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Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006

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U.S. Environmental Protection Agency

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I. <u>Executive Summary</u>

Introduction

This report summarizes key fuel economy and technology usage trends related to model year (MY) 1975 through 2006 light-duty vehicles sold in the United States. Light-duty vehicles are those vehicles that EPA classifies as cars or light-duty trucks (sport utility vehicles, vans, and pickup trucks with less than 8500 pounds gross vehicle weight ratings).

Since 1975, the fuel economy of the combined car and light truck fleet has moved through four phases:

1. a rapid increase from 1975 continuing to the mid-1980s,

2. a slow increase extending into the late-1980s,

3. a gradual decline until the mid-1990s, and

4. a period of relatively constant fuel economy since then.

MY2006 light-duty vehicles are estimated to average 21.0 miles per gallon (mpg). This average is the same as last year and in the middle of the 20.6 to 21.4 mpg range that has occurred for the past fifteen years, and five percent below the 1987 to 1988 peak of 22.1 mpg. After over two decades of steady growth, the market share for light trucks has been about half of the overall light-duty vehicle market since 2002. Most of this growth in the light truck market has been led by the increase in the popularity of sport utility vehicles (SUVs), which now account for more than one-fourth of all new light-duty vehicles. MY2006 light-duty vehicles are estimated, on average, to be the heaviest, fastest and most powerful vehicles than in any year since EPA began compiling such data.

The fuel economy values in this report are based on ‘real world’ estimates provided by the Federal government to consumers and are about 15 percent lower than the values used by manufacturers and the Department of Transportation (DOT) for compliance with the Corporate Average Fuel Economy (CAFE) program. Because it has been over two decades since the current procedures for determining real world fuel economy estimates were established and because both vehicle technology and vehicle driving patterns have changed, EPA has proposed changes to the methodology for calculating real world fuel economy estimates and expects to finalize a new methodology by the end of 2006.

Since MY1990, the CAFE standard for cars has been the value set by Congress, i.e., 27.5 mpg. The truck CAFE standards, as set by DOT, for MY2006 and MY2007 are 21.6 and 22.2 mpg, respectively. For MY2008 to 2010, the truck CAFE standards give manufacturers the option of choosing to comply with standards of 22.5 mpg for MY2008, 23.1 mpg in MY2009 and 23.5 mpg in MY2010, or choosing to comply with a reformed standard based on a relationship between vehicle size (footprint) and fuel economy. Starting in MY2011, truck CAFE standards will be based on the reformed system.

Importance of Fuel Economy

Fuel economy continues to be a major area of public and policy interest for several reasons, including:

1. Fuel economy is directly related to energy security because light-duty vehicles account for approximately 40 percent of all U.S. oil consumption, and much of this oil is imported.

2. Fuel economy is directly related to the cost of fueling a vehicle and is of great interest when crude oil and gasoline prices rise.

3. Fuel economy is directly related to emissions of greenhouse gases such as carbon dioxide. Light-duty vehicles contribute about 20 percent of all U.S. carbon dioxide emissions.

Characteristics of Light-Duty Vehicles for Four Model Years

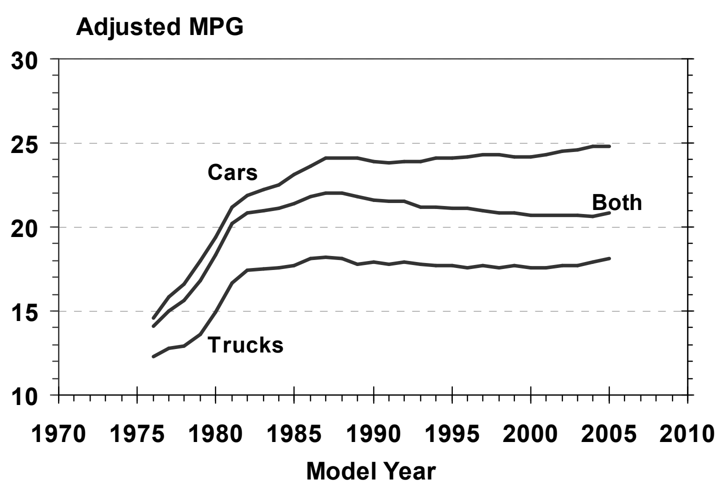
	1975	**1987**	**1997**	**2006**
Adjusted Fuel Economy	13.1	22.1	20.9	21.0
Weight (pounds)	4060	3220	3727	4142
Horsepower	137	118	169	219
0 to 60 Time (seconds)	14.1	13. 1	11.0	9.7
Percent Truck Sales	19%	28%	42%	50%
Percent Four Wheel Drive	3%	10%	19%	29%
Percent Manual Transmission	23%	29%	14%	8%

Highlight #1: Overall Fuel Economy Has Been Relatively Constant For Many Years, While Light Truck Fuel Economy Has Increased for Two Years.

> *After a decline from 22.1 mpg in 1988 to 21.0 mpg in 1994, overall fuel economy has been relatively constant for a decade. The average fuel economy for all model year 2006 light-duty vehicles is estimated to be 21.0 mpg, the same value as achieved in 1994 but five percent lower than the peak value achieved in 1987-88.*

Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases: (1) a rapid increase from 1975 to the mid-1980s, (2) a slow increase extending into the late 1980s, (3) a decline from the peak in the late 1980s until the mid-1990s, and (4) since then a period of relatively constant overall fleet fuel economy. Viewing new cars and trucks separately, since 1996, the three-year moving average fuel economy for cars has ranged from 24.2 to 24.8 mpg, while that for trucks has ranged from 17.6 to 18.1 mpg, and that for all light-duty vehicles from 20.7 to 21.1 mpg. MY2006 cars are estimated to average 24.6 mpg and are near the high end of their mpg range since 1996. For MY2006, light trucks are estimated to average 18.4 mpg, 0.7 mpg, about four percent, above their MY2004 average of 17.7 mpg. The recent increase in truck fuel economy is likely due, at least in part, to higher truck CAFE standards. These slight upward trends for both cars and trucks were accompanied by an increasing truck share of the market that continued through the early 2000s, and this has resulted in the recent flat trend in overall sales-weighted fleet fuel economy.

Adjusted Fuel Economy by Model Year (Three Year Moving Average)

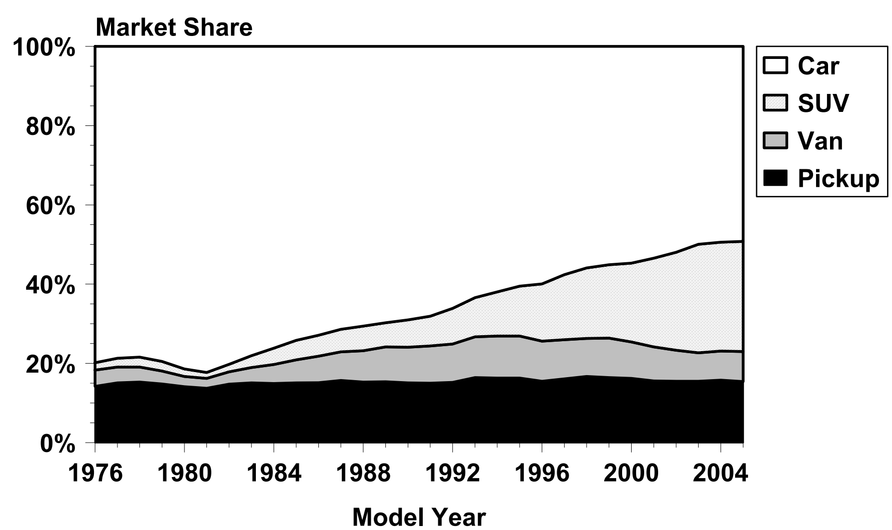


Highlight #2: Trucks Represent About Half of New Vehicle Sales.

Sales of light trucks, which include sport utility vehicles (SUVs), vans, and pickup trucks, have accounted for about 50 percent of the U.S. light-duty vehicle market since 2002. After two decades of constant growth, light truck market share has been relatively stable for five years.

Growth in the light truck market was primarily due to the increase in the market share of SUVs. The SUV market share increased by more than a factor often, from less than two percent of the overall new light-duty vehicle market in 1975 to over 25 percent of vehicles built each year since 2002. Between 1975 and the 1990, the market share for vans more than doubled, increasing from less than five percent to more than ten percent, but it has since dropped slightly. By comparison, the market share for pickups has remained relatively constant. Between 1975 and 2006, market share for new passenger cars and station wagons decreased by over 30 percent. For model year 2006, cars are estimated to average 24.6 mpg, vans 20.6 mpg, SUVs 18.5 mpg, and pickups 17.0 mpg. The increased market share of light trucks, which in recent years have averaged more than six mpg less than cars, accounted for much of the decline in fuel economy of the overall new light-duty vehicle fleet from the peak that occurred in 1987-88.

Sales Fraction by Vehicle Type
(Three Year Moving Average)

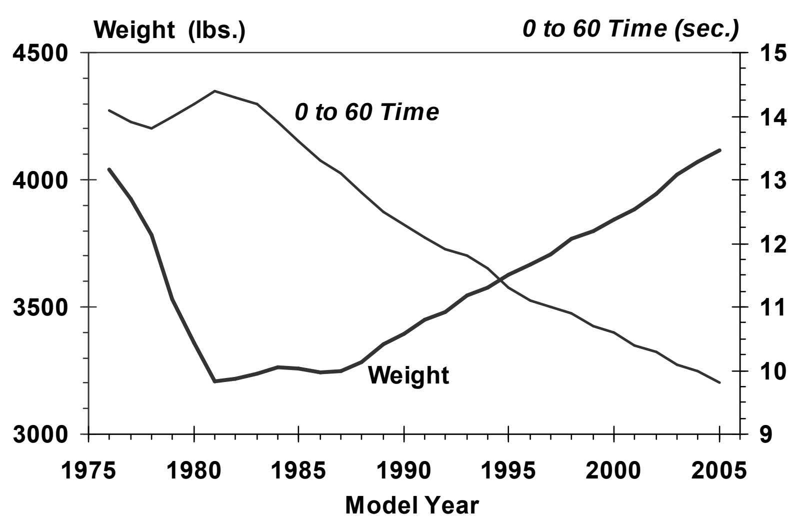


Highlight #3: As a Result of Technological Innovation, Vehicle Weight Has Increased and Performance Has Improved, While Fuel Economy Has Remained Constant.

> *Automotive engineers are constantly developing more advanced and efficient vehicle technologies. Automotive manufacturers continue to apply technological innovations to increase new light-duty vehicle weight and acceleration performance.*

Vehicle weight and performance are two of the most important engineering parameters that determine a vehicle's fuel economy. All other factors being equal, higher vehicle weight (which can be a proxy for some vehicle utility attributes) and faster acceleration performance (e.g., lower 0 to 60 time), both decrease a vehicle's fuel economy. Improved engine, transmission, and powertrain technologies continue to penetrate the new light-duty vehicle fleet. The trend has clearly been to apply these innovative technologies to accommodate increases in average new vehicle weight, power, and performance while maintaining a relatively constant level of fuel economy. This is reflected by heavier average vehicle weight, rising average horsepower, and faster average 0-to-60 mile-per-hour acceleration time. MY2006 light-duty vehicles are estimated, on average, to be the heaviest, fastest and most powerful vehicles than in any year since EPA began compiling such data.

Weight and Performance (Three Year Moving Average)



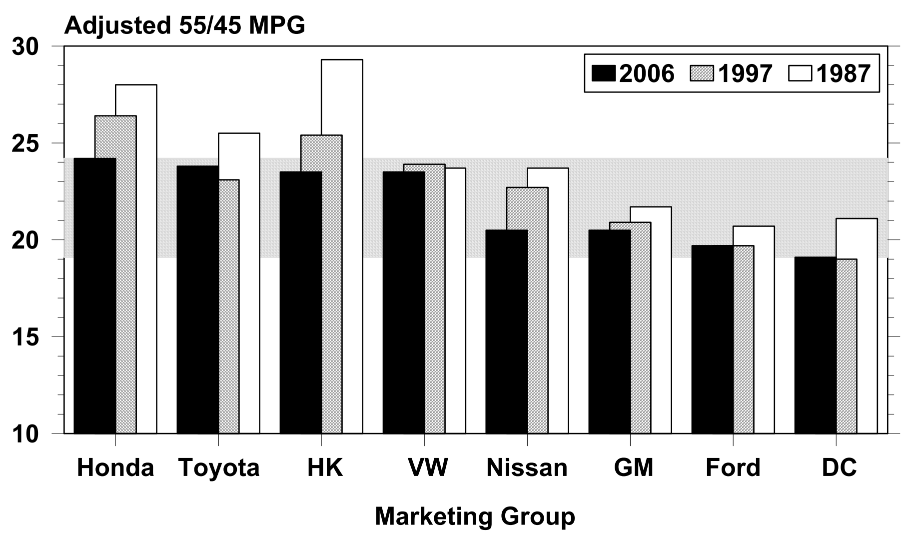
Highlight #4: Differences Between Marketing Group Fuel Economies are Narrowing.

In 1987, when industry-wide fuel economy peaked, some marketing groups had average fuel economies 6 to 8 mpg higher than other marketing groups. For MY2006, the maximum difference between marketing groups is estimated to be 5 mpg, with a typical difference between higher and lower fuel economy marketing groups being 3 to 4 mpg.

For MY2006, the eight highest-selling marketing groups (that account for over 95 percent of all sales) fall into two fuel economy groupings: Honda, Toyota, Hyundai-Kia (HK), and Volkswagen all have estimated fuel economies of 23.5 to 24.2 mpg, while General Motors, Nissan, Ford, and DaimlerChrysler all have estimated fuel economies of 19.1 to 20.5 mpg.

Each of these marketing groups has lower average fuel economy today than in 1987. Since then, the differences between marketing group fuel economies have narrowed considerably, with the higher mpg marketing groups in 1987 (e.g., Hyundai-Kia, Honda, and Nissan) generally showing a larger fuel economy decrease than the lower mpg marketing groups (e.g., Ford and General Motors). Two marketing groups (Toyota and DaimlerChrysler) show a slight increase in average fuel economy since 1997. For MY2006, the six top-selling marketing groups all have truck shares in excess of 40 percent; only Hyundai-Kia and Volkswagen have a truck market share of less than 40 percent and the Hyundai-Kia truck share is increasing rapidly.

Marketing Group Fuel Economy for Three Model Years



Important Notes With Respect to the Data Used in This Report

Unless otherwise indicated, the fuel economy values in this report are based on laboratory data and have been adjusted downward by about 15 percent, so that this data is equivalent to the real world estimates provided to consumers on new vehicle labels, in the EPA/DOE *Fuel Economy Guide,* and in EPA's *Green Vehicle Guide*. These adjusted fuel economy values are significantly lower than those used for compliance with CAFE standards. In addition to the 15 percent downward adjustment for real world driving, they also exclude credits for alternative fuel capability, including the ability to use E85 fuel, and test procedure adjustments for cars that are included in the CAFE data reported by the DOT. In addition, there typically are a few cases each model year where the methodology used for classifying vehicles for this report results in differences in the determination of whether a given vehicle is classified as a car or a light truck.

The data presented in this report were tabulated on a model year basis, but several of the figures in this report use three-year moving averages which effectively smooth the trends, and these three-year moving averages are tabulated at the midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003. All average fuel economy values were calculated using harmonic, rather than arithmetic, averaging.

The source database used to generate the tables and graphs in this report for all years was frozen in December 2005. When comparing data in this report with those in previous reports in this series, please note that revisions are made in the data for some recent model years for which more complete and accurate sales and fuel economy data have become available.

Through model year 2004, the fuel economy, vehicle characteristics, and sales data used for this report were obtained from the most complete databases used for compliance purposes for CAFE and the "gas guzzler" tax on cars. For model year 2005, EPA used data that included confidential sales projections submitted to the Agency by the automotive manufacturers, but updated the sales data to take into account information reported in trade publications. For model year 2006, EPA has exclusively used confidential projected sales data that the auto companies are required to submit to the Agency.

Over the last several years, the final fuel economy values have varied from 0.4 mpg lower to 0.3 mpg higher compared to the original estimates based exclusively on projected sales.

For More Information

"Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006" (EPA420-R-06-011) is available on EPA's Office of Transportation and Air Quality (OTAQ) Web site at:

www.epa.gov/otaq/fetrends.htm

Printed copies are available from the OTAQ library at:

U.S. Environmental Protection Agency
Office of Transportation and Air Quality Library
2000 Traverwood Drive
Ann Arbor, MI 48105
(734) 214-4311

A copy of the *Fuel Economy Guide* giving city and highway fuel economy data for individual models is available at:

www.fueleconomy.gov

or by calling the U.S. Department of Energy at (800) 423-1363.

EPA's *Green Vehicle Guide* providing information about the air pollution emissions and fuel economy performance of individual models is available on EPA's web site at:

www.epa.gov/greenvehicles/

For information about the Department of Transportation (DOT) Corporate Average Fuel Economy (CAFE) program, including a program overview, related rulemaking activities, research, and summaries of individual manufacturer's fuel economy performance since 1978, see:

www.nhtsa.dot.gov/cars/rules

II. **Introduction**

Light-duty automotive technology and fuel economy trends are examined herein, as in preceding reports in this series [1-32] using the latest and most complete EPA data available. When comparing data in this report with those in previous reports in this series, please note that revisions are made in the data for some model years for which more complete and accurate sales and fuel economy data have become available. Through model year (MY) 2004, the fuel economy, vehicle characteristics, and sales data used for this report were obtained from the most complete databases used for CAFÉ standards and "gas guzzler" compliance purposes. For all practical purposes, these databases are stable and are not expected to change in the future.

For model years 2005 and 2006, EPA has used confidential projected sales data that the auto companies are required to submit to the Agency for the Federal Government's fuel economy public information programs: the *Fuel Economy Guide* and the fuel economy labels that are placed on new vehicles. The model year 2005 data in this report uses data that included confidential sales projections submitted to the agency by the automotive manufacturers, but with updated sales data to take into account information reported in trade publications. The fuel economy databases that EPA uses for this report and other purposes are based on the consumer information and regulatory databases maintained by the Agency. For a given model year, these databases change with calendar time as the initial fuel economy values and sales projections available in the Fall of the year evolve toward final and more complete fuel economy data and actual production data. This calendar time-based process can take more than one year to complete, and during this time the database is changing.

Automotive manufacturers typically submit their initial estimates of fuel economy data over a period of several months, starting a few months before the *Fuel Economy Guide* is published, and then continuing for a few months after the start of the model year as new models and vehicle configurations continue to be introduced for sale. Similarly, manufacturers typically do not start submitting their final data until several months after the end of the model year, and this process can then take several additional months to complete. Therefore, the results for a given model year that are obtained from using the database are estimates that depend on when the analysis is done. The final fuel economy averages used in this report are often different from the initial estimates and have varied from 0.4 mpg lower to 0.3 mpg higher (i.e., about one percent) compared to the original estimates based exclusively on projected sales (see Table A-1, Appendix A). For this report, the source database was frozen in December 2005 for all model years. Appendix B lists the MY2006 nameplates used in this report by size class. Except where explicitly mentioned, MY2006 vehicles, such as the Honda Accord Hybrid, that were certified by EPA for sale after the database was frozen are excluded from all tables, graphs and analyses in this report.

All fuel economy averages in this report are sales-weighted harmonic averages. In prior reports in this series, up to and including the one for MY2000, the fuel economy values used in this series were just the laboratory-based city, highway, and combined mpg values — the same ones that are used as the basis for compliance with the fuel economy standards and the gas

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* Numbers in brackets denote references listed in the references section of this report.

guzzler tax. Since the laboratory mpg values tend to over predict the mpg achieved in actual use, adjusted mpg values are used for the Government's fuel economy information programs: the *Fuel Economy Guide* and the *Fuel Economy Labels* that are on new vehicles and in EPA's *Green Vehicle Guide.*

Starting with the report issued for MY2001, this series of reports has provided fuel economy trends in adjusted mpg values in addition to the laboratory mpg values. In this way, the fuel economy trends can be shown for both laboratory mpg and mpg values which can be considered to be an estimate of on-road mpg. In the tables, these two mpg values are called "Laboratory MPG," "Adjusted MPG," and abbreviated "LAB" MPG and "ADJ" MPG. The adjusted city mpg is obtained by multiplying the laboratory city mpg by 0.90, and the adjusted highway mpg is obtained by multiplying the laboratory highway mpg value by 0.78. Because it has been over two decades [11] since the current procedures for adjusting city and highway fuel economy were established and because both vehicle technology and vehicle driving patterns have changed over the years, EPA has evaluated the procedures used to determine the on-road mpg values and has proposed changes to these procedures. Appendix A of this report contains a summary of these proposed changes.

Where only one mpg value is presented in this report, it is the "adjusted composite 55/45 combined mpg", i.e.,

$$MPG_{55/45} = 1 / (.55/MPG_C + .45/MPG_H)$$

where MPG_C is 0.9 times the laboratory fuel economy on the EPA city driving cycle, and MPG_H is 0.78 times the laboratory fuel economy on the EPA highway driving cycle. If a combined "55/45" mpg value is calculated, the resulting mpg value is about 15 percent lower than the comparable value using the laboratory-based mpg values. It should be noted that an adjusted composite mpg value is *not* used in the Government's fuel economy information programs discussed above. Appendix A provides more information on averaging fuel economy data.

The data presented in this report were tabulated on a model year basis, but many of the figures in this report use three-year moving averages which effectively smooth the trends, and these three-year moving averages are tabulated at their midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003 (See Table A-2, Appendix A). Use of the three-year moving averages results in an improvement in discerning real trends from what might be relatively small year-to-year variations in the data.

To facilitate comparison with data in previous reports in this series, most data tables include what the $MPG_{55/45}$ value would have been had the laboratory fuel economy values not been adjusted downward, as well as the adjusted city, highway, and combined 55/45 fuel economy values. Presenting both types of mpg values facilitates the use of this report by those who study either type of fuel economy metric.

The fuel economy values reported by the Department of Transportation (DOT) for compliance with the Corporate Average Fuel Economy (CAFÉ) compliance purposes are higher than the data in this report for four reasons:

(1) the DOT data does not include the EPA on-road fuel economy adjustment factors for city and highway mpg,

(2) the DOT data include unlimited CAFE credits for those manufacturers that produce dedicated alternative fuel vehicles and CAFE credits up to 1.2 mpg for those manufacturers that produce flexible fuel vehicles,

(3) the DOT data include credits for test procedure adjustments for cars, and

(4) there are some differences in the way vehicles are classified for this report compared to the way they are classified by DOT.

Accordingly, the fuel economy values in this series of reports are always lower than those reported by DOT. Table A-4, Appendix A, compares CAFÉ data reported by The Department of Transportation (DOT) with EPA-adjusted and laboratory fuel economy data.

Other Variables

All vehicle weight data are based on inertia weight class (nominally curb weight plus 300 pounds). For vehicles with inertia weights up to and including the 3000-pound inertia weight class, these classes have 250-pound increments. For vehicles above the 3000-pound inertia weight class (i.e., vehicles 3500 pounds and above), 500-pound increments are used.

All interior volume data for cars built after model year 1977 are based on the metric used to classify cars for the DOE/EPA *Fuel Economy Guide*. The car interior volume data in this report combine that of the passenger compartment and trunk/cargo space. In the *Fuel Economy Guide*, interior volume is undefined for the two-seater class; for this series of reports, all two-seater cars have been assigned an interior volume value of 50 cubic feet.

The light truck data used in this series of reports includes only vehicles classified as light trucks with gross vehicle weight ratings (GVWR) up to 8500 pounds(lb). Vehicles with GVWR above 8500 lb are not included in the database used for this report. Omitting these vehicles influences the overall averages for all variables studied in this report. The most recent estimates we have made for the impact of these greater than 8500 lb GVWR vehicles was made for model year 2001. In that year, there were roughly 931,000 vehicles above 8500 lb GVWR. A substantial fraction (42 percent) of the MY2001 vehicles above 8500 lb GVWR were powered by diesel engines, and three-fourths of the vehicles over 8500 lb GVWR were pickup trucks. Adding in the trucks above 8500 lb GVWR increased the truck market share for that year by three percentage points.

Based on a limited amount of actual laboratory fuel economy data, MY2001 trucks with GVWR greater than 8500 lb GVWR are estimated to have fuel economy values about 14 percent lower than the average of trucks below 8500 lb GVWR. The combined fleet of all vehicles under 8500 lb GVWR and trucks over 8500 lb GVWR is estimated to average a few percent less in fuel economy compared to that for just the vehicles with less than 8500 lb GVWR.

In addition to fuel economy, some tables in this report contain alternate measures of vehicle fuel efficiency as used in reference 17.

"Ton-MPG" is defined as a vehicle's mpg multiplied by its inertia weight in tons. This metric provides an indication of a vehicle's ability to move weight (i.e., its own plus a nominal payload). Ton-MPG is a measure of powertrain/drive-line efficiency. Just as an increase in vehicle mpg at constant weight can be considered an improvement in a vehicle's efficiency, an increase in a vehicle's weight-carrying capacity at constant mpg can also be considered an improvement.

"Cubic-feet-MPG" for cars is defined in this report as the product of a car's mpg and its interior volume, including trunk space. This metric associates a relative measure of a vehicle's ability to transport both passengers and their cargo. An increase in vehicle volume at constant mpg could be considered an improvement just as an increase in mpg at constant volume can be.

"Cubic-feet-ton-MPG" is defined in this report as a combination of the two previous metrics, i.e., a car's mpg multiplied by its weight in tons and also by its interior volume. It ascribes vehicle utility to the ability to move both weight and volume.

This report also includes an estimate of 0-to-60 mph acceleration time, calculated from engine rated horsepower and vehicle inertia weight, from the relationship:

$$t = F\ (HP/WT)^{-f}$$

where the values used for F and f coefficients are .892 and .805 respectively for vehicles with automatic transmissions and .967 and .775 respectively for those with manual transmissions [33]. Other authors [34, 35, and 36] have evaluated the relationships between weight, horsepower, and 0-to-60 acceleration time and have calculated and published slightly different values for the F and f coefficients. Since the equation form and coefficients were developed for vehicles with conventional powertrains with gasoline-fueled engines, we have not used the equation to estimate 0-to-60 time for vehicles with hybrid powertrains or diesel engines. Published values are used for these vehicles instead.

The 0-to-60 estimate used in this report is intended to provide a quantitative time "index" of vehicle performance capability. It is the author's engineering judgment that, given the differences in test methods for measuring 0-to-60 time and given the fact that the weight is based on inertia weight, use of these other published values for the F and f coefficients would not result in statistically significantly different 0-to-60 averages or trends. The results of a similar calculation of estimated "top speed" are also included in some tables.

Grouping all vehicles into classes and then constructing time trends of parameters of interest, like mpg, can provide interesting and useful results. These results, however, are a strong function of the class definitions. Classes based on other definitions than those used in this report are possible, and results from these other classifications may also be useful.

For cars, vehicle classification as to vehicle type, size class, and manufacturer/origin generally follows fuel economy label, *Fuel Economy Guide*, and fuel economy standards protocols; exceptions are listed in Table A-3, Appendix A. In many of the passenger car tables, large sedans and wagons are aggregated as "Large," midsize sedans and wagons are aggregated as "Midsize," and "Small" includes all other cars. In some of the car tables, an alternative classification system is used, namely: Large Cars, Large Wagons, Midsize Cars, Midsize Wagons, Small Cars, and Small Wagons with the EPA Two-Seater, Mini-Compact, Subcompact, and Compact car classes are combined into the "Small Car" class. In some of the tables and figures in this report, only four vehicle types are used. In these cases, wagons have been merged with cars. This is because the wagon sales fraction for some instances is so small that the information is more conveniently represented by combining the two vehicle types. When they have been combined, the differences between them are not important.

The truck classification scheme used for all model years in this report is slightly different from that used in some previous reports in this series, because pickups, vans, and sports utility vehicles (SUVs) are sometimes each subdivided as "Small," "Midsize," and "Large." These truck size classifications are based primarily on published wheelbase data according to the following criteria:

	Pickup	Van	SUV
Small	Less than 105"	Less than 109"	Less than 100"
Midsize	105" to 115"	109" to 124"	100" to 110"
Large	More than 115"	More than 124"	More than 110"

This classification scheme is similar to that used in many trade and consumer publications. For those vehicle nameplates with a variety of wheelbases, the size classification was determined by considering only the smallest wheelbase produced. The classification of a vehicle for this report is based on the author's engineering judgment and is not a replacement for definitions used in implementing automotive standards legislation.

Published data is also used for two other vehicle characteristics for which data is not currently being submitted to EPA by the automotive manufacturers: (1) engines with variable valve timing (VVT) which use either cams or electric solenoids to provide variable intake and/ or exhaust valve timing and in some cases valve lift; and (2) engines with cylinder deactivation which involves allowing the valves of selected cylinders of the engine to remain closed under certain driving conditions.

III. General Car and Truck Trends

Figure 1 and Table 1 depict time trends in car, light truck, and car-plus-light truck fuel economy. Also shown on Figure 1 is the fraction of the combined fleet that are light trucks and trend lines representing three-year moving averages of the fuel economy and truck sales fraction data. Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases:

1. a rapid increase from 1975 continuing into the mid-1980s,

2. a slow increase extending into the late-1980s,

3. a gradual decline from then until the mid-1990s, and

4. a period of relatively constant fuel economy since then.

This fourth phase is characterized by three-year moving average adjusted fuel economy levels within one percent of 20.8 mpg for about a decade. (See Table A-2, Appendix A.) This 20.8 mpg value is 1.2 mpg (five percent) lower than the highest year's (1987) three-year moving average value and 6.7 mpg (48 percent) higher than the earliest three-year moving average value, that for

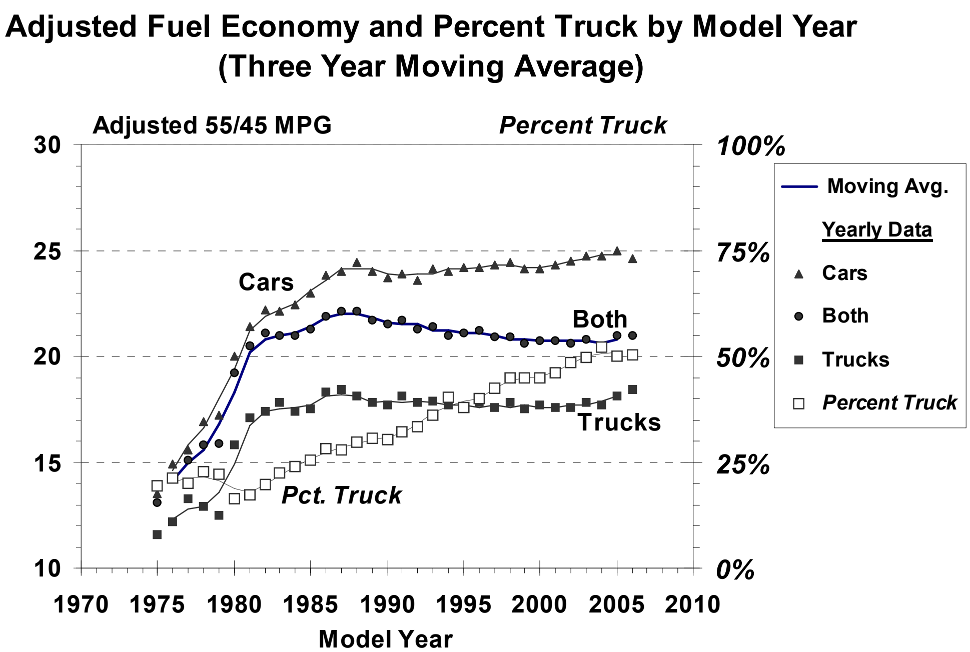

Figure 1

1976. The average fuel economy for all model year 2006 light-duty vehicles is estimated to be 21.0 mpg — the same value as achieved in 1994. The three-year moving average for car fuel economy has tended slightly upward for about 15 years and is now 1.0 mpg higher than it was in 1991. Similarly, the three year moving average for light-truck fuel economy is on a slight upward trend and is 0.5 mpg higher than it was five years ago. These slight upward mpg trends for both cars and trucks were accompanied by an increasing truck share of the market that continued through the early 2000s, and this has resulted a relatively flat trend in overall sales-weighted fleet fuel economy. Figure 1 shows that the estimated light truck share of the market, based on the three-year moving average trend, has leveled off at about 50 percent. Figure 2 compares laboratory 55/45 fuel economy for the combined car and truck fleet and the sales fraction for trucks.

MY2006 cars are estimated to average 24.6 mpg and are near the high end of their mpg range since 1996. For MY2006, light trucks are estimated to average 18.4 mpg, 0.7 mpg, about four percent, above their MY2004 average of 17.7 mpg. Fuel economy standards were unchanged for MY1996 through MY2004. In 2003 DOT raised the truck CAFE standards for MY2005, MY2006 and also for MY2007. The recent fuel economy improvement for trucks is likely due, at least in part, to these higher standards. The CAFE standard for cars has not been changed since 1990.

