Improving Automotive Fuel Efficiency Through Engine Optimization

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Background

Data

Dataset*:

- 398 cars from 1970 - 1982
- Attributes (MPG, cylinders, displacement, horsepower, weight, acceleration, year, and name)
- For statistical software demonstration at the 1983 American Statistical Association Exposition

Cleaning:

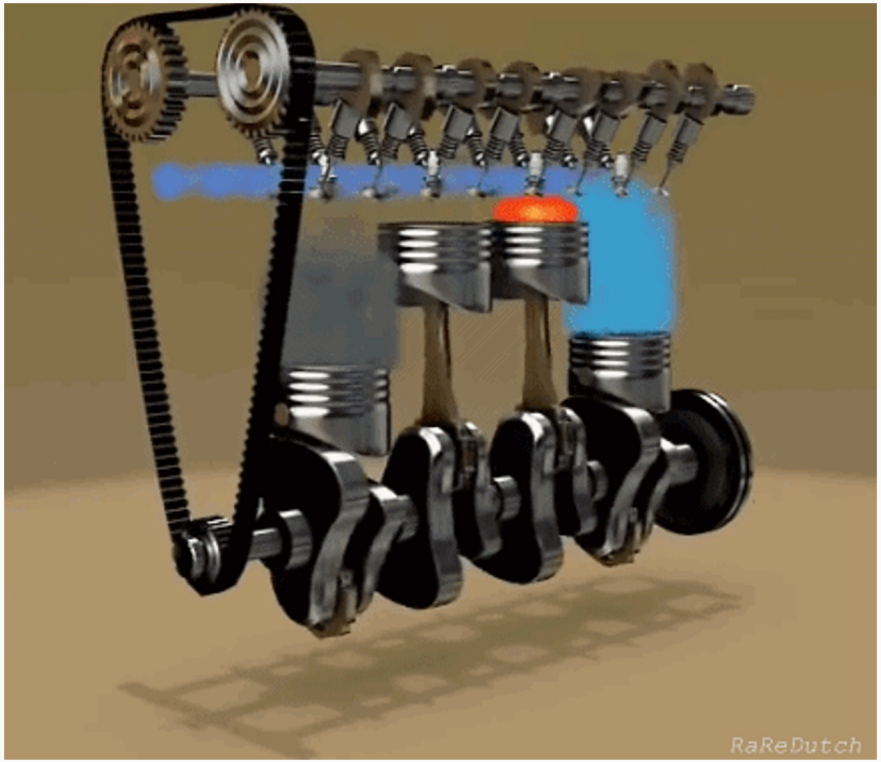
- Removed: null horsepower values & duplicate models from previous years

Observations:

- 398 -> **302**

*Dua, D. and Graff, C. (2019). UCI Machine Learning Repository (https://archive.ics.uci.edu/ml/datasets/Auto+MPG)

Key Concepts



Displacement: the volume of air swept through an engine cylinder in a single revolution (in cubic inches)

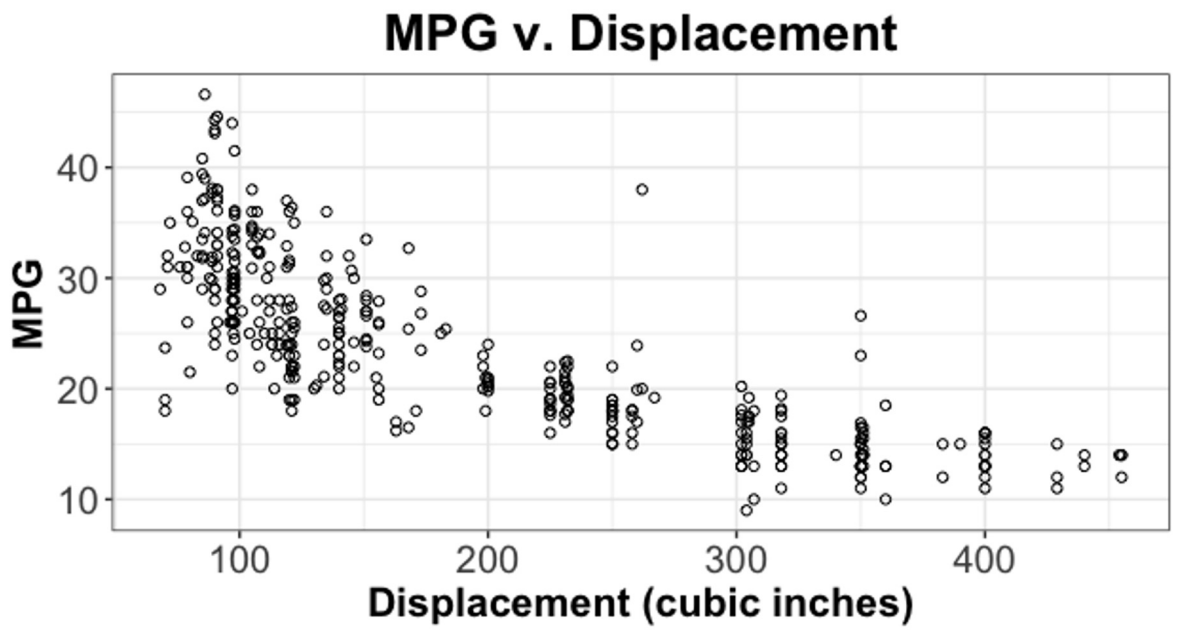
Horsepower: refers to the power an engine produces - calculated through the power needed to move 550 pounds one foot in one second

