation, etc., may drive tens of thousands of miles per year.

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APPENDIX A

LISTING OF VEHICLE MAKE MODELS

(I.E., SUBSTRATA)

SAMPLED IN ORFES

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
MINI	CHEVROLET CORVETTE (2-SEATER)	1
	DATSUN B-210	10
	DATSUN 280Z (2-SEATER)	6
	DODGE COLT	2
	HONDA CIVIC	5
	HONDA CIVIC CVCC	4
	PLYMOUTH ARROW	3
	TOYOTA CELICA	10
	VOLKSWAGON BEETLE	1
SUB-COMPACT	AMC GREMLIN	3
	BUICK SKYHAWK	3
	CHEVROLET CAMARO	10
	CHEVROLET CHEVETTE	6
	CHEVROLET VEGA	4
	DATSUN F-10	1
	DATSUN 810	1
	FORD MAVERICK	11
	FORD MUSTANG II	6
	FORD PINTO	7
	HONDA ACCORD CVCC	9
	LINCOLN-MERCURY BOBCAT	3
	LINCOLN-MERCURY COMET	1
	PONTIAC FIREBIRD	4

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
SUB-COMPACT	PONTIAC SUNBIRD	3
	TOYOTA COROLLA	11
	TOYOTA CORONA	2
	VOLKSWAGON DASHER	2
	VOLKSWAGON RABBIT	13
	VOLKSWAGON SCIROCCO	1
COMPACT	BUICK SKYLARK	8
	CADILLAC SEVILLE	2
	CHEVROLET MONTE CARLO	24
	CHEVROLET NOVA	26
	DODGE ASPEN	14
	FORD GRANADA	30
	FORD THUNDERBIRD	16
	LINCOLN-MERCURY MONARCH	9
	LINCOLN-MERCURY VERSAILLES	3
	OLDSMOBILE OMEGA	1
	PLYMOUTH VOLARE	12
	PONTIAC GRAND PRIX	17
	PONTIAC VENTURA	5
MIDSIZE	BUICK CENTURY	8
	BUICK REGAL	12
	CADILLAC ELDORADO	1
	CHEVROLET MALIBU	13

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE	CHRYSLER CORDOBA	11
	CHRYSLER LEBARON	3
	DODGE CHARGER SE	3
	FORD LTD II	10
	LINCOLN-MERCURY CONTINENTAL MARK V	3
	LINCOLN-MERCURY COUGAR	4
	LINCOLN-MERCURY COUGAR XR-7	4
	OLDSMOBILE CUTLASS	8
	OLDSMOBILE CUTLASS SUPREME	28
	PLYMOUTH FURY	4
	PONTIAC LEMANS	6
	DODGE DIPLOMAT	2
LARGE	AMC MATADOR	1
	BUICK ELECTRA	11
	BUICK LESABRE	22
	CADILLAC DEVILLE	12
	CHEVROLET CAPRICE	32
	CHEVROLET IMPALA	26
	CHRYSLER NEWPORT	8
	CHRYSLER NEW YORKER	4
	DODGE ROYAL MONACO	4
	FORD LTD	34

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE	LINCOLN-MERCURY LINCOLN CONTINENTAL	6
	LINCOLN-MERCURY MERCURY MARQUIS	11
	OLDSMOBILE DELTA 88	8
	OLDSMOBILE 98	11
	PLYMOUTH GRAN FURY	1
	PONTIAC BONNEVILLE	12
	PONTIAC CATALINA	5
SMALL STN WAGON	AMC HORNET WAGON	4
	AMC PACER WAGON	4
	DATSUN F-10 WAGON	1
	DATSUN 810 WAGON	5
	FORD PINTO WAGON	19
	HONDA CIVIC CVCC WAGON	5
	PONTIAC ASTRE SAFARI WAGON	1
	TOYOTA COROLLA WAGON	6
	TOYOTA CORONA WAGON	7
	VOLKSWAGON DASHER WAGON	4
MIDSIZE WAGON	BUICK CENTURY WAGON	4
	CHEVROLET MALIBU WAGON	16
	DODGE ASPEN WAGON	29
	DODGE MONACO WAGON	4
	FORD LTD II WAGON	1

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE WAGON	OLDSMOBILE VISTA CRUISER WAGON	8
	PLYMOUTH FURY WAGON	2
	PLYMOUTH VOLARE WAGON	36
	PONTIAC LEMANS SAFARI WAGON	5
LARGE WAGON	AMC MATADOR WAGON	4
	BUICK ESTATE WAGON	7
	CHEVROLET CAPRICE WAGON	9
	CHEVROLET IMPALA WAGON	12
	CHRYSLER TOWN & COUNTRY WAGON	2
	LINCOLN-MERCURY MARQUIS WAGON	4
	OLDSMOBILE CUSTOM CRUISER WAGON	10
	PLYMOUTH GRAN FURY SUBURBAN WAGON	1
	PONTIAC SAFARI WAGON	6
SUBCOMPACT DIES	VOLKSWAGON RABBIT	1
SMALL PICKUP-GAS	CHEVROLET LUV PICKUP	2
	DATSUN PICKUP	8
	FORD COURIER PICKUP	1
	TOYOTA HILUX PICKUP	5
STD PICKUP-GAS	CHEVROLET C-10 PICKUP	15
	CHEVROLET C-20 PICKUP	5
	CHEVROLET EL CAMINO	4
	DODGE D-100 PICKUP	4

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
STD PICKUP-GAS	DODGE D-200 PICKUP	1
	FORD F-150 PICKUP	13
	FORD F-200 PICKUP	7
	FORD RANCHERO	2
VAN-GAS	CHEVROLET SPORTVAN	14
	CHEVROLET UTILITY VAN	13
	DODGE SPORTSMAN	11
	DODGE UTILITY VAN	33
	FORD ECONOLINE VAN	16
	FORD CLUB WAGON VAN	7
	GMC RALLYE WAGON	1
	PLYMOUTH VOYAGER VAN	3
	VOLKSWAGON BUS	10
	GMC SUBURBAN	1
	CHEVROLET SUBURBAN	14
SPECIAL USE-GAS	DODGE RAMCHARGER	2
	GMC JIMMY	1
STD PICKUP 4WD	JEEP PICKUP 25	1
SPECIAL USE 4WD	DODGE RAMCHARGER	2
	GMC JIMMY	2
	CHEVROLET BLAZER	13
	FORD BRONCO	5
	JEEP CHEROKEE	3

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1977

ALL

STRATA	CAR MAKE AND MODEL	N
SPECIAL USE 4WD	JEEP CJ-5	4
	JEEP CJ-7	3
	JEEP WAGONEER	2
	PLYMOUTH TRAILDUSTER	1

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
MINI	CHEVROLET CORVETTE (2-SEATER)	3
	DATSUN B-210	11
	DATSUN 280Z (2-SEATER)	2
	DODGE CHALLENGER	3
	DODGE COLT	6
	FORD MUSTANG II	6
	FORD PINTO	15
	HONDA CIVIC	2
	LINCOLN-MERCURY BOBCAT	3
	PLYMOUTH ARROW	1
SUB-COMPACT	AMC GREMLIN	3
	BUICK OPEL	1
	CHEVROLET CAMARO	7
	CHEVROLET CHEVETTE	22
	CHEVROLET MONZA	11
	DATSUN F-10	1
	DATSUN 510	5
	FORD FIESTA	11
	HONDA CIVIC CVCC	4
	HONDA ACCORD	7
	OLDSMOBILE STARFIRE	1
	PONTIAC FIREBIRD	10
	PONTIAC SUNBIRD	4

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
SUB-COMPACT	TOYOTA CELICA	11
	TOYOTA COROLLA	14
	TOYOTA CORONA	3
	VOLKSWAGON DASHER	3
	VOLKSWAGON RABBIT	18
	VOLKSWAGON SCIROCCO	3
	DODGE OMNI	6
	PLYMOUTH HORIZON	14
COMPACT	AMC CONCORD	5
	AMC PACER	1
	BUICK SKYLARK	12
	CADILLAC SEVILLE	3
	CHEVROLET NOVA	22
	DODGE ASPEN	15
	FORD GRANADA	20
	LINCOLN-MERCURY MONARCH	7
	LINCOLN-MERCURY VERSAILLES	2
	OLDSMOBILE OMEGA	6
	PLYMOUTH VOLARE	13
	PONTIAC PHOENIX	8
MIDSIZE	AMC MATADOR COUPE	1
	BUICK CENTURY	6
	BUICK REGAL	20

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE	CHEVROLET MALIBU	26
	CHEVROLET MONTE CARLO	25
	CHRYSLER CORDOBA	8
	CHRYSLER LEBARON	11
	CHRYSLER MAGNUM SE (DODGE)	5
	DODGE DIPLOMAT	6
	DODGE MONACO	2
	FORD FAIRMONT	25
	FORD LTD II	6
	FORD THUNDERBIRD	21
	LINCOLN-MERCURY CONTINENTAL MARK V	3
	LINCOLN-MERCURY COUGAR	3
	LINCOLN-MERCURY COUGAR XR-7	12
	LINCOLN-MERCURY ZEPHYR	10
	OLDSMOBILE CUTLASS	11
	OLDSMOBILE CUTLASS CALAIS	3
	OLDSMOBILE CUTLASS SUPREME	29
	PLYMOUTH FURY	1
	PONTIAC GRAND PRIX	15
	PONTIAC LEMANS	12
LARGE	BUICK ELECTRA	8
	BUICK LESABRE	23