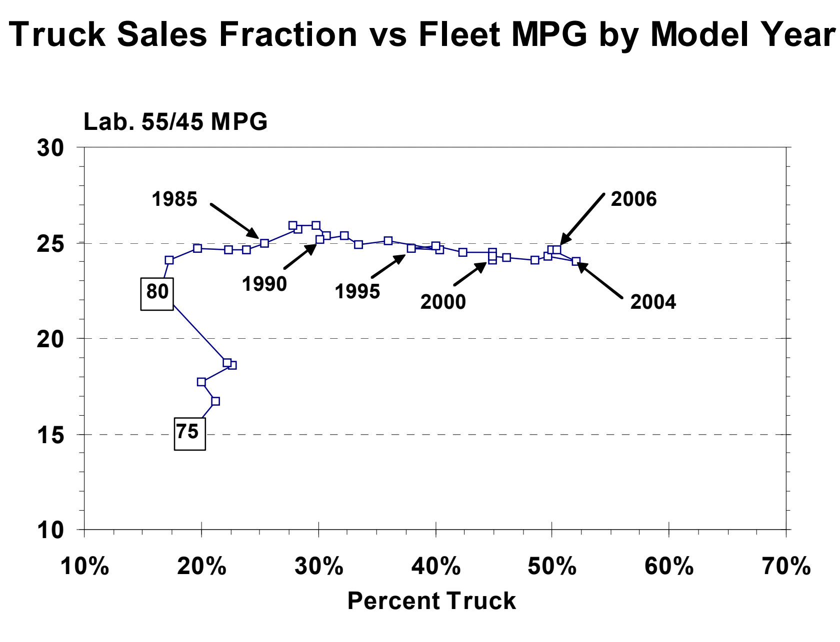

Figure 2

Table 1

Fuel Economy Characteristics of 1975 to 2006 Light-Duty Vehicles

Cars

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY LAB 55/45	ADJ CITY	ADJ HWY	ADJ 55/45 ---->	TON -MPG	CU-FT -MPG	CU-FT- TON-MPG
1975	8237	.806	15.8	12.3	15.2	13.5	27.6		
1976	9722	.788	17.5	13.7	16.6	14.9	30.2		
1977	11300	.800	18.3	14.4	17.4	15.6	31.0	1780	3423
1978	11175	.773	19.9	15.5	19.1	16.9	30.6	1908	3345
1979	10794	.778	20.3	15.9	19.2	17.2	30.2	1922	3301
1980	9443	.835	23.5	18.3	22.6	20.0	31.2	2136	3273
1981	8733	.827	25.1	19.6	24.2	21.4	33.1	2338	3547
1982	7819	.803	26.0	20.1	25.5	22.2	34.2	2419	3645
1983	8002	.777	25.9	19.9	25.5	22.1	34.7	2476	3776
1984	10675	.761	26.3	20.2	26.0	22.4	35.1	2482	3776
1985	10791	.746	27.0	20.7	26.8	23.0	35.8	2553	3884
1986	11015	.717	27.9	21.3	27.7	23.8	36.4	2608	3914
1987	10731	.722	28.1	21.5	28.0	24.0	36.5	2604	3900
1988	10736	.702	28.6	21.8	28.5	24.4	37.3	2662	4007
1989	10018	.693	28.1	21.4	28.3	24.0	37.4	2630	4034
1990	8810	.698	27.8	21.1	28.1	23.7	37.8	2574	4055
1991	8524	.678	28.0	21.2	28.3	23.9	37.8	2597	4055
1992	8108	.666	27.6	20.8	28.3	23.6	38.4	2598	4169
1993	8456	.640	28.2	21.3	28.8	24.1	38.8	2655	4213
1994	8415	.596	28.0	21.1	28.8	24.0	39.1	2637	4236
1995	9396	.620	28.3	21.2	29.3	24.2	39.6	2676	4315
1996	7890	.600	28.3	21.2	29.3	24.2	39.8	2672	4345
1997	8335	.576	28.4	21.3	29.4	24.3	39.9	2674	4341
1998	7972	.551	28.5	21.3	29.6	24.4	40.5	2684	4401
1999	8379	.551	28.2	21.1	29.2	24.1	40.6	2656	4440
2000	9128	.551	28.2	21.1	29.1	24.1	40.7	2669	4468
2001	8408	.539	28.4	21.4	29.3	24.3	41.4	2700	4525
2002	8304	.515	28.6	21.6	29.3	24.5	41.8	2723	4579
2003	7951	.504	28.9	21.8	29.7	24.7	42.6	2757	4669
2004	7538	.480	28.9	21.7	29.8	24.7	43.1	2787	4777
2005	7976	.500	29.2	22.0	30.0	25.0	44.2	2862	4939
2006	8265	.496	28.8	21.6	29.6	24.6	44.5	2824	4976

Table 1 (Continued)

Fuel Economy Characteristics of 1975 to 2006 Light-Duty Vehicles

Trucks

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY ----> LAB 55/45	ADJ CITY	ADJ HWY	ADJ 55/45	TON -MPG
1975	1987	.194	13.7	10.9	12.7	11.6	24.2
1976	2612	.212	14.4	11.5	13.2	12.2	26.0
1977	2823	.200	15.6	12.6	14.1	13.3	28.0
1978	3273	.227	15.2	12.4	13.7	12.9	27.5
1979	3088	.222	14.7	12.1	13.1	12.5	27.3
1980	1863	.165	18.6	14.8	17.1	15.8	30.9
1981	1821	.173	20.1	16.0	18.6	17.1	33.0
1982	1914	.197	20.5	16.3	19.0	17.4	33.7
1983	2300	.223	20.9	16.5	19.6	17.8	34.0
1984	3345	.239	20.5	16.1	19.3	17.4	33.5
1985	3669	.254	20.6	16.2	19.4	17.5	33.7
1986	4350	.283	21.4	16.9	20.2	18.3	34.4
1987	4134	.278	21.6	16.9	20.7	18.4	34.5
1988	4559	.298	21.2	16.5	20.4	18.1	34.9
1989	4435	.307	20.9	16.3	20.1	17.8	35.2
1990	3805	.302	20.7	16.1	20.2	17.7	35.6
1991	4049	.322	21.3	16.4	20.7	18.1	36.0
1992	4064	.334	20.8	16.1	20.4	17.8	36.2
1993	4754	.360	21.0	16.1	20.7	17.9	36.6
1994	5710	.404	20.8	16.0	20.3	17.7	36.7
1995	5749	.380	20.5	15.8	20.2	17.5	36.9
1996	5254	.400	20.8	16.0	20.7	17.8	37.8
1997	6124	.424	20.6	15.8	20.4	17.6	38.3
1998	6485	.449	20.9	16.0	20.8	17.8	38.3
1999	6839	.449	20.5	15.7	20.3	17.5	38.6
2000	7447	.449	20.8	16.0	20.5	17.7	38.9
2001	7202	.461	20.6	15.9	20.2	17.6	39.3
2002	7815	.485	20.6	15.8	20.3	17.6	40.0
2003	7824	.496	20.9	16.0	20.7	17.8	41.0
2004	8173	.520	20.8	15.9	20.6	17.7	41.8
2005	7992	.500	21.2	16.2	21.2	18.1	42.8
2006	8410	.504	21.5	16.4	21.5	18.4	43.5

Table 1 (Continued)

Fuel Economy Characteristics of 1975 to 2006 Light-Duty Vehicles

Cars and Trucks

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY LAB 55/45	ADJ CITY	ADJ HWY	ADJ 55/45 ---->	TON -MPG
1975	10224	1.000	15.3	12.0	14.6	13.1	26.9
1976	12334	1.000	16.7	13.2	15.7	14.2	29.3
1977	14123	1.000	17.7	14.0	16.6	15.1	30.4
1978	14448	1.000	18.6	14.7	17.5	15.8	29.9
1979	13882	1.000	18.7	14.9	17.4	15.9	29.5
1980	11306	1.000	22.5	17.6	21.5	19.2	31.2
1981	10554	1.000	24.1	18.8	23.0	20.5	33.1
1982	9732	1.000	24.7	19.2	23.9	21.1	34.1
1983	10302	1.000	24.6	19.0	23.9	21.0	34.5
1984	14020	1.000	24.6	19.1	24.0	21.0	34.7
1985	14460	1.000	25.0	19.3	24.4	21.3	35.3
1986	15365	1.000	25.7	19.9	25.1	21.9	35.8
1987	14865	1.000	25.9	20.0	25.5	22.1	35.9
1988	15295	1.000	25.9	19.9	25.5	22.1	36.6
1989	14453	1.000	25.4	19.5	25.2	21.7	36.7
1990	12615	1.000	25.2	19.3	25.1	21.5	37.1
1991	12573	1.000	25.4	19.4	25.3	21.7	37.2
1992	12172	1.000	24.9	18.9	25.0	21.3	37.6
1993	13211	1.000	25.1	19.1	25.2	21.4	38.0
1994	14125	1.000	24.6	18.7	24.7	21.0	38.1
1995	15145	1.000	24.7	18.8	25.0	21.1	38.6
1996	13144	1.000	24.8	18.7	25.1	21.2	39.0
1997	14459	1.000	24.5	18.6	24.8	20.9	39.2
1998	14458	1.000	24.5	18.5	24.9	20.9	39.5
1999	15218	1.000	24.1	18.3	24.4	20.6	39.7
2000	16574	1.000	24.3	18.4	24.5	20.7	39.9
2001	15610	1.000	24.2	18.4	24.3	20.7	40.4
2002	16119	1.000	24.1	18.3	24.1	20.6	40.9
2003	15775	1.000	24.3	18.5	24.4	20.8	41.8
2004	15711	1.000	24.0	18.2	24.2	20.5	42.4
2005	15968	1.000	24.6	18.7	24.8	21.0	43.5
2006	16675	1.000	24.6	18.6	24.9	21.0	44.0

The distribution of fuel economy in any model year is of interest. In Figure 3, highlights of the distribution of car mpg are shown. Since 1975, the distribution has both narrowed and widened, but half of the cars have consistently been within a few mpg of each other. The fuel economy difference between the least efficient and most efficient car increased from about 20 mpg in 1975 to nearly 50 mpg in 1986, but was less than 35 mpg in 1999. With the introduction for sale of the Honda Insight gasoline-electric hybrid vehicle in MY2000, the range became more than 50 mpg. The increased market share of hybrid cars also accounts for the increase in the fuel economy of the best 1% of cars with the cutpoint for this strata now approaching 50 mpg. The ratio of the highest to lowest has increased from about three to one in 1975 to about six to one today, because the fuel economy of the least fuel efficient cars has remained roughly constant in comparison to the most fuel efficient cars whose fuel economy has more than doubled.

The overall fuel economy distribution trend for trucks (see Figure 4) is narrower than that for cars, with a peak in the efficiency of the most efficient truck in the early 1980s when small pickup trucks equipped with diesel engines were being sold. As a result, the fuel economy range between the most efficient and least efficient truck peaked at about 25 mpg in 1982 when nine percent of all trucks used diesel engines. The fuel economy range for trucks then narrowed, but with the introduction of the hybrid Escape SUV in MY2005, it is back above 20 mpg. Like cars, half of the trucks built each year have always been within a few mpg of each year's average fuel economy value. Appendix C contains additional fuel economy distribution data.

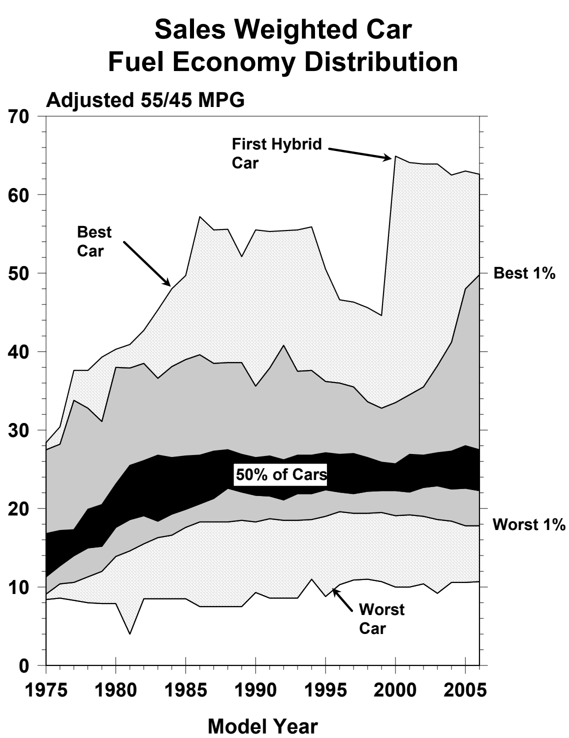

Figure 3

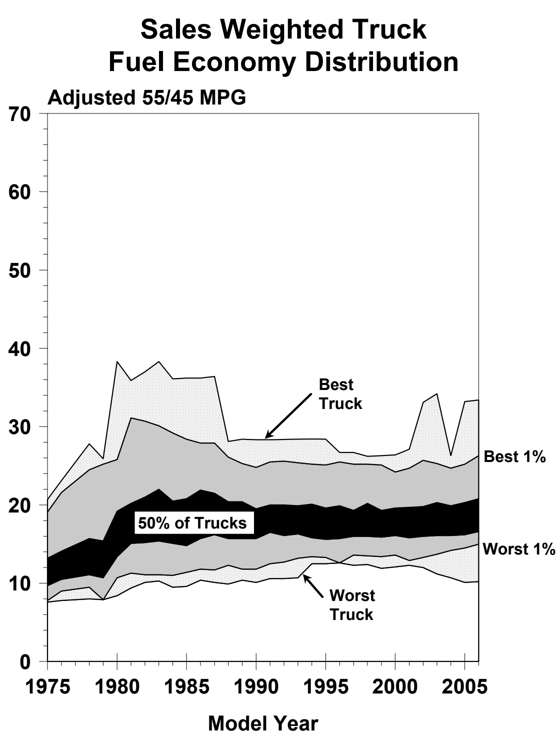

Figure 4

Table 2

Vehicle Size and Design Characteristics of 1975 to 2006

Cars

	<------- VEHICLE CHARACTERISTICS							---------->	<- PERCENT BY: ->		
		ADJ		INERTIA							
MODEL	SALES	55/45	VOL	WGHT	ENG	HP/	0-60	TOP	VEHICLE SIZE		
YEAR	FRAC	MPG	CU-FT	LB	HP	WT	TIME	SPD	SMALL	MID	LARGE
1975	.806	13.5		4058	136	.0331	14.2	111	55.4	23.3	21.3
1976	.788	14.9		4059	134	.0324	14.4	110	55.4	25.2	19.4
1977	.800	15.6	110	3944	133	.0335	14.0	111	51.9	24.5	23.5
1978	.773	16.9	109	3588	124	.0342	13.7	111	44.7	34.4	21.0
1979	.778	17.2	109	3485	119	.0338	13.8	110	43.7	34.2	22.1
1980	.835	20.0	104	3101	100	.0322	14.3	107	54.4	34.4	11.3
1981	.827	21.4	106	3076	99	.0320	14.4	106	51.5	36.4	12.2
1982	.803	22.2	106	3054	99	.0320	14.4	106	56.5	31.0	12.5
1983	.777	22.1	109	3112	104	.0330	14.0	108	53.1	31.8	15.1
1984	.761	22.4	108	3099	106	.0339	13.8	109	57.4	29.4	13.2
1985	.746	23.0	108	3093	111	.0355	13.3	111	55.7	28.9	15.4
1986	.717	23.8	107	3041	111	.0360	13.2	111	59.5	27.9	12.6
1987	.722	24.0	107	3031	112	.0365	13.0	112	63.5	24.3	12.2
1988	.702	24.4	107	3047	116	.0375	12.8	113	64.8	22.3	12.8
1989	.693	24.0	108	3099	121	.0387	12.5	115	58.3	28.2	13.5
1990	.698	23.7	107	3176	129	.0401	12.1	117	58.6	28.7	12.8
1991	.678	23.9	107	3154	132	.0413	11.8	118	61.5	26.2	12.3
1992	.666	23.6	108	3240	141	.0428	11.5	120	56.5	27.8	15.6
1993	.640	24.1	108	3207	138	.0425	11.6	120	57.2	29.5	13.3
1994	.596	24.0	108	3250	143	.0432	11.4	121	58.5	26.1	15.4
1995	.620	24.2	109	3263	152	.0460	10.9	125	57.3	28.6	14.0
1996	.600	24.2	109	3282	154	.0464	10.8	125	54.3	32.0	13.6
1997	.576	24.3	109	3274	156	.0469	10.7	126	55.1	30.6	14.3
1998	.551	24.4	109	3306	159	.0475	10.6	127	49.4	39.1	11.4
1999	.551	24.1	109	3365	164	.0481	10.5	128	47.7	39.7	12.6
2000	.551	24.1	110	3369	168	.0492	10.4	129	47.5	34.3	18.2
2001	.539	24.3	109	3380	168	.0492	10.3	129	50.9	32.3	16.8
2002	.515	24.5	109	3391	173	.0504	10.2	131	48.6	36.3	15.1
2003	.504	24.7	109	3421	176	.0510	10.0	132	50.8	33.4	15.9
2004	.480	24.7	110	3462	183	.0521	9.8	133	47.4	35.6	17.0
2005	.500	25.0	111	3490	185	.0523	9.8	134	44.3	37.6	18.1
2006	.496	24.6	112	3563	198	.0547	9.5	137	44.5	34.5	21.0

Table 2 (Continued)

Vehicle Size and Design Characteristics of 1975 to 2006

Trucks

		<----- Vehicle Characteristics: ----->						<-- Percent By: ->		
MODEL YEAR	**FRAC**	**ADJ 55/45 MPG**	**WGHT LB**	**ENG HP**	**HP/ WT**	**0-60 TIME**	**TOP SPD**	**VEHICLE TYPE VAN**	**SUV**	**PICKUP**
1975	.194	11.6	4072	142	.0349	13.6	114	23.0	9.4	67.6
1976	.212	12.2	4155	141	.0340	13.8	113	19.2	9.3	71.4
1977	.200	13.3	4135	147	.0356	13.3	115	18.2	10.0	71.8
1978	.227	12.9	4151	146	.0351	13.4	114	19.1	11.6	69.3
1979	.222	12.5	4252	138	.0325	14.3	111	15.6	13.0	71.5
1980	.165	15.8	3869	121	.0313	14.5	108	13.0	9.9	77.1
1981	.173	17.1	3806	119	.0311	14.6	108	13.5	7.5	79.1
1982	.197	17.4	3806	120	.0317	14.5	109	16.2	8.5	75.3
1983	.223	17.8	3763	118	.0313	14.5	108	16.6	12.6	70.8
1984	.239	17.4	3782	118	.0310	14.7	108	20.2	18.7	61.1
1985	.254	17.5	3795	124	.0326	14.1	110	23.3	20.0	56.6
1986	.283	18.3	3738	123	.0330	14.0	110	24.0	17.8	58.2
1987	.278	18.4	3713	131	.0351	13.3	113	26.9	21.1	51.9
1988	.298	18.1	3841	141	.0366	12.9	115	24.8	21.2	53.9
1989	.307	17.8	3921	146	.0372	12.8	116	28.8	20.9	50.3
1990	.302	17.7	4005	151	.0377	12.6	117	33.2	18.6	48.2
1991	.322	18.1	3948	150	.0379	12.6	117	25.5	27.0	47.4
1992	.334	17.8	4056	155	.0382	12.5	118	30.0	24.7	45.3
1993	.360	17.9	4073	162	.0398	12.1	120	30.3	27.6	42.1
1994	.404	17.7	4125	166	.0403	12.0	121	24.8	28.4	46.7
1995	.380	17.5	4184	168	.0401	12.0	121	28.9	31.6	39.5
1996	.400	17.8	4225	179	.0423	11.5	124	26.8	36.0	37.2
1997	.424	17.6	4344	187	.0429	11.4	126	20.7	40.0	39.3
1998	.449	17.8	4283	187	.0435	11.2	126	23.0	39.8	37.2
1999	.449	17.5	4412	197	.0446	11.0	128	21.4	41.4	37.2
2000	.449	17.7	4375	197	.0448	11.0	128	22.7	42.2	35.1
2001	.461	17.6	4463	209	.0466	10.6	131	17.1	47.9	35.0
2002	.485	17.6	4546	219	.0482	10.4	134	15.9	53.6	30.5
2003	.496	17.8	4586	221	.0481	10.4	134	15.7	52.6	31.6
2004	.520	17.7	4710	236	.0501	10.0	137	11.7	57.7	30.7
2005	.500	18.1	4711	240	.0507	10.0	138	15.8	52.6	31.6
2006	.504	18.4	4712	239	.0506	9.9	138	17.6	53.7	28.7

Table 2 (Continued)

Vehicle Size and Design Characteristics of 1975 to 2006

Cars and Trucks

MODEL YEAR	SALES FRAC	ADJ 55/45 MPG	WGHT LB	ENG HP	HP/ WT	0-60 TIME	TOP SPD
1975	1.000	13.1	4060	137	.0335	14.1	112
1976	1.000	14.2	4079	135	.0328	14.3	111
1977	1.000	15.1	3982	136	.0339	13.8	112
1978	1.000	15.8	3715	129	.0344	13.6	112
1979	1.000	15.9	3655	124	.0335	13.9	110
1980	1.000	19.2	3228	104	.0320	14.3	107
1981	1.000	20.5	3202	102	.0318	14.4	107
1982	1.000	21.1	3202	103	.0320	14.4	107
1983	1.000	21.0	3257	107	.0327	14.1	108
1984	1.000	21.0	3262	109	.0332	14.0	109
1985	1.000	21.3	3271	114	.0347	13.5	110
1986	1.000	21.9	3238	114	.0351	13.4	111
1987	1.000	22.1	3221	118	.0361	13.1	112
1988	1.000	22.1	3283	123	.0372	12.8	114
1989	1.000	21.7	3351	129	.0382	12.5	115
1990	1.000	21.5	3426	135	.0394	12.2	117
1991	1.000	21.7	3410	138	.0402	12.1	118
1992	1.000	21.3	3512	145	.0413	11.8	120
1993	1.000	21.4	3519	147	.0416	11.8	120
1994	1.000	21.0	3603	152	.0420	11.7	121
1995	1.000	21.1	3613	158	.0438	11.3	123
1996	1.000	21.2	3659	164	.0447	11.1	125
1997	1.000	20.9	3727	169	.0452	11.0	126
1998	1.000	20.9	3744	171	.0457	10.9	126
1999	1.000	20.6	3835	179	.0465	10.7	128
2000	1.000	20.7	3821	181	.0472	10.6	129
2001	1.000	20.7	3879	187	.0480	10.5	130
2002	1.000	20.6	3951	195	.0493	10.3	132
2003	1.000	20.8	3999	199	.0496	10.2	133
2004	1.000	20.5	4111	211	.0511	9.9	135
2005	1.000	21.0	4101	212	.0515	9.9	136
2006	1.000	21.0	4142	219	.0526	9.7	137

Ton-MPG by Model Year
(Three Year Moving Average)

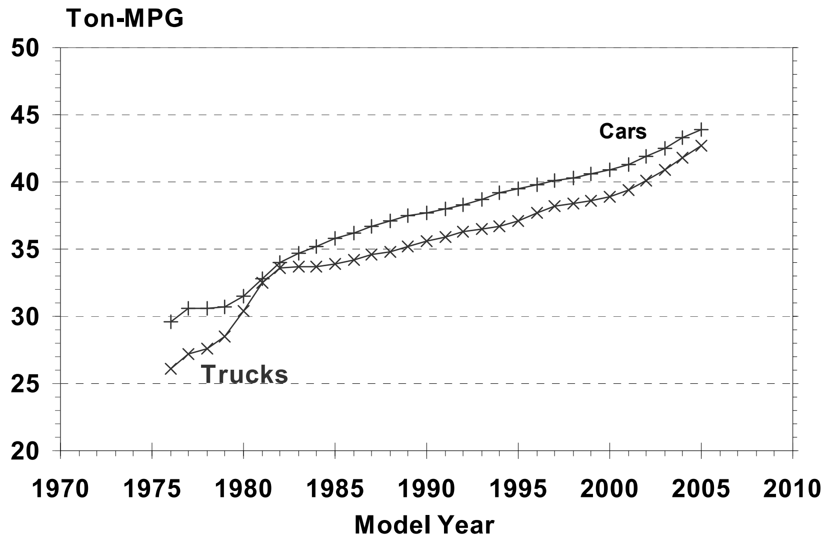

Figure 5

At 4142 lb, (see Table 2) the average weight of the model year 2006 fleet not only is nearly 950 lb heavier than it was at the minimum in 1981-82, it also is heavier than any year in the table and roughly 500 lb heavier than it was a decade ago. The model year 2006 fleet is also the most powerful and estimated to be the fastest since 1975. As shown in Figure 5, between 1975 and 2006 Ton-MPG for both cars and trucks increased substantially; i.e. over 60% for cars and 80% for trucks. Typically, Ton-MPG for both vehicle types has increased at a rate of about one or two percent a year.

Another dramatic trend over that time frame has been the substantial increase in performance of cars and light trucks as measured by their estimated 0-to-60 time. These trends are shown graphically in Figure 6 (for cars) and Figure 7 (for light trucks) which are plots of fuel economy versus performance, with model years as indicated. Both graphs show the same story: in the late 1970s and early 1980s, responding to the regulatory requirements for mpg improvement, the industry increased mpg and kept performance roughly constant. After the regulatory mpg requirements stabilized, mpg improvements slowed and performance dramatically improved. This trend toward increased performance is as important as the truck market share trend in understanding trends in overall fleet mpg. Figures 8 and 9 are similar to Figures 6 and 7, but show the trends in weight and laboratory fuel economy and show that the era of weight reductions that took place for both cars and trucks between 1975 and the early 1980s has been followed by an era of weight increases.

Car 55/45 Laboratory MPG vs 0 to 60 Time by Model Year

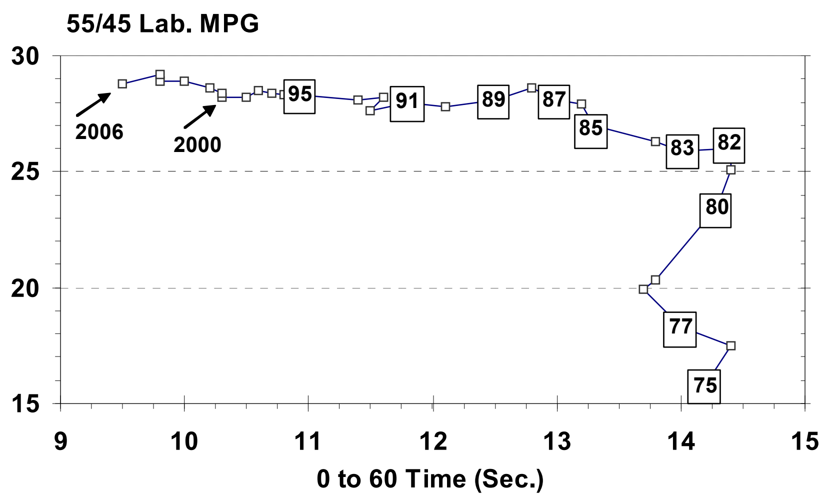

Figure 6

Truck 55/45 Laboratory MPG vs 0 to 60 Time by Model Year

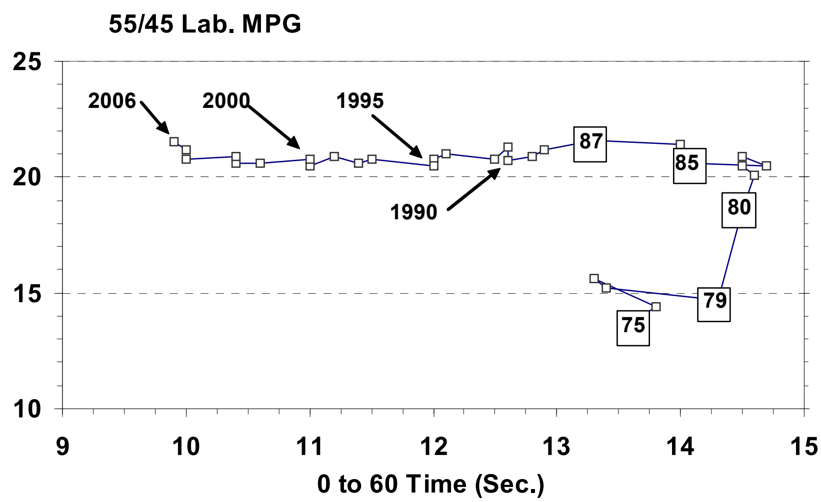

Figure 7

Car 55/45 Laboratory MPG vs Inertia Weight by Model Year

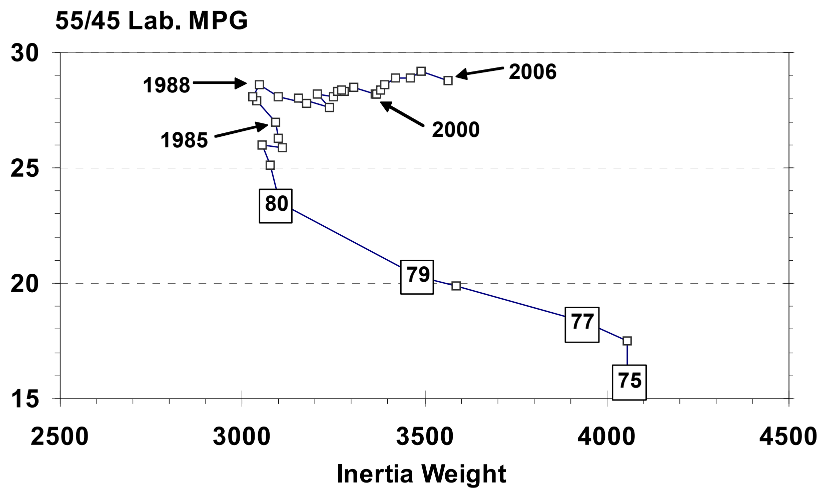

Figure 8

Truck 55/45 Laboratory MPG vs Inertia Weight by Model Year

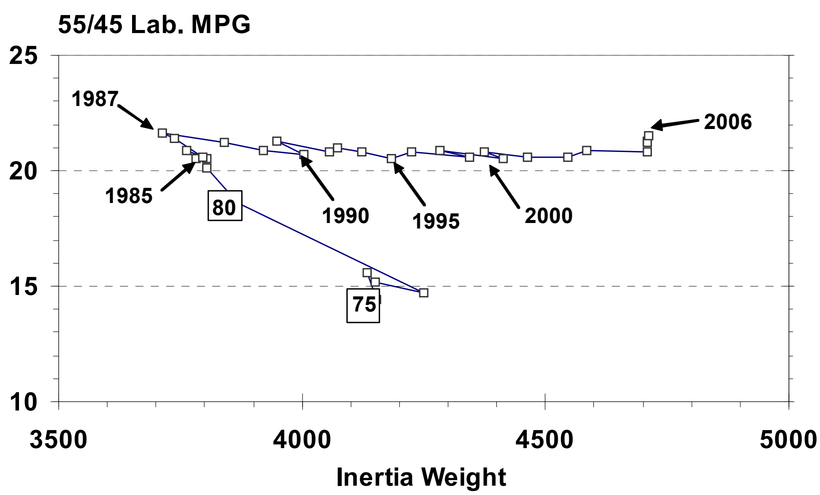

Figure 9

IV. Trends by Vehicle Type, Size, and Weight

Table 1 showed that for the past several years trucks have accounted for about 50 percent of the light-duty vehicles produced each year. Since 2004, however, truck sales fraction has dropped slightly from 52 back to 50 percent. Considering the five classes: cars, wagons, sports utility vehicles (SUVs), vans, and pickups, since 1975 the biggest overall increase in market share has been for SUVs, up from less than two percent in 1975 to 27 percent this year, but down 3 percent from 30 percent two years ago (see Figure 10 or Table 3). In 1975, less than 200,000 SUVs were sold, compared to over 4.5 million this year. The biggest overall decrease has been for cars, down from over 70 percent of the fleet in 1975 to about 45 percent. By comparison the sales fraction for pickup trucks has remained constant a nominal 15 percent of the market.

Figures 11 to 15 compare sales fractions by vehicle type and size with the fleet again stratified into five vehicle types: cars (i.e., coupes, sedans, and hatchbacks), station wagons, vans, SUVs, and pickup trucks; and three vehicle sizes: small, midsize, and large. As shown in Figure 15, large cars accounted for about 20 percent of all car sales in the late 1970s, but their share of the car market dropped in the early 1980s to about 12 percent of the market where it remained for about two decades, but has since increased. Within the car segment, the market share for small cars peaked in the late 1980s at about 65 percent and is now lower than at anytime since 1975.