Cylinders: chambers where fuel is combusted and power is generated - consists of a piston and inlet/exhaust valves

Weight: weight of entire vehicle (in pounds)

Acceleration: time for vehicle to go from 0 to 60 mph (in seconds)

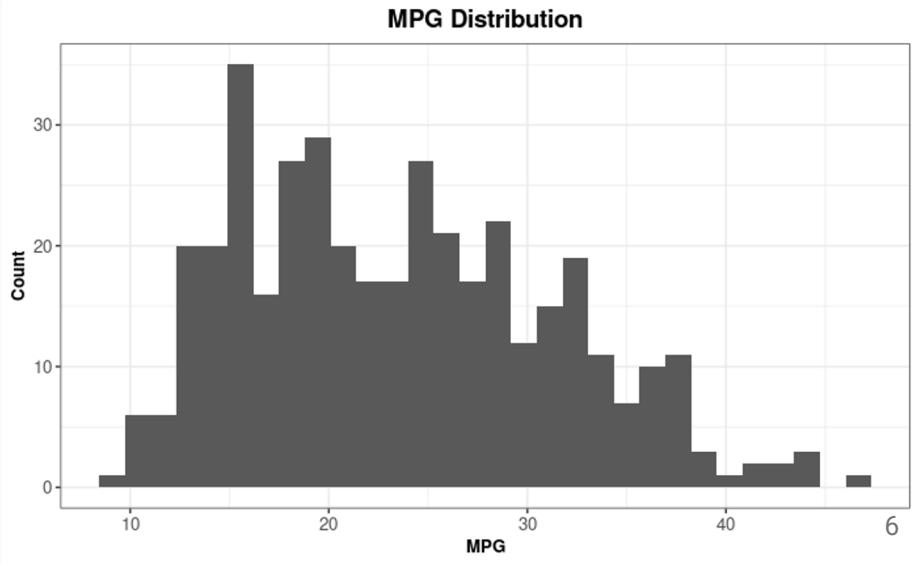
Key Modeling Decisions



$$\widehat{MPG} = \beta_0 - \beta_1 \cdot displacement - \mathbf{Z}\gamma$$

Key Modeling Decisions Cont.

- Large Sample Assumptions (n > 100)
  - **I.I.D**
    - Clustering effects due to multiple models from one manufacturer
    - Clustering from manufacturing year
  - **A Unique BLP**
    - Impossible to have infinite mpg
    - No major clustering of data
      - Allows for one linear predictor



Results

Table 1: Summary Statistics of Models

	Dependent variable:			
	Miles Per Gallon (MPG)			
	(1)	(2)	(3)	(4)
Displacement (cubic inches)	-0.07^{***}	-0.17^{***}	-0.11^{***}	-0.09^{***}
	(0.003)	(0.02)	(0.02)	(0.02)
Displacement (cubic inches) squared		0.0002^{***}	0.0002^{***}	0.0002^{***}
		(0.0000)	(0.0000)	(0.0000)
Weight			-0.01^{***}	-0.01^{***}
			(0.001)	(0.001)
Acceleration				0.43^{**}
				(0.15)
Model Year				0.77^{***}
				(0.06)
Constant	37.03^{***}	46.26^{***}	52.23^{***}	-13.52^{**}
	(0.84)	(1.75)	(1.87)	(4.92)
Observations	202	202	202	202
R^2	0.66	0.72	0.75	0.86
Residual Std. Error	4.92 (df = 200)	4.50 (df = 199)	4.22 (df = 198)	3.19 (df = 196)
Note:	*p<0.05; **p<0.01; ***p<0.001			
	HC_1 robust standard errors in parentheses.			

