

Impact of Transmission Type on Fuel Efficiency in MTCARS Data Set

Allen Hammock

June 13, 2015

Executive Summary

To view the code for this report, check out the [repository on Github](#) [1].

At *Motor Trend*, a magazine about the automobile industry, we are interested in exploring the relationship between a transmission types and fuel efficiency measured in miles per gallon (MPG). We performed a study on 32 different models and found, as a group, that the motorcars with Automatic transmissions had an overall better mean fuel efficiency of 24.4 MPG versus vehicles with Manual transmissions which had an average 17.1 MPG.

However, when we look at *cars in different weight classes* and consider how many cylinders each vehicle has, we see that the transmission type has a much lower influence on fuel efficiency than these other factors. As the coefficients on our linear model show, Manual and Automatic transmissions have approximately the same influence (less than 0.02 MPG difference) on fuel efficiency (MPG) if we hold the weight (wt coefficient) constant.

This is fairly intuitive, the fact that the heavier, "gas guzzling" cars with bigger engines tend to have a lower MPG suggests that the efficiencies of automatic transmissions may be negligible compared to these other parameters.

First Model: `lm(mpg ~ TransType - 1, mtcars)`

From our initial fit ([the code](#) [1] is hidden to save space), the expected value for MPG is just the coefficient, or the mean average of the fuel efficiency ratings for each transmission type. We have removed the intercept in all of our models.

##		Estimate	Std. Error	t value	Pr(> t)
##	TransTypeAuto	24.39231	1.359578	17.94109	1.376283e-17
##	TransTypeManual	17.14737	1.124603	15.24749	1.133983e-15

Second Model: `lm(mpg ~ wt + TransType - 1, mtcars)`

Now we adjust the outcome for the influence of both weight and transmission type. Here we see the difference between Manual and Automatic diminish dramatically.

##	Estimate	Std. Error	t value	Pr(> t)
## wt	-5.352811	0.7882438	-6.790807	1.867415e-07
## TransTypeAuto	37.297936	2.0856607	17.883032	3.326182e-17
## TransTypeManual	37.321551	3.0546385	12.217993	5.843477e-13

The t-test is significant and our confidence intervals for Manual vs. Automatic transmissions are very similar. The distribution of our residuals are normally distributed (**Figure 1**) for all three models so our assumptions that the errors are roughly iid $N(0, \sigma^2)$ seem to hold.

##	2.5 %	97.5 %
## wt	-6.96	-3.74
## TransTypeAuto	33.03	41.56
## TransTypeManual	31.07	43.57

Third Model: `lm(mpg ~ wt + Cylinders + TransType - 1, mtcars)`

Finally we update the model to adjust for the total number of cylinders. As the number of cylinders increases, the MPG decreases. We see that having a Manual transmission accounts for a very small part of the variance now and that within the confidence interval the influence could be positive or negative since it is so close to zero.

In **Figure 2** we see a better dispersion of the residuals vs. the fitted values as we add these additional parameters suggesting that we have accounted for much of the systematic variance in our model.

We also did some digging for outliers and we found that the **Toyota Corolla** and **Fiat 128** are interesting examples to look at, as **Figure 3** suggests.

##	Estimate	Std. Error	t value	Pr(> t)
## wt	-3.1495978	0.9080495	-3.4685309	1.770987e-03
## Cylinders4	33.9036951	2.0647406	16.4203170	1.412681e-15
## Cylinders6	29.6463766	2.6989703	10.9843285	1.825314e-11
## Cylinders8	27.8245763	3.2540014	8.5508802	3.644425e-09
## TransTypeManual	-0.1501031	1.3002231	-0.1154441	9.089474e-01

##	2.5 %	97.5 %
## wt	-5.01	-1.29
## Cylinders4	29.67	38.14
## Cylinders6	24.11	35.18
## Cylinders8	21.15	34.50
## TransTypeManual	-2.82	2.52