Sales Fraction by Vehicle Type
(Three Year Moving Average)

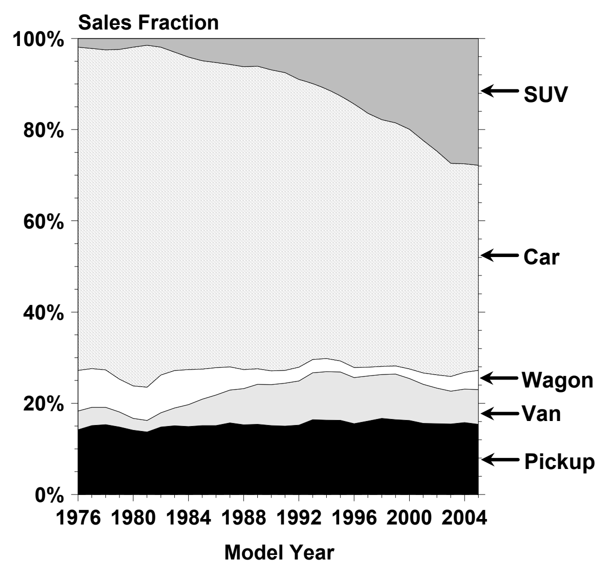

Figure 10

Large wagons accounted for more than 20 percent of the wagon segment of the market in the late 1970s but then lost market share relatively consistently and were not produced at all between 1996 and 2004 when they reemerged. They now account for about 15 percent of all wagons, but less than one percent of all light vehicles. Similarly (see Figure 13), large vehicles accounted for nearly 40 percent of all vans through the early 1980s compared to less than 10 percent the past five years. Small vans have never had a significant market share, and none have been produced in recent years. Figures 14 and 15 show that there have been an overall and significant trend towards increased market share for both large SUVs and pickups, but there has been a recent decrease in large SUV sales fraction.

Table 3 compares the sales fractions by vehicle type and size on a different basis, that for the total market. Since 1975, the largest increases in sales fractions have been for midsize and large SUVs. These two classes are expected to account for over 25 percent of all light vehicles built this year, compared to combined totals of about 1.3 and 4.5 percent in 1975 and 1988, respectively. Conversely, the largest sales fraction decrease has occurred for small cars which accounted for 40 percent of all light-duty vehicles produced in 1975 and over 43 percent in 1988, but less than 20 percent this year. While the small car class has consistently remained the largest of the 15 vehicle sizes and types, its market share of the total market has since decreased by 25 percent. An overall decrease has occurred for large cars which accounted for about 15 percent of total light-duty sales in 1975 when they ranked third. Between then and 1988, their sales fraction dropped to less than 10 percent of the total market.

Car Sales Fraction by Vehicle Size (Three Year Moving Average)

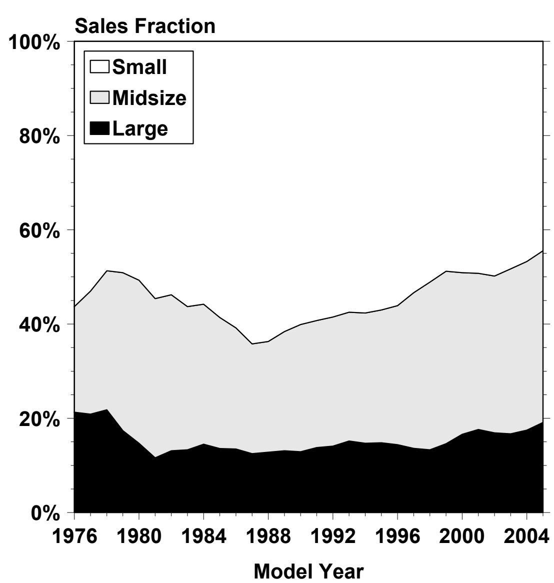

Figure 11

Wagon Sales Fraction by Vehicle Size (Three Year Moving Average)

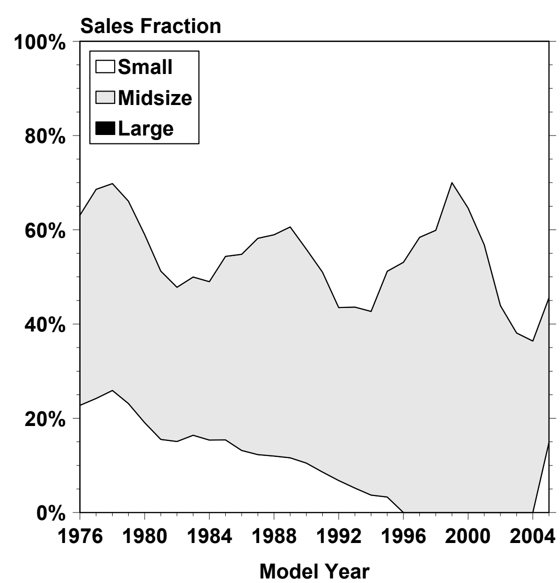

Figure 12

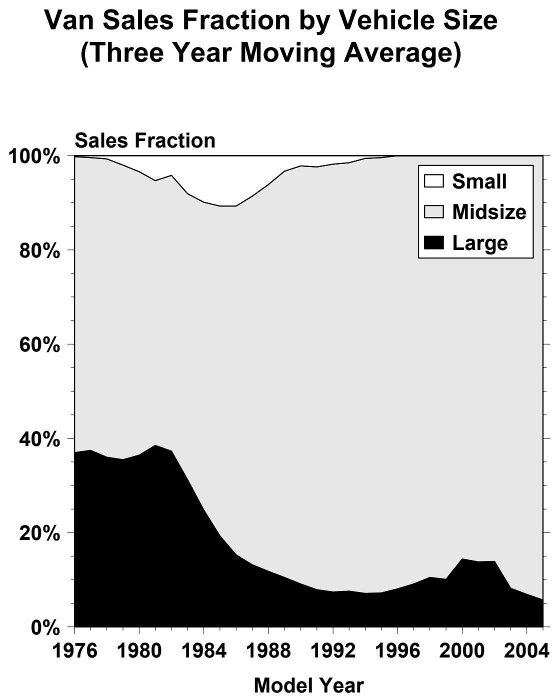

Figure 13

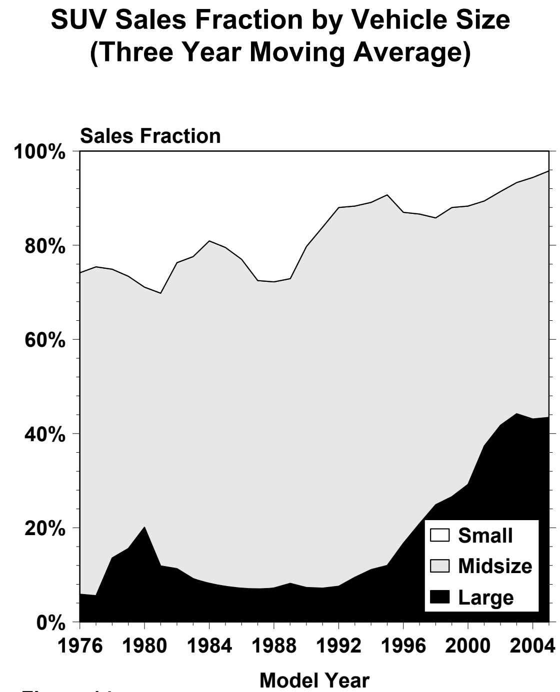

Figure 14

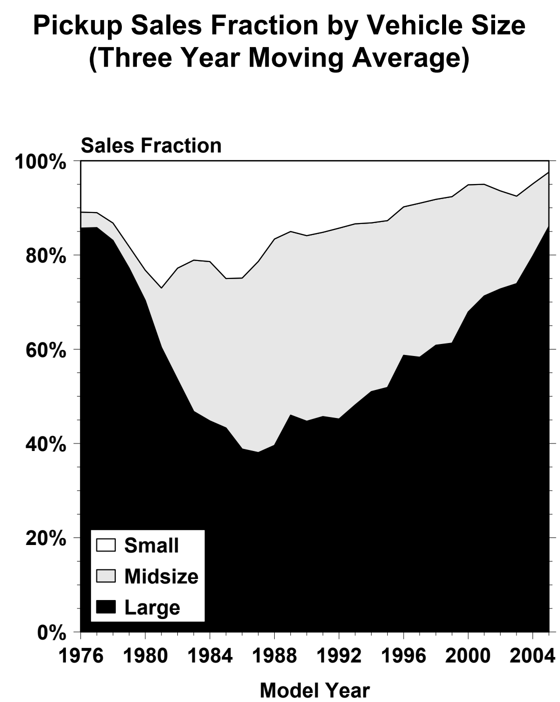

Figure 15

Table 3

Sales Fractions of MY1975, MY1987 and MY2005
Light-Duty Vehicles by Vehicle Size and Type

Vehicle Type	Size	Sales Fraction 1975	Sales Fraction 1988	Sales Fraction 2006	Differences in Sales Fraction: From 1975 To 2006	From 1975 To 1988	From 1987 To 2006
Car	Small	40.0%	43.8%	19.3%	-20.6%	3.9%	-24.5%
	Midsize	16.0%	13.8%	15.7%	-0.2%	-2.1%	1.9%
	Large	15.2%	8.5%	9.8%	-5.4%	-6.7%	1.2%
	All	71.1%	66.2%	44.8%	-26.3%	-5.0%	-21.3%
Wagon	Small	4.7%	1.7%	2.7%	-2.0%	-3.0%	1.1%
	Midsize	2.8%	1.9%	1.4%	-1.5%	-1.0%	-0.5%
	Large	1.9%	.5%	.6%	-1.3%	-1.4%	.1%
	All	9.4%	4.0%	4.7%	-4.7%	-5.4%	.7%
Van	Small	.0%	.4%	.0%	.0%	.3%	-0.4%
	Midsize	3.0%	6.2%	8.4%	5.4%	3.2%	2.2%
	Large	1.5%	.9%	.5%	-1.0%	-0.6%	-0.4%
	All	4.5%	7.4%	8.9%	4.4%	2.9%	1.5%
SUV	Small	.5%	1.9%	.6%	.1%	1.4%	-1.3%
	Midsize	1.2%	4.0%	14.6%	13.4%	2.8%	10.6%
	Large	.1%	.5%	11.8%	11.7%	.3%	11.4%
	All	1.8%	6.3%	27.1%	25.2%	4.5%	20.8%
Pickup	Small	1.6%	2.2%	.0%	-1.5%	.7%	-2.2%
	Midsize	.5%	6.9%	1.4%	.9%	6.3%	-5.5%
	Large	11.0%	7.0%	13.0%	2.0%	-4.1%	6.0%
	All	13.1%	16.1%	14.5%	1.3%	2.9%	-1.6%
All	Trucks	19.4%	29.8%	50.4%	31.0%	10.4%	20.6%

Figures 16 through 20 show trends in performance, weight, and adjusted fuel economy for cars, wagons, vans, SUVs, and pickups. For all five vehicle types, there has been for the past 15 to 20 years, a clear long term trend towards increased weight with average weight for all three types of trucks higher now, than in 1975. You have to go back to 1978 to find a heavier car or wagon fleet. On the average 2006 cars, wagons, vans, SUVs, and pickups are as powerful and fast as they have ever been. Their respective Ton-mpg values are also the highest ever. In this measure of efficiency, vans lead, cars and wagons are about the same and better than SUVs which are like pickups.

Table 4 shows the lowest, average, and highest adjusted mpg performance by vehicle class and size for three selected years. For both 1988 and 2006, the mpg performance is such that the midsize vehicles in all classes have better fuel economy than the corresponding entry for small vehicles in 1975. In addition, the average MY2006 large car, large wagon and large SUV gets higher fuel economy in 2006 than the corresponding small car, small wagon and small SUV counterparts did 31 years ago. In Table 5, the percentage changes obtainable from the entries in Table 4 are presented. Average mpg for four classes (midsize cars, large cars, midsize wagons and large SUVs) have improved over 90 percent since 1975. The average fuel economy improvements between 1975 and 2006 for the truck classes ranges from 13 percent for midsize

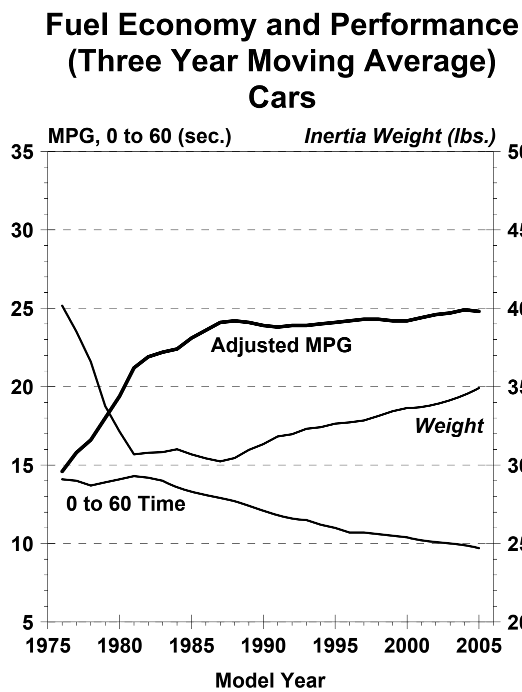

Figure 16

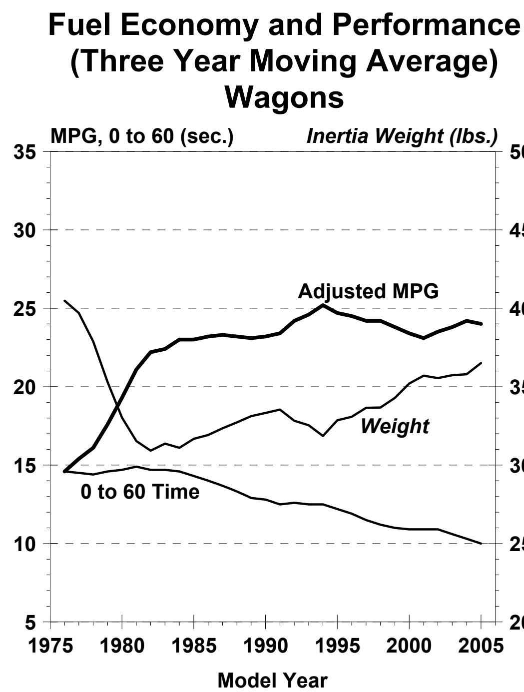

Figure 17

Fuel Economy and Performance (Three Year Moving Average) Vans

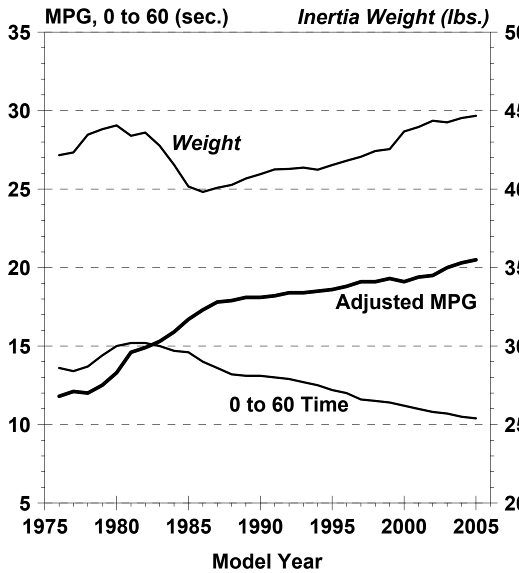

Figure 18

Fuel Economy and Performance (Three Year Moving Average) SUVs

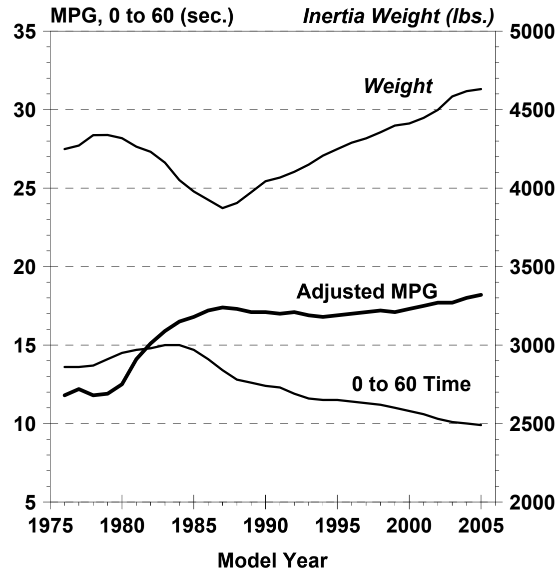

Figure 19

Fuel Economy and Performance (Three Year Moving Average) Pickups

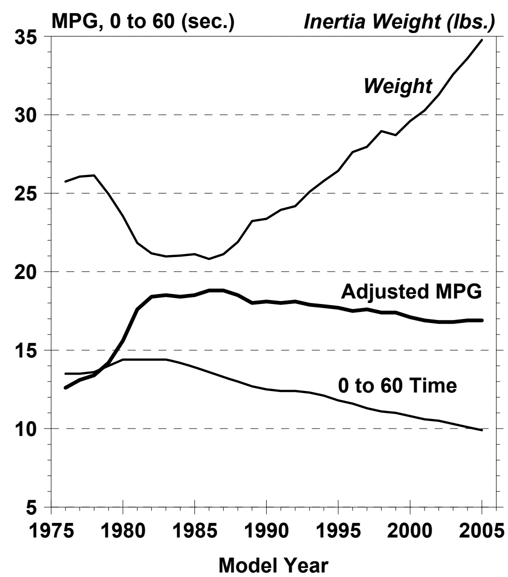

Figure 20

Table 4

Lowest, Average and Highest Adjusted Fuel Economy
by Vehicle Type and Size

Vehicle		**1975**			**1988**			**2006**		
Type	**Size**	**Low.**	**Avg.**	**High.**	**Low.**	**Avg.**	**High.**	**Low.**	**Avg.**	**High.**
Car	Small	8.6	15.6	28.3	7.5	26.0	55.6	10.7	25.9	62.6
	Midsize	8.6	11.6	18.4	10.6	22.8	28.0	11.8	25.1	55.3
	Large	8.4	11.2	14.6	10.1	20.7	26.3	11.8	22.0	28.0
	All	8.4	13.4	28.3	7.5	24.5	55.6	10.7	24.7	62.6
Wagon	Small	11.8	19.1	24.1	17.3	26.6	33.7	17.2	26.9	32.7
	Midsize	8.4	11.3	25.0	17.7	22.4	28.0	16.3	22.7	29.2
	Large	8.4	10.2	12.8	19.4	19.5	19.6	14.9	18.6	20.2
	All	8.4	13.8	25.0	17.3	23.5	33.7	14.9	24.1	32.7
Van	Small	16.2	17.5	18.5	15.7	20.8	25.3	****	****	****
	Midsize	8.2	11.3	18.4	11.4	18.6	23.7	18.9	21.0	22.7
	Large	8.9	10.7	14.5	10.0	14.4	17.0	14.4	16.2	17.5
	All	8.2	11.1	18.5	10.0	18.0	25.3	14.4	20.6	22.7
SUV	Small	10.2	13.7	16.3	15.8	20.6	28.2	15.6	19.7	24.8
	Midsize	8.2	10.2	18.4	10.3	16.6	23.9	16.1	19.8	33.3
	Large	7.9	10.3	13.7	12.3	14.2	19.0	13.6	17.1	22.1
	All	7.9	11.0	18.4	10.3	17.4	28.2	13.6	18.5	33.3
Pickup	Small	13.0	19.2	20.8	13.5	21.2	24.9	20.3	22.4	24.8
	Midsize	17.8	17.9	18.0	15.5	21.5	26.2	16.8	20.3	25.7
	Large	7.6	11.1	18.5	9.9	15.4	21.2	10.2	16.7	23.2
	All	7.6	11.9	20.8	9.9	18.3	26.2	10.2	17.0	25.7
All	Cars	8.4	13.5	28.3	7.5	24.4	55.6	10.7	24.6	62.6
All	Trucks	7.6	11.6	20.8	9.9	18.1	28.2	10.2	18.4	33.3
All	Vehicles	7.6	13.1	28.3	7.5	22.1	55.6	10.2	21.0	62.6

Table 5

Percent Change in Lowest, Average and Highest Adjusted Fuel Economy by Vehicle Type and Size

Vehicle Type	Size	From 1975 to 2006 Low.	Avg.	High.	From 1975 to 1988 Low.	Avg.	High.	From 1988 to 2006 Low.	Avg.	High.
Car	Small	24%	66%	121%	-12%	67%	96%	43%	0%	13%
	Midsize	37%	116%	201%	23%	97%	52%	11%	10%	97%
	Large	40%	96%	92%	20%	85%	80%	17%	6%	6%
	All	27%	84%	121%	-10%	83%	96%	43%	1%	13%
Wagon	Small	46%	41%	36%	47%	39%	40%	0%	1%	-2%
	Midsize	94%	101%	17%	111%	98%	12%	-7%	1%	4%
	Large	77%	82%	58%	131%	91%	53%	-22%	-4%	3%
	All	77%	75%	31%	106%	70%	35%	-13%	3%	-2%
Van	Small	****	***	***	-2%	19%	37%	***	***	***
	Midsize	130%	86%	23%	39%	65%	29%	66%	13%	-3%
	Large	62%	51%	21%	12%	35%	17%	44%	13%	3%
	All	76%	86%	23%	22%	62%	37%	44%	14%	-9%
SUV	Small	53%	44%	52%	55%	50%	73%	0%	-3%	-11%
	Midsize	96%	94%	81%	26%	63%	30%	56%	19%	39%
	Large	72%	66%	61%	56%	38%	39%	11%	20%	16%
	All	72%	68%	81%	30%	58%	53%	32%	6%	18%
Pickup	Small	56%	17%	19%	4%	10%	20%	50%	6%	0%
	Midsize	-5%	13%	43%	-12%	20%	46%	8%	-5%	-1%
	Large	34%	50%	25%	30%	39%	15%	3%	8%	9%
	All	34%	43%	24%	30%	54%	26%	3%	-6%	-1%
All	Cars	27%	82%	121%	-10%	81%	96%	43%	1%	13%
All	Trucks	34%	59%	60%	30%	56%	36%	3%	2%	18%
All	Vehicles	34%	60%	121%	0%	69%	96%	36%	-4%	13%

pickups to 94% for midsize SUVs. Since 1988, average fuel economy has decreased for four cases (large wagons, small SUVs, midsize pickups and large pickups) and the largest improvements in average mpg has been 19 and 20 percent for midsize and large SUVs respectively.

Cars and light trucks with conventional drivetrains have a fuel consumption and weight relationship which is well known and is shown on Figures 21 and 22. Fuel consumption increases linearly with weight. Because vehicles with different propulsion systems, i.e., diesels and hybrids, occupy a different place on such a fuel consumption and weight plot, the data for hybrid and diesel vehicles are plotted separately and excluded from the regression lines shown on the graphs. At constant weight, MY2006 cars consume about 30 to 40 percent less fuel per mile than their MY1975 counterparts

On this same constant weight basis, this year's cars with diesel engines nominally consume about 30 percent less fuel than the conventionally powered ones, while this year's hybrid cars are about 50 percent better. Similarly, at constant weight this year's conventionally powered trucks achieve about 40 percent better fuel consumption than MY1975 vehicles did. On a constant weight basis, the Ford Escape, Toyota Highlander and Lexus RX400H hybrid SUVs achieve about 40 percent better fuel consumption than their MY2006 conventional counterparts, but the GM C15 and K15 pickups are only about 10 percent better.

Figures 23 and 24 show that the relationship between interior volume and fuel consumption is currently not as important as it used to be. The data points on both of these graphs exclude two seaters and represent sales weighted average fuel consumption calculated at increments of 1.0 cu. ft. As was done for Figures 21 and 22, the data points for hybrid and diesel vehicles were plotted separately from that for the conventionally powered vehicles. The data for the trend line shown on Figure 23 has an r^2 value of just .11 because of the large amount of scatter in the data, while the trend line for the data Figure 23 has an r^2 of .01 compared to values of .97 and .88 for the 1975 and 2006 cars in Figure 21, and .87 and .97 for 1975 and 2006 trucks in Figure 22 respectively. Car fuel consumption as a function of interior volume, thus, is more homogenous than it used to be.

Figures 25 and 26 show the improvement that occurred between 1975 and 2005 for fuel consumption as a function of 0-to-60 time for cars and trucks. Figures 27 and 28 compare Ton-MPG data vs 0-to-60 time and show that at constant vehicle performance, there has been substantial improvement in Ton-mpg, particularly for hybrid and diesel vehicles. While hybrid powertrains offer significant potential for fuel economy and vehicle performance improvement, their market share is not yet significant because some five years after the introduction for sale of the first hybrid car (the MY2000 Insight), they account for less than two percent of all MY2006 cars and an even smaller percentage of MY2006 trucks.

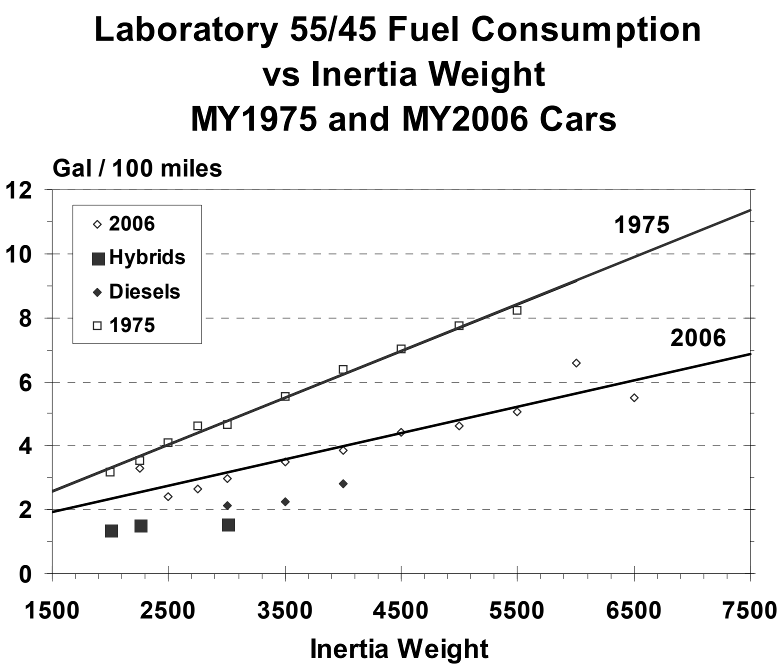

Figure 21

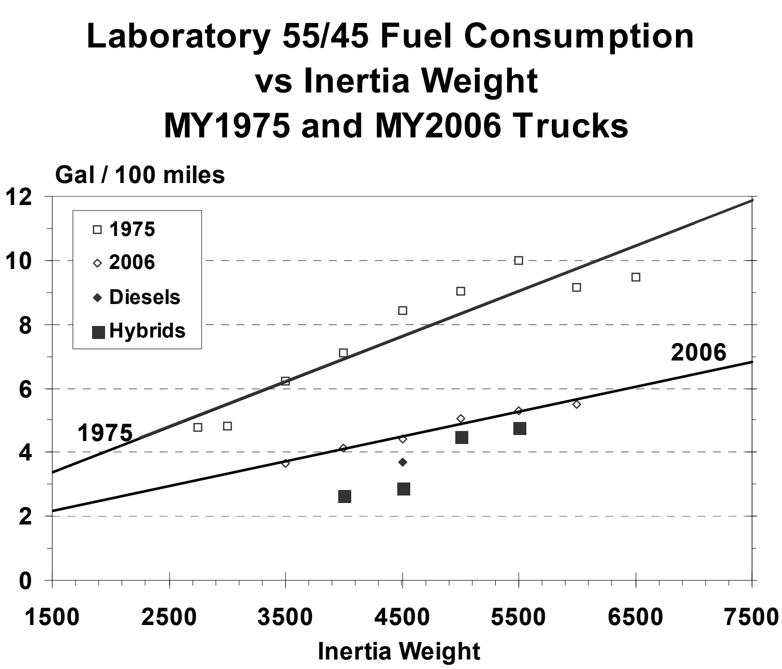

Figure 22

Laboratory 55/45 Fuel Consumption vs Interior Volume MY1978 Cars

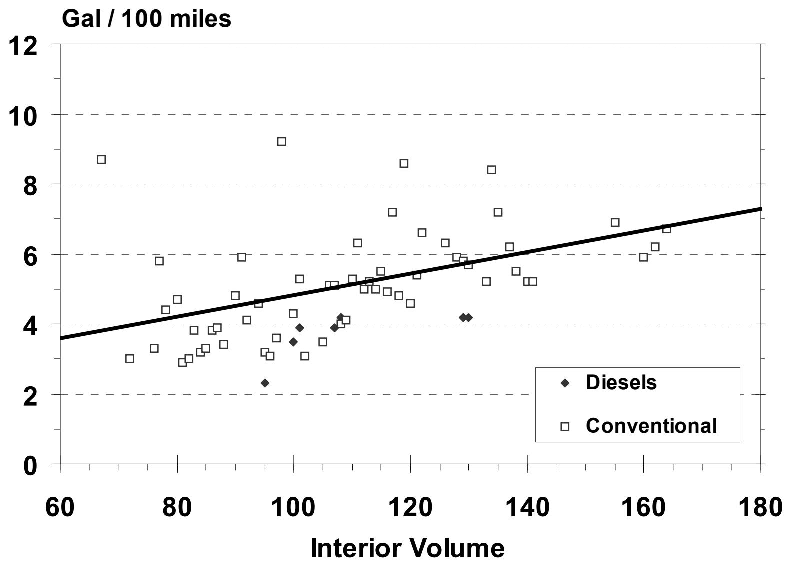

Figure 23

Laboratory 55/45 Fuel Consumption vs Interior Volume MY2006 Cars

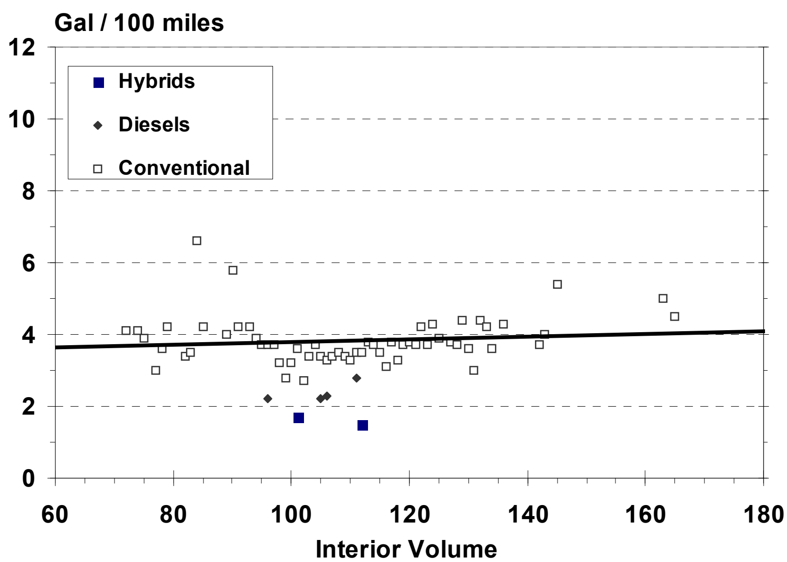

Figure 24

Table 6

Adjusted Fuel Consumption (Gal./100 Miles) by Vehicle Type and Size

Vehicle Type	**Size**	**1975 Worst**	**1975 Avg.**	**1975 Best**	**1988 Worst**	**1988 Avg.**	**1988 Best**	**2006 Worst**	**2006 Avg.**	**2006 Best**
Car	Small	11.6	6.4	3.5	13.3	3.8	1.8	9.3	3.9	1.6
	Midsize	11.6	8.6	5.4	9.4	4.4	3.6	8.5	4.0	1.8
	Large	11.9	8.9	6.8	9.9	4.8	3.8	8.5	4.5	3.6
	All	11.9	7.5	3.5	13.3	4.1	1.8	9.3	4.0	1.6
Wagon	Small	8.5	5.2	4.1	5.8	3.8	3.0	5.8	3.7	3.1
	Midsize	11.9	8.8	4.0	5.6	4.5	3.6	6.1	4.4	3.4
	Large	11.9	9.8	7.8	5.2	5.1	5.1	6.7	5.4	5.0
	All	11.9	7.2	4.0	5.8	4.3	3.0	6.7	4.1	3.1
Van	Small	6.2	5.7	5.4	6.4	4.8	4.0	---	---	---
	Midsize	12.2	8.8	5.4	8.8	5.4	4.2	5.3	4.8	4.4
	Large	11.2	9.3	6.9	10.0	6.9	5.9	6.9	6.2	5.7
	All	12.2	9.0	5.4	10.0	5.6	4.0	6.9	4.9	4.4
SUV	Small	9.8	7.3	6.1	6.3	4.9	3.5	6.4	5.1	4.0
	Midsize	12.2	9.8	5.4	9.7	6.0	4.2	6.2	5.1	3.0
	Large	12.7	9.7	7.3	8.1	7.0	5.3	7.4	5.8	4.5
	All	12.7	9.1	5.4	9.7	5.7	3.5	7.4	5.4	3.0
Pickup	Small	7.7	5.2	4.8	7.4	4.7	4.0	4.9	4.5	4.0
	Midsize	5.6	5.6	5.6	6.5	4.7	3.8	6.0	4.9	3.9
	Large	13.2	9.0	5.4	10.1	6.5	4.7	9.8	6.0	4.3
	All	13.2	8.4	4.8	10.1	5.5	3.8	9.8	5.9	3.9
All	Cars	11.9	7.4	3.5	13.3	4.1	1.8	9.3	4.1	1.6
All	Trucks	13.2	8.6	4.8	10.1	5.5	3.5	9.8	5.4	3.0
All	Vehicles	13.2	7.6	3.5	13.3	4.5	1.8	9.8	4.8	1.6