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE	BUICK RIVIERA	3
	CADILLAC DEVILLE	12
	CADILLAC FLEETWOOD	2
	CHEVROLET CAPRICE	27
	CHEVROLET IMPALA	20
	CHRYSLER NEWPORT	3
	FORD LTD	22
	LINCOLN-MERCURY LINCOLN CONTINENTAL	1
	LINCOLN-MERCURY MARQUIS	8
	OLDSMOBILE DELTA 88	27
	OLDSMOBILE 98	14
	PONTIAC BONNEVILLE	15
	PONTIAC CATALINA	6
SMALL STN WAGON	AMC CONCORD WAGON	3
	AMC PACER WAGON	1
	DATSUN F-10 WAGON	4
	DATSUN 510 WAGON	8
	DATSUN 810 WAGON	1
	FORD PINTO WAGON	4
	HONDA CIVIC WAGON	8
	LINCOLN-MERCURY BOBCAT WAGON	2
	PONTIAC SUNBIRD SAFARI WAGON	2

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL STN WAGON	TOYOTA COROLLA WAGON	8
	TOYOTA CORONA WAGON	1
	TOYOTA CRESSIDA WAGON	1
	VOLKSWAGON DASHER WAGON	1
MIDSIZE WAGON	BUICK CENTURY WAGON	6
	CHEVROLET MALIBU WAGON	18
	CHRYSLER LEBARON WAGON	7
	DODGE ASPEN WAGON	15
	DODGE DIPLOMAT WAGON	1
	DODGE MONACO WAGON	1
	FORD FAIRMONT WAGON	27
	LINCOLN-MERCURY ZEPHYR WAGON	13
	OLDSMOBILE CUTLASS CRUISER WAGON	9
	PLYMOUTH FURY WAGON	1
	PLYMOUTH VOLARE WAGON	18
	PONTIAC LEMANS SAFARI WAGON	9
LARGE WAGON	AMC MATADOR WAGON	1
	BUICK ESTATE WAGON	8
	CHEVROLET CAPRICE WAGON	14
	CHEVROLET IMPALA WAGON	12
	FORD LTD WAGON	11
	LINCOLN-MERCURY MARQUIS WAGON	3

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE WAGON	OLDSMOBILE CUSTOM CRUISER WAGON	7
	PONTIAC CATALINA SAFARI WAGON	4
SUBCOMPACT DIES	VOLKSWAGON RABBIT	7
LARGE DIESEL	OLDSMOBILE 98	24
	OLDSMOBILE 88	68
LG WAGON-DIES	OLDSMOBILE CUSTOM CRUISER WAGON	24
SMALL PICKUP-GAS	CHEVROLET LUV PICKUP	4
	DATSUN PICKUP	7
	FORD COURIER PICKUP	3
	TOYOTA HILUX	6
STD PICKUP-GAS	CHEVROLET EL CAMINO	6
	CHEVROLET C-10	29
	CHEVROLET C-20	3
	DODGE D-150	7
	DODGE D-200	1
	FORD F-100	13
	FORD F-150	20
	FORD F-250	1
	FORD RANCHERO	2
	GMC C1500	6
	GMC C2500	3
VAN-GAS	CHEVROLET G-10	9

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
VAN-GAS	CHEVROLET G-20	20
	DODGE B-100	3
	DODGE B-200	9
	FORD E-100	1
	FORD E-150	32
	GMC G-1500	2
	GMC G-2500	2
	PLYMOUTH VOYAGER VAN	3
	VOLKSWAGON BUS (WAGON,KOMBI,CAMPMOBILE)	10
	FORD CLUB WAGON	14
	DODGE SPORTSMAN	5
	CHEVROLET SPORTVAN	9
	CHEVROLET SUBURBAN	14
	GMC RALLY	4
	GMC SUBURBAN	2
SPECIAL USE-GAS	CHEVROLET BLAZER	2
	GMC JIMMY	1
SPECIAL USE 4WD	CHEVROLET SUBURBAN	2
	CHEVROLET BLAZER	19
	GMC JIMMY	5
	DODGE RAMCHARGER	4
	FORD BRONCO	18

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1978

ALL

STRATA	CAR MAKE AND MODEL	N
SPECIAL USE 4WD	JEEP CHEROKEE	5
	JEEP CJ-1	5
	JEEP CJ-5	3
	JEEP WAGONEER	6
	PLYMOUTH TRAIL DUSTER	1
STD PKUP DIE 2WD	CHEVROLET C-10	18
	GMC C-1500	3

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
MINI	CHEVROLET CORVETTE (2-SEATER)	2
	DODGE COLT	1
	FORD PINTO	10
	HONDA CIVIC	7
	LINCOLN-MERCURY BOBCAT	2
	VOLKSWAGON BEETLE CONVERTIBLE	1
	HONDA PRELUDE	1
SUB-COMPACT	BUICK OPEL	1
	CHEVROLET CAMARO	18
	CHEVROLET CHEVETTE	37
	CHEVROLET MONZA	14
	DATSUN 210	17
	DATSUN 310	8
	DATSUN 510	2
	DODGE CHALLENGER	1
	DODGE COLT HATCHBACK	6
	DODGE OMNI	14
	FORD FIESTA	8
	FORD MUSTANG	21
	HONDA ACCORD	18
	LINCOLN-MERCURY CAPRI	10
	OLDSMOBILE STARFIRE	2
	PLYMOUTH HORIZON	19

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
SUB-COMPACT	PLYMOUTH SAPPORO	2
	PONTIAC FIREBIRD	6
	PONTIAC SUNBIRD	5
	TOYOTA CELICA	10
	TOYOTA CELICA SUPRA	1
	TOYOTA COROLLA	20
	TOYOTA CORONA	3
	TOYOTA CRESSIDA	1
	VOLKSWAGON RABBIT	19
	VOLKSWAGON SCIROCCO	4
COMPACT	AMC CONCORD	8
	BUICK SKYLARK	7
	CADILLAC SEVILLE	1
	CHEVROLET NOVA	8
	FORD GRANADA	16
	LINCOLN-MERCURY MONARCH	9
	LINCOLN-MERCURY VERSAILLES	2
	OLDSMOBILE OMEGA	3
MIDSIZE	BUICK CENTURY	2
	BUICK REGAL	29
	BUICK RIVIERA	6
	CADILLAC ELDORADO	3
	CHEVROLET MALIBU	36

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE	CHEVROLET MONTE CARLO	21
	CHRYSLER CORDOBA	7
	CHRYSLER LEBARON	13
	DODGE ASPEN	6
	DODGE DIPLOMAT	3
	DODGE MAGNUM	4
	FORD FAIRMONT	31
	FORD LTD II	3
	FORD THUNDERBIRD	21
	LINCOLN-MERCURY CONTINENTAL MARK V	1
	LINCOLN-MERCURY ZEPHYR	10
	OLDSMOBILE CUTLASS	6
	OLDSMOBILE CUTLASS CALAIS	2
	OLDSMOBILE CUTLASS SUPREME	47
	OLDSMOBILE TORONADO	2
	PLYMOUTH VOLARE	14
	PONTIAC GRAND PRIX	20
	PONTIAC LEMANS	12
	PONTIAC GRAND AM	1
	MERCURY COUGAR XR7	12
LARGE	BUICK ELECTRA	11
	BUICK LESABRE	20

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE	CADILLAC DEVILLE	16
	CADILLAC FLEETWOOD	3
	CHEVROLET CAPRICE	34
	CHEVROLET IMPALA	23
	CHRYSLER NEWPORT	5
	CHRYSLER NEW YORKER	2
	DODGE ST. REGIS	3
	FORD LTD	30
	LINCOLN-MERCURY LINCOLN CONTINENTAL	5
	LINCOLN-MERCURY MARQUIS	10
	OLDSMOBILE DELTA 88	25
	OLDSMOBILE NINETY-EIGHT	9
	PONTIAC BONNEVILLE	20
	PONTIAC CATALINA	6
SMALL STN WAGON	AMC CONCORD WAGON	6
	AMC PACER WAGON	2
	DATSUN 210 WAGON	12
	DATSUN 510 WAGON	5
	DATSUN 810 WAGON	2
	FORD PINTO WAGON	18
	HONDA CIVIC CVCC WAGON	7
	LINCOLN-MERCURY BOBCAT WAGON	3

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL STN WAGON	PONTIAC SUNBIRD SAFARI WAGON	1
	TOYOTA COROLLA WAGON	4
	TOYOTA CORONA WAGON	2
	VOLKSWAGON DASHER WAGON	3
MIDSIZE WAGON	BUICK CENTURY WAGON	5
	CHEVROLET MALIBU WAGON	21
	CHRYSLER LEBARON WAGON	6
	DODGE ASPEN WAGON	4
	DODGE DIPLOMAT WAGON	3
	FORD FAIRMONT WAGON	24
	LINCOLN-MERCURY ZEPHYR WAGON	5
	OLDSMOBILE CUTLASS WAGON	20
	PLYMOUTH VOLARE WAGON	13
	PONTIAC LEMANS SAFARI WAGON	19
LARGE WAGON	CHEVROLET CAPRICE	13
	CHEVROLET IMPALA	19
	BUICK ESTATE WAGON	3
	FORD LTD WAGON	12
	LINCOLN-MERCURY MARQUIS WAGON	4
	OLDSMOBILE CUSTOM CRUISER WAGON	9
	PONTIAC BONNEVILLE SAFARI WAGON	3
	PONTIAC CATALINA SAFARI WAGON	3

