SWT-2017-5 MARCH 2017

ON-ROAD FUEL ECONOMY OF VEHICLES IN THE UNITED STATES: 1923-2015

MICHAEL SIVAK
BRANDON SCHOETTLE

SUSTAINABLE WORLDWIDE TRANSPORTATION
UNIVERSITY OF MICHIGAN

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Michael Sivak
Brandon Schoettle

The University of Michigan
Sustainable Worldwide Transportation
Ann Arbor, Michigan 48109-2150
U.S.A.

Report No. SWT-2017-5
March 2017

Technical Report Documentation Page

1. Report No. SWT-2017-5	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle On-Road Fuel Economy of Vehicles in the United States: 1923-2015		5. Report Date March 2017
		6. Performing Organization Code 383818
7. Author(s) Michael Sivak and Brandon Schoettle		8. Performing Organization Report No. SWT-2017-5
9. Performing Organization Name and Address The University of Michigan Sustainable Worldwide Transportation 2901 Baxter Road Ann Arbor, Michigan 48109-2150 U.S.A.		10. Work Unit no. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address The University of Michigan Sustainable Worldwide Transportation http://www.umich.edu/~umtriswt		13. Type of Report and Period Covered
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report documents and analyzes the changes in fuel economy of vehicles on U.S. roads between 1923 and 2015. Information about distances driven and fuel consumed was used to calculate the actual, on-road fuel economy for the entire fleet of all vehicles and for different classes of vehicles, with primary interest in light-duty vehicles (cars, pickup trucks, vans, and SUVs).

As a sample from the results, the following are the main findings for the entire fleet of all vehicles. Fuel economy *decreased* from 14.0 mpg in 1923 to 11.9 mpg in 1973. Starting in 1974, fuel economy increased rapidly to 16.9 mpg in 1991. Thereafter, improvements have been small, with fuel economy in 2015 at 17.9 mpg.

17. Key Words Road transportation, fuel economy, historical trends, cars, light trucks, medium- and heavy-duty trucks			18. Distribution Statement Unlimited
19. Security Classification (of this report) None	20. Security Classification (of this page) None	21. No. of Pages 10	22. Price

Contents

Introduction

This study is an update of the analysis in Sivak and Schoettle (2015). That study examined actual, on-road vehicle fuel economy in the United States from 1923 through 2013. The present study extends the data through 2015.

Method

The data for this analysis consisted of estimated miles driven per gallon of fuel for each year from 1923 through 2015. For 1923 through 1935, fuel economy was calculated by dividing the estimated distance driven (National Safety Council, 2007) by the estimated fuel consumption for highway use (U.S. Department of Commerce, 1957). For 1936 through 1985, fuel economy was calculated from the information in U.S. Department of Transportation (1987). Finally, online versions of annual statistics (U.S. Department of Transportation, annual) were the sources of the information for 1986 through 2015.

For 1923 through 1935, fuel-economy information is available only for the entire fleet of all vehicles. For 1936 through 1965, separate estimates are available for cars and trucks. For this time period, "cars" included motorcycles as well. However, the mileage driven by motorcycles represented only a negligible fraction of the total mileage. This is evidenced by the fact that in 1966 (the first year for which separate mileage information for motorcycles is available), motorcycles accumulated 0.3% of the combined mileage for cars and motorcycles (U.S. Department of Transportation, annual).

Starting in 1966, the U.S. Department of Transportation divided the truck category into other two-axle, four-tire vehicles (labeled here "light trucks"), single-unit, two-axle, six-tire trucks ("medium-duty trucks"), and combination trucks ("heavy-duty trucks").[1] The light-truck category originally included only pickup trucks, but was expanded to include vans and SUVs when they were introduced.

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[1] This classification of trucks by the number of axles and tires does not necessarily correspond to other classifications, such as a classification by gross vehicle weight rating (U.S. Department of Energy, 2015).

The analysis also examined the combined group of all light-duty vehicles. Prior to 2007, this group included cars and other two-axle, four-tire vehicles. Starting with 2007, the U.S. Department of Transportation changed the division of light-duty vehicles from cars and other two-axle, four-tire vehicles, to short-wheel-base light-duty vehicles and long-wheel-base light-duty vehicles. For simplicity, in the present report we will be referring to these two groups of vehicles as "cars" and "light trucks" throughout.

It is important to note that despite the change in 2007 in how all light-duty vehicles were subdivided, the overall classification of the combined group of all light-duty vehicles did not change in 2007.

Results

Figure 1 shows the changes in on-road vehicle fuel economy between 1923 and 2015.