Table 7

Percent Improvement in Adjusted Fuel Consumption by Vehicle Type and Size

Vehicle Type	**Size**	**From 1975 to 2006 Worst**	**Avg.**	**Best**	**From 1975 to 1988 Worst**	**Avg.**	**Best**	**From 1988 to 2006 Worst**	**Avg.**	**Best**
Car	Small	20%	40%	55%	15%	40%	49%	30%	-0%	11%
	Midsize	27%	54%	67%	-19%	49%	34%	10%	9%	49%
	Large	29%	49%	48%	-17%	46%	44%	14%	6%	6%
	All	21%	46%	55%	12%	45%	49%	30%	1%	11%
Wagon	Small	31%	29%	26%	-32%	28%	28%	-1%	1%	-3%
	Midsize	48%	50%	14%	-53%	50%	11%	-9%	1%	4%
	Large	44%	45%	37%	-57%	48%	35%	-30%	-5%	3%
	All	44%	43%	24%	-51%	41%	26%	-16%	2%	-3%
Van	Small	—--	—	—	3%	16%	27%	—--	—--	—
	Midsize	57%	46%	19%	-28%	39%	22%	40%	11%	-4%
	Large	38%	34%	17%	-11%	26%	15%	31%	11%	3%
	All	43%	46%	19%	-18%	38%	27%	31%	13%	-11%
SUV	Small	35%	30%	34%	-35%	33%	42%	-1%	-5%	-14%
	Midsize	49%	48%	45%	-20%	39%	23%	36%	16%	28%
	Large	42%	40%	38%	-36%	27%	28%	10%	17%	14%
	All	42%	41%	45%	-23%	37%	35%	24%	6%	15%
Pickup	Small	36%	14%	16%	-4%	9%	16%	33%	5%	-0%
	Midsize	-6%	12%	30%	15%	17%	31%	8%	-6%	-2%
	Large	25%	34%	20%	-23%	28%	13%	3%	8%	9%
	All	25%	30%	19%	-23%	35%	21%	3%	-8%	-2%
All	Cars	21%	45%	55%	12%	45%	49%	30%	1%	11%
All	Trucks	25%	37%	38%	-23%	36%	26%	3%	2%	15%
All	Vehicles	25%	38%	55%	1%	41%	49%	26%	-5%	11%

Laboratory 55/45 Fuel Consumption vs 0 to 60 Time MY1975 and MY2006 Cars

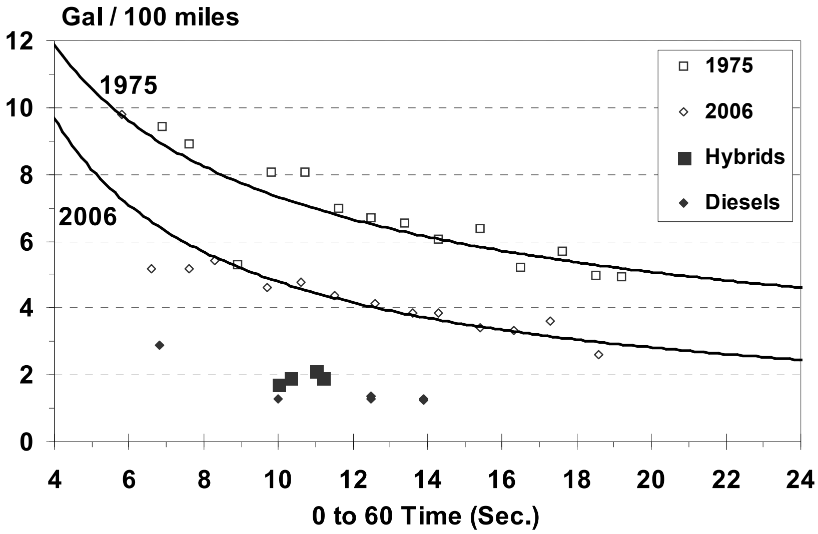

Figure 25

Laboratory 55/45 Fuel Consumption vs 0 to 60 Time MY1975 and MY2006 Trucks

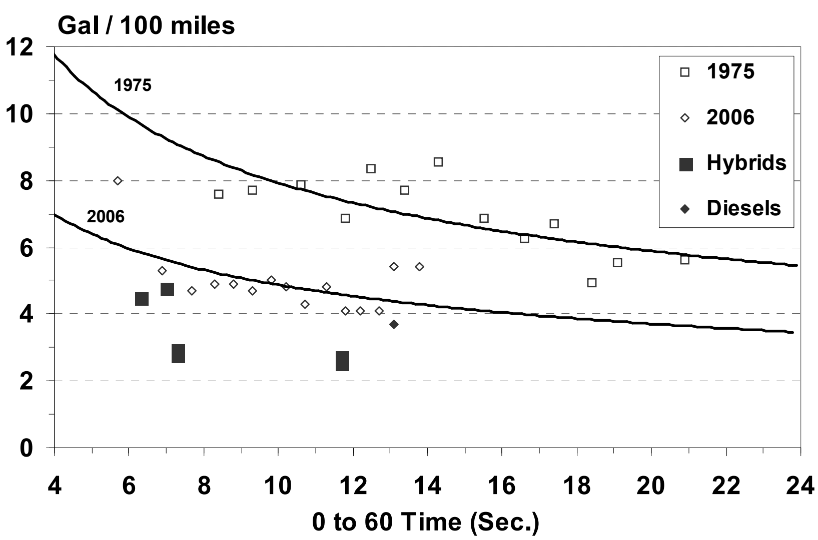

Figure 26

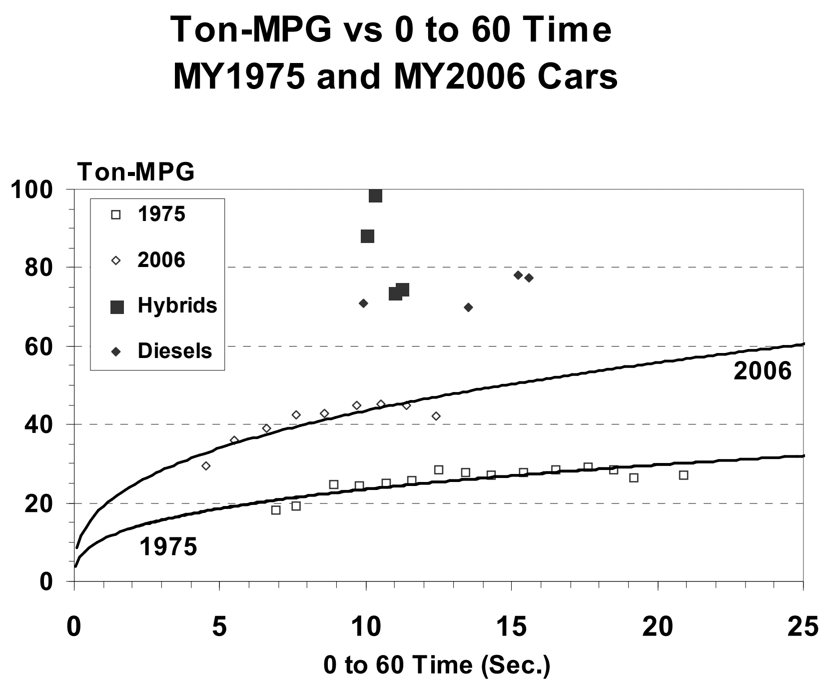

Figure 27

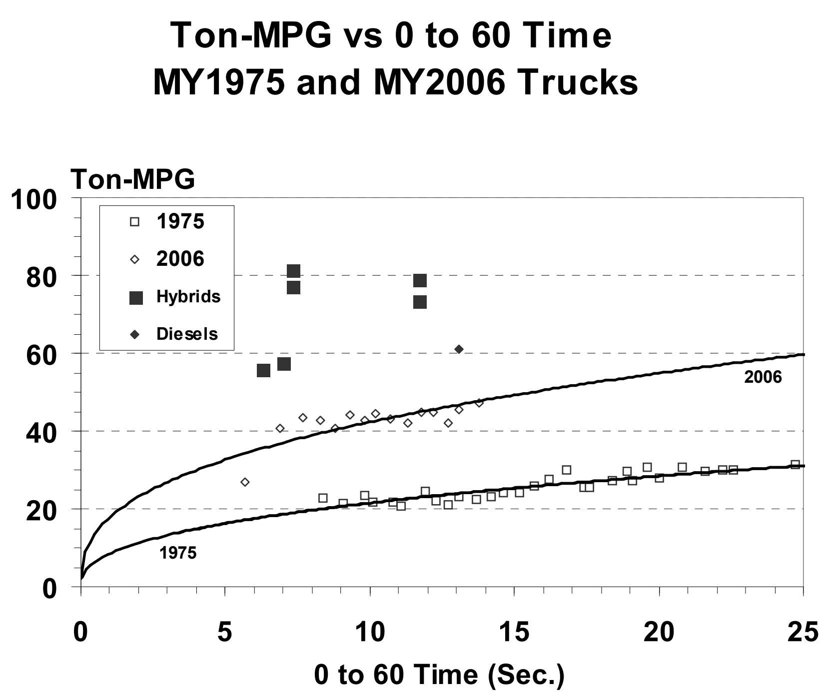

Figure 28

Figure 29 and Table 8 show some of the changes in the distribution of inertia weight that have occurred over the years for the light-duty fleet. In 1975, over 20 percent of all light-duty vehicles had inertia weights of less than 3000 lb compared to only three percent this year. Similarly, less than nine percent of the 1975 vehicles had inertia weights of 5000 lb or higher compared to over 20 percent this year. Three inertia weight classes (3500, 4000, and 4500 lb) have accounted for roughly 60 percent of all light-duty vehicles for all the three years shown in Table 8 and Figure 28.

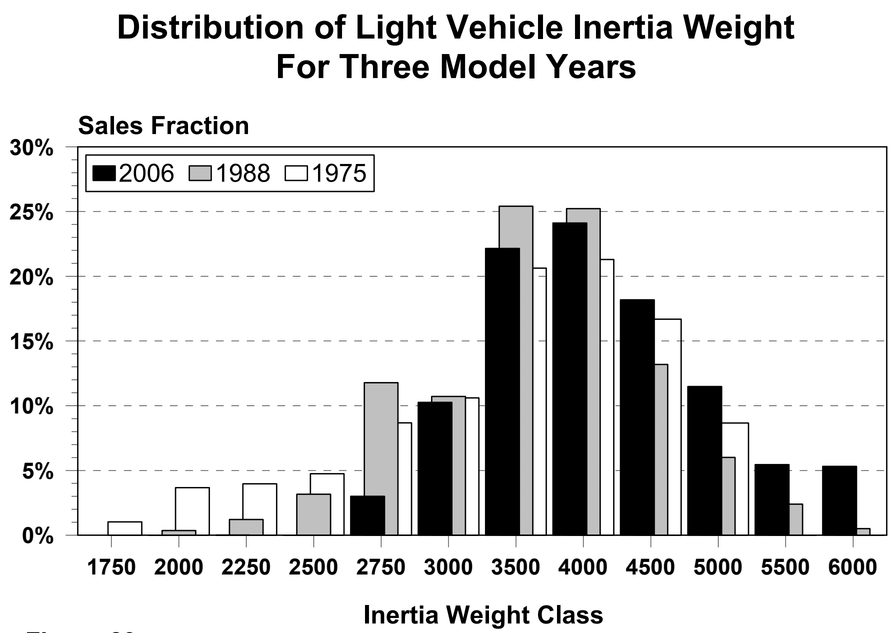

Figure 29

Table 8

Light Vehicle Sales Fraction by Inertia Weight Class for Three Model Years

Inertia Weight	1975	1988	2006
	<--- Model Year --->		
<3000	22.1%	16.5%	3.0%
3000	10.6%	10.7%	10.3%
3500	20.6%	25.4%	22.1%
4000	21.3%	25.2%	24.1%
4500	16.7%	13.2%	18.2%
5000	8.7%	6.0%	11.5%
>5500	.0%	2.9%	10.8%
Avg Wt.	4060	3283	4142

Figures 30 through 34 provide an indication of the market share of different weight vehicles within the different classes. Trends within classes are shown which underlie the increasing weight shown by the fleet as a whole. In 1975, about half of the cars had an inertia weight of 4500 lb or more compared to about 5 percent this year. For MY2006, three weight classes (3000, 3500 and 4000 lbs) account for nearly 90 percent of all cars. Conversely, the market share of trucks in the inertia weight classes of 4500 lb or more have increased substantially, and these vehicles currently account for over 75 percent of all trucks, compared to about 30 percent in 1975. Figures 32, 33, and 34 provide additional details of the truck data presented in Figure 31 for vans, SUVs, and pickups respectively. Appendixes D, E, and F contain a series of tables describing light-duty vehicles at the vehicle size/type level of stratification in more detail; Appendix G provides similar data by vehicle type and inertia weight class.

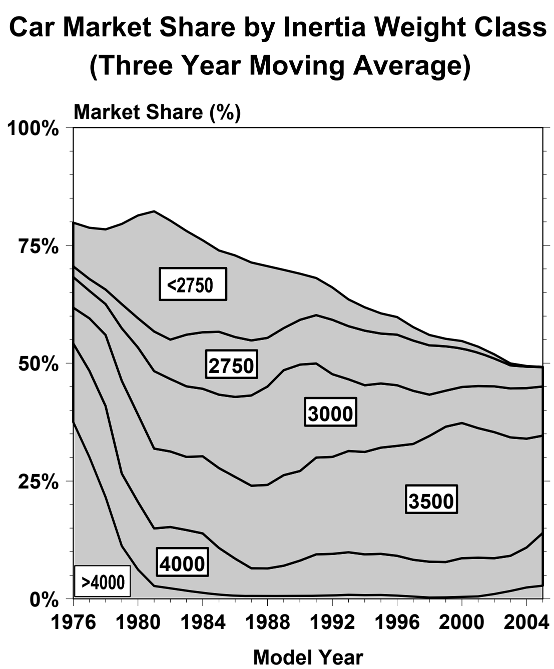

Figure 30

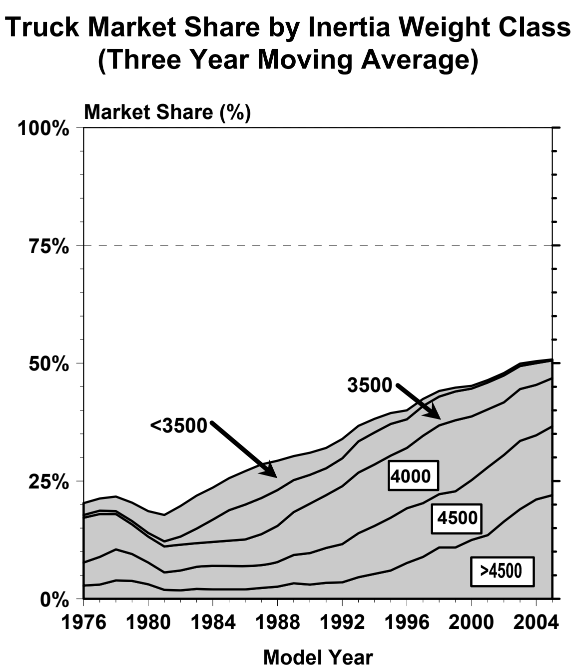

Figure 31

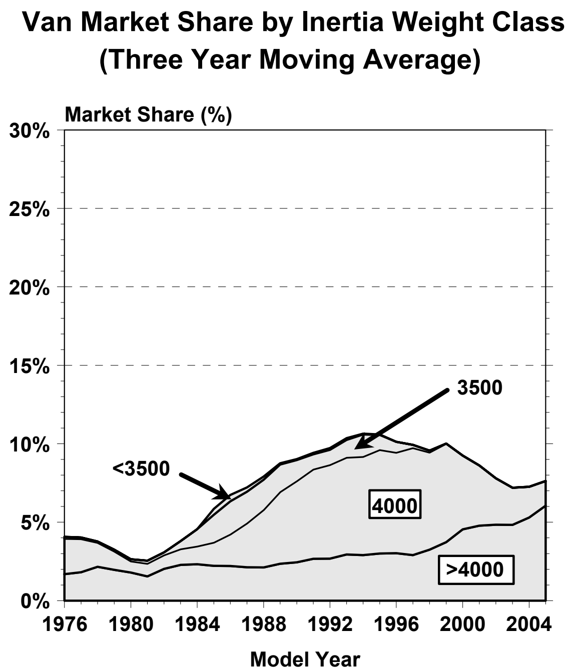

Figure 32

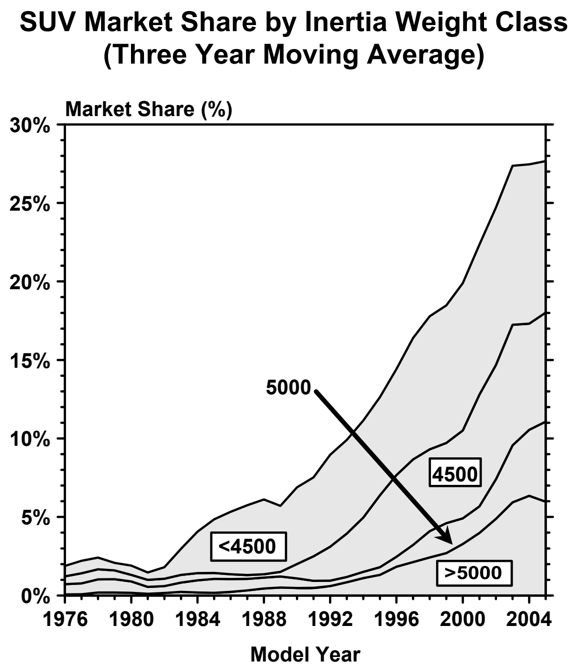

Figure 33

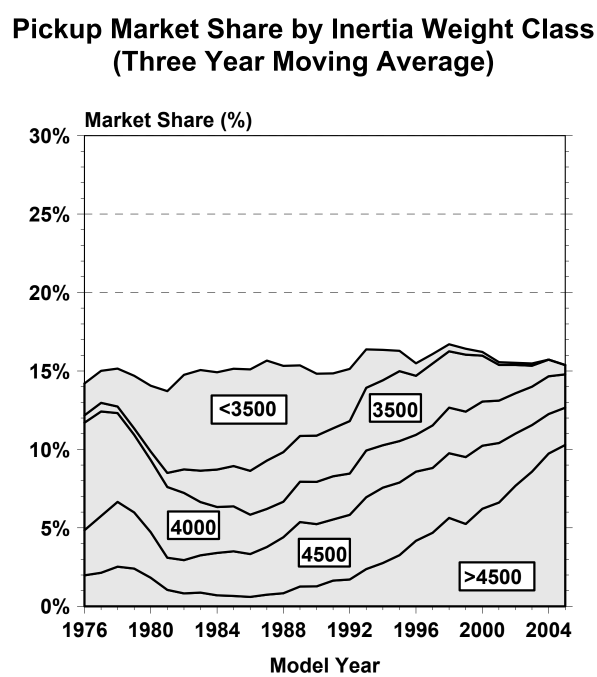

Figure 34

V. **Technology Trends**

Table 9 repeats the sales fraction and adjusted 55/45 fuel economy data from Tables 1 and 2 and adds three measures of powertrain information: engine displacement (CID), horsepower (HP), and specific power (HP/CID). This table also includes sales fraction data giving the percent of vehicles that: have front- (FWD) or four-wheel drive (4wd); have manual, lockup, or continuously variable (CVT) transmissions; have port or throttle body fuel injection (TBI) or are Diesels; are equipped with engines that have more than two valves per cylinder; use variable valve timing (VVT); and use hybrid vehicle technology.

For MY2006, cars are almost entirely powered by gasoline-fueled engines; over 80 percent of which have more than two valves per cylinder; and over 60 percent use VVT technology. Front wheel drive usage for cars has dropped to about 75 percent from a peak of over 87 percent in 1999 because of the increased use of both 4wd and rear wheel drive. Over 17 percent of this year's cars will have rear wheel drive, the highest use of this technology in a decade and a half. Nearly 85 percent of this year's cars have lockup automatic transmissions; less than three percent use CVTs, and the sales fraction for manual transmission cars is less than half of what it was two decades ago (i.e., 12 percent this year vs 25 percent in 1986.) About 40 percent of the MY2006 trucks still have two valves per cylinder; over 90 percent have lockup automatic transmissions and about half have four wheel drive. It has been over two decades since diesel engines have been used in more than one percent of the fleet. Appendix K contains additional data on fuel metering and number of valves per cylinder.

Table 10 compares technology usage for MY2006 by vehicle type and size. As discussed earlier, wheelbase is used in this report to distinguish whether a truck is small, mid-size, or large, and four EPA car classes (Two-Seater, Minicompact, Compact, and Subcompact) have been combined to form the small car class. For this table, the car classes are separated into cars and station wagons, so that the table stratifies light-duty vehicles into a total of 15 vehicle types and sizes. Note that this table does not contain any data for small vans, because none have been produced since 1996.

Front-wheel drive (FWD) is used heavily in all of the car classes, in small wagons and in midsize vans. By comparison, none of this year's pickups or large vans will have front-wheel drive, and it is used less often in SUVs or large vans than in midsize wagons. Conversely, four-wheel drive (4WD) is used heavily in SUVs and pickups. A large portion of the midsize and large wagons also have 4WD, but very little use of it is made in vans and cars.

Manual transmissions are used more in small vehicles in 2006 than in the larger ones, except for midsize pickups. Similarly, usage of engines with more than two valves per cylinder is more prevalent on small and midsize vehicles than on larger ones..

Detailed tabulations of different technology types, including technology usage percentages for other model years, can be found in the Appendixes.

Table 9

Powertrain Characteristics of 1975 to 2006 Cars (Percentage Basis)

MODEL YEAR	SALES FRAC	ADJ 55/45 MPG	ENGINE CID	ENGINE HP	HP/ CID	DRIVETRAIN Front	DRIVETRAIN 4wd	TRANSMISSION Manual	TRANSMISSION Lock	TRANSMISSION CVT	FUEL METERING Port	FUEL METERING TBI	FUEL METERING Dsl	Multi- Valve	VVT	Hybrid
1975	.806	13.5	288	136	.515	6.5		19.9			5.1		.2			
1976	.788	14.9	287	134	.502	5.8		17.1			3.2		.3			
1977	.800	15.6	279	133	.516	6.8		16.8			4.2		.5			
1978	.773	16.9	251	124	.538	9.6		20.2	6.7		5.1		.9			
1979	.778	17.2	238	119	.545	11.9	.3	22.3	8.0		4.7		2.1			
1980	.835	20.0	188	100	.583	29.7	.9	31.9	16.5		6.2	.7	4.4			
1981	.827	21.4	182	99	.594	37.0	.7	30.4	33.3		6.1	2.6	5.9			
1982	.803	22.2	175	99	.609	45.6	.8	29.7	51.4		7.2	9.8	4.7			
1983	.777	22.1	182	104	.615	47.3	3.1	26.5	56.7		9.5	18.9	2.1			
1984	.761	22.4	179	106	.637	53.7	1.0	24.1	58.3		15.0	24.4	1.7			
1985	.746	23.0	177	111	.671	61.6	2.1	22.8	58.7		21.4	32.0	.9			
1986	.717	23.8	167	111	.701	71.1	1.1	24.8	58.0		36.7	28.4	.3			
1987	.722	24.0	162	112	.732	77.0	1.1	24.9	59.5		42.5	30.5	.3			
1988	.702	24.4	160	116	.759	81.7	.8	24.3	66.1		53.7	30.0				
1989	.693	24.0	163	121	.783	82.5	1.0	21.0	69.3	.1	62.4	27.8	.0			
1990	.698	23.7	163	129	.829	84.6	1.0	19.6	72.9	.0	77.5	21.1	.0		.6	
1991	.678	23.9	163	132	.851	83.2	1.4	20.5	73.5	.0	78.0	21.8	.1		2.4	
1992	.666	23.6	170	141	.868	80.8	1.1	17.4	76.4	.0	89.5	10.4	.1		4.6	
1993	.640	24.1	166	138	.865	85.1	1.2	17.8	77.0		91.6	8.4			4.8	
1994	.596	24.0	168	143	.884	84.4	.4	16.7	79.3		94.9	5.1			8.0	
1995	.620	24.2	167	152	.945	82.0	1.2	16.3	81.9		98.8	1.2	.1		9.8	
1996	.600	24.2	165	154	.958	86.5	1.5	14.8	83.6	.0	98.8	1.1	.1		11.7	
1997	.576	24.3	164	156	.974	86.5	1.7	13.5	85.8	.1	99.1	.8	.1	58.6	11.3	
1998	.551	24.4	164	159	.993	87.0	2.3	12.3	87.3	.1	99.7	.1	.2	61.4	18.4	
1999	.551	24.1	166	164	1.009	87.2	2.2	10.9	88.4	.0	99.7	.1	.2	64.6	17.1	
2000	.551	24.1	165	168	1.032	84.9	2.1	11.2	87.7	.0	99.7	.1	.2	65.1	23.4	.1
2001	.539	24.3	165	168	1.042	84.1	3.2	11.4	87.5	.2	99.7		.3	67.2	28.3	.0
2002	.515	24.5	166	173	1.066	84.9	3.8	11.2	88.1	.4	99.6		.4	69.9	33.9	.3
2003	.504	24.7	166	176	1.086	81.7	3.8	11.1	87.9	.9	99.6		.4	73.5	41.2	.6
2004	.480	24.7	168	183	1.106	80.8	5.4	10.2	88.2	1.4	99.7		.3	77.3	44.2	.9
2005	.500	25.0	169	185	1.111	78.5	5.3	12.0	84.7	2.2	99.6		.4	78.2	50.5	1.8
2006	.496	24.6	176	198	1.144	76.4	6.2	12.2	84.8	2.7	99.8		.2	81.9	61.6	1.6

Table 9 (continued)

Powertrain Characteristics of 1975 to 2006 Trucks (Percentage Basis)

MODEL	SALES	ADJ	ENGINE		HP/	DRIVETRAIN		TRANSMISSION			FUEL METERING			Multi-		
YEAR	FRAC	55/45 MPG	CID	HP	CID	Front	4wd	Manual	Lock	CVT	Port	TBI	Dsl	Valve	VVT	Hybrid
1975	.194	11.6	311	142	.476		17.1	37.0				.1				
1976	.212	12.2	319	141	.458		22.9	34.8				.1				
1977	.200	13.3	318	147	.482		23.6	32.0				.1				
1978	.227	12.9	314	146	.481		29.0	32.4				.1	.8			
1979	.222	12.5	298	138	.486		18.0	35.2	2.1			.3	1.8			
1980	.165	15.8	248	121	.528	1.4	25.0	53.0	24.6			1.7	3.5			
1981	.173	7.1	247	119	.508	1.9	20.1	51.6	31.1			1.1	5.6			
1982	.197	17.4	243	120	.524	1.7	20.0	45.7	33.2			.7	9.3			
1983	.223	17.8	231	118	.543	1.4	25.8	45.9	36.1			.6	4.7			
1984	.239	17.4	224	118	.557	4.9	31.0	42.1	35.1		1.9	.6	2.3			
1985	.254	17.5	224	124	.586	7.1	30.6	37.1	42.2		8.7	3.5	1.1			
1986	.283	18.3	211	123	.621	5.9	30.3	42.7	42.0		21.8	18.7	.7			
1987	.278	18.4	210	131	.654	7.4	31.5	39.9	44.8		33.3	33.6	.3			
1988	.298	18.1	227	141	.650	9.0	33.3	35.5	53.1		43.3	44.4	.2			
1989	.307	17.8	234	146	.653	9.9	32.0	32.7	56.8		45.9	47.6	.2			
1990	.302	17.7	237	151	.668	15.5	31.3	28.1	67.4		55.2	40.8	.2			
1991	.322	18.1	228	150	.681	9.7	35.3	31.0	67.4		55.0	43.2	.1			
1992	.334	17.8	234	155	.685	13.6	31.4	27.3	71.5		65.9	32.5	.1			
1993	.360	17.9	235	162	.710	15.1	29.4	23.3	75.7		73.4	25.7				
1994	.404	17.7	239	166	.717	13.1	36.9	23.5	75.1		77.2	22.5				
1995	.380	17.5	244	168	.715	17.7	40.7	20.5	78.6		79.8	20.2				
1996	.400	17.8	243	179	.757	20.1	37.1	15.6	83.5		99.9		.1			
1997	.424	17.6	248	187	.775	13.9	43.2	14.6	85.0		100.0		.0			
1998	.449	17.8	242	187	.795	18.7	42.0	13.4	86.0		100.0		.0			
1999	.449	17.5	249	197	.814	17.4	44.6	9.1	90.5		100.0					
2000	.449	17.7	242	197	.832	19.4	42.4	8.0	91.7		100.0				4.7	
2001	.461	17.6	243	209	.882	18.5	43.8	6.3	93.4		100.0				9.3	
2002	.485	17.6	244	219	.918	18.5	47.6	4.9	94.7	.0	100.0				16.2	
2003	.496	17.8	243	221	.927	19.2	46.5	4.8	93.7	1.2	100.0				19.8	
2004	.520	17.7	252	236	.953	17.2	52.3	3.7	95.0	1.0	100.0			48.4	31.6	
2005	.500	18.1	248	240	.980	21.7	49.6	2.8	94.5	2.0	99.9		.1	53.0	40.9	.2
2006	.504	18.4	246	239	.987	24.0	50.8	3.7	93.6	2.6	99.9		.1	58.6	47.5	1.0

Table 9 (Continued)

Powertrain Characteristics of 1975 to 2006 Cars and Trucks (Percentage Basis)

MODEL YEAR	SALES FRAC	ADJ 55/45 MPG	ENGINE CID	ENGINE HP	HP/ CID	DRIVETRAIN Front	DRIVETRAIN 4wd	TRANSMISSION Manual	TRANSMISSION Lock	TRANSMISSION CVT	FUEL METERING Port	FUEL METERING TBI	FUEL METERING Dsl	Multi-Valve	VVT	Hybrid
1975	1.000	13.1	293	137	.507	5.3	3.3	23.2			4.1		.2			
1976	1.000	14.2	294	135	.493	4.6	4.8	20.9			2.5	.0	.2			
1977	1.000	15.1	287	136	.510	5.5	4.7	19.8			3.4	.0	.4			
1978	1.000	15.8	266	129	.525	7.4	6.6	23.0	5.2		3.9	.0	.9			
1979	1.000	15.9	252	124	.532	9.2	4.3	25.1	6.7		3.7	.1	2.0			
1980	1.000	19.2	198	104	.574	25.0	4.9	35.4	17.8		5.2	.8	4.3			
1981	1.000	20.5	193	102	.580	31.0	4.0	34.1	33.0		5.1	2.4	5.9			
1982	1.000	21.1	188	103	.593	37.0	4.6	32.8	47.8		5.8	8.0	5.6			
1983	1.000	21.0	193	107	.599	37.0	8.1	30.8	52.1		7.3	14.8	2.7			
1984	1.000	21.0	190	109	.618	42.1	8.2	28.4	52.8		11.9	18.7	1.8			
1985	1.000	21.3	189	114	.650	47.8	9.3	26.5	54.5		18.2	24.8	.9			
1986	1.000	21.9	180	114	.678	52.6	9.3	29.8	53.5		32.5	25.7	.4			
1987	1.000	22.1	175	118	.710	57.7	9.6	29.1	55.4		39.9	31.4	.3			
1988	1.000	22.1	180	123	.726	60.0	10.5	27.6	62.2		50.6	34.3	.1			
1989	1.000	21.7	185	129	.743	60.2	10.5	24.6	65.5		57.3	33.9	.1			
1990	1.000	21.5	185	135	.781	63.8	10.1	22.2	71.2		70.8	27.0	.1			
1991	1.000	21.7	184	138	.796	59.6	12.3	23.9	71.6		70.6	28.7	.1			
1992	1.000	21.3	191	145	.807	58.4	11.2	20.7	74.8		81.6	17.8	.1			
1993	1.000	21.4	191	147	.809	59.9	11.3	19.8	76.5		85.0	14.6				
1994	1.000	21.0	197	152	.816	55.6	15.2	19.5	77.6		87.7	12.1				
1995	1.000	21.1	196	158	.857	57.6	16.2	17.9	80.7		91.6	8.4	.0			
1996	1.000	21.2	197	164	.878	60.0	15.7	15.1	83.5		99.3	.7	.1			
1997	1.000	20.9	199	169	.890	55.8	19.3	14.0	85.5		99.5	.5	.1	39.6		
1998	1.000	20.9	199	171	.904	56.4	20.1	12.8	86.7		99.8	.1	.1	40.9		
1999	1.000	20.6	203	179	.921	55.8	21.3	10.1	89.4		99.9	.1	.1	43.4		
2000	1.000	20.7	200	181	.942	55.5	20.2	9.7	89.5		99.8	.0	.1	44.8	15.0	
2001	1.000	20.7	201	187	.968	53.8	21.9	9.0	90.2		99.9		.1	49.0	19.6	
2002	1.000	20.6	203	195	.994	52.7	25.0	8.1	91.3	.0	99.8		.2	53.3	25.3	
2003	1.000	20.8	204	199	1.007	50.7	25.0	8.0	90.8	1.2	99.8		.2	55.5	30.6	
2004	1.000	20.5	212	211	1.026	47.7	29.8	6.8	91.8	1.0	99.9		.1	62.3	37.6	.5
2005	1.000	21.0	209	212	1.045	50.1	27.5	7.4	89.6	2.0	99.7		.3	65.6	45.7	1.0
2006	1.000	21.0	211	219	1.065	50.0	28.7	7.9	89.2	2.6	99.8		.2	70.1	54.5	1.3

Table 10

MY2006 Technology Usage by Vehicle Type and Size
(Percent of Vehicle Type/Size Strata)

Vehicle Type	Size	Front Wheel Drive	Four Wheel Drive	Manual Trans.	Multi-Valve	Variable Valve
Car	Small	74.	5.	22.	89	66.
	Midsize	86.	4.	6.	87.	78.
	Large	69.	5.	1.	54.	33.
	All	77.	4.	12.	81.	63.
Wagon	Small	90.	10.	19.	99.	59.
	Midsize	34.	43.	9.	85.	37.
	Large	44.	56.	***	86.	18.
	All	68.	25.	14.	93.	47.
Van	Small	**	*	***	***	***
	Midsize	95.	5.	***	42.	35.
	Large	**	8.	***	**	***
	All	89.	5.	***	40.	33.
SUV	Small	**	100.	23.	57.	5.
	Midsize	22.	63.	3.	74.	51.
	Large	8.	67.	1.	68.	58.
	All	15.	66.	3.	71.	53.
Pickup	Small	***	100.	23.	100.	**
	Midsize	***	19.	30.	69.	60.
	Large	***	54.	6.	45.	60.
	All	***	51.	8.	47.	46.