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
SUBCOMPACT DIES	VOLKSWAGON RABBIT	112
COMPACT DIESEL	CADILLAC SEVILLE	4
MIDSIZE DIESEL	CADILLAC ELDORADO	1
	OLDSMOBILE CUTLASS	4
	OLDSMOBILE CUTLASS SUPREME	27
	OLDSMOBILE TORONADO	9
LARGE DIESEL	OLDSMOBILE 88	37
	OLDSMOBILE 98	19
MID WAGON-DIES	OLDSMOBILE CUTLASS CRUISER WAGON	21
LG WAGON-DIES	OLDSMOBILE CUSTOM CRUISER WAGON	20
SMALL PICKUP-GAS	CHEVROLET LUV PICKUP	5
	DATSUN PICKUP	4
	DODGE D50 PICKUP	3
	FORD COURIER PICKUP	4
	TOYOTA HILUX	2
STD PICKUP-GAS	CHEVROLET C-10	34
	CHEVROLET C-20	3
	CHEVROLET EL CAMINO	5
	DODGE D100	5
	DODGE D 150	2
	DODGE D 200	1
	FORD F-100	11

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
STD PICKUP-GAS	FORD F 150	20
	FORD F 250	5
	FORD RANCHERO	1
	GMC CABALLERO	1
	GMC C1500	3
VAN-GAS	CHEVROLET G10	9
	CHEVROLET G20	13
	DODGE B100	1
	DODGE B200	18
	FORD E-100	3
	FORD E-150	20
	GMC G1500	1
	GMC G-2500	4
	VOLKSWAGON BUS (WAGON,KOMBI,CAMPMOBILE)	5
	FORD CLUB WAGON	8
	DODGE SPORTSMAN	5
	CHEVROLET SPORT VAN	12
	CHEVROLET SUBURBAN	11
	GMC RALLY	5
	GMC SUBURBAN	3
SPECIAL USE-GAS	CHEVROLET BLAZER	3
SPECIAL USE 4WD	CHEVROLET BLAZER	13

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1979

ALL

STRATA	CAR MAKE AND MODEL	N
SPECIAL USE 4WD	DODGE RAMCHARGER	1
	FORD BRONCO	19
	GMC JIMMY	2
	JEEP CHEROKEE	10
	JEEP CJ-5	4
	JEEP CJ-7	14
	JEEP WAGONEER	6
STD PKUP DIE 2WD	CHEVROLET C-10	32
	GMC C-15	7

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
MINI	CHEVROLET CORVETTE (2-SEATER)	1
	FORD PINTO	11
	HONDA CIVIC	17
	HONDA PRELUDE	5
	LINCOLN-MERCURY BOBCAT	2
	PLYMOUTH ARROW	2
SUB-COMPACT	AMC EAGLE	5
	AMC SPIRIT	7
	CHEVROLET CAMARO	10
	CHEVROLET CHEVETTE	46
	CHEVROLET MONZA	16
	DATSUN 200 SX	10
	DATSUN 210	27
	DATSUN 310	12
	DATSUN 510	6
	DODGE CHALLENGER	1
	DODGE COLT	7
	DODGE OMNI	25
	FORD FIESTA	13
	FORD MUSTANG	35
	HONDA ACCORD	35
	LINCOLN-MERCURY CAPRI	4
	OLDSMOBILE STARFIRE	1

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
SUB-COMPACT	PLYMOUTH CHAMP	8
	PLYMOUTH HORIZON	18
	PLYMOUTH SAPPORO	1
	PONTIAC FIREBIRD	4
	PONTIAC SUNBIRD	20
	TOYOTA CELICA	18
	TOYOTA CELICA SUPRA	1
	TOYOTA COROLLA	42
	TOYOTA COROLLA TERCEL	23
	TOYOTA CORONA	5
	TOYOTA CRESSIDA	1
	VOLKSWAGON JETTA	1
	VOLKSWAGON RABBIT	16
	VOLKSWAGON RABBIT CONVERTIBLE	2
	VOLKSWAGON SCIROCCO	4
COMPACT	AMC CONCORD	12
	AMC PACER	1
	BUICK SKYLARK	44
	FORD GRANADA	10
	LINCOLN-MERCURY MONARCH	3
	OLDSMOBILE OMEGA	26
MIDSIZE	BUICK CENTURY	23
	BUICK REGAL	44

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE	BUICK RIVIERA	3
	CADILLAC ELDORADO	2
	CADILLAC SEVILLE	2
	CHEVROLET CITATION	120
	CHEVROLET MALIBU	25
	CHEVROLET MONTE CARLO	15
	CHRYSLER CORDOBA	3
	CHRYSLER LEBARON	8
	DODGE ASPEN	9
	DODGE DIPLOMAT	5
	DODGE MIRADA	4
	FORD FAIRMONT	36
	FORD THUNDERBIRD	19
	LINCOLN-MERCURY COUGAR XR7	5
	LINCOLN-MERCURY ZEPHYR	11
	OLDSMOBILE CUTLASS	8
	OLDSMOBILE CUTLASS CALAIS	1
	OLDSMOBILE CUTLASS SUPREME	52
	OLDSMOBILE TORONADO	4
	PLYMOUTH VOLARE	11
	PONTIAC GRAND PRIX	10
	PONTIAC LEMANS	9
	PONTIAC PHOENIX	28

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE	BUICK ELECTRA	4
	BUICK LESABRE	8
	CADILLAC DEVILLE	4
	CADILLAC FLEETWOOD	3
	CHEVROLET CAPRICE	17
	CHEVROLET IMPALA	12
	CHRYSLER NEWPORT	4
	CHRYSLER NEW YORKER	1
	DODGE ST. REGIS	2
	FORD LTD	11
	LINCOLN-MERCURY CONTINENTAL	2
	LINCOLN-MERCURY CONTINENTAL MARK VI	3
	LINCOLN-MERCURY MARQUIS	7
	OLDSMOBILE DELTA 88	15
	OLDSMOBILE NINETY-EIGHT	4
	PONTIAC BONNEVILLE	10
	PONTIAC CATALINA	2
SMALL STN WAGON	AMC CONCORD WAGON	5
	DATSUN 210 WAGON	8
	DATSUN 510 WAGON	7
	DATSUN 810 WAGON	2
	DODGE COLT WAGON	3

(CONTINUED)

TABLE 3
MAKE AND MODEL,
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL STN WAGON	FORD PINTO WAGON	14
	HONDA CIVIC WAGON	19
	LINCOLN-MERCURY BOBCAT WAGON	2
	TOYOTA COROLLA WAGON	12
	TOYOTA CRESSIDA WAGON	1
	VOLKSWAGON DASHER WAGON	2
MIDSIZE WAGON	BUICK CENTURY WAGON	6
	CHEVROLET MALIBU WAGON	21
	CHRYSLER LEBARON WAGON	2
	DODGE ASPEN WAGON	5
	FORD FAIRMONT WAGON	28
	LINCOLN-MERCURY ZEPHYR WAGON	8
	OLDSMOBILE CUTLASS WAGON	12
	PLYMOUTH VOLARE WAGON	8
	PONTIAC LEMANS SAFARI WAGON	4
LARGE WAGON	BUICK ESTATE WAGON	2
	CHEVROLET CAPRICE WAGON	3
	CHEVROLET IMPALA WAGON	3
	FORD LTD WAGON	4
	OLDSMOBILE CUSTOM CRUISER WAGON	3
	PONTIAC CATALINA SAFARI WAGON	1
SUBCOMPACT DIES	VOLKSWAGON RABBIT	25

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE DIESEL	CADILLAC ELDORADO	4
	CADILLAC SEVILLE	5
	OLDSMOBILE CUTLASS	3
	OLDSMOBILE CUTLASS CALAIS	2
	OLDSMOBILE CUTLASS SUPREME	43
	OLDSMOBILE TORONADO	6
LARGE DIESEL	BUICK ELECTRA	7
	BUICK LESABRE	10
	CADILLAC DEVILLE	8
	CADILLAC FLEETWOOD	2
	PONTIAC BONNEVILLE	16
	OLDSMOBILE 88	30
	OLDSMOBILE 98	16
SMALL WAGON-DIES	VOLKSWAGON DASHER	5
MID WAGON-DIES	OLDSMOBILE CUTLASS CRUISER WAGON	18
LG WAGON-DIES	CHEVROLET CAPRICE WAGON	28
	CHEVROLET IMPALA WAGON	8
	OLDSMOBILE CUSTOM CRUISER WAGON	21
	BUICK ELECTRA ESTATE WAGON	1
	PONTIAC BONNEVILLE WAGON	2
SMALL PICKUP-GAS	CHEVROLET LUV PICKUP 2WD	8
	DATSUN PICKUP 2WD	17

