New Methodology for Estimating Fuel Economy by Vehicle Class

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Introduction and Objectives

Oak Ridge National Laboratory (ORNL) was tasked by the Federal Highway Administration (FHWA) to develop a new methodology for estimating annual average fuel efficiency and number of motor vehicles registered by vehicle class for Table VM-1 of *Highway Statistics*. The objectives are:

- Use the most up-to-date data from federal agencies such as FHWA and other credible sources
- Employ a theoretically sound and well-established model
- Reconcile fuel efficiency and fuel usage data with VM-1 data
- Develop a computer model to simplify user interactions
- Generate more reliable and consistent estimates by vehicle class of fuel economy and number of motor vehicles registered for Table VM-1

Conceptual Framework

Two-Step Approach

First Step:

Preliminary fuel efficiency rates are estimated based on vehicle stock models for different classes of vehicles.

Second Step:

A reconciliation model is used to adjust the initial fuel consumption rates and preliminary VMT information from the Highway Performance Monitoring System (HPMS) to match the fuel consumption information published in Table MF-21 of *Highway Statistics*.

System Design And Data

- Implemented in a Microsoft Office 2007 Excel-based program under the Windows 7 operating system
- User interface allows user to initiate program runs with a simple click
- Data on fuel economy, VMT, and population were gathered for five vehicle classes for 1998-2008
- Vehicle stock models were constructed using this data for 1998-2008
- The reconciliation model was executed to produce new MPG estimates for 1998-2008

Vehicle Stock Model

- Also known as vehicle fleet models
- Econometric models used by transportation analysts and traffic engineers to estimate/forecast policy impacts related to the overall fleet performance
- Used to study the introduction of new and the scrappage of old vehicles by different vintage model years
- Separate vehicle stock models were constructed for five vehicle classes:
  - Passenger vehicle
  - Light truck
  - Motorcycle
  - Bus
  - Heavy truck
- These stock models are theoretically similar, with variations as a result of availability of data (e.g., the motorcycle stock model was based on engine size rather than fuel type)

Passenger Vehicle Stock Model Example

The passenger vehicle stock model can be expressed mathematically as:

$$Passenger\ Veh\ MPG_f = \frac{\sum_y VMT_y \times Pop_{yf}}{\sum_y \frac{VMT_y \times Pop_{yf}}{MPG_y}}$$

$VMT_y = average\ annual\ VMT\ \ per\ vehicle\ \ for\ model\ year\ y$

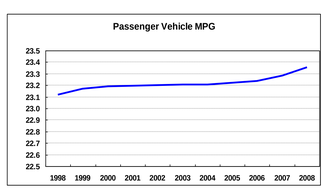
$MPG_{yf} = fleet\ \ MPG\ \ for\ model\ year\ y\ and\ \ fuel\ type\ \ f$

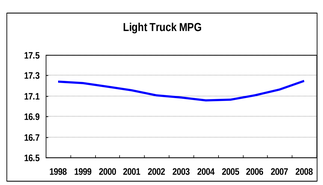
$Pop_{yf} = number\ of\ \ vehicles\ in\ operation\ \ for\ model\ year\ y\ and\ \ fuel\ type\ \ f$

Data Used in Passenger Vehicle Stock Model

- Number of vehicles in operation is from Polk's National Vehicle Population Profile (NVPP)
- VMT information is from the 2009 National Household Travel Survey (NHTS)
- Fleet fuel economy data is from the EPA's *Light-duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2009*

Results





MPG estimates generated from passenger car stock model consistent with industry trends. Modest improvement over time on fuel economy prior to 2004. Significantly higher fuel prices increased demand for more fuel efficient vehicles. MPG estimates generated from the light truck stock model are also consistent with industry trends.

MPG & VMT Reconciliation Model

- Inputs:
  - VMT information from Table VM-1 of *Highway Statistics*
  - Fuel efficiency estimates from the vehicle stock models and previous year's Table-VM-1
- Estimates MPG by vehicle type subject to the following constraint:
  - Fuel consumption estimates by vehicle type must sum to the current year's total fuel consumption estimate published in Table MF-21

$$Minimize\ \sum_v \sum_f \left[\frac{\boldsymbol{MPG_{vf}^t} - MPG_{vf}^{VS}}{MPG_{vf}^{VS}}\right]^2 + \left[\frac{\boldsymbol{MPG_{vf}^t} - MPG_{vf}^{t-1}}{MPG_{vf}^{t-1}}\right]^2$$

$$Subject\ to: \quad \sum_v \left[\frac{\sum_h VMT_{vhf}^t}{\boldsymbol{MPG_{vf}^t}}\right] = Total\ Fuel_f^t$$

$VMT_{vhf}^t = current\ year\ VMT\ \ for\ vehicle\ type\ v\ highway\ class\ h\ and\ \ fuel\ type\ \ f$

$\boldsymbol{MPG_{vf}^t} = current\ year\ MPG\ \ for\ vehicle\ v\ and\ \ fuel\ type\ \ f$

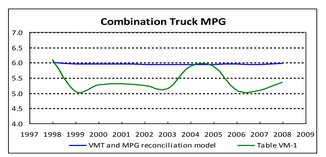
$MGT_{vf}^{t-1} = previous\ year\ MPG\ \ for\ vehicle\ v\ and\ \ fuel\ type\ \ f$

$MPG_{vf}^{VS} = vehicle\ stock\ model\ MPG\ \ for\ vehicle\ v\ and\ \ fuel\ type\ \ f$

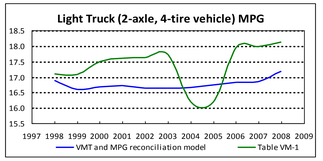
$Total\ Fuel_f^t = current\ year\ total\ \ fuel\ consumption\ \ for\ \ fuel\ type\ \ f$

Results

For 1998-2003 MPG passenger vehicle results from the reconciliation model are similar to those published in Table VM-1 of Highway Statistics. Since 2004, passenger vehicle MPG results from the reconciliation model are higher and with less variation than those published in Table VM-1.



The combination truck MPG estimates produced by the reconciliation model are higher than those published in Table VM-1 and show very little variation.



The systematic reconciliation model produces lower MPG estimates for light truck when compared with estimates published in Table VM-1. The dip shown in published Table VM-1 between 2003 and 2006 was not observed under the new model. This dip was pointed out as an anomaly by Greene in the "Rebound 2007: Analysis of U.S. Light-duty Vehicle Travel Statistics".

On-going Improvements

- New classification based on wheel spacing of passenger vehicles (121" and less) and light trucks (greater than 121")
- More detailed MPG and VMT information was used in the construction of the passenger vehicle and light truck stock models
  - Previously, data was collected by vehicle class and model year
  - Currently, data is being collected by make, model, model year, and vehicle class (i.e., passenger vehicle and light truck.