Figures 35 through 39 show trends in drive use for the five vehicle classes. Cars used to be nearly all rear-wheel drive; from 1988 to 2004 they were over 80 percent front-wheel drive with a small four-wheel (4WD) drive fraction. In recent years, there has been a significant increase in the use of rear wheel drive from less than 12 percent in 1998 to over 22 percent this year, and a slight increase in the use of four wheel drive in cars with use of this technology increasing from about one percent in the late 1990s to four percent this year. Only a small percentage of wagons still have rear-wheel drive, but in recent years they have made substantial use of 4WD.

The trend towards increased use of front wheel drive for vans is vert similar to that for cars, except it started a few years later and appears to be continuing. Five out of six vans currently use front-wheel drive, compared to essentially none before 1984. SUVs are mostly 4WD; but a trend toward front-wheel drive SUVs started in MY2000. Pickups remain the bastion of rear-wheel drive with the increasing amount of 4WD the only other drive option. Except for a brief period in the early 1980s, front-wheel drive has not been used in pickups

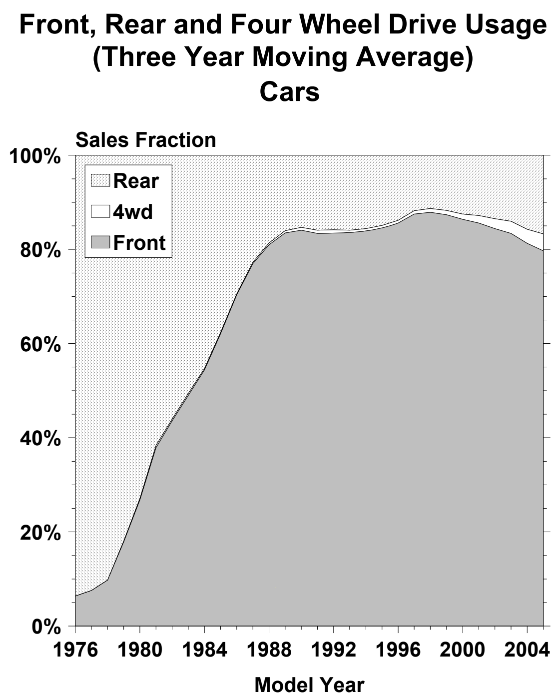

Figure 35

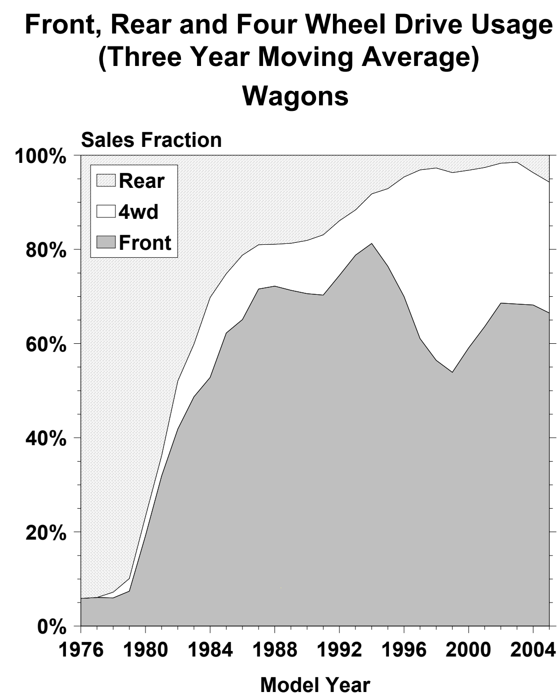

Figure 36

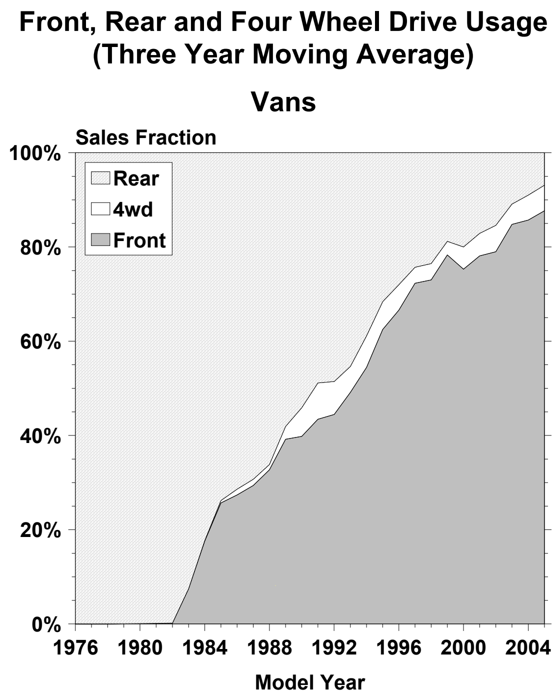

Figure 37

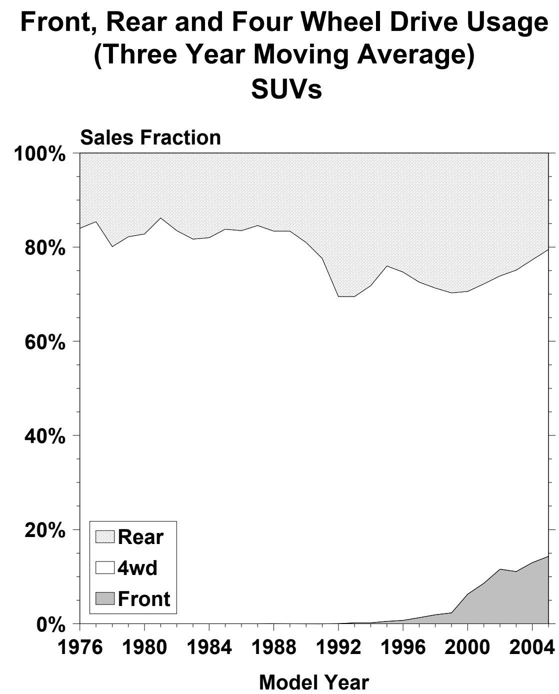

Figure 38

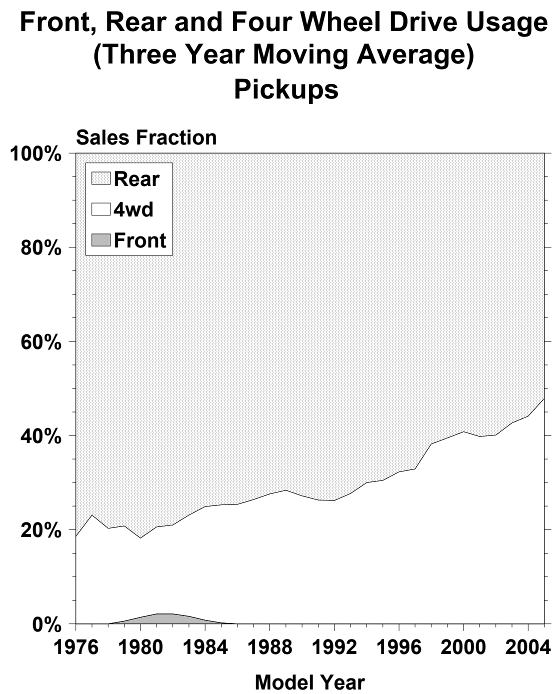

Figure 39

Laboratory 55/45 MPG vs 0 to 60 Time
MY2006 Cars

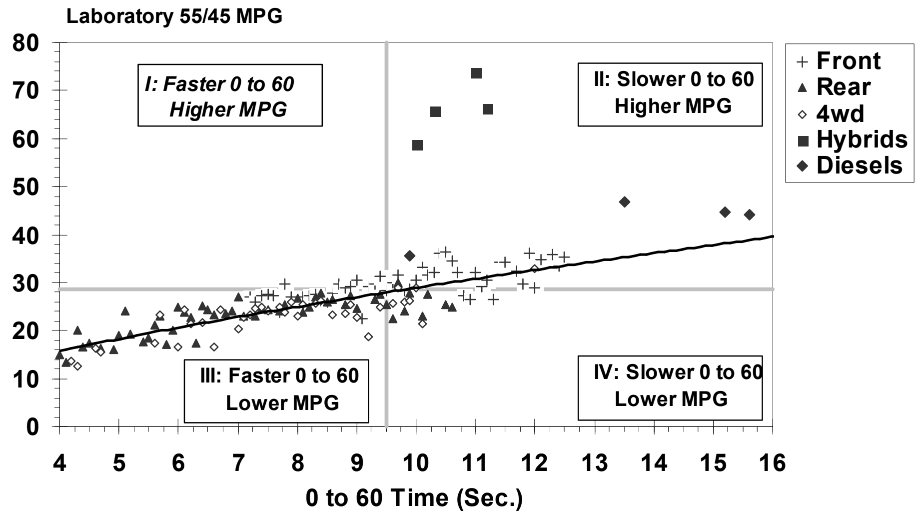

Figure 40

Figures 40 and 41 and Tables 11 and 12 give, as an indication of how the different drive types are currently used, plots of fuel economy and performance for cars and trucks. The data points in these graphs represent sales-weighted averages calculated at estimated 0-to-60 time increments of 0.1 sec. The trend lines in these two figures reflect the fuel economy/ performance tradeoff for conventionally powered vehicles, on the average. By drawing a vertical line at the average performance, and a horizontal line at the average mpg, the space in each figure is divided into four areas of better/worse performance crossed with better/worse fuel economy

Table 11

Distribution of MY2006 Car Sales
by Technology, 0-to-60 Time and Lab 55/45 MPG

0 to 60 Time	**< 9.5 Sec.**	**> 9.5 Sec.**	**< 9.5 Sec.**	**> 9.5 Sec.**
Lab 55/45 MPG	**> 28.5 MPG**	**> 28.5 MPG**	**< 28.5 MPG**	**< 28.5 MPG**
Vehicle Technology	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
Front Drive	14%	46%	23%	17%
Rear Drive	0%	1%	77%	21%
4wd	0%	5%	51%	44%
Hybrids	0%	100%	0%	0%
Diesels	0%	100%	0%	0%
All Cars	11%	37%	34%	19%

Laboratory 55/45 MPG vs 0 to 60 Time
MY2006 Trucks

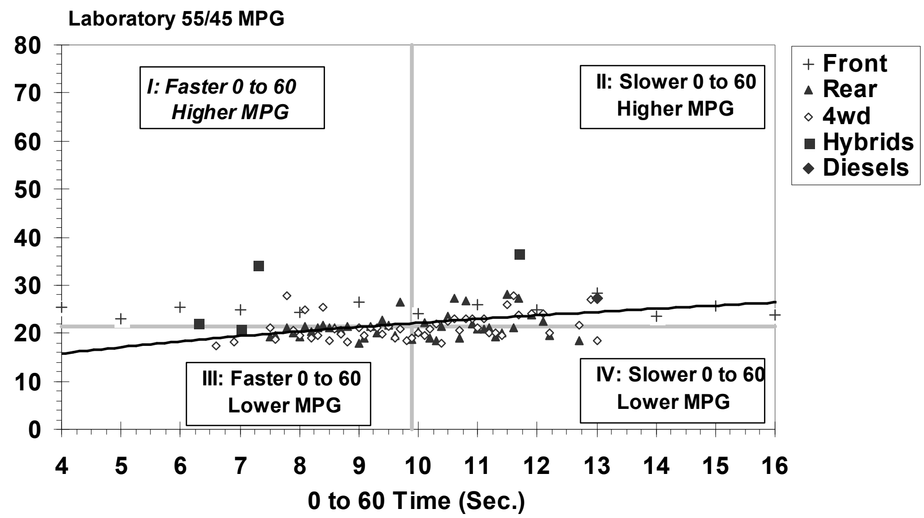

Figure 41

compared to the average 0 to 60 time and mpg. The vehicles in Quadrant I, for example, have faster than average 0- to-60 time and higher than average fuel economy, but this quadrant accounts for only 11 percent of all 2006 car sales and 13 percent of all truck sales. Nearly half of all front wheel drive car sales are in Quadrant II (the Slower/Higher one), as are over two thirds of the FWD truck sales, but only one percent of the rear drive and five percent of 4wd cars. Over three fourths of the rear drive cars and over half of the 4wd cars are in Quadrant III (the Faster/Lower one) as are nearly half of the rear and four wheel drive trucks. Similar data for 0-to-60 time and Laboratory Ton MPG are presented in Figures 42 and 43 and Tables 13 and 14.

Table 12

Distribution of MY2006 Truck Sales
by Technology, 0-to-60 Time and Lab 55/45 MPG

0-to-60 Time **Lab 55/45 MPG**	**< 9.9 Sec.** **> 21.5 MPG**	**> 9.9 Sec.** **> 21.5 MPG**	**< 9.9 Sec.** **< 21.5 MPG**	**> 9.9 Sec.** **< 21.5 MPG**
Vehicle Technology	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
Front	32%	68%	0%	0%
Rear	6%	15%	46%	33%
4wd	7%	20%	41%	32%
Hybrids	75%	24%	1%	0%
Diesels	0%	100%	0%	0%
All	13%	30%	32%	24%

Laboratory Ton-MPG vs 0 to 60 Time
MY2006 Cars

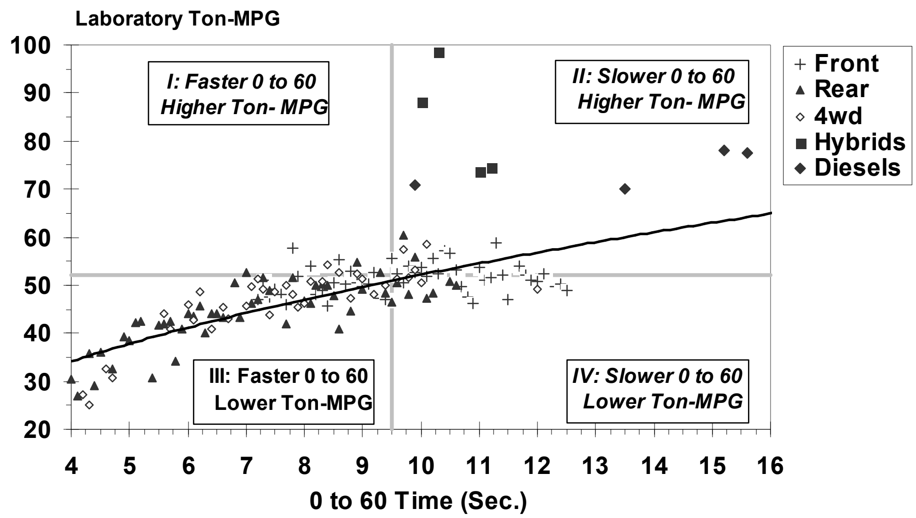

Figure 42

Laboratory Ton-MPG vs 0 to 60 Time
MY2006 Trucks

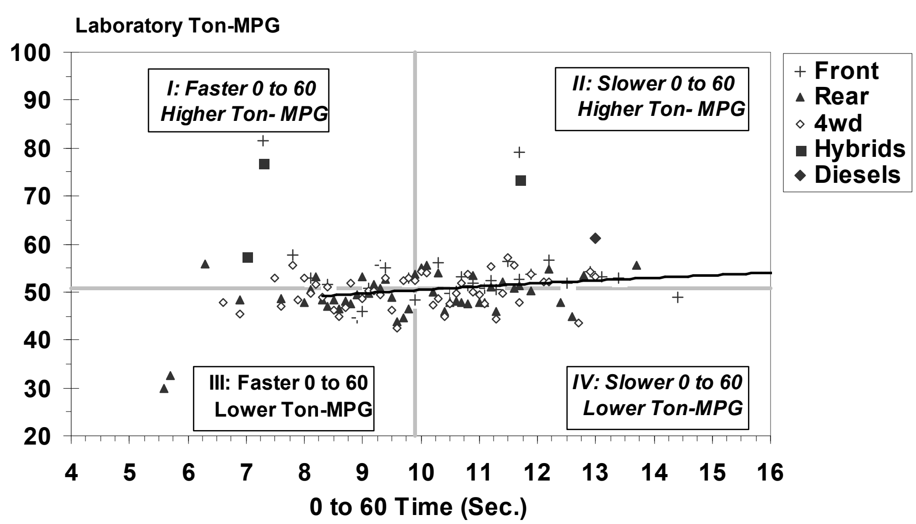

Figure 43

Table 13

Distribution of MY2006 Car Sales
by Technology, 0-to-60 Time and Lab Ton-MPG

0-to-60 Time	**< 9.5 Sec.**	**> 9.5 Sec.**	**< 9.5 Sec.**	**> 9.5 Sec.**
Lab-Ton MPG	**> 52.0 MPG**	**> 52.0 MPG**	**< 52.0 MPG**	**< 52.0 MPG**
Vehicle	Quadrant	Quadrant	Quadrant	Quadrant
Technology	I	II	III	IV
Front	7%	50%	30%	13%
Rear	5%	7%	72%	16%
4wd	6%	27%	45%	22%
Hybrid	0%	100%	0%	0%
Diesel	0%	100%	0%	0%
All	6%	42%	38%	14%

Table 14

Distribution of MY2006 Truck Sales
by Technology, 0-to-60 Time and Lab Ton-MPG

0-to-60 Time	**< 9.9 Sec.**	**> 9.9 Sec.**	**< 9.9 Sec.**	**> 9.9 Sec.**
Lab 55/45 MPG	**> 50.9 MPG**	**> 50.9 MPG**	**< 50.9 MPG**	**< 50.9 MPG**
Vehicle	Quadrant	Quadrant	Quadrant	Quadrant
Technology	I	II	III	IV
Front	28%	54%	5%	14%
Rear	11%	18%	41%	30%
4wd	13%	25%	35%	27%
Hybrid	81%	19%	0%	0%
Diesel	0%	100%	0%	0%
All	17%	30%	29%	24%

The increasing trend in Ton-MPG shown in Table 1 can be attributed to better vehicle design, including more efficient engines, better transmission designs, and better matching of the engine and transmission. Powertrains are matched to the load better when the engine operates closer to its best efficiency point more of the time. For many conventional engines, this point is approximately 2000 RPM and 2/3 of the maximum torque at that speed. One way to make the engine operate more closely to its best efficiency point is to increase the number of gears in the transmission and, for automatic transmissions, employing a lockup torque converter. Three important changes in transmission design have occurred in recent years:

1) the use of additional gears for both automatic and manual transmissions,

2) for the automatics, conversion to lockup (L3, L4, L5, L6 and now L7) torque converter transmissions, and

3) the use of continuously variable transmissions (CVTs).

Table 15 compares Ton-MPG by transmission and vehicle type for 1988, the peak year for passenger car fuel economy, and this year. In 1988, every transmission type shown in the table achieved less than 40 Ton-MPG. This year, every transmission type achieves at least 40 Ton-MPG. Figures 44 to 47 indicate that the L4 transmission is losing its position as the predominant transmission type for all vehicle classes. Use of the L4 transmission for cars peaked at about 80 percent in 1999 and is now down to 45 percent. Similarly, its use peaked at over 90 percent in 1996 for SUVs and has dropped below the 40 percent level. Over half of this year's pickups will still have L4 transmissions, as will about 60 percent of the vans. Where manual transmissions are used, the 5-speed (M5) transmission now predominates. Because only a small fraction of vehicles are equipped with M6, L7, and CVT transmissions in MY2006, these transmission types are combined as 'Other' on Figure 44. Their combined sales fraction barely shows on Figures 45 to 47.

Transmissions alter the ratio of engine speed to drive wheel speed. In conventional transmissions, this speed ratio is limited to a fixed number of discrete values, but for a CVT, the ratio is continuous. These transmissions differ from conventional automatic transmissions and manual transmissions in that CVTs do not have a fixed number of gears with the advantage that the engine speed/drive wheel speed ratio can be altered to enhance vehicle performance or fuel economy in ways not available with conventional transmissions. While this vehicle technology has great potential, two decades after being introduced for use in an MY1987 Subaru Justy, CVTs are currently used in less than three percent of the light-duty vehicle fleet, up slightly from about two percent last year.

More data stratified by transmission type can be found in Appendix I.

Transmission Sales Fraction (Three Year Moving Average) Cars

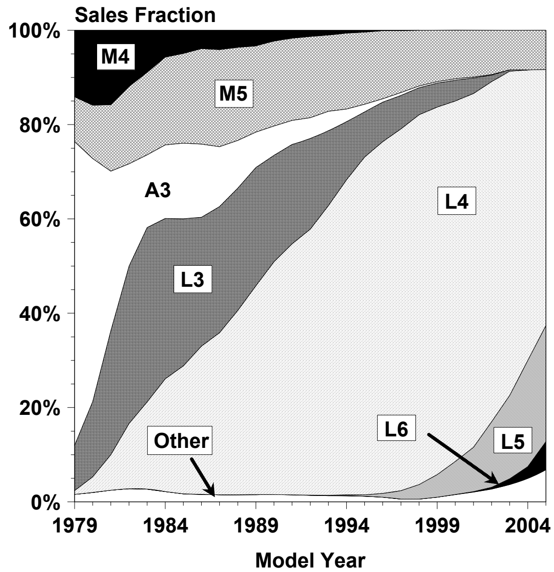

Figure 44

Transmission Sales Fraction (Three Year Moving Average) Vans

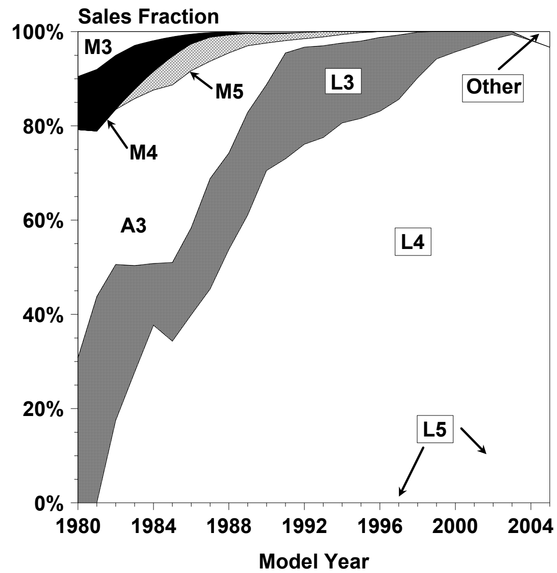

Figure 45

Transmission Sales Fraction (Three Year Moving Average) SUVs

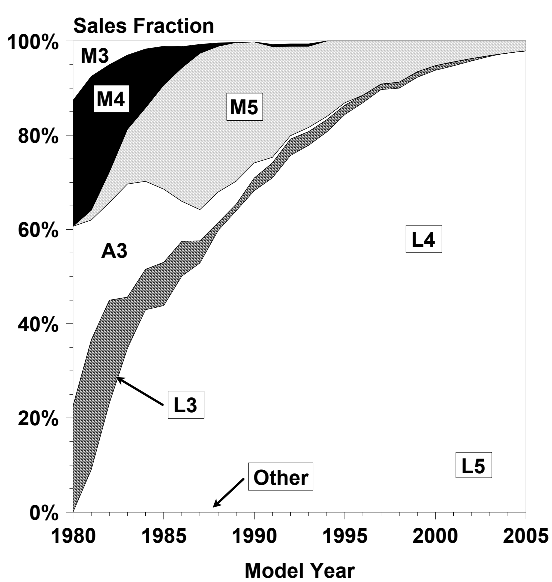

Figure 46

Transmission Sales Fraction (Three Year Moving Average) Pickups

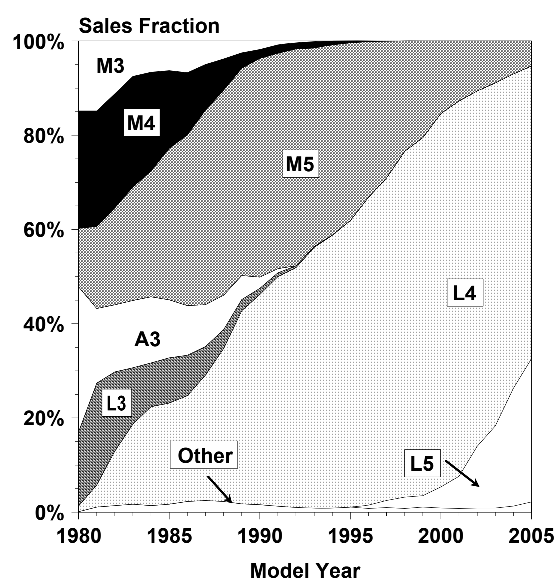

Figure 47

Table 15

Ton-MPG by Transmission and Vehicle Type

(Conventionally Powered Vehicles)

	Car		**Van**		**SUV**		**Pickup**	
Trans	**1988**	**2006**	**1988**	**2006**	**1988**	**2006**	**1988**	**2006**
M4	38	--	--	--	--	--	33	--
M5	38	44	38	--	34	43	36	42
M6	--	40	--	--	--	--	--	41
CVT	--	44	--	46	--	46	--	--
L3	36	44	37	--	34	--	32	--
L4	38	45	37	45	34	43	34	44
L5	--	44	--	48	37	42	35	41
L6	--	43	--	--	--	44	--	--

Table 16 and Figures 48 through 51 compare horsepower (HP), displacement (CID), and specific power or horsepower per cubic inch (HP/CID) for cars, vans, SUVs, and pickups. For all four vehicle types, significant CID reductions occurred in the late 1970s and early 1980s. Engine displacement has been flat for cars and vans since the mid-1980s and has been flat for SUVs since the mid-1990s, but has been increasing for two decades for pickups. Average horsepower has increased substantially for all of these vehicle types since 1981 with the highest increase occurring for pickups whose HP is now more than double what it was then (i.e., 259 vs 115 HP). Light-duty vehicle engines, thus, have also improved in specific power with the highest specific power being for engines used in passenger cars. In fact, for the past many years, car engines have averaged at least 1.0 HP/CID. As shown in Table 16, SUVs also achieve more than 1.0 HP/CID. but vans and pickups have yet to reach the 1.0 HP/CID level.

Table 16

MY2006 Engine Characteristics by Vehicle Type

Vehicle Type	**HP**	**CID**	**HP/ CID**	**Multi-Valve**	**Variable Valve**	**Cylinder Deactivation**
Car	198	176	1.14	82%	62%	2%
Van	210	219	.97	40%	33%	9%
SUV	239	236	1.03	71%	53%	6%
Pickup	259	281	.93	47%	46%	6%
All	219	211	1.07	70%	55%	4%

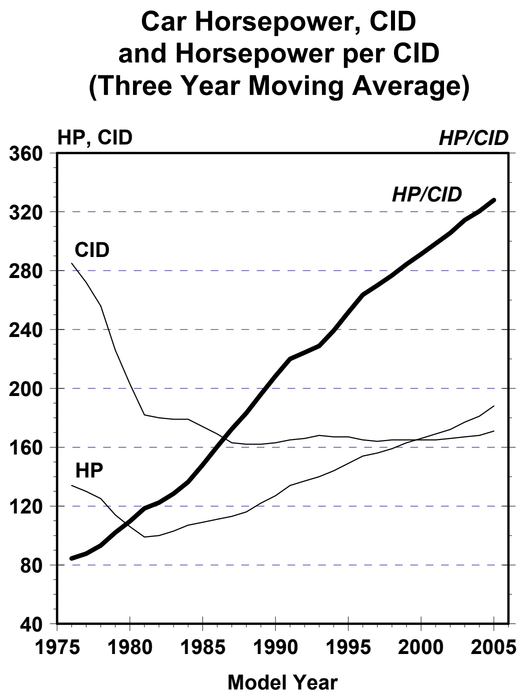

Figure 48

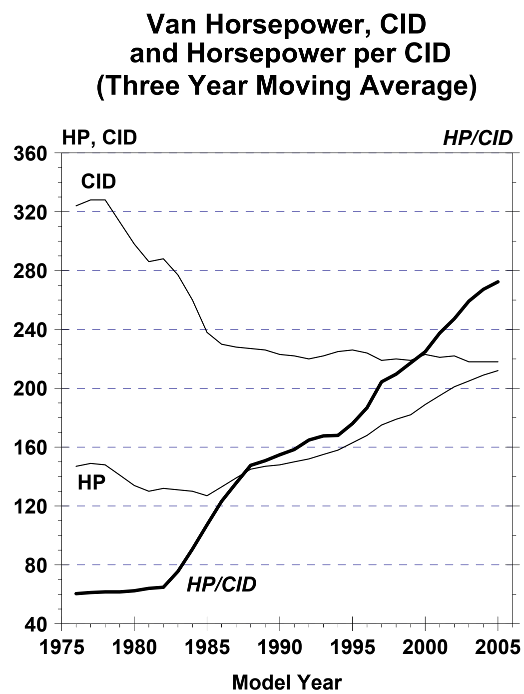

Figure 49

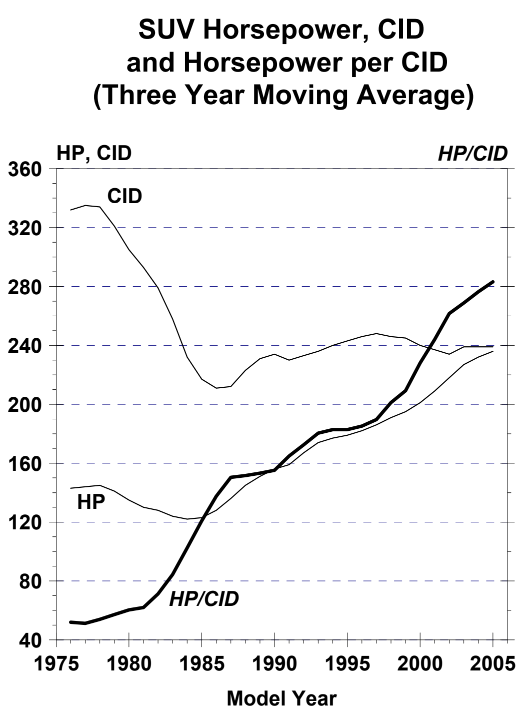

Figure 50

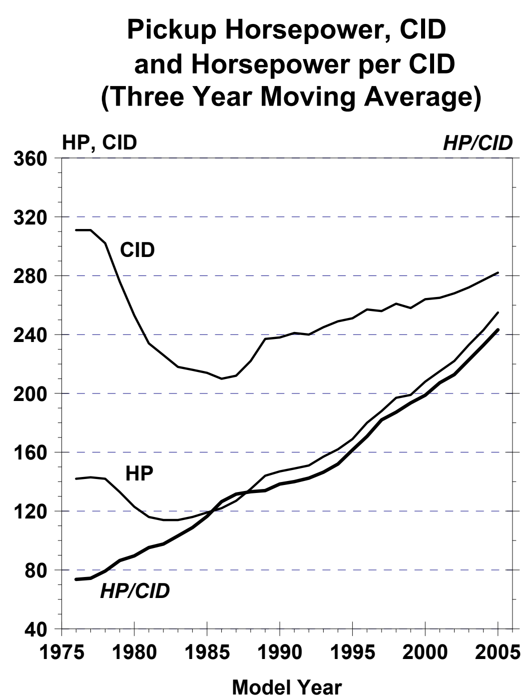

Figure 51

Table 17 compares CID, HP, and HP/CID by vehicle type and number of cylinders for model years 1988 and 2006. Table 17 shows that the increase in horsepower shown for the fleet in Table 9 extends to all vehicle type and cylinder number strata with one minor exception: SUVs with three-valve engines. These increases in horsepower range from 40 to over 80% . Because displacement has remained relatively constant (-7% to 13%), it can be seen that the primary reason for the horsepower increase is increased specific power — up between 35 and 86% from 1988 to 2006.