Appendix

Figure 1 -- Normal QQ

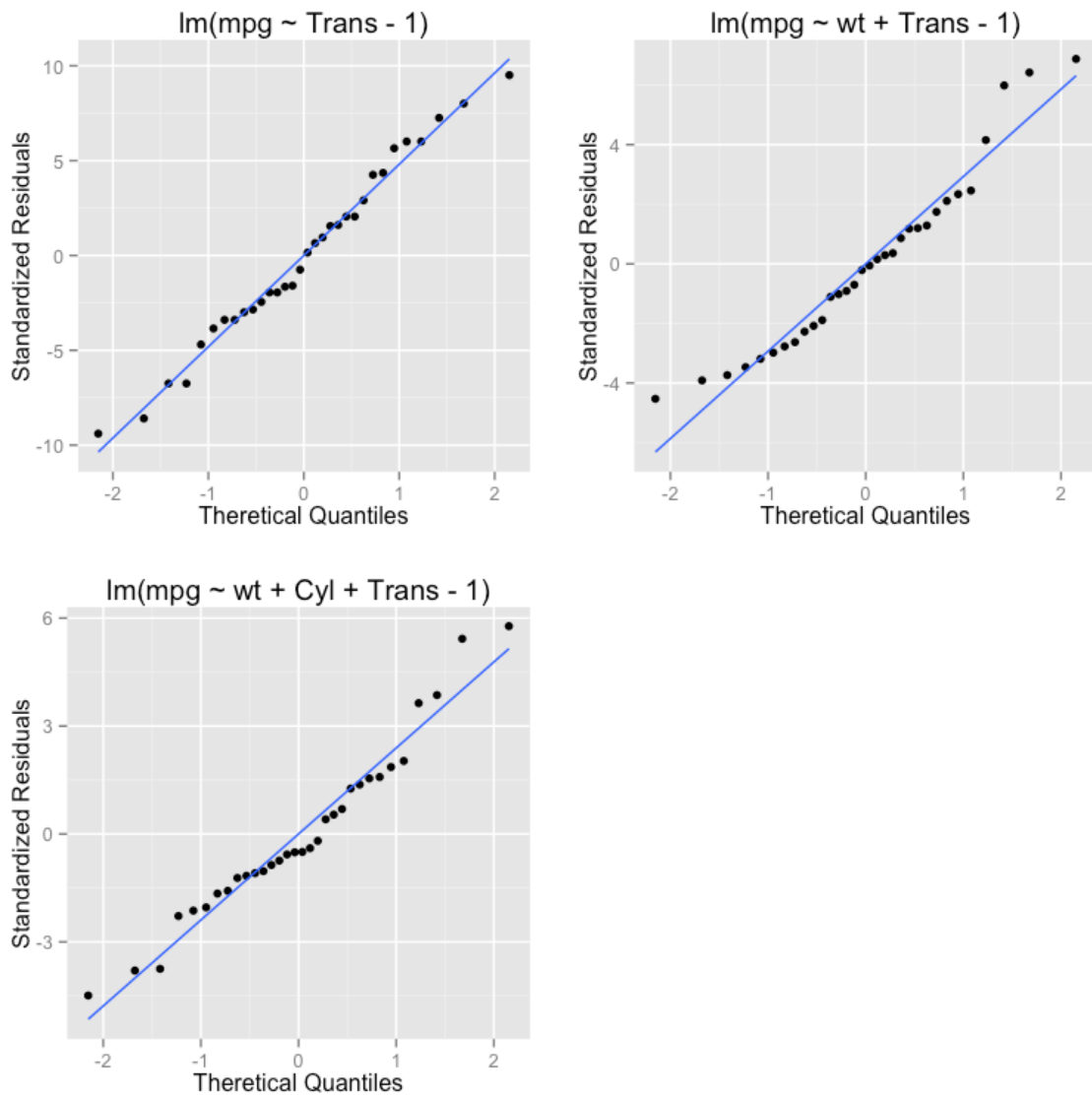


Figure 2 - Fitted vs Residuals

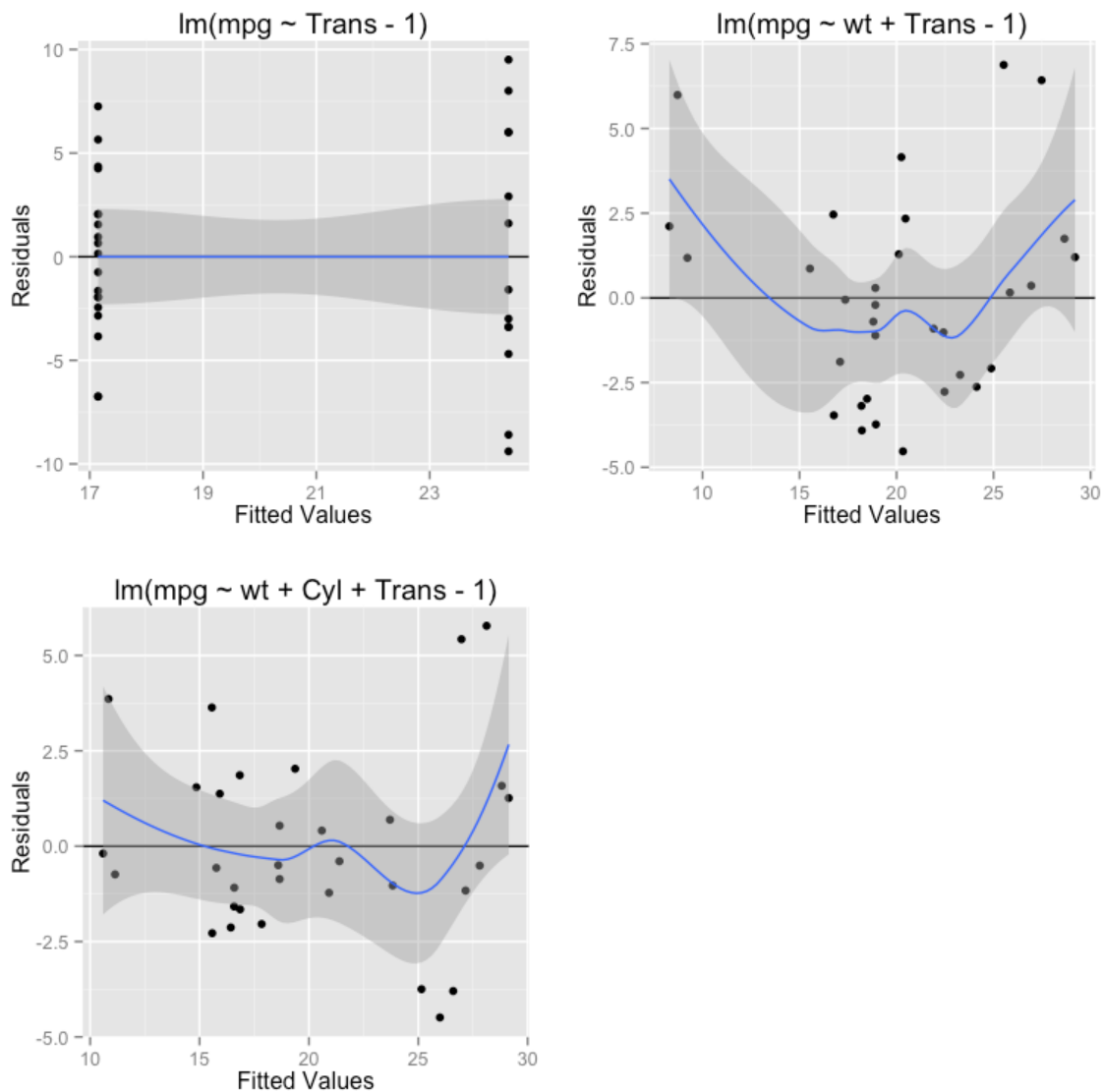


Figure 3 - Outliers

##		mpg	wt	Cylinders	TransType
##	Toyota Corolla	33.9	1.835	4	Auto
##	Fiat 128	32.4	2.200	4	Auto

	mpg ~ Trans	mpg ~ Trans	mpg ~ Cyl + Trans
Toyota Corolla	-28.05%	-18.95%	-17.04%
Fiat 128	-24.72%	-21.23%	-16.75%

References

<1>

<https://github.com/brainvat/RegressionModelsProject/blob/master/report.Rmd>