Stat 401 B – Lecture 32

Indicator Variables

- Response: Highway MPG
- Explanatory: 2 explanatory variables
  - Indicator variables for types of drive – All Wheel, Rear Wheel, and Front Wheel.

All Wheel Indicator

- All Wheel = 1 if the vehicle has all wheel drive.
- All Wheel = 0 if the vehicle does not have all wheel drive.

Rear Wheel Indicator

- Rear Wheel = 1 if the vehicle has rear wheel drive.
- Rear Wheel = 0 if the vehicle does not have rear wheel drive.

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Front Wheel Indicator

- There is no need for a separate indicator variable for front wheel drive.
- If All Wheel = 0 and Rear Wheel = 0, then the vehicle has front wheel drive.

Multiple Regression

- Fit a multiple regression model with the two indicator variables as the explanatory variables and Highway MPG as the response.

Response Highway MPG

Summary of Fit

RSquare	0.254103
RSquare Adj	0.238723
Root Mean Square Error	5.311626
Mean of Response	27.7
Observations (or Sum Wgts)	100

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	932.3031	466.152	16.5224
Error	97	2736.6969	28.213	Prob > F
C. Total	99	3669.0000		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	29.983333	0.685728	43.72	<.0001*
All Wheel	-7.374638	1.302648	-5.66	<.0001*
Rear Wheel	-3.453922	1.459395	-2.37	0.0199*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
All Wheel	1	1	904.23720	32.0500	<.0001*
Rear Wheel	1	1	158.02813	5.6012	0.0199*

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Prediction Equation

Predicted Highway MPG = 29.983
- – 7.375*All Wheel
- – 3.454*Rear Wheel

Summary

- R^2 = 0.254
- adj R^2 = 0.239
- RMSE = 5.312
- Model is useful. F = 16.5224, P-value < 0.0001

Interpretation

- Estimated intercept: When All Wheel = 0 and Rear Wheel = 0 the predicted Highway MPG is 29.983.
- The average Highway MPG for front wheel drive cars is 29.983.

Interpretation

- Estimated slope for All Wheel: Holding Rear Wheel = 0, if you change All Wheel from 0 to 1 you are comparing the Front Wheel drive to the All Wheel drive.
- An All Wheel drive vehicle gets, on average, 7.375 mpg less than a Front Wheel drive vehicle.

Interpretation

- Estimated slope for Rear Wheel: Holding All Wheel = 0, if you change Rear Wheel from 0 to 1 you are comparing the Front Wheel drive to the Rear Wheel drive.
- An Rear Wheel drive vehicle gets, on average, 3.454 mpg less than a Front Wheel drive vehicle.

Comparisons

- Are the differences between All Wheel and Front Wheel and Rear Wheel and Front Wheel statistically significant?

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Comparison

- All Wheel to Front Wheel.
- Difference in average Highway mpg is 7.375.
  - t = –5.66, F = 32.05
  - P-value < 0.0001
- The difference is statistically significant because the P-value is so small.

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Comparison

- Rear Wheel to Front Wheel.
- Difference in average Highway mpg is 3.454.
  - t = –2.37, F = 5.60
  - P-value < 0.0199
- The difference is statistically significant because the P-value is so small.

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Comparison

- All Wheel to Rear Wheel.
- This comparison is not considered in the JMP output.
- However, there is enough information to figure it out.

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Predictions

- All Wheel: Predicted Highway MPG = 29.983 – 7.375 = 22.608
- Rear Wheel: Predicted Highway MPG = 29.983 – 3.454 = 26.529

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Comparison

- All Wheel to Rear Wheel.
- Difference in average Highway mpg is 22.608 – 26.529 = –3.921
- Is this difference statistically significant?

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Test of Significance

- Difference in means

$$t = \frac{(\bar{y}_1 - \bar{y}_2)}{RMSE\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$df = df_{Error}$$

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Summary

	Mean	Sample Size
All Wheel	22.608	23
Rear Wheel	26.529	17
Front Wheel	29.983	60

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Comparison

- All Wheel to Rear Wheel

$$t = \frac{(\bar{y}_1 - \bar{y}_2)}{RMSE\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{(22.608 - 26.529)}{5.3116\sqrt{\left(\frac{1}{23} + \frac{1}{17}\right)}}$$

$$t = \frac{-3.921}{1.6989} - 2.308 \text{ with } df = 97$$

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Comparison

- All Wheel to Rear Wheel.
- Difference in average Highway mpg is 3.921.
  - t = –2.31, F = 5.33
  - P-value = 0.0231
- The difference is statistically significant because the P-value is so small (< 0.05).

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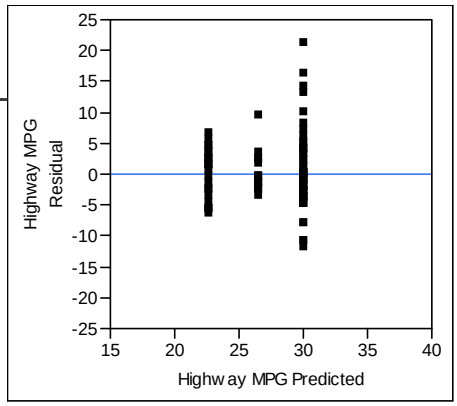

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Residuals vs. Predicted

- The predicted values correspond to the three types of drive; All Wheel, Rear Wheel and Front Wheel.
- Front Wheel drive vehicles show more variation than the other types of drives.

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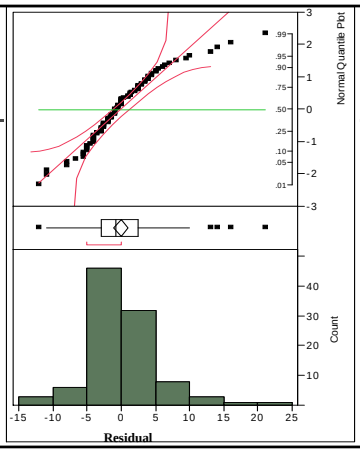

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Interpretation

- Histogram: Mounded to the left of zero and skewed to the right.
- Box Plot: Skewed right with one potential outlier on the negative side and several potential outliers on the positive side.

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Interpretation

- Normal Quantile Plot: the points start off following the red diagonal (normal model) line but then dip below, curve above and dip below. This indicates a skewed right distribution.

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Conditions?

- Equal standard deviation condition may not be met.
- Identically distributed condition may not be met.
- Normally distributed condition may not be met.

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