At the number-of-cylinders level of stratification, model year 2006 cars consistently achieve higher specific power than vans, SUVs or pickups. Four-cylinder vans, SUVs and pickups, however, are now over the 1.0 HP/CID level as are six-cylinder SUVs. A reason for the lower specific power of some truck engines is that these vehicles may be used to carry heavy loads or pull trailers and thus need more "torque rise," (i.e., an increase in torque as engine speed falls from the peak power point) to achieve acceptable driveability. Engines equipped with four valves per cylinder typically have inherently lower torque rise than two valve engines with lower specific power.

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Table 17

Changes in Horsepower, Engine Size and Specific Power by Vehicle Type and Number of Cylinders

Vehicle Type	Cyl.	HP 1988	HP 2006	Percent Change	CID 1988	CID 2006	Percent Change	HP/CID 1988	HP/CID 2006	Percent Change
Cars	4	95	152	60.%	118	128	8.%	.805	1.191	48.%
	6	142	225	58.%	193	203	5.%	.744	1.120	50.%
	8	164	300	83.%	301	297	-1.%	.544	1.012	86.%
Vans	4	98	150	53.%	145	148	2.%	.678	1.014	50.%
	6	149	209	40.%	213	215	1.%	.722	.974	35.%
	8	168	249	48.%	322	301	-7.%	.520	.826	59.%
SUVs	4	94	156	66.%	122	142	16.%	.773	1.093	41.%
	6	147	228	55.%	211	218	3.%	.706	1.047	48.%
	8	183	295	61.%	338	313	-7.%	.541	.948	75.%
Pickups	4	97	163	68.%	142	160	13.%	.685	1.013	48.%
	6	142	221	56.%	229	234	2.%	.644	.947	47.%
	8	180	286	59.%	329	316	-4.%	.544	.903	66.%

Table 18

Changes in Horsepower, Engine Size and Specific Power by Vehicle Type and Number of Cylinders

Inertia Weight	HP 1988	HP 2006	Percent Change	CID 1988	CID 2006	Percent Change	HP/CID 1988	HP/CID 2006	Percent Change
Cars									
2000	59	73	24.%	77	61	-21.%	.770	1.197	55.%
2250	73	170	133.%	90	102	13.%	.808	1.620	100.%
2500	78	106	36.%	100	91	-9.%	.785	1.165	48.%
2750	97	119	23.%	123	104	-15.%	.804	1.140	42.%
3000	114	139	22.%	145	120	-17.%	.797	1.154	45.%
3500	151	192	27.%	212	168	-21.%	.732	1.160	59.%
4000	160	245	53.%	289	218	-25.%	.569	1.146	101.%
4500	144	282	96.%	305	289	-5.%	.474	.980	107.%
5000	207	259	25.%	408	221	-46.%	.509	1.167	129.%
5500	205	292	42.%	412	246	-40.%	.498	1.199	141.%
6000	205	536	161.%	412	373	-9.%	.498	1.444	190.%
Vans									
4000	149	182	22.%	214	195	-9.%	.717	.935	30.%
4500	169	216	28.%	320	220	-31.%	.528	.990	88.%
5000	156	221	42.%	312	272	-13.%	.500	.817	64.%
5500	195	253	30.%	346	298	-14.%	.562	.845	50.%
6000	126	280	122.%	379	323	-15.%	.332	.865	160.%
SUVs									
3500	147	163	11.%	210	150	-29.%	.712	1.090	53.%
4000	135	200	48.%	190	195	3.%	.723	1.037	44.%
4500	147	234	59.%	311	225	-28.%	.494	1.049	112.%
5000	181	260	44.%	330	260	-21.%	.545	1.012	86.%
5500	200	306	53.%	350	311	-11.%	.572	.990	73.%
6000	162	303	87.%	368	323	-12.%	.445	.943	112.%
Pickups									
3500	129	157	22.%	183	163	-11.%	.719	.968	35.%
4000	154	198	29.%	282	205	-27.%	.555	.969	75.%
4500	174	233	34.%	322	241	-25.%	.539	.979	82.%
5000	193	267	38.%	342	297	-13.%	.565	.894	58.%
5500	178	289	62.%	363	319	-12.%	.495	.904	83.%
6000	140	301	115.%	379	330	-13.%	.369	.910	146.%

Table 18 shows similar data to that in Table 17, but the stratification is based on inertia weight. This table clearly shows that, for every case for which a comparison can be made between 1988 and 2006, there were increases in HP, substantial increases in specific power ranging from 30 to 160%, and with just two exceptions (2250 lb cars and 4000 lb SUVs) substantial decreases in CID. For MY2006, the 2250 lb weight class, however, consists of just two vehicles, one of which is the Honda Insight Hybrid.

HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Cars

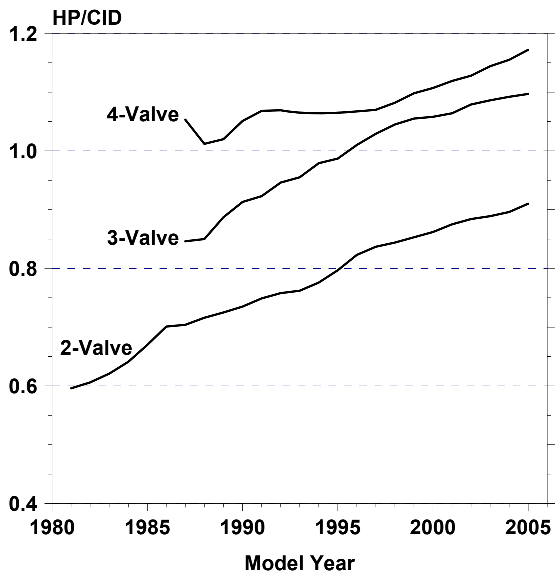

Figure 52

HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Vans

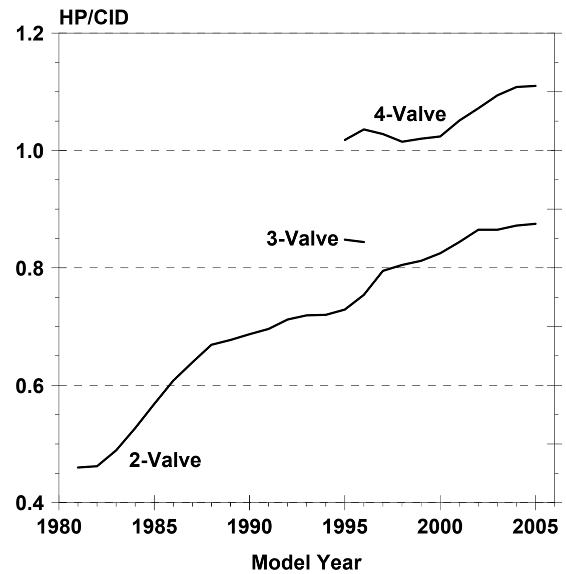

Figure 53

HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) SUVs

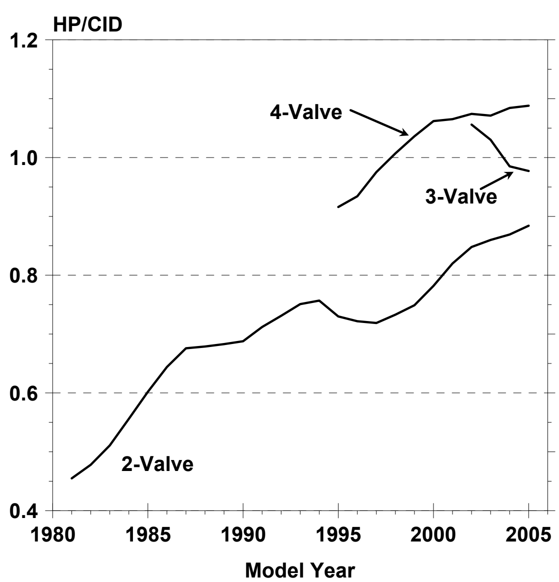

Figure 54

HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Pickups

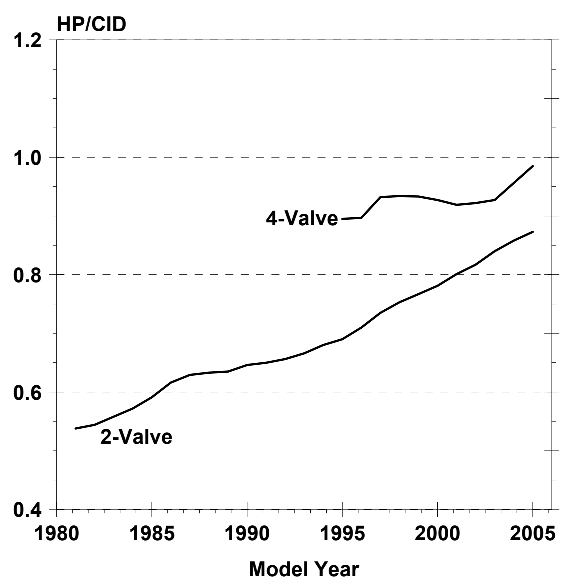

Figure 55

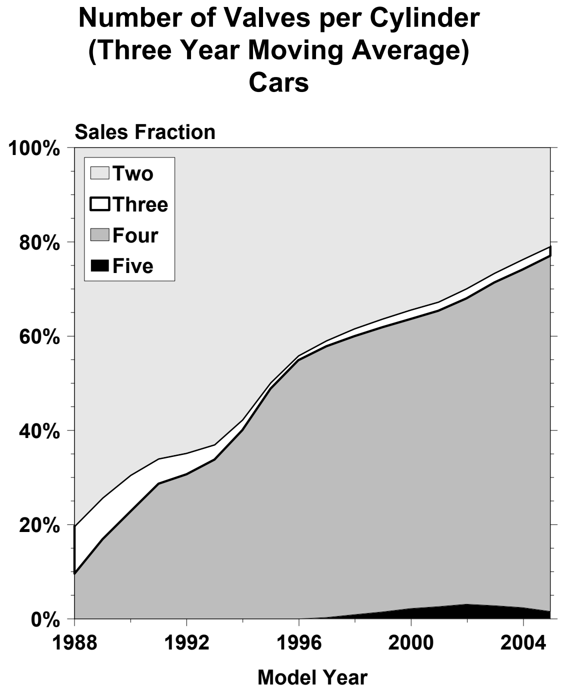

Figure 56

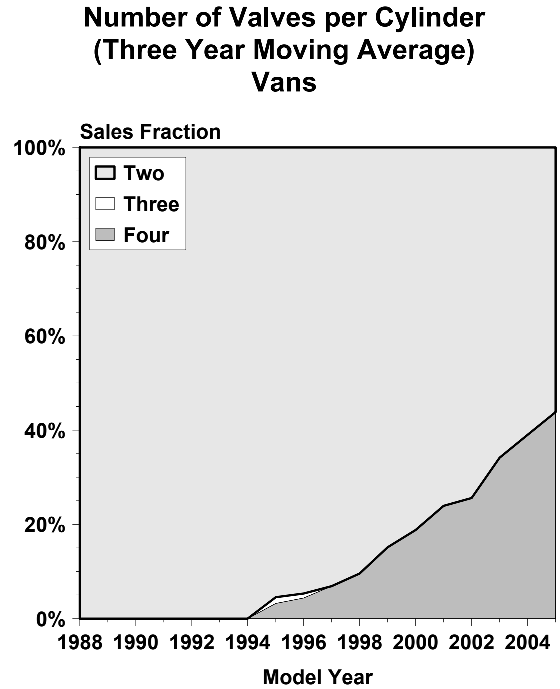

Figure 57

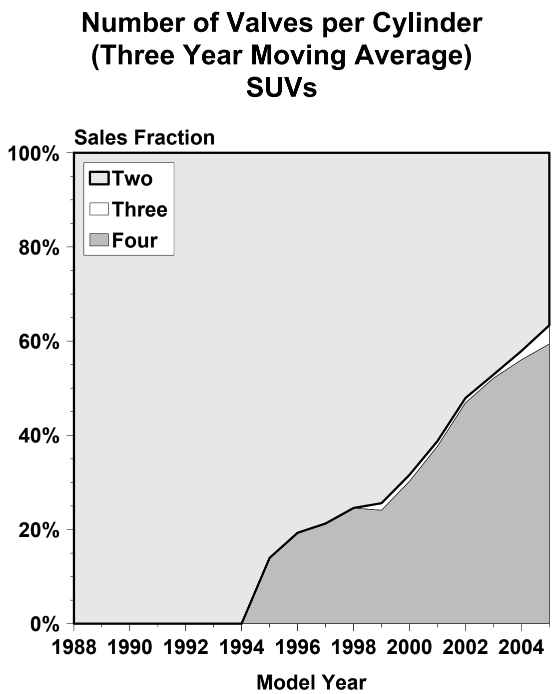

Figure 59

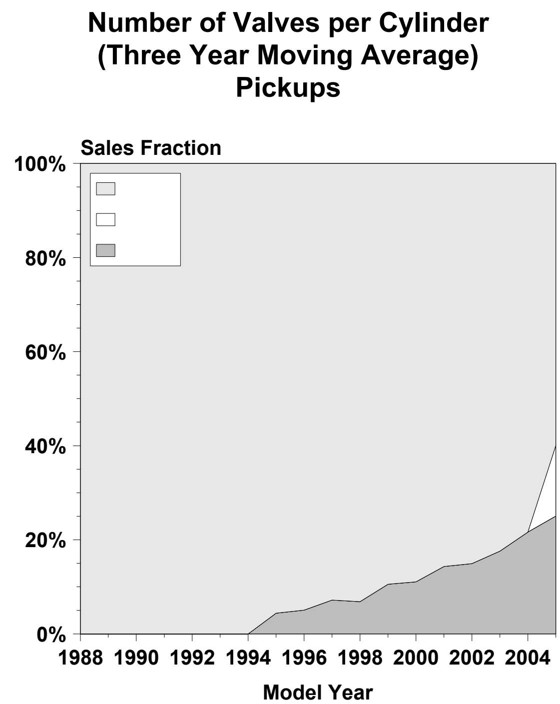

Figure 59

Figures 52 through 55 show that increases in HP per CID apply to all of the engines, regardless of the number of valves they. Engines with more valves per cylinder deliver higher values of HP per CID. Engines with *only* two valves per cylinder deliver substantially more horsepower per CID then they used to, typically about a 50 percent increase for the time period shown. The increases in HP and HP-per-CID is due to changes in engine technologies. Figures 56 through 59 show that usage of multi-valve engines is increasing for all vehicle types and as shown in Table 16 for MY2006, is now over 80 percent for cars, 70 percent for SUVs, about 50 percent for pickups, and 40 percent for vans.

Figures 60 and 61 and Table 19 show how the car and truck fleet have evolved from one that consisted almost entirely of carbureted engines to one which is now almost entirely port fuel injected, with a clear trend towards increased use of variable valve timing. In 1975, about 95 percent of all cars had carburetors as did almost all of the trucks, by 1988 use of carburetors had dropped below the 20 percent level for all vehicle types. For MY2006, about 60 percent of cars have multi-valve, port fuel injected engines with variable valve timing, as do over half of the SUVs; 46 percent of the pickups, but only 33 percent of the vans.

Car Sales Fraction by Engine Type (Three Year Moving Average)

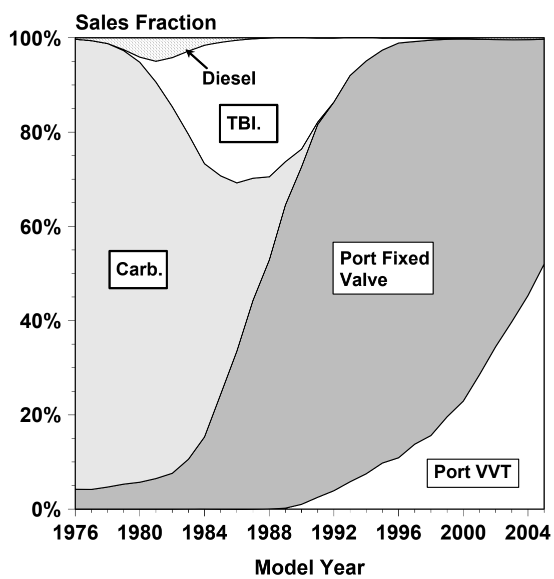

Figure 60

Truck Sales Fraction by Engine Type (Three Year Moving Average)

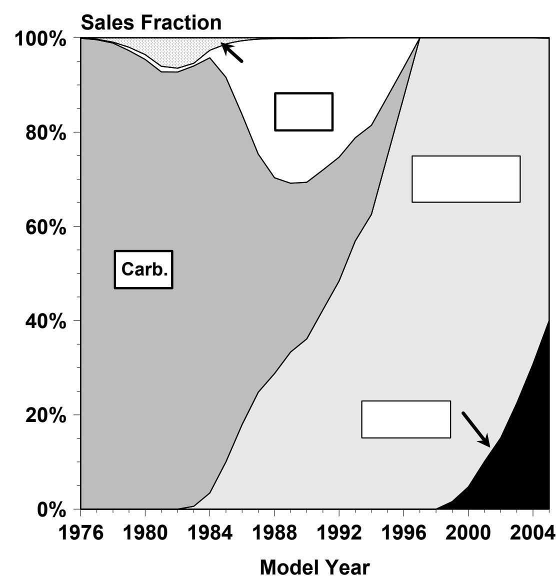

Figure 61

Table 19

Sales Fraction of MY1988 and MY2006 Light Vehicles by Engine Type and Valve Timing

Engine Type Vehicles	Cars		Vans		SUVs		Pickups		All	
	1988	**2006**	**1988**	**2006**	**1988**	**2006**	**1988**	**2006**	**1988**	**2006**
Carb	16%	---	<1%	---	16%	---	16%	---	15%	---
TBI	30%	---	43%	---	37%	---	48%	--	34%	---
Port Fixed	54%	38%	57%	67%	47%	46%	36%	54%	51%	45%
Port Variable	---	60%	---	33%	---	52%	---	46%	---	53%
Diesel	0%	<1%	<1%	---	<1%	<1%	<1%	---	---	<1%
Hybrids	---	1%	---	---	---	2%	---	<1%	---	1%

For over a decade and an half, automotive manufacturers have been using engines which use either cams or electric solenoids to provide variable intake and/ or exhaust valve timing and in some cases valve lift. Conventional engines use camshafts which are permanently synchronized with the engine's crankshaft so that they operate the valves at a specific fixed point in each combustion cycle regardless of the speed and load at which the engine is operated. The ability to control valve timing allows the design of an engine combustion chamber with a higher compression level than in engines equipped with fixed valve timing engines which in turn provides greater engine efficiency, more power and improved combustion efficiency. Variable valve timing (VVT) also allows the valves to be operated at different points in the combustion cycle, to provide performance that is precisely tailored to the engine's specific speed and load at any given instant with the valve timing set to allow the best overall performance across the engine's normal operating range. This results in improved engine efficiency under low-load conditions, such as at idle or highway cruising, and increased power at times of high demand. In addition, variable valve timing can result in reduced pumping losses, from the work required to pull air in and push exhaust out of the cylinder.

Because automobile manufacturers are not currently required to provide EPA with data on the type of valve timing their engines have, the data base used to generate EPA's fuel economy trend report was augmented to indicate whether a vehicle had fixed or variable valve timing. The data augmentation was based on data from trade publications, data published by automotive manufacturers, and, in some cases, by car enthusiasts. In addition, no differentiation between engines which used cams or solenoids to control the valve timing was made, nor was valve lift considered. For cars, the augmented data covers model years 1989 to 2006, while for trucks the augmentation covered model years 1999 to 2006.

Table 20 **Comparison of MY1988 and MY2006 Cars by Engine Fuel Metering, Number of Valves and Valve Timing**

Fuel Metering	Number of Valves	Valve Timing	Horsepower		CID		HP/CID		Ton MPG		0 to 60 Time	
			1988	2006	1988	2006	1988	2006	1988	2006	1988	2006
Carb		Fixed	88	---	131	---	.75	----	38.2	----	14.3	---
TBI	2	Fixed	97	---	141	---	.71	----	37.3	----	13.7	---
Port	2	Fixed	136	226	193	247	.74	.91	36.9	43.5	12.0	9.1
Port	4	Fixed	137	185	131	163	1.05	1.15	38.3	42.4	11.1	9.9
Port	4	Variable	---	192	---	158	----	1.21	----	44.7	----	9.5
Percent Improvement over 1988 Port Two Valve, Fixed Valve Timing												
Carb		Fixed	-35%	---	-32%	---	1%	---	4%	---	19%	---
TBI	2	Fixed	-29%	---	-27%	---	-4%	---	1%	---	14%	---
Port	2	Fixed	0%	66%	0%	28%	0%	24%	0%	18%	0%	-24%
Port	4	Fixed	1%	36%	-32%	-16%	42%	56%	4%	15%	-8%	-18%
Port	4	Variable	---	41%	---	-18%	---	65%	--	21%	---	-21%

Table 20 compares horsepower, engine size (CID), specific power (HP/CID), Ton- mpg, and estimated 0-to-60 acceleration time for five selected MY1988 and 2006 engine types. When the MY2006 car fleet is stratified by both the number of valves and valve timing, four valve VVT engines have the highest sales fraction (i.e., 55 percent), followed by four valve, fixed valve timing engines at 20 percent and two valve, fixed valve timing at just 15 percent, with diesels, hybrids. These three engine types thus account for 90 percent of the MY2006 cars with diesels, hybrids and all other fuel induction combinations accounting for the remaining 10 percent of the fleet.

Because 1988 was the peak year for car fuel economy, and because the two valve, fixed valve timing, port injected engine accounted for about half of the car engines built that year, it was selected as a base line engine its average characteristics compared to those for the MY2006 two- and four-valve, fixed valve timing and four- valve VVT engines. As shown in Figure 62, all three of these MY2006 engine types had substantially higher horsepower than the baseline MY1988 engine, but the MY2006 four valve engines fixed and VVT engines are considerable smaller and have substantially higher specific power. Not all of these improvements in engine design for these engine types that occurred between 1988 and 2006 were used to improve fuel economy as indicated by the nominal 20 percent decrease in 0-to-60 time each achieved. As mentioned earlier, in this report vehicle performance for conventionally powered vehicles is determined by an estimate of 0-to-60 acceleration time calculated from the ratio of vehicle power to weight. Obtaining increased power to weight in a time when weight is trending upwards implies that horsepower is increasing. Increased horsepower can be obtained by increasing the engine's displacement, the engine's specific power (HP/CID), or both. Increasing specific power has been the primary driver for increases in performance for the past two decades.

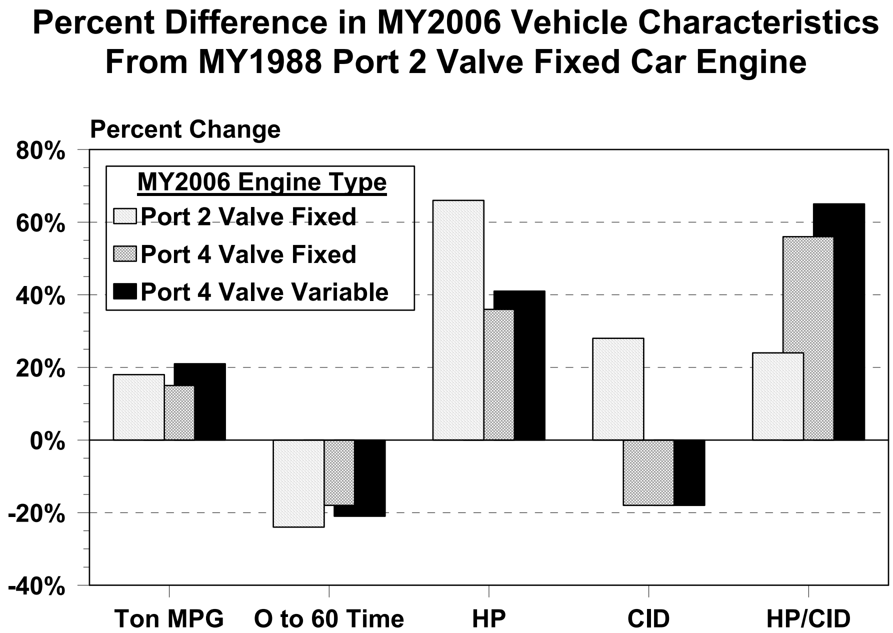

Figure 62

For the current model year fleet, specific power has been studied at an even more detailed level of stratification with both car and truck engines being classified according to: (1) the number of valves per cylinder, (2) the manufacturer's fuel recommendation, (3) the presence or absence of an intake boost device such as a turbocharger or supercharger and (4) whether or not the engine had fixed or variable valve timing. (See Tables 21 and 22.) Higher HP/CID is associated with: (a) more valves per cylinder, (b) higher octane fuel, ©) intake boost and (4) use of variable valve timing. The technical approaches result in specific power ranges for cars and trucks from about .9 to about 1.6 and about .9 to 1.4, respectively. The relative sales fractions in Tables 21 and 22 are just for each technical option in the table and exclude hybrids.

Tables 21 and 22 show the incremental effect, on a sales weighted basis, of adding each technical option, but not all of the technical options are sales significant. The effect of the use of higher octane fuel cannot be discounted, because roughly 20 percent of the current car fleet is comprised of vehicles which use engines for which high octane fuel is recommended. By comparison, about six percent of this year's light trucks require premium fuel.

Engine technology which delivers improved specific power thus can be used in many ways ranging from reduced displacement and improved fuel economy at constant (or worse) performance, to increased performance and the same fuel economy at constant displacement.

Table 21

HP/CID and Sales Fraction by Fuel and Engine Technology

Model Year 2006 Cars

Number of Valves per Cylinder

Fuel/Boost/Valves	**Two**		**Three**		**Four**		**Five**		**Total**
	HP/CID	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**Sales Fract.**
Regular/No Boost/FIX	.90	.136	----	----	1.10	.187	----	----	.324
Regular/No Boost/VVT	1.05	.027	1.07	.007	1.16	.427	----	----	.461
Regular/Boost /FIX	----	----	----	----	1.64	.002	----	----	.002
Regular/Boost /VVT	----	----	----	----	1.66	----	----	----	.000
Premium/No Boost/FIX	1.06	.014	1.00	.010	1.34	.012	----	----	.037
Premium/No Boost/VVT	1.18	.001	1.29	.003	1.29	.122	1.31	.002	.128
Premium/Boost /FIX	1.13	.001	1.78	.001	1.61	.016	1.64	.001	.020
Premium/Boost /VVT	----	----	----	----	1.58	.027	----	----	.027
Diesel/No Boost	----	----	----	----	1.02	----	----	----	.000
Diesel/Boost	.86	.002	----	----	----	----	----	----	.002
Total		.181		.022		.794		.003	1.000

Table 22

HP/CID and Sales Fraction by Fuel and Engine Technology

Model Year 2006 Trucks

Number of Valves per Cylinder

Fuel/Boost/Valves	**Two**		**Three**		**Four**		**Five**		**Total**
	HP/CID	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**HP/CID**	**Sales Fract.**	**Sales Fract.**
Regular/No Boost/FIX	.88	.396	----	----	1.03	.111	----	----	.507
Regular/No Boost/VVT	1.01	.006	.93	.076	1.07	.346	----	----	.428
Regular/Boost /FIX	----	----	----	----	----	----	----	----	----
Regular/Boost /VVT	----	----	----	----	----	----	----	----	----
Premium/No Boost/FIX	.99	.012	1.00	.002	.95	.003	----	----	.017
Premium/No Boost/VVT	----	----	1.19	.006	1.19	.036	1.22	.001	.043
Premium/Boost /FIX	----	----	----	----	1.40	-----	----	----	.000
Premium/Boost /VVT	----	----	----	----	1.38	.004	----	----	.004
Diesel/No Boost	----	----	----	-----	.94	.001	----	----	.001
Diesel/Boost	----	----	----	-----	----	----	----	----	----
Total		.414		.084		.501		.001	1.000

A recent engine development has been the reintroduction of cylinder deactivation, an automotive technology that was used by General Motors in some MY1981 V-8 engines that could be operated in 8- , 6- and 4-cylinder modes. This approach, which has also been called by a number of names including 'variable displacement', 'displacement on demand', 'active fuel management' and 'multiple displacement', involves allowing the valves of selected cylinders of the engine to remain closed and interrupting the fuel supply to these cylinders when engine power demands are below a predetermined threshold, as typically happens under less demanding driving conditions, such as steady state operation. Under light load conditions, the engine can thus provide better fuel mileage than would otherwise be achieved. Although frictional and thermodynamic energy losses still occur in the cylinders that are not being used, these losses are more than offset by the increased load and reduced specific fuel consumption of the remaining cylinders. Typically half of the usual number of cylinders are deactivated. Challenges to the engine designer for this type of engine include mode transitions, idle quality, and noise and vibration.

For MY2006, it is estimated that on the order of 200,000 cars and over 500,000 trucks will be equipped with cylinder deactivation engines. While their total sales fraction is still relatively small, it is roughly three times that for hybrids and about ten times that for diesels. Currently, cylinder deactivation is being in seven vehicle classes/types: mid-size cars, mid-size wagons, large cars, mid-size vans, mid-size SUVs, large SUVs and large pickups.

Table 23

Comparison of MY2006 Cars with Engines with Cylinder Deactivation

Car Class	Model Name	Drive	Trans	Inertia Weight	Engine CID	Engine HP	Lab. 55/45 MPG	Cyl. Deact.	Pct. HP	Change MPG
Midsize	Grand Prix	Front	L4	4000	325	290	25.0	Yes	16%	-2%
Car	Grand Prix				231	250	25.6	No		
Large	Impala	Front	L4	4000	325	290	25.9	Yes	5%	12%
Car	Lucerne				279	275	23.2	No		
	Charger	Rear	L5	4500	348	330	23.0	Yes	30%	-9%
	Charger				215	253	25.3	No		
	300C AWD	4wd	L5	4500	348	340	23.1	Yes	34%	1%
	300C AWD				215	253	22.8	No		
Midsize	Magnum AWD	4wd	L5	4500	348	340	23.1	Yes	34%	1%
Wagon	Magnum AWD				215	253	22.8	No		

Table 24

Comparison of MY2006 Trucks with Engines with Cylinder Deactivation

Truck Class	Model Name	Drive	Trans	Inertia Weight	Engine CID	HP	Lab. 55/45 MPG	Cyl. Deact	Pct. HP	Change MPG
Midsize Van	Odyssey	Front	L5	4500	212	244	26.5	Yes	0%	16%
	Kia Sedona (VQ)				244	244	22.8	No		
Midsize SUV	Grand Cherokee	Rear	L5	5000	348	345	19.5	Yes	60%	3%
	Montero				234	215	19.0	No		
Large SUV	Envoy XL	Rear	L4	5000	325	280	21.3	Yes	2%	7%
	Envoy XL				254	275	19.8	No		
	Envoy XL	4wd	L4	5500	325	280	20.5	Yes	2%	-1%
	Envoy XL				254	275	20.6	No		
	Durango	Rear	L5	5500	348	345	19.5	Yes	13%	8%
	Armada				339	305	18.0	No		
Large Pickup	Ram 1500	Rear	L5	5000	348	345	19.5	Yes	13%	6%
	Titan				339	305	18.4	No		
	Ram 1500	4wd	L5	5500	348	345	18.8	Yes	13%	5%
	Titan				339	305	17.9	No		

Table 23 compares examples of MY2006 cars with cylinder deactivation with selected vehicles that do not have this feature, but which are in the same EPA car class, and which also have the same inertia weight, drive and transmission. For every case in the table, the version of the vehicle equipped with cylinder deactivation has horsepower ratings that are significantly higher than the vehicle to which it is being compared. In three cases in the table, the vehicle with cylinder deactivation has significantly higher horsepower and about the same fuel economy. For one case (the Impala - Lucerne comparison), the horsepower ratings are about the same, but the cylinder deactivation equipped vehicle achieves 12% higher fuel economy. Similarly, some of the truck examples in Table 24 indicate that vehicles equipped with cylinder deactivation can achieve both higher horsepower and fuel economy than their counterparts. For example, the rear- and four-wheel drive versions of the Ram 1500 have 13% higher horsepower than the corresponding Nissan Titan and also achieve 5 and 6 percent higher fuel economy, respectively. The data in Tables 23 and 24 indicate cylinder deactivation can be used to increase fuel economy at constant horsepower, or to maintain equivalent fuel economy at higher horsepower levels, or to increase both horsepower and fuel economy.