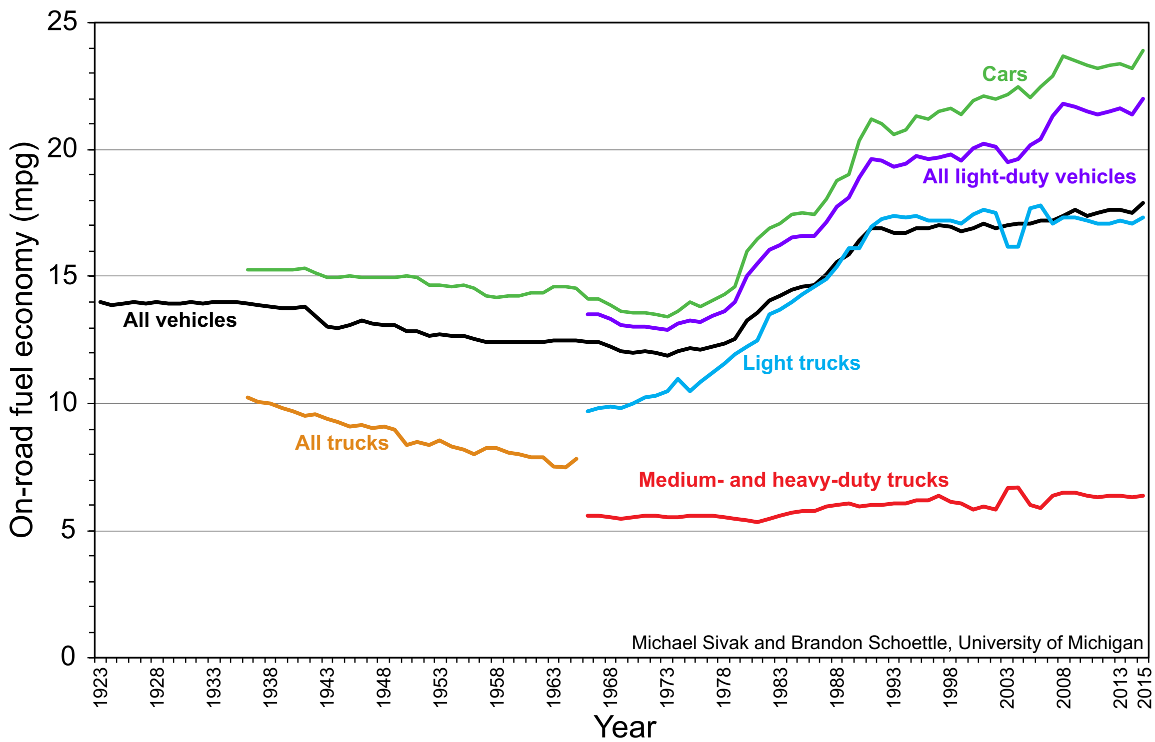

Figure 1. On-road fuel economy of vehicles from 1923 to 2015. (In 2007, there was a change in how light-duty vehicles were divided into cars and light trucks; see text.)

All vehicles (including cars, motorcycles, trucks, and buses)

From 1923 through 1935, on-road fuel economy stayed approximately constant at around 14 mpg. Starting in 1936, fuel economy gradually declined, falling to its lowest level, 11.9 mpg, in 1973—the year of the first oil embargo. Starting in 1974, fuel economy increased rapidly to 16.9 mpg in 1991. Thereafter, improvements have been small, with fuel economy reaching 17.9 mpg in 2015.

Cars

The data for cars follow a pattern similar to that of all vehicles. On-road fuel economy decreased from 1936 to 1973 (from 15.3 mpg to 13.4 mpg). This was followed by major improvements from 1973 to 1991 (from 13.4 mpg to 21.2 mpg). (The first Corporate Average Fuel Economy [CAFE] standards for new light-duty vehicles were enacted in 1975 and became effective with 1978 model year vehicles.) The improvements since 1991 were modest, with fuel economy at 23.9 mpg in 2015.

All trucks

For all trucks combined, the on-road fuel economy decreased from 10.2 mpg in 1936 to 7.8 mpg in 1965. (This trend likely reflects, in part, the increases in vehicle size and cargo loads.)

Medium- and heavy-duty trucks

Since 1966 (when light trucks were split into a separate category), on-road fuel economy of medium- and heavy-duty trucks has improved from 5.6 mpg to 6.4 mpg in 2015.

Light trucks

On-road fuel economy of light trucks increased rapidly from 9.7 mpg in 1966 to 17.0 mpg in 1991. However, the improvements since 1991 were small, with fuel economy at 17.3 mpg in 2015.

All light-duty vehicles (cars and light trucks)

On-road fuel economy of the combined group of all light-duty vehicles decreased from 1966 to 1973 (from 13.5 mpg to 12.9 mpg). This was followed by a rapid improvement to 19.6 mpg in 1991. However, the improvements since 1991 were only modest, with fuel economy at 22.0 mpg in 2015.