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL PICKUP-GAS	DODGE D50 PICKUP 2WD	9
	FORD COURIER PICKUP 2WD	16
	PLYMOUTH ARROW PICKUP 2WD	1
	TOYOTA PICKUP 2WD	7
	VOLKSWAGON PICKUP 2WD	3
STD PICKUP-GAS	CHEVROLET C10 PICKUP 2WD	24
	CHEVROLET C20 PICKUP 2WD	1
	CHEVROLET EL CAMINO PICKUP 2WD	6
	DODGE D150 PICKUP 2WD	8
	DODGE D200 PICKUP 2WD	1
	FORD F100	23
	FORD F150 PICKUP 2WD	15
	FORD F250 PICKUP 2WD	2
	GMC C15 PICKUP 2WD	5
	GMC C25 PICKUP 2WD	1
	TOYOTA PICKUP 3/4 TON 2WD	8
VAN-GAS	CHEVROLET G10 VAN	4
	CHEVROLET G20 VAN	3
	CHEVROLET G20 SPORTVAN	1
	DODGE B100 VAN	2
	DODGE B200 VAN	5
	DODGE B100 SPORTSMAN	1
	DODGE B200 SPORTSMAN	1

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
VAN-GAS	DODGE B300 SPORTSMAN	2
	FORD E 100 CLUB WAGON	4
	FORD E 150 CLUB WAGON	14
	GMC G25 VAN	1
	PLYMOUTH PB100 VOYAGER	1
	VOLKSWAGON VANAGON	4
SPECIAL USE-GAS	CHEVROLET C10 BLAZER	1
	CHEVROLET C10 SUBURBAN	2
	CHEVROLET C20 SUBURBAN	1
SMALL PICKUP 4WD	CHEVROLET LUV	20
	TOYOTA PICKUP	24
STD PICKUP 4WD	CHEVROLET K-10	15
	CHEVROLET K-20	8
	DODGE D150	2
	DODGE W200	1
	FORD F150	24
	FORD F250	11
	GMC K15	4
	JEEP J10	2
SPECIAL USE 4WD	CHEVROLET K10 BLAZER	4
	CHEVROLET K10 SUBURBAN	1
	DODGE AW100 RAMCHARGER	2
	FORD BRONCO	15

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1980

ALL

STRATA	CAR MAKE AND MODEL	N
SPECIAL USE 4WD	GMC K15 JIMMY	2
	GMC K15 SUBURBAN	1
	JEEP CHEROKEE	2
	JEEP CJ-5	3
	JEEP CJ-7	7
	JEEP WAGONEER	1
	PLYMOUTH PW100 TRAIL DUSTER	1
SML PKUP DIE 2WD	VOLKSWAGON	2
STD PKUP DIE 2WD	CHEVROLET C-10	39
	GMC C15	12

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
MINI	CHEVROLET CORVETTE (2-SEATER)	3
	DATSUN 280ZX (2-SEATER)	5
	HONDA CIVIC	46
	HONDA PRELUDE	20
	TOYOTA STARLET	12
SUB-COMPACT	AMC EAGLE	1
	AMC EAGLE KAMMBACK SX4	3
	AMC SPIRIT	7
	CHEVROLET CAMARO	12
	CHEVROLET CHEVETTE	105
	DATSUN 200SX	10
	DATSUN 210	29
	DATSUN 280ZX 2+2	2
	DATSUN 310	6
	DATSUN 510	5
	DATSUN 810	1
	DODGE CHALLENGER	2
	DODGE COLT	8
	DODGE O24	21
	FORD MUSTANG	17
	HONDA ACCORD	52
	LINCOLN-MERCURY CAPRI	7
	PLYMOUTH CHAMP	10

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
SUB-COMPACT	PLYMOUTH SAPPORO	6
	PLYMOUTH TC3	16
	PONTIAC FIREBIRD	6
	TOYOTA CELICA	35
	TOYOTA CELICA SUPRA	2
	TOYOTA COROLLA	66
	TOYOTA COROLLA TERCEL	43
	TOYOTA CORONA	6
	TOYOTA CRESSIDA	8
	VOLKSWAGON RABBIT	8
	VOLKSWAGON SCIROCCO	1
COMPACT	AMC CONCORD	2
	BUICK SKYLARK	63
	DODGE OMNI	31
	FORD ESCORT	75
	LINCOLN-MERCURY LYNX	32
	OLDSMOBILE OMEGA	32
	PLYMOUTH HORIZON	36
MIDSIZE	BUICK CENTURY	21
	BUICK REGAL	35
	BUICK RIVIERA	4
	CADILLAC ELDORADO	7
	CADILLAC SEVILLE	2

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE	CHEVROLET CITATION	77
	CHEVROLET MALIBU	19
	CHEVROLET MONTE CARLO	29
	CHRYSLER CORDOBA	4
	CHRYSLER IMPERIAL	2
	CHRYSLER LEBARON	6
	DODGE ARIES	31
	DODGE DIPLOMAT	1
	DODGE MIRADA	1
	FORD FAIRMONT	19
	FORD GRANADA	19
	FORD THUNDERBIRD	8
	LINCOLN-MERCURY COUGAR	1
	LINCOLN-MERCURY XR7	5
	LINCOLN-MERCURY ZEPHYR	5
	OLDSMOBILE CUTLASS	22
	OLDSMOBILE CUTLASS CALAIS	6
	OLDSMOBILE CUTLASS SALON	8
	OLDSMOBILE CUTLASS SUPREME	41
	PLYMOUTH RELIANT	34
	PONTIAC GRAND PRIX	27
	PONTIAC LEMANS	10
	PONTIAC PHOENIX	37

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
LARGE	BUICK ELECTRA	6
	BUICK LESABRE	11
	CADILLAC DEVILLE	10
	CADILLAC FLEETWOOD	1
	CHEVROLET CAPRICE	16
	CHEVROLET IMPALA	5
	CHRYSLER NEWPORT	1
	CHRYSLER NEW YORKER	1
	FORD LTD	7
	LINCOLN-MERCURY MARQUIS	8
	OLDSMOBILE DELTA 88	17
	OLDSMOBILE NINETY-EIGHT	4
	PONTIAC BONNEVILLE	13
	PONTIAC CATALINA	1
	LINCOLN MARK VI	5
	LINCOLN CONTINENTAL TOWN & COUNTRY	10
SMALL STN WAGON	AMC EAGLE WAGON	8
	AMC CONCORD WAGON	4
	DATSUN 210 WAGON	24
	DATSUN 510 WAGON	11
	DATSUN 810 WAGON	1
	HONDA CIVIC WAGON	32

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL STN WAGON	TOYOTA COROLLA WAGON	36
	TOYOTA CORONA WAGON	5
	TOYOTA CRESSIDA WAGON	2
MIDSIZE WAGON	BUICK CENTURY WAGON	7
	CHEVROLET MALIBU WAGON	21
	CHRYSLER LEBARON WAGON	2
	DODGE ARIES WAGON	38
	FORD FAIRMONT WAGON	18
	LINCOLN-MERCURY ZEPHYR WAGON	7
	OLDSMOBILE CUTLASS WAGON	10
	PLYMOUTH RELIANT WAGON	42
	PONTIAC LEMANS SAFARI WAGON	10
LARGE WAGON	CHEVROLET CAPRICE	4
	CHEVROLET IMPALA	6
	BUICK ELECTRA ESTATE WAGON	1
	FORD LTD WAGON	6
	LINCOLN-MERCURY MARQUIS WAGON	3
	OLDSMOBILE CUSTOM CRUISER WAGON	3
	PONTIAC BONNEVILLE SAFARI WAGON	2
SUBCOMPACT DIES	VOLKSWAGON RABBIT	74
MIDSIZE DIESEL	CADILLAC ELDORADO	3
	OLDSMOBILE CUTLASS	21

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
MIDSIZE DIESEL	OLDSMOBILE CUTLASS CALAIS	6
	OLDSMOBILE CUTLASS SUPREME	34
	PONTIAC GRAND PRIX	6
	OLDSMOBILE TORONADO	4
LARGE DIESEL	BUICK ELECTRA	3
	BUICK LESABRE	9
	CADILLAC DEVILLE	11
	CADILLAC FLEETWOOD	4
	CHEVROLET CAPRICE	10
	CHEVROLET IMPALA	3
	PONTIAC BONNEVILLE	21
	OLDSMOBILE 88	46
	OLDSMOBILE 98	15
SMALL WAGON-DIES	VOLKSWAGON DASHER	5
MID WAGON-DIES	OLDSMOBILE CUTLASS CRUISER WAGON	27
LG WAGON-DIES	BUICK ELECTRA ESTATE WAGON	2
	OLDSMOBILE CUSTOM CRUISER WAGON	27
	CHEVROLET CAPRICE WAGON	27
	PONTIAC BONNEVILLE WAGON	4
SMALL PICKUP-GAS	CHEVROLET LUV PICKUP	8
	DATSUN PICKUP	20
	DODGE RAM50 PICKUP	5

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
SMALL PICKUP-GAS	FORD COURIER PICKUP	9
	PLYMOUTH ARROW PICKUP	1
	TOYOTA TRUCK	12
	VOLKSWAGON PICKUP	2
STD PICKUP-GAS	CHEVROLET C10 PICKUP	35
	CHEVROLET C20 PICKUP	6
	CHEVROLET EL CAMINO PICKUP	10
	DODGE D150 PICKUP	9
	DODGE D250 PICKUP	2
	FORD F100	42
	FORD F150 PICKUP	26
	FORD F250 PICKUP	7
	GMC C15 PICKUP	7
	GMC C25 PICKUP	2
	TOYOTA PICKUP 3/4 TON	2
VAN-GAS	CHEVROLET G20 VAN	9
	CHEVROLET G10 SPORTVAN	2
	CHEVROLET G20 SPORTVAN	2
	DODGE B150 VAN	11
	DODGE B250 VAN	6
	DODGE B150 SPORTVAN	1
	DODGE B250 SPORTSMAN	3
	FORD E100 ECONOLINE	4

