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# Effects of Vehicle Fuel Economy, Distance Travelled, and Vehicle Load on the Amount of Fuel Used for Personal Transportation in the U.S.: 1970-2010

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16. Abstract

This study examined the changes in the U.S. in vehicle fuel economy, distance travelled, and vehicle load (occupants carried) between 1970 and 2010, and the effects of those changes on the amounts of fuel consumed. All light-duty vehicles were included in the analysis.

The results indicate that during the 40-year period examined, vehicle distance travelled increased by 155%. However, because vehicle load decreased by 27%, occupant distance travelled increased by only 84%. Vehicle fuel economy (of the entire fleet of light-duty vehicles) improved by 40%. However, because of the decrease in vehicle load, occupant fuel economy improved by only 17%. As a consequence of the changes in vehicle fuel economy, vehicle distance travelled, and vehicle load, the total amount of fuel used increased by 53%.

Also included in the report is a brief discussion of the effects of potential future changes in vehicle fuel economy, vehicle distance travelled, and vehicle load on the amount of fuel used. Considerations included were increased vehicle distance travelled as a consequence of improved vehicle fuel economy, and decreased vehicle distance travelled and worsened vehicle fuel economy as consequences of increased vehicle load.

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## Contents

# Introduction

The amount of fuel consumed for personal transportation using vehicles with internal combustion engines depends on three major parameters: vehicle fuel economy of the entire fleet, vehicle distance travelled, and vehicle load (occupants carried). This study examines (1) the changes in the U.S. in these three parameters between 1970 and 2010, and the effects of those changes on the amounts of fuel consumed, and (2) the potential effects of future changes in these three parameters on reductions of fuel used for personal transportation.

# Method

The analysis was based on 1970 and 2010 data from the U.S. Department of Transportation (RITA, 2013) on the extent of travel in personal vehicles and the fuel consumed. Both short wheelbase and long wheelbase light-duty vehicles were included in the analysis.

## Results

Table 1 presents basic facts concerning personal transportation in 1970 and 2010 based on the information in RITA (2013). During the 40-year period examined, vehicle distance travelled increased by 155% (from 1.674 to 4.261 trillion km). However, because vehicle load decreased by 27% (from 1.9 to 1.38 occupants), occupant distance travelled increased by only 84% (from 3.182 to 5.867 trillion km).

Vehicle fuel economy (of the entire fleet of light-duty vehicles) improved by 40% (from 18.1 to 10.9 liters per 100 km). However, because of the decrease in vehicle load, occupant fuel economy improved by only 17% (from 9.5 to 7.9 liters per 100 km).

As a consequence of the changes in vehicle fuel economy, vehicle distance travelled, and vehicle load, the total amount of fuel used increased by 53% (from 303 to 463 billion liters).

Table 1
Basic facts concerning personal transportation in the U.S. in 1970 and 2010.

| Measure | 1970 | 2010 | Change |
|---|---|---|---|
| Vehicle distance travelled (million km) | 1,673,717 | 4,260,994 | +155% |
| Fuel consumed (million liters) | 303,333 | 463,233 | +53% |
| Vehicle fuel economy (liters per 100 km) | 18.1 | 10.9 | -40% |
| Occupant distance travelled (million km) | 3,181,673 | 5,866,651 | +84% |
| Occupant fuel economy (liters per 100 km) | 9.5 | 7.9 | -17% |
| Vehicle load (persons) | 1.9 | 1.38 | -27% |

## Discussion

Effects of potential future changes in vehicle fuel economy, vehicle distance travelled, and vehicle load on reductions of energy used for personal transportation are discussed below.

### Improvement in vehicle fuel economy

Fuel consumption (in liters per 100 kilometers, but not in miles per gallon) is a linear function of vehicle fuel economy. The nominal reduction in fuel consumed due to improvements in vehicle fuel economy, however, needs to be adjusted because improved vehicle fuel economy leads to an increase in the distance travelled (the so-called rebound effect). EPA recommends using a rebound effect of 10% (EPA, 2011), meaning that 10% of the gain in vehicle fuel economy is assumed effectively to be lost due to an increased amount of travel.

Let's consider an example of a 20% improvement in vehicle fuel economy from the actual value in 2010—from 10.9 to 8.7 liters per 100 km. Taking the rebound effect into account would result in an effective vehicle fuel economy of 8.9 liters per 100 km—a net improvement of 18%.

Importantly, however, changes in fuel economy of new vehicles take a long time to substantially influence the fuel economy of the entire fleet. This is the case because it takes a long time to turn over the fleet. For example, the 14.5 million light-duty vehicles sold in 2012 (Reuters, 2013), accounted for only about 6% of the entire fleet of light-duty vehicles.[1] Consequently, an 18% reduction in fuel used by vehicles purchased in a given year (due to a 20% improvement in their fuel economy) would result in only about a 1% reduction of the fuel used by the entire fleet. The required long lead time to substantially influence the fuel economy of the entire fleet was one of the facts used recently by Karplus, Paltsev, Babiker, and Reiley (2013) to argue that policy emphasis should be on reducing vehicle distance travelled through an increased fuel tax (which would have an immediate fleet-wide effect).

[1] The latest data—for 2010 (FHWA, 2013)—indicate that there are about 230 million light-duty vehicles.

## Reduction in vehicle distance travelled

The amount of fuel consumed is directly proportional to vehicle distance travelled (holding everything else constant). Thus, a 20% decrease in vehicle distance travelled (e.g., by an increase in telecommuting) would translate into a 20% reduction in fuel used.

## Increase in vehicle load

Increasing vehicle load (through various forms of ride sharing) has two effects. One effect is a reduction in vehicle distance travelled. However, vehicle distance travelled is not inversely related to vehicle load. For example, if two people share a ride of the same distance, the total vehicle distance travelled is generally reduced not by 50% but by a smaller amount. This is the case because sharing a ride requires making a detour to accommodate the added passenger (unless both occupants have the same origin and destination). There are no reliable estimates about the eventual, total, vehicle distance travelled; for the present calculations we will assume that when two persons share a trip of the same length, the total vehicle distance travelled is reduced by 45%. For example, if each person's individual trip were 100 km, the combined trip would be 110 km long (110 km being 55% of 200 km).

The other effect of increasing vehicle load is a worsening of vehicle fuel economy because of the added weight. However, this effect is relatively small: EPA (2012) estimates that each additional 45 kg can worsen vehicle fuel economy by up to 2%.

So what would be the net consequence of increasing vehicle load by 20% (from the current 1.38 to 1.66 occupants)? Vehicle distance travelled would be reduced by about 15%, while vehicle fuel economy would worsen by about 1% (because the additional load for 0.28 of an average person weighing 80 kg [CDC, 2013] is about 22 kg). Combining these two effects yields a reduction of about 14% in the amount of fuel used.

## Comparing the effects

Table 2 provides a summary of the estimated reductions in the amount of fuel used by 20% improvements in vehicle fuel economy of the entire fleet, vehicle distance travelled, and vehicle load.

Table 2
Estimated reductions in the amount of fuel used by 20% improvements in vehicle fuel economy of the entire fleet, vehicle distance travelled, and vehicle load.

| Parameter change | Change in the amount of fuel used |
|---|---|
| 20% improvement in vehicle fuel economy of the entire fleet | -18% |
| 20% decrease in vehicle distance travelled | -20% |
| 20% increase in vehicle load from current load | -14% |

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