- *Displacement* coefficients are highly statistically significant across all models
- **Model 2** - *Displacement* squared increases magnitude of *Displacement* as well as explanatory power
- **Model 3** - adding *Weight* gives the model a similar increase in explanatory power
- **Model 4** - shows *Acceleration* is significant as well as our strongest effect (*Model Year*) and biggest increase in explanatory power

Limitations

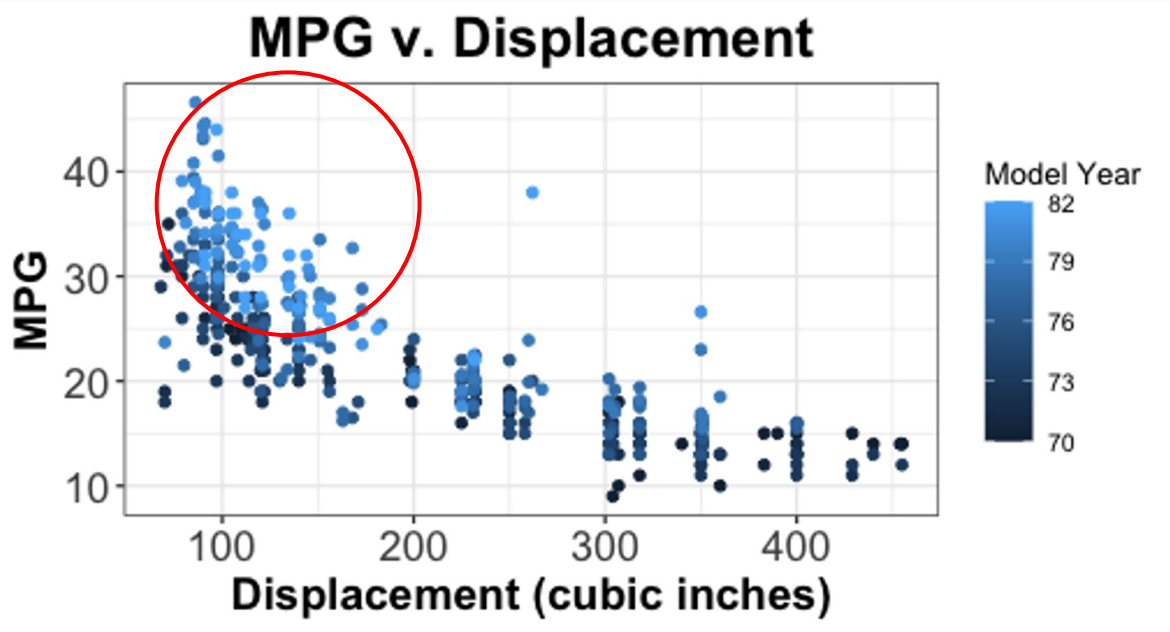
- Data is limited - would ideally have more observations

- Omitted variables:
  - Gearing/transmission: could make our model underpredict MPG
  - Aerodynamics: need more data - could make model over or underpredict MPG

- Non-adjustable parameters such as model, origin and year

Limitations Cont.

- Later model years appear to have less displacement and high MPG
- Clustering of values around milestone numbers (i.e. 300, 350, 400)



Conclusion

- This study estimated the impact of a vehicle's engine displacement on its fuel efficiency (MPG).
- For every cubic inch reduction of displacement to a vehicle's engine, our models predict a **0.07** to **0.17** increase in MPG.
  - Ex: for cars with average displacement per the dataset (194 cu. in.) a **10%** decrease in displacement will increase fuel efficiency by **1.27** to **3.27** MPG or **5-13%** of the dataset mean MPG (24.34)
- Future research can refine these models by collecting data on gearing/transmission, aerodynamics, fuel/engine type, etc and survey cars manufactured at the same point in time

Thank you