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
VAN-GAS	FORD E150 ECONOLINE	8
	FORD E250 ECONOLINE	1
	GMC G15 VAN	2
	GMC G25 VAN	3
	GMC G25 SPORTVAN	1
	PLYMOUTH PB150 VOYAGER	2
	VOLKSWAGON VANAGON	4
SPECIAL USE-GAS	CHEVROLET C10 BLAZER	3
	CHEVROLET C10 SUBURBAN	4
	CHEVROLET C20 SUBURBAN	1
	GMC C15 SUBURBAN	1
SMALL PICKUP 4WD	CHEVROLET LUV	5
	DATSUN	17
	TOYOTA PICKUP	25
STD PICKUP 4WD	CHEVROLET K-10	23
	CHEVROLET K-20	10
	DODGE W150	1
	DODGE W250	1
	FORD F150	40
	FORD F250	7
	GMC K15	1
	GMC K25	4
	JEEP J10	2

(CONTINUED)

TABLE 3
MAKE AND MODEL
CARYEAR= 1981

ALL

STRATA	CAR MAKE AND MODEL	N
STD PICKUP 4WD	JEEP J20	1
SPECIAL USE 4WD	CHEVROLET K10 BLAZER	7
	DODGE AW100 RAMCHARGER	3
	FORD BRONCO	13
	GMC K15 SUBURBAN	1
	JEEP CJ-5	1
	JEEP CJ-7	3
	JEEP CJ-8 (SCRAMBLER)	5
	JEEP WAGONEER	5
	TOYOTA LAND CRUISER WAGON	1
SML PKUP DIE 2WD	TOYOTA	32
	VOLKSWAGON	45
STD PKUP DIE 2WD	CHEVROLET C-10	16
	GMC C15	6

APPENDIX B

ESTIMATION OF AVERAGE VEHICLE AGE

ESTIMATION OF AVERAGE VEHICLE AGE FROM VEHICLE SALES DATA

Month (Yr)	Vehicle Sales[a]	Proportion of Monthly Sales Assumed to Be Model Yr 1977	% Sales by Month, Model Yr 1977	Average Vehicle Age, in months as of 1 July 1978
October '76	730,216	2/3	5.36	20.5
November '76	720,772	3/4	6.40	19.5
December '76	694,457	ALL	7.64	18.5
January '77	601,325	"	6.62	17.5
February '77	665,978	"	7.33	16.5
March '77	895,319	"	9.85	15.5
April '77	821,969	"	9.04	14.5
May '77	833,333	"	9.17	13.5
June '77	919,142	"	10.11	12.5
July '77	731,033	"	8.04	11.5
August '77	726,422	"	7.99	10.5
September '77	656,600	"	7.23	9.5
October '77	869,920	1/3	3.19	8.5
November '77	737,362	1/4	2.03	7.5
December '77	645,991	None	0	--

Source: a - Automotive News, various weekly publications for 1976 - 1978.

The average vehicle age for the 1977 Model Year fleet, as of 1 July 1978, is computed from the above table by taking the sales-weighted average of the individual monthly ages of the vehicles (e.g., the sum of the products of the numbers in columns 4 and 5 of the table). This number turns out to be:

14.34 months = 1.195 years

or approximately 1.2 years.

Thus on 1 July 1983, the midpoint of the 1983 On-Road Survey, Model Year 1977 vehicles would be approximately 1.2 + 5 or 6.2 years old.

Note in column 3 of the table that all vehicle sales from December 1976 through September 1977 are considered to be 1977 Model Year vintage, whereas only portions of the sales for months October and November 1976, and October and November 1977 are considered to be Model Year 1977 vehicles. This is done to account for the sale of carry-over model year vehicles into the beginning of the subsequent model year.

The year 1977 has been assumed as typical insofar as portraying the distribution of vehicle sales by month, and hence the computation of average vehicle age, as used in Chapter 3 of the report.

APPENDIX C

SURVEY SUPPORT MATERIALS

O.M.B. No. 2127-0037
Expires 9/30/84

U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

400 Seventh St., S.W.
Washington, D.C. 20590

PRENOTIFICATION LETTER — NHTSA

Dear Driver:

We need your help . . .

Your name has been selected at random from among all owners of late model cars and light trucks to participate in a nationwide survey.

The National Highway Traffic Safety Administration, an Agency of the U.S. Department of Transportation, is sponsoring the survey to measure the gas mileage performance of late model vehicles. Information obtained in the survey will tell us how much the Nation is saving as a result of the more fuel-efficient vehicles produced in the last few years, and will help determine future directions in energy conservation efforts.

The National Opinion Research Center, an experienced survey firm, will conduct the study for us. Within the next few days, they will be sending you a copy of a simple fuel-mileage log. Completion of the log will require only a few minutes of your time. The information, of course, will be vital to our study but we believe you will find it personally useful as well.

We want to assure you that while your participation in this survey is entirely voluntary, your response is very important to ensure the accuracy of the results. The survey complies with all Federal regulations concerning privacy and confidentiality and the results will be used only in statistical summaries.

We look forward to your cooperation in this important undertaking.

Sincerely,

Barry Felrice

Barry Felrice
Associate Administrator for
Plans and Programs

U.S. Department of Transportation

National Highway Traffic Safety Administration

O.M.B. No. 2127-0037
Expires 9/30/84

400 Seventh St., S.W.
Washington, D.C. 20590

PRENOTIFICATION LETTER — SURVEY CONTRACTOR

Dear

If you are like most of us, you have become very aware of the high cost of gasoline in today's family budget. "Miles-per-gallon" is the first thing most of us think of when we shop for a new or used car or truck.

In order to meet the problems of fuel conservation and cost, automobile companies have been manufacturing smaller and lighter vehicles in recent years.

We have been asked by the National Highway Traffic Safety Administration (see letter enclosed) to find out just how efficient these new vehicles have become. To do this, we are conducting a nationwide survey of vehicle owners like yourself who have purchased these late models.

How can you help us? By keeping a simple record of your gas purchases over the next month for the vehicle listed below.

In a few days, we will send you a small fuel-mileage log. Completion of the log will take only a few minutes of your time. In the event you no longer own the vehicle, or will not be operating it next month, please detach the form below and return it to us as soon as possible.

We look forward to your participation in this important study.

Sincerely,

Jean Atkinson

Jean Atkinson
Senior Survey Director

Conducted by: National Opinion Research Center • 6030 South Ellis • Chicago, IL 60637
University of Chicago

PLEASE DETACH THIS FORM AND RETURN IN THE POSTAGE-PAID ENVELOPE

VEHICLE: MAKE MODEL YEAR |_|_|_|_|_|_|_|_|

If your household no longer owns this vehicle, please answer the following:

1. The vehicle has been junked 1 [ ]
2. The vehicle has been sold 2 [ ] If sold, please give the name and address of the person to whom it was sold.

(Name) ____________________

(Address) ____________________

(City/State) ____________ / ________ (Zip Code) ____________

3. If your household still owns the vehicle but it will not be driven during the next month, please say why (e.g., the vehicle is being repaired).

____

NORC 4349

U.S. Department of Transportation
National Highway Traffic Safety Administration

O.M.B. No. 2127-0037
Expires 9/30/84

400 Seventh St., S.W.
Washington, D.C. 20590

ON THE ROAD FUEL ECONOMY SURVEY

QUESTIONNAIRE TRANSMITTAL LETTER—FIRST WAVE

Dear Driver:

A few days ago we wrote that you had been chosen to participate in a national On The Road Fuel Economy Survey.

Enclosed is a Fuel Mileage Log and two decals for this U.S. Department of Transportation study. The Log should be kept in some convenient spot inside your vehicle next month for ready access at "fill-up" time. One of the decals can be placed on the dash near the fuel gauge, as a reminder to you, or anyone else who drives, to record each gas purchase for the month. The decal can be easily removed after the survey, and will leave no residue on your vehicle.

Before placing the Log in your vehicle, please complete the description of your vehicle in Section A. Then, each time you buy gas next month, simply fill in one line of Section B, the Gas Mileage Log.

Please try to fill the tank completely, at least for the first and last purchases of the month, to enable us to make good estimates of your mileage.

At the end of the month, please return the Log to us. Simply fold the Log as indicated, seal with (second) decal or tape, and drop it in the mail. No postage is needed.

Because we believe you may find a record of your fuel mileage personally useful, we have enclosed a handy booklet which you may keep for yourself. You may also find the booklet a convenient place to keep the Log during the survey month.

The information you supply will be an important aid in determining future energy needs of our country, and we are looking forward to your participation in our study.

