Evaluating the Effect of Fuel Economy Standards on Driver Safety

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Overview
New Federal corporate average fuel economy (CAFE) standards are currently set to increase from 33.3 to 37.8 miles per gallon for cars and 25.4 to 28.8 mpg for trucks by 2016 and are likely to substantially increase thereafter. A common strategy to meet this standard is to decrease vehicle weight. This project creates a data set to analyze accident frequency and severity as a function of vehicle weight. Series of OLS estimations are utilized to explore relationships between factors of vehicle death rates, carbon emissions, and vehicle operation costs and vehicle weight. We find that safety gains for drivers of heavier cars exceed decreases in safety for those in other vehicles. Overall, it seems as though lowering the weight of cars as a reaction to stricter CAFE standards will lead to

Data
- National Household Travel Survey (2009)
  - Driver and travel pattern information such as percentage of miles driven by males
- Fatality Analysis Reporting System (2009)
  - Accident information for fatal accidents
- Consumer Reports
  - Basic Vehicle Information such as weight or size

Modeling Vehicle Accident Death Rates
The death rate for a particular make, model, and generation of a vehicle \( i \) can be found by:

\[
\text{Death Rate}_i = (RR)(P)_i(\text{RR})
\]

Where
- \( RR \) = Mean Accident Rate: Accident rate for average vehicle
- \( RR \) = Relative Risk: Accident rate for a vehicle type \( i \) / \( RR \)
- \( P \) = Fatality Risk; Probability of dying, given that vehicle is in accident

With respect to this study:
- Death Rate per mile driven is found from FARS and NHTS data
- RR is an unknown constant

Calculating Fatality Risk
For each two car accident in the FARS dataset, the make/model/generation (MMG) of each car was recorded along with whether the driver of the car died as a result of the accident. The likelihood of observing a particular pattern of deaths in the two cars is a function of the probability of driver death for the particular MMG of cars in the accident.

For example, if a MMG 3 car was in an accident with a MMG 113 car, the likelihood of the three possible combinations of deaths would be:

\[
l = \begin{cases} 
\frac{p_3p_{113}}{p_3 + p_{113} - p_3p_{113}} & \text{if } d_3 = d_{113} = 1 \\
\frac{p_3 + 1 - p_{113}}{p_3 + p_{113} - p_3p_{113}} & \text{if } d_3 = 1 & d_{113} = 0 \\
\frac{p_3 + p_{113} - p_3p_{113}}{p_3 + p_{113} - p_3p_{113}} & \text{if } d_3 = 0 & d_{113} = 1 \\
\end{cases}
\]

Where \( p_i \) is the probability of driver death for MMG \#i and \( d_i \) is equal to one if the driver of the MMG \#n car died. The likelihood function is the product of many such terms. Maximum likelihood estimates for the probability of driver death for each MMG of car were obtained using Matlab. A similar procedure was used to obtain the probability of death of the driver of the other car for each MMG of car.

Exploring Relative Risk
We find a value proportional to the true relative risk ratio by \( RR_{prop} = (Death Rate)/P \) and explore the relationship of \( RR_{prop} \) to weight through OLS with robust standard errors. The first model has no controls, the second includes a set of demographic variables for drivers of each vehicle type. Finally, a model is estimated with a dummy variable for each make.

<table>
<thead>
<tr>
<th>Dependent Variable: Relative Risk</th>
<th>No Controls</th>
<th>Demographic</th>
<th>Vehicle Make</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Weight</td>
<td>3.41e-12</td>
<td>-3.18e-13</td>
<td>-9.59e-13</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.02</td>
<td>0.36</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Differences across \( RR \) are due to other vehicle characteristics besides vehicle weight. For example, driver selection could be at play.

Fatality Risk's Relationship to Vehicle Weight
Using the values of \( P \) for those driving a particular vehicle and those involved in an accident with that vehicle it is possible to explore the effect of changes in vehicle weight on fatality risks and death rate. First the following model is estimated with OLS for both internal and external fatality risk:

\[
P = \beta_0 + \beta_1(\text{weight}) + \beta_2(\text{weight})^2
\]

Then for a set vehicle weights ranging from 2,500-6,500 pounds predicted P values are found from the coefficients estimates. This equation is also used to find \( d(P)/d(weight) \).

Marginal Percent Changes in Fatality Risk as a Function of Weight

Carbon Costs of Vehicle Weight
Similar to the fatality risk procedure the change in carbon dioxide emissions due to weight is found by estimating

\[
CPM = \beta_1(\text{weight}) + \beta_2(\text{weight})^2
\]

and predicting values for the weight range. Carbon dioxide/mile is derived from Consumer Report's gas mileage changes in safety and environmental costs.

Comparing Safety and Environmental Effects
To find the net cost of driving heavier vehicles it is necessary to convert gains in driver safety and environmental costs to the same unit. We monetize both effects:

1) The value of statistical lives saved by increasing weight \( D(VSL)/dVt = \text{Death rate change/trillion mi}) \times $10,000,000
   - Survey by Viscusi and Aldi
2) The cost of increasing carbon emissions
   \( D(Carbon)/dVt = \text{Tons of Carbon Change/trillion mi}) \times $67
   - Environmental Protection Agency highest estimate
3) The cost of purchasing and driving a heavier vehicle
   Cost Per Mile = \( \beta_1(\text{weight}) \)
   - Consumer Reports purchase, fuel, insurance, etc. costs breakdown of vehicle weight costs

Preliminary Results
- Reducing car weight to comply with stricter CAFE standards will likely lead to an increase in automobile accident deaths.
- The marginal private cost of increased car weight is significantly higher than internal safety benefits, external safety costs, and environmental costs. This suggests that reducing the weight of cars could lead to private costs that greatly exceed the private safety costs and externalities measured in this study.

Acknowledgements
Special Thanks to Dr. Damien Sheehan-Connor for all his assistance and support in the completion of the project. I am grateful to Emmanuel Kaparakis for the data analysis lessons.