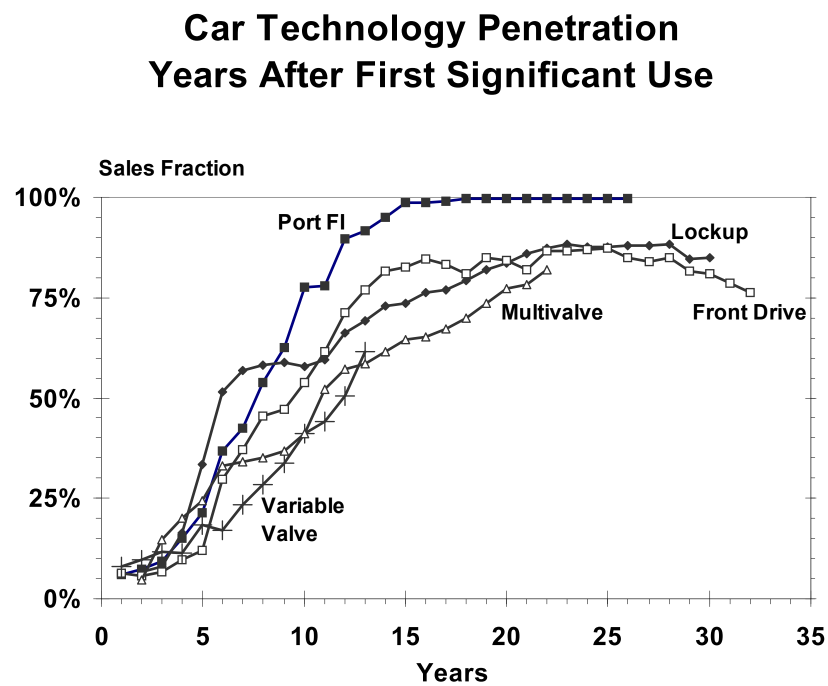

Figure 63

Figure 63 compares penetration rates for five passenger car technologies, namely port fuel injection (Port FI), front-wheel drive (FWD), multi-valve engines (i.e., engines with more than two valves per cylinder), lockup transmissions, and engines with variable valve timing. The sales fraction for VVT car engines has increased in a similar fashion to the others shown in the figure. This indicates that it may take a decade for a technology to prove itself and attain a sales fraction of 40 to 50 percent and as long as another five or ten years to reach maximum market penetration. It thus takes some time after the introduction of a new technology for it to fully penetrate the market.

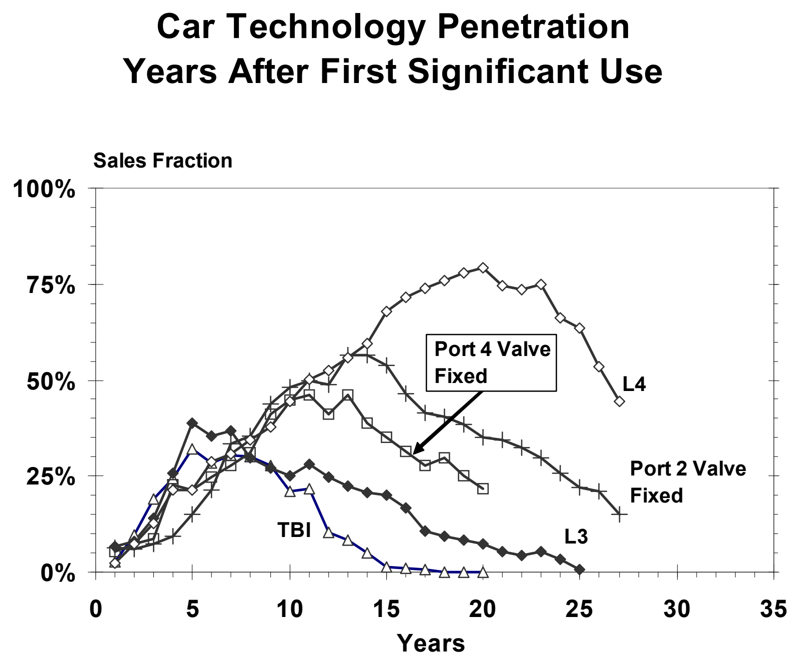

Figure 64

A similar comparison of five technologies whose sales fraction peaked out is shown in Figure 64. This figure shows that it often may take a number of years for technologies such as throttle body fuel injection (TBI), lockup 3-speed (L3) and 4-speed (L4) transmissions to reach their maximum sales fraction, and, even then, use of these technologies may continue for a decade or longer. For the limited number of cases studied, the time a given technology needs to attain and then pass a market share of about 40 to 50 percent appears to be an indicator of whether it will ever attain a stabilized high level of market penetration. L4 transmissions and both two- and four-valve, port injected, fixed valve timing car engines (Port 2V- and 4V- Fixed) now can be classified with technologies such as TBI engines and L3 transmissions which have reached their peak sales fractions and, thus, are likely to disappear from the new vehicle fleet.

Table 25 compares inertia weight, the fuel economy ratings, the ratio of highway to city fuel economy, and ton-mpg of the MY2006 hybrid and diesel vehicles with those for the average conventionally powered MY2006 car and truck. All of the hybrid and some of the diesel vehicles in the table have a lower highway/city ratio than the average conventional car or truck.

Table 25

Characteristics of MY2006 Hybrid and Diesel Vehicles

Model Name	Inertia Weight	CID	Trans	Lab 55/45 MPG	<-- Adjusted City MPG	HWY MPG	55/45 MPG -->	Hwy/ City Ratio	Ton-MPG
Hybrid Cars									
Accord	4000	183	L5	27.5	24.8	33.6	28.1	1.36	56.1
Civic	3000	82	CVT	58.8	49.1	50.7	49.8	1.03	74.7
Insight	2000	61	M5	73.8	60.3	65.7	62.6	1.09	62.6
Insight	2250	61	CVT	66.4	56.5	55.7	56.1	.99	63.2
Prius	3000	91	CVT	65.8	59.9	50.5	55.3	.84	83.0
Hybrid Trucks									
Escape FWD	4000	140	CVT	39.5	35.6	30.8	33.3	.86	66.5
Escape 4wd	4000	140	CVT	36.7	32.9	28.8	30.9	.87	61.9
Tribute 4wd	4000	140	CVT	36.7	32.9	28.8	30.9	.87	61.9
Mariner 4wd	4000	140	CVT	36.7	32.9	28.8	30.9	.87	61.9
RX 400H 2wd	4500	202	CVT	36.2	33.1	27.7	30.4	.84	68.5
Highlander 2wd	4500	202	CVT	36.2	33.1	27.7	30.4	.84	68.5
RX 400H 4wd	4500	202	CVT	34.3	30.8	26.7	28.8	.87	64.9
Highlander 4wd	4500	202	CVT	34.3	30.8	26.7	28.8	.87	64.9
GM C15 Pickup 2w	5000	325	L4	22.3	17.8	20.7	19.0	1.16	47.5
GM K15 Pickup 4w	5500	325	L4	20.9	16.7	19.4	17.8	1.17	48.9
Diesel Vehicles									
Mercedes E320	4000	197	L5	35.5	26.6	36.7	30.3	1.38	60.7
Golf	3000	116	M5	46.7	36.7	44.1	39.7	1.20	59.6
Golf	3500	116	L5	43.5	32.9	44.3	37.2	1.35	65.0
Jetta	3500	116	L6	44.2	34.8	41.9	37.7	1.20	65.9
Jetta	3500	116	M5	44.6	35.7	40.9	37.9	1.14	66.3
New Beetle	3000	116	M5	46.7	36.7	44.1	39.7	1.20	59.6
New Beetle	3500	116	L6	44.2	34.8	41.9	37.7	1.20	65.9
Liberty-Cherokee	4500	171	L5	27.2	21.5	25.5	23.1	1.19	52.1
Average Car	3563	176	–	28.8	21.6	29.6	24.6	1.37	43.8
Average Truck	4711	246	–	21.5	16.4	21.5	18.4	1.31	43.3

In addition, there are several cases in the table (e.g. the Ford Escape) for which the highway to city ratio is less than 1.0, and these represent cases where a vehicle achieves higher fuel economy in city than in highway driving. This year's diesel cars achieve ton-mpg values that are roughly the same as some of the hybrid cars. For MY2006, the Toyota Prius achieves 83 Ton-mpg, almost twice that of the average car.

All but two of the vehicles in Table 25 (the Honda Insight and the Toyota Prius) have conventionally powered counterparts. Tables 26 and 27 compare the adjusted 55/45 fuel economy and an estimate of annual fuel usage (assuming 15,000 miles per year) for these vehicles with their conventionally powered (baseline) counterparts. The comparisons in both tables are limited to a basis of: model name, drive, inertia weight, transmission, and engine size (CID), and for simplicity there is only one listing for "twin" vehicles, namely: the Escape/ Mariner/ Tribute, the GM C15-K15 Silverado/ Sierra pickups and the Highlander/ RX400 H. Differences in the performance attributes of these vehicles complicate making the forward analysis of the fuel economy improvement potential due to hybridization and dieselization. In particular, hybrid vehicles are often reported to have faster 0-to-60 acceleration times than their conventional counterparts, while vehicles equipped with diesel engines have higher low-end

Table 26

Comparison of MY2006 Hybrid Vehicles With Their Conventional Counterparts

	<---- Hybrid Version ----->					<--- Baseline Version --->					<Improvement>	
Model Name	**Inertia Weight**	**CID**	**Trans**	**ADJ 55/45 MPG**	**Gal Per Year***	**Inertia Weight**	**CID**	**Trans**	**ADJ 55/45 MPG**	**Gal Per Year***	**ADJ 55/45 MPG**	**Gal Per Year***
Accord	4000	183	L5	28.1	534	3500	183	L5	23.4	640	20%	106
Civic	3000	82	CVT	49.8	301	3000	110	L5	33.7	446	48%	145
Escape FWD	4000	140	CVT	33.3	451	3500	140	L4	23.7	633	40%	182
						3500	140	M5	25.8	581	29%	130
Escape 4wd	4000	140	CVT	30.9	485	3500	140	L4	22.1	679	40%	194
						3500	140	M5	23.7	634	31%	149
Highlander 2wd	4500	202	CVT	30.4	493	4000	202	L5	21.3	703	43%	210
Highlander 4wd	4500	202	CVT	28.8	520	4500	202	L5	20.6	730	40%	210
GM C15 Pickup 2wd	5000	325	L4	19.0	789	5000	325	L4	17.6	855	8%	65
GM K15 Pickup 4wd	5500	325	L4	17.8	843	5500	325	L4	16.6	906	7%	63

*Note:

Gallons per year calculation is based on all vehicles being driven 15,000 miles per year. Because the Honda Accord Hybrid was certified for sale after the database for this report was frozen, Tables 25 and 26 are the only tables in the report to take its characteristics into account.

torque, but slower 0-to-60 times. In addition, some hybrid vehicles use technologies such as cylinder deactivation and CVT transmissions that are not offered in their counterparts. Given the difficulty in choosing the “right” baseline vehicle, Table 25 thus typically includes a comparison for the CVT-equipped Escape Hybrid with baseline data for both manual and automatic transmission versions of this vehicle.

Fuel economy improvements and fuel savings per year for the hybrid vehicles in Table 26 vary considerably from about 7 percent for the GM pickups to about 50 percent for the CVT-equipped Civic hybrid. Even though the GM hybrid pickup trucks offer relatively low fuel economy improvements, for a vehicle driven 15,000 miles per year, their fuel saving potential is relatively significant. Similarly, fuel economy improvements for diesels range from about 25 to nearly 55 percent, and these vehicles also offer relatively high savings in fuel usage. Several years after the introduction for sale in the U.S. of the first hybrid vehicle, the MY2000 Honda Insight, hybrid vehicles account for only about one percent of the combined car/truck fleet. In addition, the sales fraction for diesels remains below a quarter of one percent, more than an order of magnitude smaller than their 5.9 percent sales fraction in 1981. By comparison the sales fraction for SUVS increased from 2 percent in the early 1980s to over 25 percent by MY2001.

Table 27

Comparison of MY2006 Diesel Vehicles With Their Conventional Counterparts

	<----- Diesel Version ----->					<---- Baseline Version ---->					<Improvement>	
Model Name	**Inertia Weight**	**CID**	**Trans**	**ADJ 55/45 MPG**	**Gal Per Year***	**Inertia Weight**	**CID**	**Trans**	**ADJ 55/45 MPG**	**Gal Per Year***	**ADJ 55/45 MPG**	**Gal Per Year***
E320 CDI	4000	197	L5	30.3	494	4000	213	L5	20.7	725	47%	231
New Beetle	3500	116	L6	37.7	398	3000	151	L6	26.0	576	45%	178
	3000	116	M5	39.7	378	3000	151	M5	25.6	587	55%	209
Jetta	3500	116	L6	37.7	398	3500	121	L6	27.6	544	37%	145
	3500	116	M5	37.9	396	3500	121	M6	26.6	565	43%	169
Golf	3500	116	L5	37.2	404	3000	121	L4	26.6	563	40%	160
	3000	116	M5	39.7	378	3000	121	M5	26.8	560	48%	183
Liberty 4wd	4500	171	L5	23.1	648	4000	226	L4	18.8	799	23%	151

*Note:

Gallons per year calculation is based on all vehicles being driven 15,000 miles per year.

VI. **Marketing Groups**

In its century of evolution, the automotive industry existed first as small, individual companies that relatively quickly went out of business or grew into larger corporations. In that context, the historic term 'manufacturer' usually meant a corporation that was associated with a single country that manufactured vehicles for sale in just that country and perhaps exported vehicles to a few other countries, too. Over the years, the nature of the automotive industry has changed substantially, and it has evolved into one in which global consolidations and alliances among heretofore independent manufacturers have become the norm, rather than the exception.

The reports in this series include analyses of fuel economy trends in terms of the whole fleet of cars and light trucks and in various subcategories of interest, e.g., by weight class, by size class, etc. In addition, there has been a treatment of trends by groups of manufacturers. Initially, these groups were derived from the "Domestic" and "Import" categories which are part of the automobile fuel economy standards categories. This classification approach evolved into a market segment approach in which cars were apportioned to a "Domestic," "European," and "Asian" category, with trucks classified as "Domestic" or "Imported." As the automotive industry has become more transnational in nature, this type of vehicle classification has become less useful. In this report, trends by groups of manufacturers are now used to reflect the transnational and transregional nature of the automobile industry. To reflect the transition to an industry in which there are only a small number of independent companies, the fleet has been divided into eight major marketing group segments, and an ninth catch-all group ("Others") that contains independent manufacturers not assigned to one of the eight major marketing groups.

These eight major marketing groups are:

1) The General Motors Group includes GM, Opel, Saab, Isuzu, Suzuki and Daewoo;

2) The Ford Motor Group includes Ford, Jaguar, Volvo, Land Rover, Aston Martin, and Mazda;

3) The DaimlerChrysler Group includes Chrysler and Mercedes Benz;

4) The Toyota Group includes Toyota, Scion and Lexus;

5) The Honda Group includes Honda and Acura;

6) The Nissan Group includes Nissan and Infiniti;

7) The Hyundai-Kia (HK) Group includes Hyundai and Kia; and

8) The VW Group includes Volkswagen, Audi, SEAT, Skoda, Porsche and Bentley.

Taken together, the eight major marketing groups comprise over 95 percent of the MY2006 new vehicle market in the U.S. It is expected that these marketing groups will continue to evolve and perhaps expand, or possibly contract as further changes in the automotive industry occur. For example, in March, 2006 General Motors announced it was selling its 7.9 percent stake in Isuzu.

Table 28 compares laboratory fuel economy values for the marketing groups described above for model year 2006 with the overall fleet average. For each marketing group, the table also shows the effect of adding each of the manufacturers in that group. For example, if just GM cars were considered, the GM group would have an average laboratory car fuel economy of 28.0 mpg, adding cars manufactured by Suzuki and Daewoo doesn't change GM's average fuel economy for cars, but including Saab increases it to 28.2 mpg.

The GM, Ford, and DC groups are above the fleet average in percent truck and also below the overall fleet average in combined car and truck fuel economy. Toyota is now at the fleet average for percent truck, but above the fleet mpg averages. Nissan, on the other hand, is slightly below the fleet average for percent truck, but below the fleet mpg averages. The remaining groups are all below the fleet average in percent truck and are above the overall fleet average in mpg. Table 29 presents similar data to that in Table 28, except this table uses adjusted fuel economy values.

A more detailed comparison of model year 2006 laboratory fuel economy, by vehicle type and size, is presented in Table 30. Stratifying by marketing group, vehicle type and size for MY2006, the GM group achieves the highest fuel economy in two of the 12 vehicle type and size classes for which they manufacturer vehicles; Toyota leads in four classes, Honda in three, Ford and Daimler Chrysler lead one class each, Subaru as part of "Others" leads two classes. Table 31 is a companion table to Table 30, but like Table 29 uses adjusted mpg data.

Figures 65 through 72 compare for model years 1975 to 2006: percent truck, laboratory 55/45 fuel economy for cars, trucks, and both cars and trucks for the GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai-Kia, Nissan, and VW marketing groups, respectively. For all of these marketing groups, combined car and truck fuel economy is lower now than it was in 1988 Because the absolute values of fuel economy differ somewhat across the marketing groups, a separate presentation of the fuel economy trends was prepared by normalizing the fuel economy for each Group by the fuel economy in 1988, the year in which fuel economy for the fleet as a whole was the highest. In this way, a relative measure of how each group, compared to its own value in 1988, can be seen. The results are shown in Figures 73 through 76.

All the marketing groups have lower absolute fuel economy now than they did in 1988. The declines are very similar, except the VW Group has not declined as much, due at least in part to the fact their truck share (shown on Figure 72) has remained very low. More information stratified by marketing group can be found in the Appendixes L through O.

Table 28

Model Year 2006 Laboratory 55/45 Fuel Economy by Marketing Group

Group	**Group Member Added**	**<-- FUEL ECONOMY -->** **Cars**	**Trucks**	**Both**	**Percent Truck**
GM	GM	28.0	20.9	23.8	52%
	Above plus Suzuki	28.0	21.0	23.9	52%
	Above plus Daewoo	28.0	21.0	23.9	52%
	Above plus Saab	28.2	21.0	24.0	51%
	Above plus Isuzu	28.2	21.0	24.0	51%
	Entire GM Group	28.2	21.0	24.0	51%
Ford	Ford	27.0	20.2	22.5	58%
	Above plus Mazda	27.5	20.3	23.1	54%
	Above plus Volvo	27.5	20.3	23.2	53%
	Above plus Land Rover	27.5	20.2	23.0	54%
	Above plus Jaguar	27.3	20.2	23.0	53%
	Above plus Ast. Mart.	27.3	20.2	23.0	53%
	Entire Ford Group	27.3	20.2	23.0	53%
DC	Chrysler	25.6	21.2	22.3	73%
	Above plus Mercedes	25.1	21.2	22.3	68%
	Entire DC Group	25.1	21.2	22.3	68%
Toyota	Toyota	34.3	23.5	27.9	50%
Honda	Honda	32.7	24.5	28.3	47%
Nissan	Nissan	28.6	20.6	24.1	49%
HK	Kia	30.4	22.5	26.3	45%
	Above plus Hyundai	30.1	23.2	27.4	33%
VW	VW	29.0	18.9	28.5	3%
	Above plus Porsche	28.8	18.7	27.7	7%
	Above plus Bentley	28.6	18.7	27.5	7%
Others		27.2	23.5	25.9	31%
All	Fleet Average	28.8	21.5	24.6	50%

Table 29

Model Year 2006 Adjusted 55/45 Fuel Economy by Marketing Group

		<-- FUEL ECONOMY -->			
Percent					
Group	**Group Member Added**	**Cars**	**Trucks**	**Both**	**Truck**
GM	GM	24.0	17.9	20.3	52%
	Above plus Suzuki	24.0	17.9	20.4	52%
	Above plus Daewoo	24.0	17.9	20.4	52%
	Above plus Saab	24.1	17.9	20.5	51%
	Above plus Isuzu	24.1	17.9	20.5	51%
	Entire GM Group	24.1	17.9	20.5	51%
Ford	Ford	23.1	17.2	19.3	58%
	Above plus Mazda	23.5	17.3	19.7	54%
	Above plus Volvo	23.5	17.3	19.8	53%
	Above plus Jaguar	23.5	17.3	19.6	54%
	Above plus Land Rover	23.4	17.3	19.7	53%
	Above plus Ast. Mart.	23.4	17.3	19.7	53%
	Entire Ford Group	23.4	17.3	19.7	53%
DC	Chrysler	21.8	18.1	19.0	73%
	Above plus Mercedes	21.5	18.1	19.1	68%
	Entire DC Group	21.5	18.1	19.1	68%
Toyota	Toyota	29.2	20.0	23.8	50%
Honda	Honda	28.0	21.0	24.2	47%
Nissan	Nissan	24.4	17.6	20.5	49%
HK	Kia	26.0	19.2	22.5	45%
	Above plus Hyundai	25.7	19.8	23.5	33%
VW	VW	24.8	16.1	24.4	3%
	Above plus Porsche	24.6	16.0	23.7	7%
	Above plus Bentley	24.5	16.0	23.5	7%
Others		23.2	20.1	22.1	31%
All	Fleet Average	24.6	18.4	21.0	50%

Table 30

Model Year 2006 Laboratory 55/45 Fuel Economy by Marketing Group

VEHICLE TYPE/SIZE	GM	Ford	DC	Toyota	Honda	Nissan	HK	VW	Others	All
Cars										
Small	29.5	28.9	25.3	34.4	37.7	28.9	34.5	29.3	27.9	30.3
Midsize	27.1	28.2	27.5	36.2	29.9	29.1	31.8	27.1	26.5	29.3
Large	26.0	24.9	24.1	28.8		23.5	27.4	22.6	22.4	25.7
All	27.7	27.3	25.5	34.1	32.7	28.6	30.1	28.5	27.1	28.8
Wagons										
Small	32.8	28.3	27.6	36.3				30.5	27.9	31.6
Midsize	26.1	27.8	24.1					24.6	27.6	26.6
Large			21.7							21.7
All	32.8	27.8	24.4	36.3				29.6	27.7	28.3
All Cars										
Small	30.1	28.9	26.1	34.7	37.7	28.9	34.5	29.4	27.9	30.5
Midsize	27.1	28.1	26.5	36.2	29.9	29.1	31.8	27.0	26.9	29.1
Large	26.0	24.9	23.1	28.8		23.5	27.4	22.6	22.4	25.4
All	28.2	27.3	25.1	34.3	32.7	28.6	30.1	28.6	27.2	28.8
Vans										
Small										
Midsize	24.0	23.6	24.7	24.7	26.1	24.8	22.8			24.5
Large	19.4	18.7								19.0
All	22.8	22.4	24.7	24.7	26.1	24.8	22.8			24.1
SUVs										
Small			18.7						28.7	23.1
Midsize	26.5	22.4	21.0	25.4	24.7	20.9	23.3		23.1	23.2
Large	20.5	18.7	19.1	18.8		21.0		18.7	20.8	20.0
All	21.0	20.7	20.3	24.3	24.7	21.0	23.3	18.7	23.9	21.7
Pickups										
Small									26.3	26.3
Midsize	24.3	22.6		24.9						23.8
Large	20.3	18.5	19.3	20.3	21.4	19.4			20.1	19.5
All	20.5	19.0	19.3	21.4	21.4	19.4			21.2	19.9
Fleet										
All	24.0	23.0	22.3	27.9	28.3	24.1	27.4	27.5	25.9	24.6

Table 31

Model Year 2006 Adjusted 55/45 Fuel Economy by Marketing Group

VEHICLE TYPE/SIZE	GM	Ford	DC	Toyota	Honda	Nissan	HK	VW	Others	All
Cars										
Small	25.2	24.7	21.6	29.4	32.2	24.6	29.5	25.1	23.8	25.9
Midsize	23.3	24.1	23.5	30.9	25.6	24.9	27.2	23.2	22.6	25.1
Large	22.3	21.3	20.6	24.7		20.1	23.4	19.3	19.2	22.0
All	23.7	23.3	21.8	29.1	28.0	24.4	25.7	24.4	23.2	24.7
Wagons										
Small	28.0	24.2	23.5	30.9				26.0	23.8	26.9
Midsize	22.4	23.7	20.6					21.1	23.6	22.7
Large			18.6							18.6
All	28.0	23.7	20.8	30.9				25.3	23.6	24.1
All Cars										
Small	25.7	24.7	22.3	29.6	32.2	24.6	29.5	25.1	23.8	26.0
Midsize	23.3	24.1	22.6	30.9	25.6	24.9	27.2	23.1	23.0	24.9
Large	22.3	21.3	19.8	24.7		20.1	23.4	19.3	19.2	21.8
All	24.1	23.3	21.5	29.2	28.0	24.4	25.7	24.5	23.2	24.6
Vans										
Small										
Midsize	20.5	20.2	21.1	21.1	22.3	21.2	19.5			21.0
Large	16.6	16.0								16.2
All	19.5	19.2	21.1	21.1	22.3	21.2	19.5			20.6
SUVs										
Small			15.9						24.5	19.7
Midsize	22.6	19.1	17.9	21.6	21.1	17.9	19.9		19.7	19.8
Large	17.5	16.0	16.3	16.0		17.9		16.0	17.8	17.1
All	18.0	17.6	17.3	20.7	21.1	17.9	19.9	16.0	20.4	18.5
Pickups										
Small									22.4	22.4
Midsize	20.8	19.3		21.3						20.3
Large	17.3	15.8	16.5	17.2	18.3	16.6			17.2	16.7
All	17.5	16.2	16.5	18.3	18.3	16.6			18.1	17.0
Fleet										
All	20.5	19.7	19.1	23.8	24.2	20.5	23.5	23.5	22.1	21.0

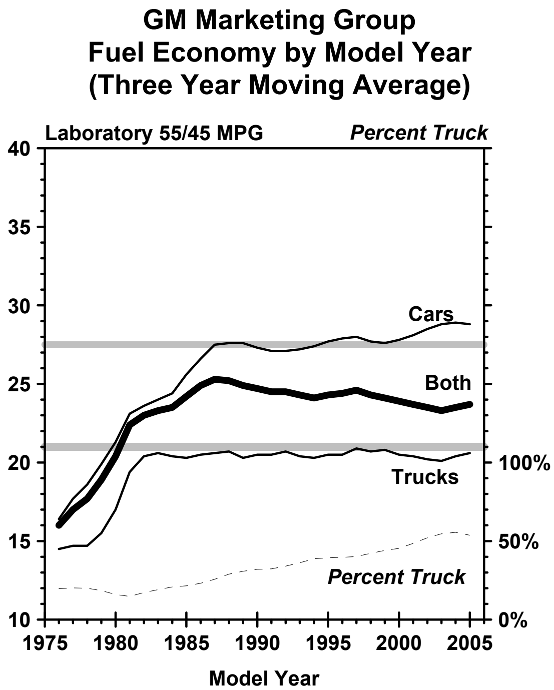

Figure 65

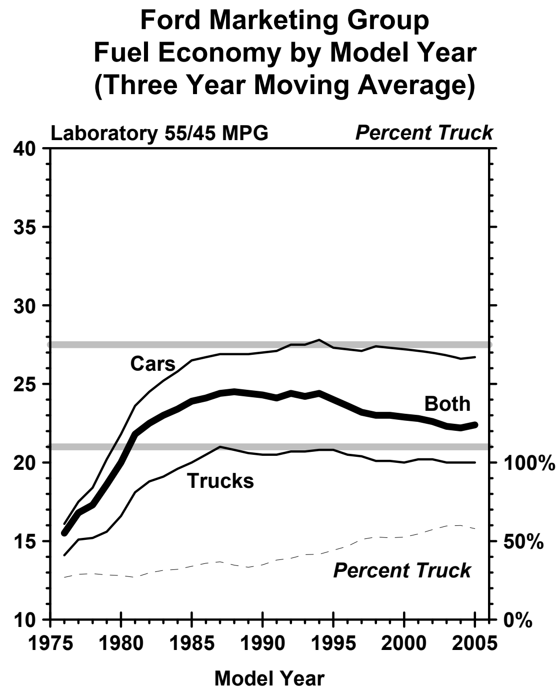

Figure 66

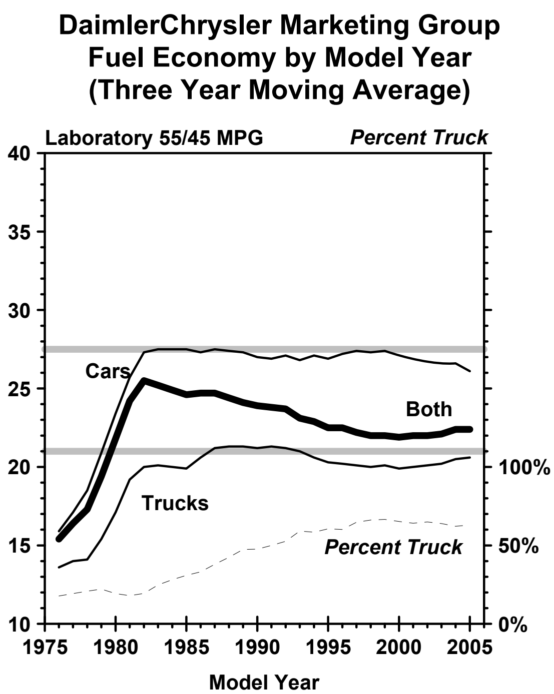

Figure 67

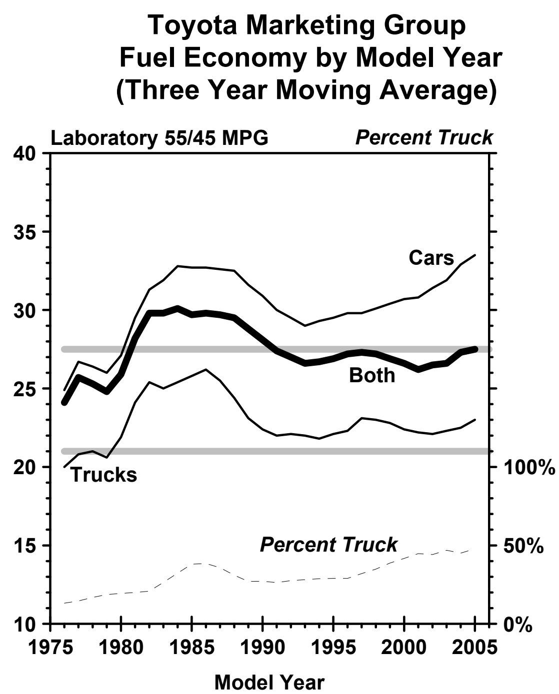

Figure 68

Honda Marketing Group
Fuel Economy by Model Year
(Three Year Moving Average)

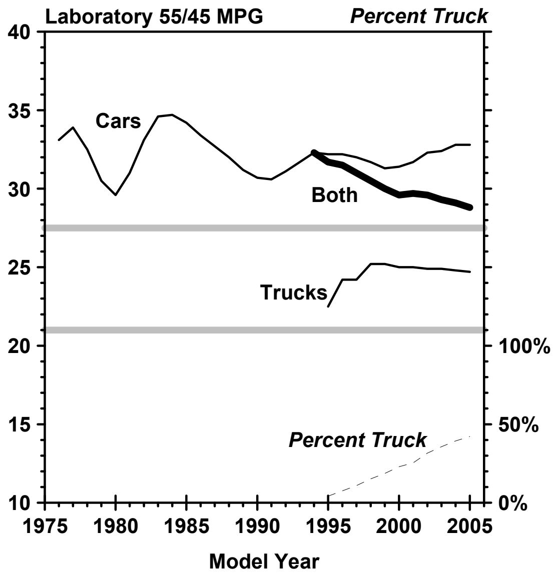

Figure 69

Nissan Marketing Group
Fuel Economy by Model Year
(Three Year Moving Average)

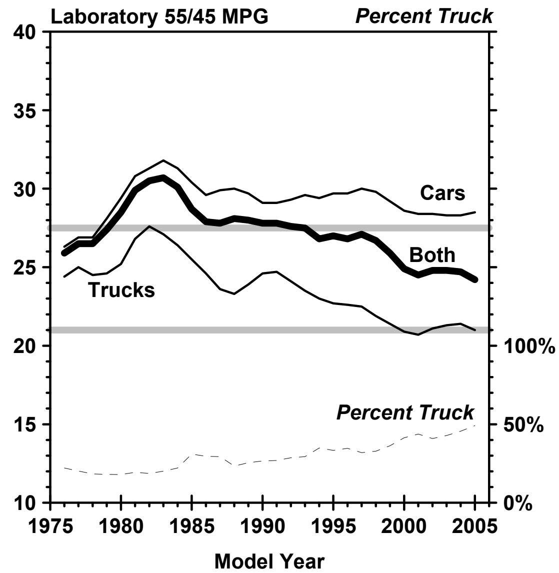

Figure 70

Hyundai-Kia Marketing Group
Fuel Economy by Model Year
(Three Year Moving Average)