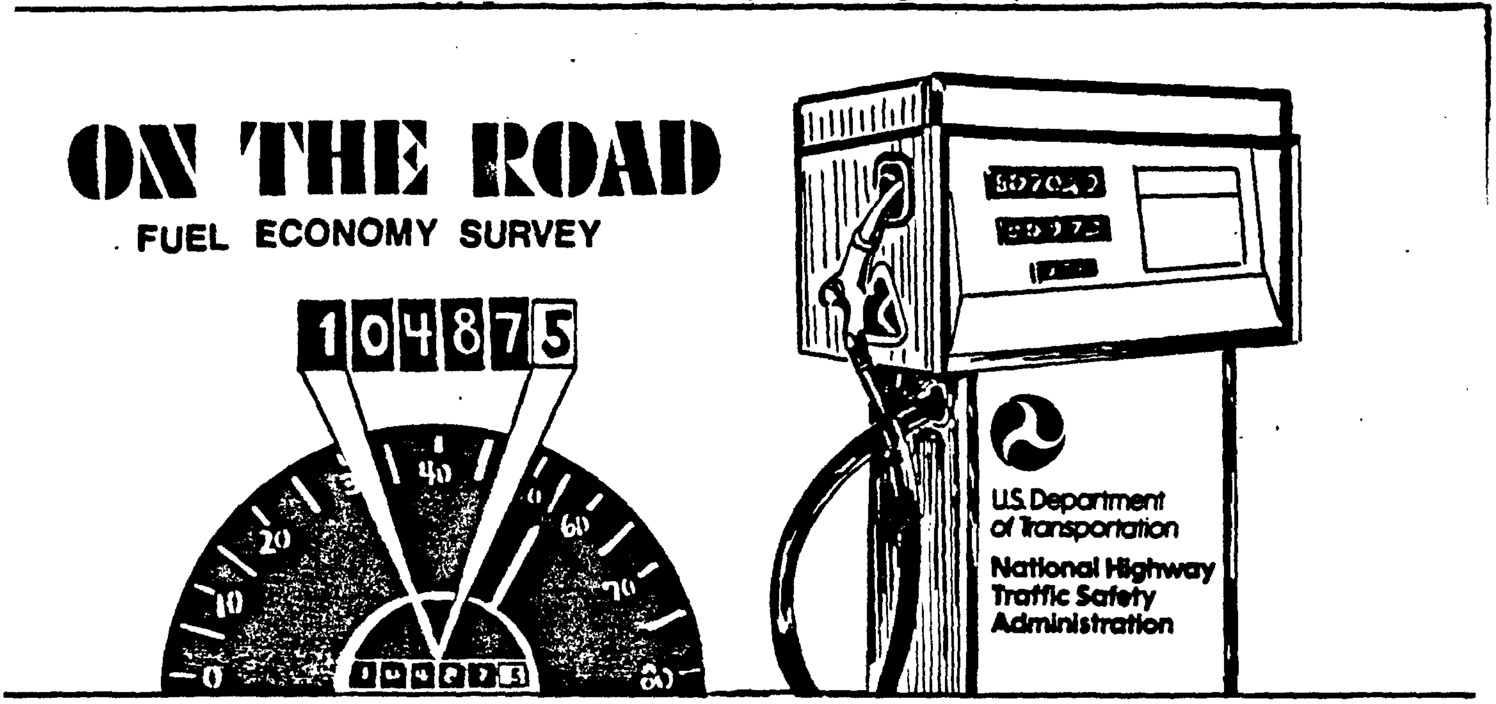
Thank you for your help.

Sincerely,

Jean Atkinson

Jean Atkinson
Senior Survey Director

Enclosures



Booklet Cover

GAS PURCHASES									TYPE OF DRIVING EACH PERIOD	
DATE OF PURCHASE	FUEL AMOUNT GALLONS	10TH	OR	LITERS	10TH	FUEL COST	ODOMETER READING WHOLE MILES	10TH	MOSTLY CITY	HIGHWAY
			OR							
			OR							
			OR							
			OR							
			OR							
			OR							
			OR							
			OR							

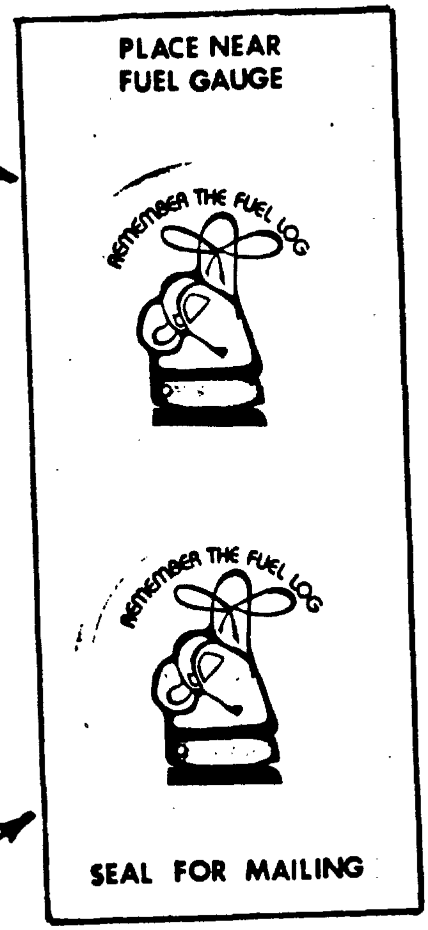
Specimen Pages

DATE	NOTES

DECALS

Log entry reminder

For sealing questionnaire



REMINDER POSTCARDS

ON THE ROAD
FUEL ECONOMY SURVEY

A few days ago we sent you a request to participate in the National On The Road Fuel Economy Survey. We trust you received our request and are keeping the log of gas purchases for this important study.

We realize that keeping the log requires a conscientious effort on your part—particularly remembering to fill it in with each gas purchase—and you have our sincere thanks. If you haven't begun keeping your log it isn't too late to start. We need your help.

Jean Atkinson

P.S. If others in your household buy gas for the vehicle your're reporting on, please call their attention to the log. Keeping the log in the car will make it convenient to record every gas purchase. Thank you.

First reminder

ON THE ROAD
FUEL ECONOMY SURVEY

A month has passed since we sent you a request to participate in the National On The Road Fuel Economy Survey. This is just a reminder to ask that you mail in your Fuel Mileage Log.

Send only the Fuel Mileage Log. (You may keep the booklet.) Use one of the decals we sent you or some tape to seal the edge.

Jean Atkinson

P.S. *If you have already mailed the log, please disregard this letter.*

THANK YOU FOR HELPING US IN THIS SURVEY.

Second (end-of-period) reminder

U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

O.M.B. No. 2127-0037
Expires 9/30/84

400 Seventh St., S.W.
Washington, D.C. 20590

ON THE ROAD FUEL ECONOMY SURVEY

QUESTIONNAIRE TRANSMITTAL LETTER – SECOND WAVE

Dear Driver:

About two months ago we wrote to say that you had been selected to participate in our national On the Road Fuel Economy Survey. Because our letters and Fuel Mileage Log may not have reached you, we are writing again to ask for your help.

Enclosed is a Fuel Mileage Log and two decals for this U.S. Department of Transportation study. The Log should be kept in some convenient spot inside your vehicle next month, for ready access at "fill-up" time. One of the decals can be placed on the dash near the fuel gauge, as a reminder to you, or anyone else who drives, to record each gas purchase for the month. The decal can be easily removed after the survey and will leave no residue on your vehicle.

Before placing the Log in your vehicle, please complete the description of your vehicle in Section A. Then, each time you buy gas next month, simply fill in one line of Section B, the Gas Mileage Log. Please try to fill the tank completely, at least for the first and last purchases of the month, to enable us to make good estimates of your mileage.

At the end of the month, please return the Log to us. Simply fold the Log as indicated, seal with second decal or tape, and drop it in the mail. No postage is needed.

Because we believe you may find a record of your fuel mileage personally useful, we have enclosed a handy booklet which you may keep for yourself. You may also find the booklet a convenient place to keep the Log during the survey month.

The information you supply will be an important aid in determining future energy needs of our country, and we are looking forward to your participation in our study.

Thank you for your help.

Sincerely,

Jean Atkinson

Jean Atkinson
Senior Survey Director

Enclosures

Conducted by National Op[illegible] • 6030 South Ellis • Chicago IL 60637
University of Chicago
U.S. GOVERNMENT PRINTING OFFICE 1982—801-882

TELEPHONE QUESTIONNAIRE

FORM APPROVED THRU 9/30/84
O.M.B. NO. 2127-0037

ON THE ROAD NONRESPONSE FOLLOWUP

TELEPHONE QUESTIONNAIRE

THE SALUTATION AND CLOSING OF THE INTERVIEWER'S MESSAGE WILL BE AS FOLLOWS:

Salutation - "Hello (name). This is (INTERVIEWER'S NAME) from the National Opinion Research Center of the University of Chicago. I am calling to check whether you received any of the letters we have sent to you in the past month(s) about the national On The Road Survey we are conducting for the Department of Transportation." (On to Questionnaire Item 1)

IF RESPONDENT VOLUNTEERS THAT HE OR SHE HAS RECEIVED NO INFORMATION INTERVIEWER WILL EXPLAIN, "We have been asked by the National Highway Traffic Administration to find out just how efficient new vehicles have become in miles per gallon for the average motorist. To do this, we are conducting a nationwide survey of late model vehicles, and we understand that you own one." (On to Questionnaire Item 2)

Closing - IF THE RESPONDENT IS RELUCTANT TO PARTICIPATE THE CALL WILL BE POLITELY TERMINATED WITH THE INTERVIEWER EXPRESSING GRATITUDE FOR HIS OR HER COOPERATION IN RECEIVING THE CALL.

- IF THE RESPONDENT AGREES TO ACCEPT LOG THE INTERVIEWER WILL SAY

  "Thank you for agreeing to help us in this survey, the information you supply will be an important aid in the development of more fuel-efficient vehicles in this country.

  Within a few days you will receive a fuel mileage log and a complimentary booklet from the Department of Transportation. Recording your gas purchases will be simple if you keep the log in your vehicle. Thank you again."

