WDS, HW 3

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Due: 10:00PM, July 21, 2021

Contents

Case study: Automobiles efficiency

Are cars being built more efficient? Are Asian cars more efficient than cars built in America or Europe? To answer the questions we will use the `Auto` dataset from ISLR. The original dataset contains 408 observations about cars. It is similar to the CARS dataset that we use in our lectures. But it also collects information by years. To get the data, first install the package ISLR. The `Auto` dataset should be loaded automatically. The original data source is here: https://archive.ics.uci.edu/ml/datasets/auto+mpg

Get familiar with this dataset first. A good data set should be well documented. Use the command `?ISLR::Auto` to view a description of the dataset. Please add the variable list with names, brief descriptions and units of the variables below.

EDA

Explore the data first.

i. What is the range of `year`? Why is this important to know?

- The range of `year` is 12. This is important because it shows the time span of the dataset.

ii. Should `origin` be a continuous variable? Why or why not. In any case make `origin` a categorical variable.

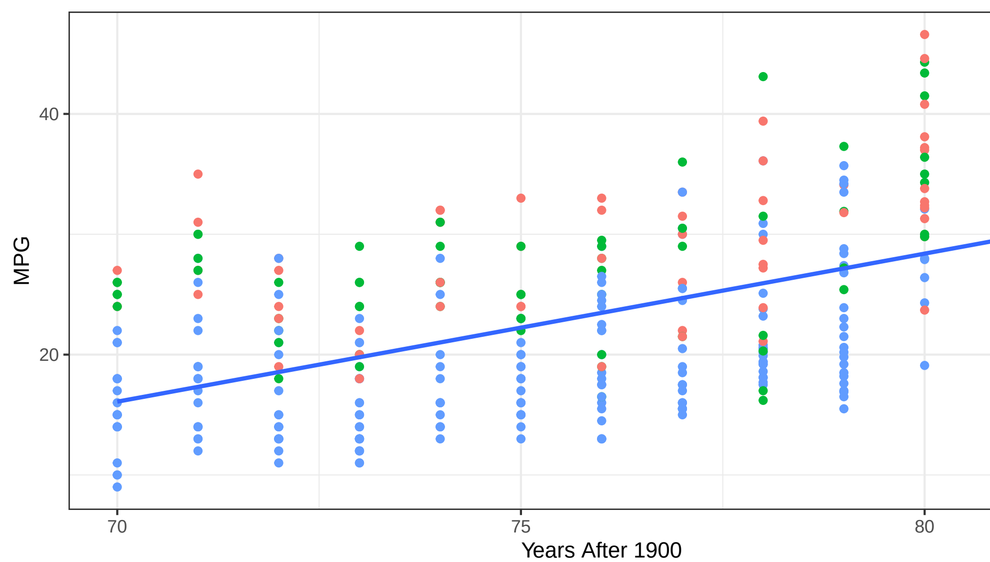
- By first looking at `origin`, we may think it is a continous variable as it is made up of the numbers 1, 2, and 3. However it is a catagorical varibale and `origin 1, 2, 3` suggest different origins.

iii. Do you see any peculiarity in the data?

- Most of the dataset looks fine, except that the `origin` is named `1, 2, 3`, while we would think they would have distingushed names. This makes it rather peculiar.

What effect does `time` have on `MPG`?

i. Show a scatter plot of `mpg` vs. `year` with the LS line imposed. Does the plot show a positive trend?



- Yes, there is a positive trend.

ii. Now run a simple regression of `mpg` vs. `year` and report R's `summary` output. Is `year` a significant variable at the .05 level? State what effect `year` has on `mpg`, if any, according to this model.

- As `year` has three stars, we can conclude that it as a variable has `0.01` significance. According to this model, when `year` is increased by one, `mpg` increases by 1.2300.

iii. Add `horsepower` on top of the variable `year` to your linear model. Is `year` still a significant variable at the .05 level? Give a precise interpretation of the `year`'s effect found here.

- In this model, when `horsepower` is kept constant, when `year` changes by 1 or increases by 1, the `mpg` increase by 0.65727. `year` still has significance of 0.001.

iv. The two 95% CI's for the coefficient of year differ among ii. and iii. How would you explain the difference to a non-statistician?

The two confidence intervals for the coefficient of year differ among ii. and iii. because in iii. the linear regression model has to account for both year and horsepower (keeping horsepower constant but still as a factor), whereas in ii. the linear regression model only has to account for the year. In turn, the confidence interval for ii. will accept more values into the interval based upon its coefficient, whereas the confidence interval for iii. will accept less values into the interval at a lower coefficient.

v. Create a model with interaction by fitting `lm(mpg ~ year * horsepower)`. Is the interaction effect significant at .05 level? Explain the year effect (if any).

- Yes, the interaction effect is significant at .05 level (3 stars). The `year` effect is best expressed as follows.

$$\Delta mpg = (\beta_1 + \beta_3 hp) \cdot \Delta year$$

Bring `origin` into the model

Do `mpg`'s differ on average among different `origin`? Fit a linear model with `mpg` vs. `origin`. Report the output.

```
##
## Call:
## lm(formula = mpg ~ data1$origin, data = data1)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -12.45  -5.03  -1.03   3.65  18.97
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)      30.451      0.720   42.31   <2e-16 ***
## data1$origin2    -2.848      1.058   -2.69   0.0074 **
## data1$origin1   -10.417      0.828  -12.59   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.4 on 389 degrees of freedom
## Multiple R-squared:  0.332,  Adjusted R-squared:  0.328
## F-statistic: 96.6 on 2 and 389 DF,  p-value: <2e-16
```

i. Are `mpg`'s on average different among three regions? Perform a test at .01 level. When you reject the null hypothesis, what have you proved?

- The f statistic produced by `Anova` function is 96.6 which is significantly larger than 1. Since an f statistic of 1 shows the null hypothesis, the very large f statistic shows that we can reject the null hypothesis and accept the alternate hypothesis that average of the three `origins` are different in a statistically significant way.

```
## Anova Table (Type II tests)
##
## Response: mpg
##               Sum Sq  Df F value Pr(>F)
## data1$origin   7904   2    96.6 <2e-16 ***
## Residuals     15915 389
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

i. Describe on average which `origin` has the highest `mpg` and what it is. Which `origin` has the smallest `mpg` on average and what is it?

   - On average, `origin 3` has the highest `mpg` of 30.451, and `origin 1` has the lowest average `mpg` of 20.033.