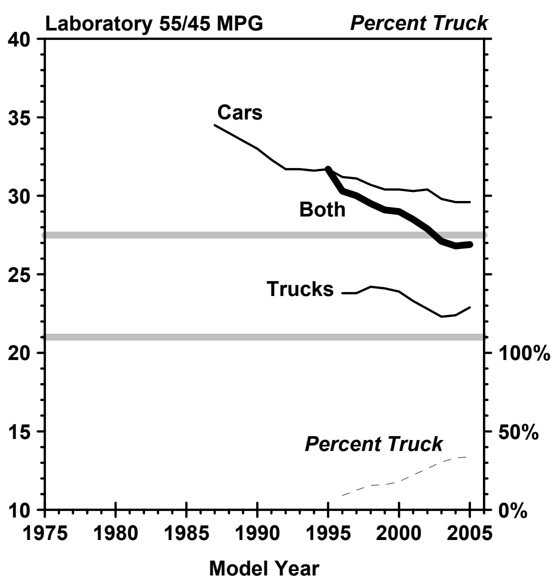

Figure 71

VW Marketing Group
Fuel Economy by Model Year
(Three Year Moving Average)

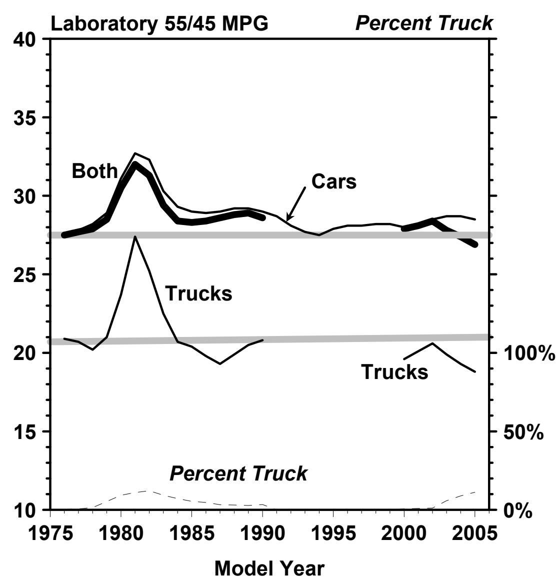

Figure 72

Normalized Fuel Economy
GM Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

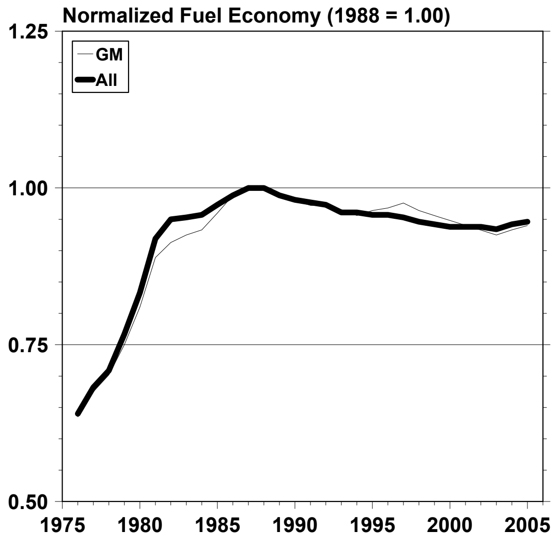

Figure 73

Normalized Fuel Economy
Ford Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

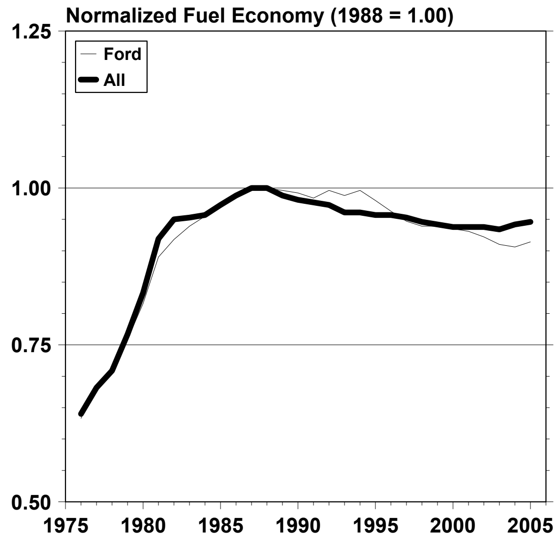

Figure 74

Normalized Fuel Economy
DC Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

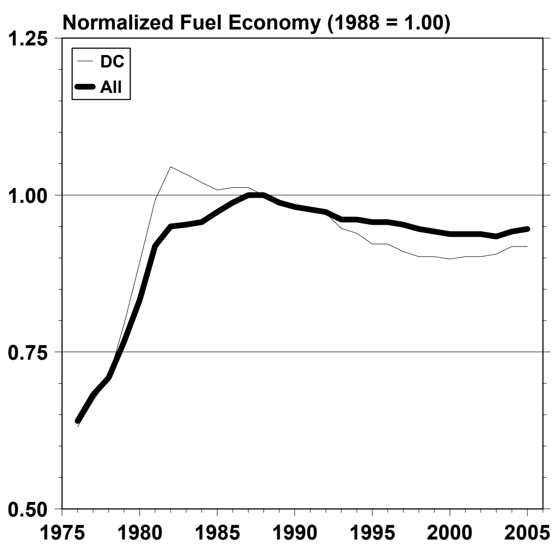

Figure 75

Normalized Fuel Economy
Toyota Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

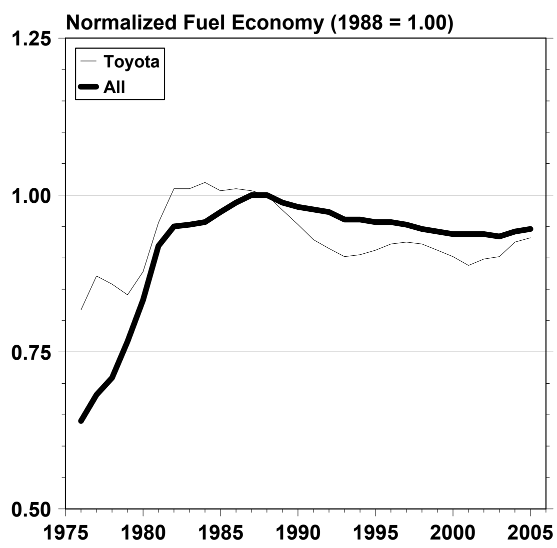

Figure 76

Normalized Fuel Economy
Honda Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

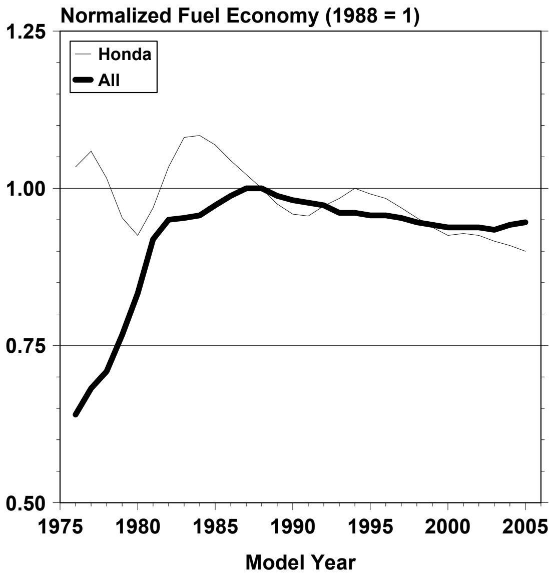

Figure 77

Normalized Fuel Economy
Nissan Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

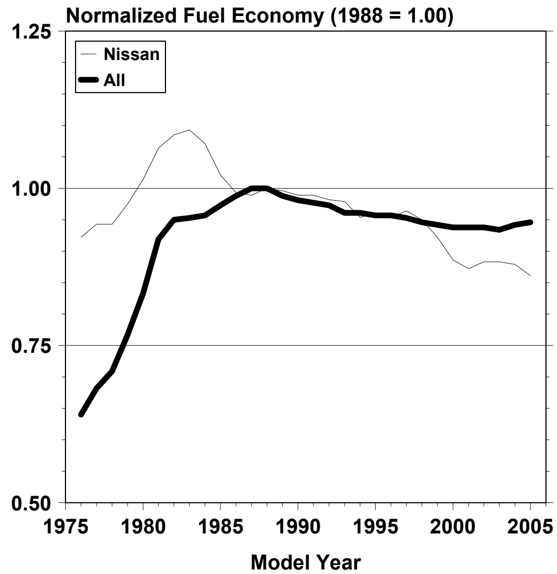

Figure 78

Normalized Fuel Economy
Hyundai Kia Group
(Three Year Moving Average)
Both Cars and Trucks

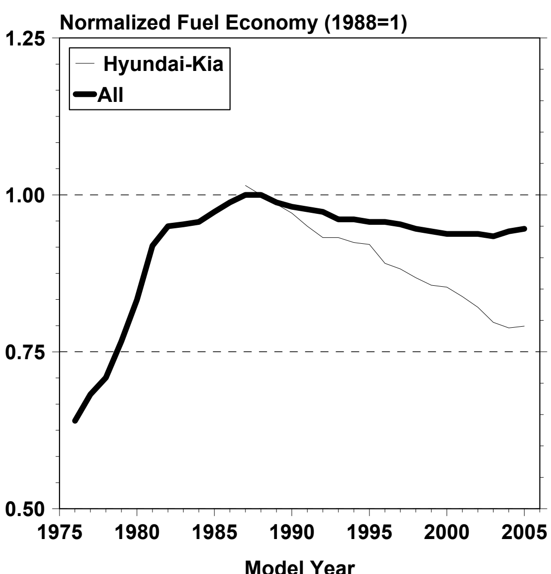

Figure 79

Normalized Fuel Economy
VW Marketing Group
(Three Year Moving Average)
Both Cars and Trucks

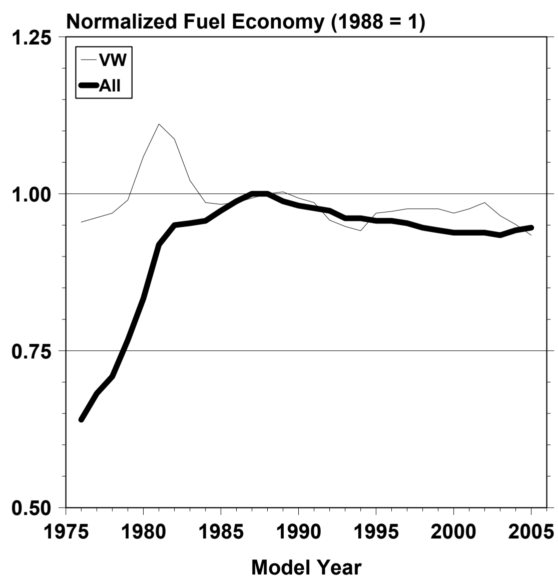

Figure 80

VII. **<u>Characteristics of Fleets Comprised of Existing Fuel-Efficient Vehicles</u>**

This section is limited to a discussion of hypothetical fleets of vehicles comprised of existing fuel-efficient vehicles and the fuel economy and other characteristics of those fleets. While it includes a discussion of some of the technical and engineering factors that affect fleet fuel economy, it does not attempt to evaluate either the benefits or the costs of achieving various fuel economy levels. In addition, the analysis presented here also does not attempt to evaluate the marketability or the public acceptance of any of the hypothetical fleets that result from the scenarios studied and discussed below.

There are several different ways to look at the potential for improved fuel economy from the light-duty vehicle fleet. Many of these approaches utilize projections of more fuel efficient technologies that are not currently being used in the fleet today. As an example, a fleet made up of a large fraction of fuel cell vehicles could be considered. Such projections can be associated with a good deal of uncertainty, since uncertainty in the projections of market share compound with uncertainties about the fuel economy performance of yet uncommercialized technology. These uncertainties can be thought of as a combination of technical risk, i.e., can the technology be developed and mass produced?, and market risk, i.e., will people buy vehicles with the improved fuel economy?

One general approach used in this report is to consider only the fuel economy performance of those technologies which exist in today's fleet. This eliminates uncertainty about the feasibility and production readiness of the technology and reduces or eliminates the technical risk but, as mentioned above, does not treat market risk. Therefore, the analysis can be thought of as the fuel economy potential now in the fleet, with no new technologies added, if the higher mpg choices available were to be selected.

As was shown in Figures 3 and 4, there is a wide distribution of fuel economy. Because of the interest in the high end of this spectrum, this portion of the database was examined in more detail using three "best in class" (BIC) analysis techniques. This type of technique is not new, and in fact was one of the methods used to investigate future fleet fuel economy capability when the original fuel economy standards were set.

In any group or class of vehicles there will be a distribution of fuel economy performance, and the "best in class" method relies on that fact. The analysis involves dividing the fleet of vehicles into classes, selecting a set of representative high mpg "role model" vehicles from each class, and then calculating the average characteristics of the resultant fleet using the same relative sales proportions as in the baseline fleet.

One potential problem with a BIC analysis is that the high mpg cars used in the analysis may be unusual in some way — so unusual that the hypothetical fleet made up of them may be deficient in some other attributes considered desirable by vehicle buyers. Because the BIC analysis is also sensitive to the selection of the best vehicles, three different procedures were used to select the role models.

Two of these selection procedures use the EPA car size classes (which for cars are the same as those used for the EPA/DOE *Fuel Economy Guide*) and the truck type/size classes described previously in this report. Note that this classification system includes nine car and nine truck classes and for this model year one of these eighteen classes is not represented (Small Vans). The third best-in-class role model selection procedure is based on using the vehicle inertia weight classes used for EPA's vehicle testing and certification process.

The advantage of using and analyzing data from the best-in-size class methods is that if the sales proportions of each class are held constant, the sales distribution of the resultant fleet by *vehicle type and size* does not change. This means that the size of the average vehicle does not change a lot, but there can be some fluctuation in interior volume for cars because of the distribution of interior volume within a car class. Similarly, there also is an advantage in using the inertia weight classes to determine the role models, since, if the sales proportions in each inertia weight class are held constant, the sales distribution of the resultant fleet by *weight* does not change, and in this case, the average weight remains the same.

One way of performing a best-in-class (BIC) analysis is to use as role models the four nameplates with the highest fuel economy in each size class. (See Tables Q-1 and Q-2 in Appendix Q.) Under this procedure, all vehicles in a class with the same nameplate are included as role models regardless of vehicle configuration. Each role model nameplate from each class was assigned the same sales weighting factor, but the original sales weighting distribution for different vehicle configurations within a given nameplate (e.g., transmission type, engine size, and/or drive type) was retained. The resulting values were used to recalculate the fleet average values using the same relative proportions in each of the size classes that constitute the fleet. In cases where two identical vehicles differ by only one characteristic but have slightly different nameplates (such as the two-wheel drive Chevrolet C1500 and the four-wheel drive Chevrolet K1500 pickups), both are considered to have the different nameplates. Conversely, in the cases where there are technically identical vehicles with different nameplates (e.g., the Buick LeSabre and Pontiac Bonneville sedans), only one representative vehicle nameplate was considered in the BIC analysis.

The second best-in-class role model selection procedure involves selecting as role models the best dozen vehicles in each size class with each vehicle configuration considered separately. Tables Q-3 and Q-4 in Appendix Q give listings of the representative vehicles used in this method. As with the previous procedure, in cases where technically identical vehicle configurations have different nameplates, only one representative vehicle was considered. Under this best-in-class method, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to re-calculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

The third best-in-class procedure involves selecting as role models the best dozen vehicles in each weight class. As with the previous method, each vehicle configuration was considered separately. (See Tables Q-5 and Q-6 in Appendix Q for a listing of the vehicles used in this analysis.) It should be noted that some of the weight classes have less than a dozen representative vehicles. In addition, as in the previous two best-in-class methods, where technically identical vehicle configurations with different nameplates are used, only one representative vehicle was included. As with the two best-in-size class methods, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to recalculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

Tables 32 to 34 compare, for cars, trucks, and both cars and trucks, respectively, the results of the best-in-class analysis with actual average data for model year 2006. As discussed earlier, for the size class scenarios, the percentage of vehicles that are small, midsize, or large are the same as for the baseline fleet, and in the weight class scenarios, the average weight of the BIC data sets is the same as the actual one. Average interior volume for cars in the BIC weight class analysis is within less than two percent of the actual average (i.e., 110 vs 112 cu. ft.). The slight difference in interior volume between the size class scenarios and the actual vehicle fleet can be attributed to the fact that, within a size class, there is considerable variation in interior volume (i.e., not all vehicles in each size class have exactly the same interior volume).

Under all of the best-in-class (BIC) scenarios, the vehicles used for the BIC analysis have less powerful engines, have slower 0-to-60 acceleration times, and are more likely to be equipped with manual transmissions than the entire fleet as a whole. For trucks, the BIC data set vehicles make greater use of front-wheel drive.

For both cars and trucks, the "Best 12 Vehicles" in Size Class scenario results in significantly higher fuel economy than the actual fleet, but the vehicles in the BIC size set are lighter than their counterparts from the other scenarios. Depending on the scenario chosen, for model year 2006, cars could have achieved from 17 to 22 percent better fuel economy than they did. Similarly, for trucks the fuel economy improvement ranges from 11 to 25 percent better fuel economy, and the combined car and truck fleet could have been 14 to 24 percent better.

The best-in-class analyses can be thought of as the mpg potential now in the fleet with no new technologies added if the higher mpg choices available were selected. As such, the best-in-class analyses provide a useful reference point indicating the variation in fuel economy levels that results in large part from consumer preferences as opposed to technological availability.

One of the characteristics of the best-in-class analysis is that it typically results in a hypothetical fleet of vehicles which has characteristics which may not be realistic for the U.S. market. For example, as a consequence of the methodology, the BIC analysis results in a larger fraction of manual and CVT transmissions than today's fleet does. This indicates there may be some potential for CVTs for the U.S. market, where automatic transmissions have dominated for many years.

Table 32

Best in Class Results 2006 Cars

Vehicle Characteristic	**Selection Basis**	**Actual Data**	**Size Class**	**Size Class**	**Weight Class**
	Selection Criteria	**All Cars**	**Best 4 Nameplates**	**Best 12 Vehicles**	**Best 12 Vehicles**
Fuel Economy	Lab. 55/45	28.8	35.0	34.3	33.8
	Adjusted City	21.6	27.0	26.2	25.8
	Adjusted Highway	29.6	34.5	34.2	33.8
	Adjusted 55/45	24.6	29.9	29.3	28.9
Vehicle Size	Weight (lb.)	3563	3224	3282	3563
	Volume (Cu. Ft.)	112	110	111	110
Engine	CID	176	134	136	138
	HP	198	153	150	168
	HP/CID	1.14	1.14	1.11	1.22
	HP/WT.	.055	.046	.045	.046
	Percent Multivalve	82%	89%	80%	79%
	Percent Variable Valve	62%	73%	66%	74%
	Percent Diesel	.2%	8%	12%	19%
Performance	0-60 Time (Sec.)	9.5	10.2	10.9	10.9
	Top Speed	137	125	123	127
	Ton-MPG	44.5	50.5	49.3	52.6
	Cu. Ft. MPG	2824	3490	3355	3282
	Cu. Ft. Ton-MPG	4976	5578	5473	5748
Drive	Front	76%	87%	91%	75%
	Rear	17%	10%	6%	11%
	4WD	6%	3%	3%	14%
Transmission	Manual	12%	31%	36%	30%
	Lockup	85%	55%	55%	60%
	CVT	3%	14%	7%	8%
Hybrid Vehicle		1.6%	14%	5%	4%

Table 33

Best in Class Results 2006 Trucks

Vehicle Characteristic	**Selection Basis**	**Actual Data**	**Size Class**	**Size Class**	**Weight Class**
	Selection Criteria	**All Trucks**	**Best 4 Nameplates**	**Best 12 Vehicles**	**Best 12 Vehicles**
Fuel Economy	Lab. 55/45	21.5	27.0	26.0	23.9
	Adjusted City	16.4	21.4	20.1	18.4
	Adjusted Highway	21.5	25.3	25.3	23.5
	Adjusted 55/45	18.4	23	22.2	20.4
Vehicle Size	Weight (lb.)	4711	4208	4128	4711
Engine	CID	246	197	188	221
	HP	239	199	199	227
	HP/CID	.99	1.02	1.06	1.05
	HP/WT.	.051	.047	.048	.048
	Percent Multivalve	59%	89%	89%	67%
	Percent Variable Valve	48%	56%	65%	49%
	Percent Diesel	.1%	—	---	3%
Performance	0-60 Time (Sec.)	9.9	9.8	10.2	10.2
	Top Speed	138	131	131	134
	Ton-MPG	43.5	50.1	46.4	48.6
Drive	Front	24%	43%	47%	30%
	Rear	25%	22%	25%	27%
	4WD	51%	35%	29%	43%
Transmission	Manual	4%	10%	18%	16%
	Lockup	94%	46%	64%	71%
	CVT	3%	45%	18%	14%
Hybrid Vehicle		1.0%	36%	12%	11%

Table 34

Best in Class Results 2006 Light Duty Vehicles

Vehicle Characteristic	**Selection Basis**	**Actual Data**	**Size Class**	**Size Class**	**Weight Class**
	Selection Criteria	**All Vehicles**	**Best 4 Nameplates**	**Best 12 Vehicles**	**Best 12 Vehicles**
Fuel Economy	Lab. 55/45	24.6	30.5	29.5	28.0
	Adjusted City	18.6	23.8	22.7	21.5
	Adjusted Highway	24.9	29.2	29.0	27.7
	Adjusted 55/45	21.0	26.0	25.2	23.9
Vehicle Size	Weight(lb.)	4142	3721	3709	4142
Engine	CID	211	166	162	180
	HP	219	176	174	198
	HP/CID	1.07	1.08	1.09	1.13
	HP/WT.	.053	.047	.047	.047
	Percent Multivalve	70%	89%	85%	73%
	Percent Variable Valve	55%	65%	65%	61%
	Percent Diesel	.2%	4%	6%	11%
Performance	0-60 Time (sec.)	9.7	10.0	10.5	10.5
	Top Speed	137	128	127	130
	Ton-MPG	44	50.3	47.9	50.6
Drivetrain	Front	50%	65%	69%	52%
	Rear	21%	16%	16%	19%
	4WD	29%	19%	16%	29%
Transmission	Manual	8%	20%	27%	23%
	Lockup	89%	50%	59%	66%
	CVT	3%	30%	13%	11%
	Hybrid	1.3%	25%	8%	7%

Another general approach for determining potential fuel economy improvement is to study the effects on fuel economy caused by the changes that have occurred in the distributions of vehicle weight and size. This technique involves preserving the average characteristics of vehicles within each size or weight strata in today's fleet, but re-mixing the sales distributions to match those of a baseline year and then calculating the fleet wide averages for those characteristics using the re-mixed sales data. The sales distribution of the resultant fleet by *vehicle type and size,* thus is forced to be the same as that for the base year. As with the best in car size class technique, there can be some fluctuation in average interior volume for cars because of the distribution of interior volume within a car class. Similarly, if the sales proportions in each inertia weight class are held the same as the base year's, the sales distribution of the resultant fleet by *weight* remains the same as that for the base year change, and the recalculated average weight is the same as the base year's. In should be noted that both hybrid and diesel vehicles were excluded from the analysis so that only vehicles with conventional powertrains were considered

Table 35 compares fuel economy, weight, interior volume, engine CID and HP, estimated 0-to-60 time and fuel economy for conventionally powered MY2006 cars as calculated from the actual 2006 sales distribution and then recalculated using the size and weight distributions from MY1981 and MY1988. This table includes the actual 1981 and 1988 fleet

Table 35

Characteristics of MY2006 Cars

Calculated From:	**Inertia Weight**	**Interior Volume**	**Engine CID**	**Engine HP**	**0 to 60 Time**	**Lab 55/45 MPG**
2006 Actual Distribution	3573	112	177	200	9.4	28.5
1981 Weight Distribution	3043	98	139	168	9.6	32.2
1988 Weight Distribution	3047	103	133	156	10.2	33.2
1981 Size Distribution	3494	108	170	194	9.5	29.0
1988 Size Distribution	3464	108	168	191	9.6	29.2
Reference: 1981 Actual	3043	106	178	99	14.1	24.9
Reference: 1988 Actual	3047	107	160	116	12.8	28.6
Percent Change:						
2006 Actual Distribution	0%	0%	0%	0%	0%	0%
1981 Weight Distribution	-15%	-13%	-21%	-16%	2%	13%
1988 Weight Distribution	-15%	-8%	-25%	-22%	9%	16%
1981 Size Distribution	-2%	-4%	-4%	-3%	1%	2%
1988 Size Distribution	-3%	-4%	-5%	-5%	2%	2%
Reference: 1981 Actual	-15%	-5%	1%	-51%	50%	-13%
Reference: 1988 Actual	-15%	-4%	-10%	-42%	36%	0%

averages as a point of reference. In both of the weight distribution cases, the fuel economy of the re-mixed 2006 fleet would have been higher than actually is: 13% if the 1981 weight distribution is used, 16% if the 1988 weight distribution is used. For both re-mixed weight cases, interior volume is smaller by 13 and 8 percent, respectively, and horsepower substantially lower. Using the MY1981 and MY1988 size mix distributions results in a much smaller change of only a two percent increase in car fuel economy.. In addition both of these remixed car class scenarios results in an average weight and horsepower for the hypothetical remixed fleets that is very close to the actual 2006 data.

Table 36 shows similar data for trucks, and as with the car class cases using either the 1981 or the 1988 sales distribution by weight class, results in higher recalculated fuel economy than using the corresponding size class sales distribution. Figures 81 to 84 compare actual fuel economy for all model years from 1975 to 2006 with what it would have been had the distributions of weight or size been the same as 1981 or 1988. For both cars and trucks, using either the 1981 or 1988 weight class distribution, results in significantly high fuel economy improvements than the similar size class cases. An obvious exception occurs for the base year's data because, by definition, the sales distributions and resultant averages can not change when a year's distribution is remixed to itself.

Table 36

Characteristics of MY2006 Trucks

Calculated From:	**Inertia Weight**	**Engine CID**	**HP**	**0 to 60 Time**	**55/45 MPG Lab.**
2006 Actual Distribution	4715	247	240	10.0	21.4
1981 Weight Distribution	3841	181	192	10.0	26.9
1988 Weight Distribution	3838	181	186	10.4	26.7
1981 Size Distribution	4684	247	236	10.1	21.3
1988 Size Distribution	4351	223	215	10.2	22.6
Reference: 1981 Actual	3841	252	121	14.4	19.7
Reference: 1988 Actual	3838	227	141	12.9	21.2
Percent Change:					
2006 Actual Distribution	0%	0%	0%	0%	0%
1981 Weight Distribution	-19%	-27%	-20%	0%	26%
1988 Weight Distribution	-19%	-27%	-23%	4%	25%
1981 Size Distribution	-1%	0%	-2%	1%	-0%
1988 Size Distribution	-8%	-10%	-10%	2%	6%
Reference: 1981 Actual	-19%	2%	-50%	44%	-8%
Reference: 1988 Actual	-19%	-8%	-41%	29%	-1%

Effect of Weight and Size On Car Fuel Economy

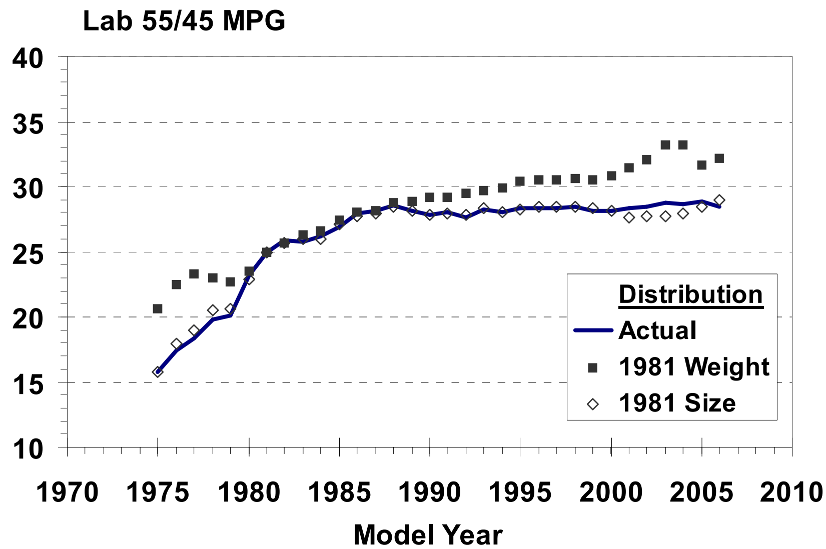

Figure 81

Effect of Weight and Size On Truck Fuel Economy

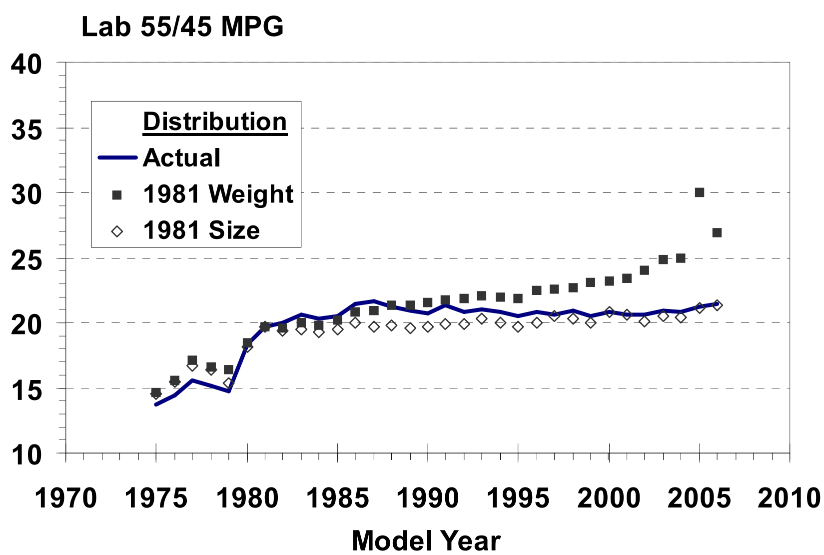

Figure 82

Effect of Weight and Size On Car Fuel Economy

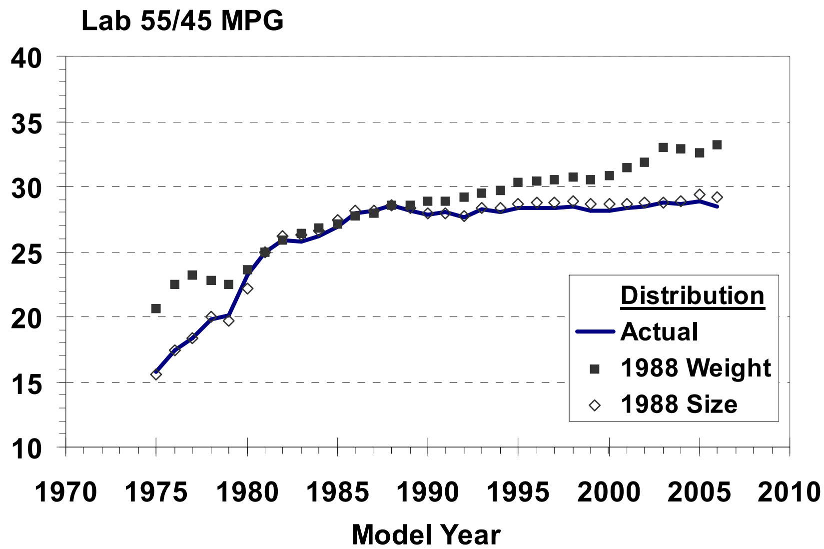

Figure 83

Effect of Weight and Size On Truck Fuel Economy

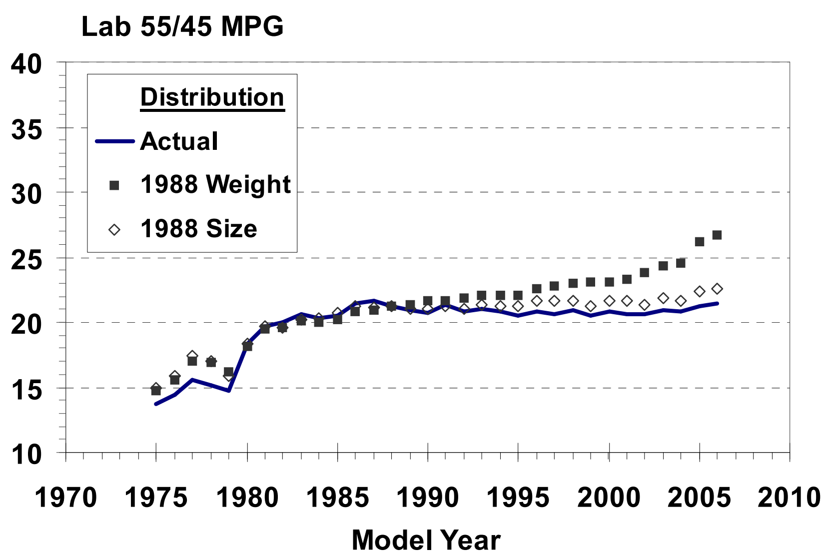

Figure 84

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