Telephone Interview

(See introduction page)

1. Did you receive any of our recent letters about this survey?

Yes	[ ]	1
No	[ ]	2

2. Have you ever owned
(READ Label Below)

Make: ________ Model: ________ Year: ________

Yes	[ ]	1 ASK 3
No	[ ]	2 GO TO 5B AND END INTERVIEW

IF YES TO 2:

3. Do you still own this vehicle?

Yes	[ ]	1 ASK 6
No	[ ]	2 ASK 4

4. What became of the vehicle?

It was sold	[ ]	1 ASK 5
It was junked	[ ]	2
Other specify*	[ ]	3

____

____

5. A. Do you have the name and address of the person to whom it was sold?

(Name) ________________________

(Address) ________________________

____

(Town) ________________ (Zip) ________

B. THANK RESPONDENT AND TERMINATE INTERVIEW IF RESPONDENT NO LONGER OWNS CAR.

---

*INTERVIEWER INSTRUCTION—CONTINUE INTERVIEW IF CAR IS STILL OWNED/USED BY PERSON(S) IN RESPONDENT'S HOUSEHOLD.

6. We are trying to improve our survey procedures and I would like to ask you a few questions about why you were unable to participate in the On the Road Survey. This should take only a few minutes of your time.

Why were you unable to complete the fuel mileage log?

Did not drive the vehicle	1	ASK 7
Did not wish to participate	2	ASK 8
Too busy	3	ASK 8
Object to surveys (Probe "Why is that?")	4	ASK 8
Did not understand about the survey or task (Probe: "What was it you didn't understand?")	5	ASK 8
Other reason (SPECIFY) ________	6	ASK 8

7. Is the car now back on the road?

Yes [ ]	1	GO TO 8
No [ ]	2	GO TO 5B END INTERVIEW

8. I have a few questions about your vehicle.

INTERVIEWER COMPLETE FACSIMILE OF CAR MILEAGE LOG NEXT PAGE AND CHECK BELOW.

Section A & B completed .... [ ]	1
Not completed (give reason) ... [ ]	2

SECTION A - VEHICLE INFORMATION

	MAKE	MODEL	MODEL YEAR
1. The vehicle we want information about is your:			

2. BODY STYLE
   a. CAR: ☐ 2-Door ☐ 4-Door ☐ Station Wagon
      TRUCK: ☐ Pick-up ☐ Van ☐ Jeep, Blazer, Bronco, etc. ☐ Truck-based Station Wagon (e.g., Suburban, etc.)
   b. TYPE DRIVE: ☐ 2-Wheel Drive ☐ 4-Wheel Drive

3. AIR CONDITIONED ☐ Yes ☐ No

4. RADIAL TIRES ☐ Yes ☐ No

5. ENGINE
   a. NO. OF CYLINDERS ☐ 8 ☐ 6 ☐ 4
   b. TURBO-CHARGED ☐ Yes ☐ No
   c. FUEL ☐ Gasoline ☐ Diesel
   d. FUEL SYSTEM ☐ Carburetor ☐ Fuel Injection
   e. SIZE/DISPLACEMENT (Fill in only one) ☐☐☐ Cubic Inches ☐☐☐☐ Cubic Centimeters ☐.☐ Liters

6. TRANSMISSION
   MANUAL: ☐ 3-Speed ☐ 4-Speed ☐ 5-Speed
   AUTOMATIC: ☐ 3-Speed ☐ 4-Speed

7. VEHICLE MAINTENANCE. Within the last 3-months has the vehicle had (Check all that apply) ☐ Tune-up ☐ Wheel Alignment ☐ Tire Pressure Check

8. VEHICLE OWNERSHIP ☐ OWNED ☐ LEASED ☐ Company Car

SECTION B - GAS MILEAGE LOG

17. What type of driving have you done recently, in the month of (Record month) ________ in your (Name vehicle)?

TYPE DRIVING EACH PERIOD

   a. Was it mostly city or mostly highway by which I mean 20-45 mph, short trips or 50-55 mph driving? — Mostly City ☐ Mostly Highway ☐
   b. Did driving involve heavy usage such as towing, off-road use, heavy loads, or in snow? — Heavy Usage: Yes ☐ No ☐

18. I would be happy to send you a log if you feel you could help us by keeping it over the coming month. May I send it?

   Yes .... ¢___¢ 1 Go to 19
   No .... ¢___¢ 2

19. (See concluding remarks page 1.)

U.S. GOVERNMENT PRINTING OFFICE: 1982—381-883

U.S. Department of Transportation
National Highway Traffic Safety Administration

O.M.B. No. 2127-0037
Expires 9/30/84

400 Seventh St., S.W.
Washington, D.C. 20590

ON THE ROAD FUEL ECONOMY SURVEY

QUESTIONNAIRE TRANSMITTAL LETTER — TELEPHONE FOLLOWUP

Dear Driver:

Thank you for agreeing to participate in our important survey of On The Road Fuel Economy.

Enclosed is a Fuel Mileage Log and two decals for this U.S. Department of Transportation study. The Log should be kept in some convenient spot inside your vehicle next month, for ready access at "fill-up" time. One of the decals can be placed on the dash near the fuel gauge, as a reminder to you, or anyone else who drives, to record each gas purchase for the month. The decal can be easily removed after the survey and will leave no residue on your vehicle.

Before placing the Log in your vehicle, please complete the description of your vehicle in Section A. Then, each time you buy gas next month, simply fill in one line of Section B, the Gas Mileage Log. Please try to fill the tank completely, at least for the first and last purchases of the month, to enable us to make good estimates of your mileage.

At the end of the month, please return the Log to us. Simply fold the Log as indicated, seal with second decal or tape, and drop it in the mail. No postage is needed.

Because we believe you may find a record of your fuel mileage personally useful, we have enclosed a handy booklet which you may keep for yourself. You may also find the booklet a convenient place to keep the Log during the survey month.

The information you supply will be an important aid in determining future energy needs of our country, and we are looking forward to your participation in our study.

Thank you for your help.

Sincerely,

Jean Atkinson

Jean Atkinson
Senior Survey Director

Enclosures

Conducted by: National Opinion Research Center • 6030 South Ellis • Chicago, IL 60637
University of Chicago

APPENDIX D

METHODOLOGY AND DATA FOR ESTIMATING REDUCED ENERGY CONSUMPTION AND EQUIVALENT DOLLAR VALUE

ANNUAL AND LIFETIME MILEAGE ESTIMATES, AVERAGE PASSENGER CAR AND LIGHT TRUCK

In order to estimate total lifetime reduction in energy consumption and dollar equivalent values for the vehicles studied in the On-the-Road Fuel Economy Survey, it is necessary to have an estimate of the total miles that an average vehicle will travel in its lifetime and also an estimate of how this mileage is distributed by the age of the vehicle.

In Chapter 3, Table 3-10, estimates were developed for the average vehicle miles per vehicle age for the U.S. population of privately[1] owned passenger cars and light trucks. These estimates constitute the principal basis for estimating lifetime and yearly miles traveled for the average vehicle. Two adjustments must be made to these data, however, before they can be used to estimate total lifetime reductions in energy consumption and dollar equivalent values.

First, an adjustment must be made to account for the miles driven by fleet vehicles, which were not sampled in the survey. Fleet vehicles are known to be newer, in general, and also to be driven, on a per vehicle basis, more miles annually than the average vehicle in the U.S. population. Secondly, the miles per year data in Table 3-10 represent travel by vehicles which are still on the road at age x. In order to get miles per year for

[1] The ORFES sampling frame included only vehicles owned and operated by private individuals. Fleet vehicles such as business fleets, rental fleets, police fleets, taxi fleets, government fleets, etc., were not sampled due to the operational constraints of collecting reliable data on these vehicles, as explained in the report.

the average vehicle in the U.S. population, these numbers must be multiplied by the probability than a given vehicle will still be on the road, or survive to, age x.

Tables D-1 and D-2 contain the vehicle travel data adjusted as described above, that were used to develop the estimates of energy reduction and dollar equivalent values in this report, for cars and trucks, respectively. The second columns of each table are a reproduction of the last column of Table 3-10 from Chapter 3 with the following two exceptions:

(1) Rows 1-6 of Table D-1 have been revised to incorporate annual travel by fleet vehicles. The bases for these estimates are that fleet vehicles number about 10,000,000[2,3] travel an average of 24,000 miles per vehicle, per year; and have a total life-span of approximately six years.[4]

---

2 "Transportation Energy Data Book," Edition 7, Op. Cit.
3 "Characteristics of Automotive Fleets in the United States, Shonka, Op. Cit.
4 Shonka, Op. Cit., gives 2.5 years as the average age of fleet cars at the time they are resold. Since some vehicles will be replaced earlier than this, and some later, 6 years is taken as the maximum time a fleet car will remain in a fleet status.

TABLE D-1

ESTIMATED VEHICLE MILES, LIFETIME PASSENGER CARS

Vehicle Age Years	Vehicle Miles Traveled[a/]	Vehicle Survival Probability[b/]	Vehicle Miles Traveled, Lifetime, Average Vehicle
1	15,700	1.000	15,700
2	14,040	.993	13,942
3	13,550	.982	13,306
4	11,028	.964	10,631
5	9,468	.935	8,853
6	8,483	.892	7,567
7	4,485	.831	3,727
8	3,885	.753	2,925
9	3,427	.662	2,269
10	3,066	.568	1,741
11	2,773	.476	1,320
12	2,532	.394	998
13	2,329	.323	752
14	2,156	.263	567
15	2,007	.213	427
16	1,878	.172	323
17	1,764	.139	245
18	1,663	.112	186
19	1,573	.090	142
20	1,493	.073	109
		TOTAL	85,730

a/ From Table 3-10 of Chapter 3, adjusted to incorporate fleet vehicle travel, as described in accompanying text.

b/ Source: "Scrappage and Survival Rates of Passenger Cars and Trucks in 1970-1982 ," P. Hu, Transportation Energy Group, Oak Ridge National Laboratory, August 10, 1983.