Discussion

Changes in fuel economy from 1923 to 1935

From 1923 through 1935, fuel-economy information is available only for the entire fleet of all vehicles. During this period, fuel economy stayed approximately the same (at around 14 mpg).

Changes in fuel economy from 1935 to 1973

Fuel economy *decreased* from 1935 to 1973. This was the case for the entire fleet, as well as for cars and all light-duty vehicles. However, this does not imply that powertrains for vehicles have not improved during this period. Instead of focusing on fuel-economy improvements, vehicle manufacturers focused on increasing power and acceleration.

Changes in fuel economy from 1973 to 2015

After the 1973 oil embargo, vehicle manufacturers achieved major improvements in fuel economy. However, the slope of the improvement has decreased substantially since 1991. For example, from 1973 to 1991, fuel economy of all light-duty vehicles improved from 12.9 mpg to 19.6 mpg, representing a compound rate of improvement of 2.4% per year. On the other hand, from 1991 to 2015, fuel economy improved from 19.6 mpg to 22.0 mpg, representing a compound rate of improvement of 0.5% per year.

Fleet turnover

One fundamental problem with improving the average fuel economy of the on-road fleet is that improvements in fuel economy for new vehicles take a long time to substantially influence the fuel economy of the entire on-road fleet. This is the case because it takes many years to turn over the fleet. For example, the 17.6 million light-duty vehicles sold in the United States in 2016 (CNN, 2017) accounted for only 6.7% of the entire fleet of 264 million registered light-duty vehicles (IHS Markit, 2017), and the average age of light-duty vehicle on the road is currently 11.6 years (IHS Markit, 2017).

Where do improvements matter most?

As has been eloquently argued by Larrick and Soll (2008), equal absolute increases in fuel economy result in greater absolute fuel savings as the baseline fuel economy of a vehicle decreases (despite what most of us intuitively believe). Consider the following two scenarios, each involving 12,000 miles of driving per year. In the first scenario, an improvement from 40 to 41 mpg yields a reduction of about 7 gallons of fuel per year. In the second scenario, an improvement from 15 to 16 mpg yields a reduction of 50 gallons of fuel per year.

This observation, however, does not necessarily argue that we should focus our efforts on those classes of vehicles that currently have the lowest fuel economy, such as medium- and heavy-duty trucks, and buses. For medium- and heavy-duty trucks, the relevant societal measure is not miles per gallon but ton-miles of freight per gallon. Alternatively, the relevant measure for buses is passenger-miles per gallon.

The above observations suggest that our focus should be on the lower tails of the distributions of fuel economy *in each vehicle class*. In other words, society has much more to gain from improving a car from 15 mpg to 16 mpg than from 40 mpg to 41 mpg. Similarly, the benefits to society are greater when improving a heavy-truck from 4 mpg to 4.5 mpg than from 7 mpg to 7.5 mpg (while keeping the load-carrying capacity the same).

Changes in fuel economy versus changes in energy consumed

The measure used in the present analysis—miles per gallon—is based on the distance driven (in miles) and the amount of fuel consumed (in gallons). The following considerations do not allow us to make direct inferences from the presented data regarding changes in total energy consumed (e.g., total Btu).

Gasoline versus diesel. The energy content of diesel is about 14% greater per volume than the energy content of gasoline (EIA, 2017). No attempt was made to document the proportion of gasoline to diesel usage, or to account for changes in that proportion over time.

Ethanol. The energy content of ethanol is about 33% less than the energy content of pure gasoline (EIA, 2016). In 2015, ethanol accounted for about 10% of the total volume of finished gasoline consumed in the United States (EIA, 2016), primarily due to sales of ethanol blends such as E10 (10% ethanol; 97% of all gasoline sold) and E85 (also called flex fuel; 51%-83% ethanol) (AFDC, 2017b). Again, no attempt was made to document the proportion of ethanol to pure gasoline usage, or to account for changes in that proportion over time.

Biodiesel. As with ethanol-blended gasoline, biodiesel blends contain slightly less energy per volume than petroleum diesel. For example, B20 (6% to 20% biodiesel) contains about 1-2% less energy than petroleum diesel, while B100 (100% biodiesel) contains approximately 7% less energy than petroleum diesel (AFDC, 2017a). Similarly, no attempt was made to document the proportion of biodiesel to petroleum diesel usage, or to account for changes in that proportion over time.

Plug-in vehicles. Plug-in hybrids consume some electric energy (in addition to consuming gasoline), while battery-electric vehicles rely entirely on electric energy. However, the contribution of electric energy to the total energy consumed by all light-duty vehicles is currently very small: Even if *all* plug-in vehicles that were sold in the U.S. through December 2015 (about 406,000; Inside EVs, 2017) were still on the road, they would represent only about 0.2% of all registered light-duty vehicles in 2015.

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