TABLE D-2

ESTIMATED VEHICLE MILES, LIFETIME LIGHT TRUCKS

Vehicle Age Years	Vehicle Miles Traveled[a]	Vehicle Survival Probability[b]	Vehicle Miles Traveled, Lifetime, Average Vehicle
1	15,470	1.000	15,470
2	13,260	.991	13,141
3	12,608	.979	12,343
4	9,250	.963	8,908
5	7,174	.943	6,765
6	5,862	.918	5,381
7	4,956	.888	4,401
8	4,293	.852	3,658
9	3,427	.810	2,776
10	3,066	.763	2,339
11	2,773	.712	1,974
12	2,532	.658	1,666
13	2,329	.603	1,404
14	2,156	.548	1,181
15	2,007	.495	993
16	1,878	.444	834
17	1,764	.397	700
18	1,663	.353	587
19	1,573	.313	492
20	1,493	.277	414
		TOTAL	85,427

a/ From Table 3-10 of Chapter 3, adjusted to incorporate fleet/business vehicle travel, as described in accompanying text.

b/ Source: "Scrappage and Survival Rates of Passenger Cars and Trucks in 1970-1982 ," P. Hu, Transportation Energy Group, Oak Ridge National Laboratory, August 10, 1983.

(2) Rows 1-8 of Table D-2 have been revised to incorporate annual travel for light trucks operating in a fleet environment or read for business purposes. The bases for these estimates are that fleet/business[5] trucks represent approximately one-half of the total light truck population[6]; travel approximately 21 percent more miles annually, than private-use trucks, and have a total lifespan of approximately 8 years.[7]

The third columns of Tables D-1 and D-2 contain the vehicle survival probability estimates.[8] The last column of each table is the estimated yearly travel for the average vehicle and is merely the product of the annual miles traveled (column 2) and the probability that the vehicle will survive to age x (column 3). The sum of column 4 represents the estimated total lifetime travel for the average vehicle, 85,730 miles, and 85,427 miles, for cars and trucks respectively.

---

5 49.1 percent of total pickup trucks are classified as having vehicle and operational characteristics other than for personal transportation (i.e., mining, construction, utilities, etc.) Sources: 1972 Census of Transportation, Volume II, Truck Inventory and Use Survey, U.S. Department of Commerce, issued March 1974; "Projection of Light Truck Population Year 2025," Oak Ridge National Laboratory, ORNL/Sub-78/14285/1 Special, October 1978.

6 Average annual mileage for pickup trucks used for fleet business purpose = 11,945 versus 9,900 for pickup trucks used for personal transportation ((11,945-9,900)/9,900 = 21 percent). Source: 1972 Census of Transportation, Op. Cit.

7 Available data on survival rates show trucks to have a somewhat longer lifespan than cars; hence 8 years is taken as the maximum time a truck will remain in a fleet/business status. Source: "Scrappage and Survival Rates in Passenger Cars and Truck in 1970-1972, P. Hu, Transportation Energy Group, Oak Ridge National Laboratory, August 10, 1983.

8 "Scrappage and Survival Rates in Passenger Cars and Trucks in 1970-1982," Op. Cit.

FUEL REDUCTION ESTIMATES

In order to estimate per vehicle lifetime reduction in fuel use for a given model year, say 1978 passenger cars, it is merely necessary to take the product of the total estimated lifetime mileage (from column 4, Table D-1) and the per vehicle reduction in fuel use, in gallons of fuel per mile driven versus the 1977 models (as computed in Chapter 2). For total model year reduction (i.e., all vehicles sold), the per vehicle reduction is simply multiplied by the total number of vehicles sold in the given model year.

EQUIVALENT DOLLAR VALUE OF REDUCTION IN ENERGY USE

In order to estimate dollar equivalent value of the reduced fuel consumption, it is necessary to have estimates of the cost of gasoline in addition to the estimates of vehicle miles traveled and the per vehicle reduction in fuel consumption in fuel per unit of travel for the study vehicle over the baseline vehicle.

Since annual vehicle travel varies with vehicle age (specifically, the survey data from Chapter 3 shows a distinct decline in the rate of travel as vehicle age increases, with a large proportion of total lifetime travel occurring in the early years of vehicle life), and since the real price of gasoline is projected to increase over time, it is therefore necessary to estimate dollar value per each year of vehicle life. Finally, since a portion of the reduction in fuel use will occur in future years, it is customary to discount such values to arrive at their present estimated value.

For each vehicle of a given model year, the following formula was used to determine the estimated, lifetime dollar equivalent of reduced fuel consumption:

$$D(\text{vehicle})_j = \sum_{i=1}^{20} [(VMT)_i \; P(S)_i \; FS_j \; C_i \; D_i] \qquad (1)$$

where,

$(VMT)_i$ = average annual vehicle miles traveled for a vehicle of age i, from columns of Tables D-1 and D-2. Twenty years is taken as the maximum age that a vehicle can attain.[9]

$P(S)_i$ = probability that a vehicle will survive to age i, from column 3, Tables D-1 and D-2.

9 P. Hu, "Scrappage and Survival Rates in Passenger Cars and Trucks in 1970-1982," Op. Cit.

FS_j = per vehicle reduction in fuel consumption in gallons per mile driven, for vehicle of model year j.

C_i = estimated cost, in dollars, per gallon of fuel for year i, from Table D-3.

D_i = discount factor for year i (to arrive at present value of future reductions), from Table D-4.

The total dollar value for a given model year, j, is simply the product of the per vehicle dollar value from equation (1) and the total number of vehicles sold in model year j, or

$$D_{(model\ year)j} = N_j \, D_{(vehicle)j}$$

The future cost of fuel (gasoline), Table D-3, is based on data from the Department of Energy.

All dollar values of reduced energy consumed are expressed in terms of 1984 dollars. A discount rate of 10 percent[10] has ben used to estimate the present (1984) value of fuel reductions that will accrue in future years. For reductions in years prior to 1984, a discount factor of 1.0 has been used since these represent historic values having already occurred and hence not subject to future uncertainties. Table D-4 lists the discount factors used.

---

[10] OMB Circular No. A-94, March 27, 1972.

TABLE D-3

ESTIMATED AVERAGE PRICE OF UNLEADED GASOLINE, 1984 DOLLARS

Year	Price (Dollars/Gallon)
1979	$1.234
1980	1.558
1981	1.574
1982	1.396
1983	1.33
1984	1.25
1985	1.19
1986	1.16
1987	1.16
1988	1.19
1989	1.21
1990	1.23
1991	1.29
1992	1.35
1993	1.41
1994	1.47
1995	1.52
1996	1.56
1997	1.60
1998	1.64
1999	1.68
2000	1.73
2001	1.77

Sources: "Transportation Energy Data Book: Edition 7, Oak Ridge Laboratory, ORNL-6050, Date of Issue - June 1984." (Source of data on current year price of unleaded gasoline for years 1978-1982.)

"Economic Report of the President, Transmitted to the Congress, February 1985." (Source of price deflator data for adjusting 1978-1982 gasoline prices to constant 1984 dollars).

Price data for 1983-1984 adapted from estimates made by NHTSA for use in regulatory impact analyses of the 1986 CAFE standards. Projections for 1985-1984 were adapted from the U.S. Department of Energy (DOE) Middle World Oil Price Case, Gasoline Price Projections for the Transportation Section in "Annual Energy Outlook, 1984," Energy Information Administration, DOE/EIA-9383(84), January 1985. Projections for 1995-2001 are DOE's "reference case projections," in "Energy Projections to the Year 2010, A Technical Report in Support of the National Energy Policy Plan," draft report, April 2, 1985. NHTSA adjusted the projections slightly to include only the price of unleaded gasoline; some values were interpolated.

TABLE D-4

DISCOUNT FACTORS FOR ESTIMATING PRESENT VALUE (1984 DOLLARS) OF FUTURE REDUCTION IN FUEL CONSUMPTION

YEAR OF REDUCTION	DISCOUNT FACTORS
1979	1.000
1980	1.000
1981	1.000
1982	1.000
1983	1.000
1984	1.000
1985	.9091
1986	.8264
1987	.7513
1988	.6830
1989	.6209
1990	.5645
1991	.5132
1992	.4665
1993	.4241
1994	.3855
1995	.3505
1996	.3186
1997	.2897
1998	.2633
1999	.2394
2000	.2176
2001	.1978

For discount rate = 10 percent. Note that a factor of 1.0 is used for years 1979-1984 since the cost of fuel (Table D-3) for each of these years is in terms of 1984 dollars. The years 1979-1983 represent "historic" prices that have already occurred. They have been updated to 1984 dollars as explained in Table D-3. If this study had also estimated costs of the Federal standards (in addition to benefits), such costs would also have been updated to 1984 from the years in which the costs were incurred, employing the same price adjustment factors as used here for benefits (i.e., reduced fuel consumption).