The Impact of Automatic or Manual Transmission on Car Fuel Efficiency

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This report is an analysis of the 1974 *Motor Trend* car data that is part of the standard R datasets. The dataset contains 11 variables across 32 car models from 1973 to 1974. The objective of this report is to answer the following question using Regression Modeling: **"Is an automatic or manual transmission better for MPG?"** Any differences between automatic and manual transmissions will then be quantified using the most appropriate regression model(s).

The median mpg for manual cars is 22.8, while the median mpg for automatic cars is 17.3. This simple comparison would suggest that manual transmissions improve fuel efficiency by roughly 5.5 mpg.

A simple linear regression model of mpg vs transmission gives a similar answer with an intercept of 24.39 for manual transmissions and 17.15 for automatic transmissions. The difference in fuel efficiency between manual and automatic transmissions is also apparent when visualized in a boxplot (Appx Fig 1).

```
##             Estimate Std. Error t value  Pr(>|t|)
## amAutomatic    17.15      1.125   15.25 1.134e-15
## amManual       24.39      1.360   17.94 1.376e-17
```

A plot of the residuals from the simple linear model suggest a fair amount of variation is still unaccounted for in the dataset (Appx Fig 2). As there are other factors known to affect fuel efficiency for vehicles I examined other variables within the dataset to ensure I had the best possible model. A quick check of car weight (Appx Fig 3) showed that most of the cars with manual transmission were lighter (2320 lbs) than those with automatic transmissions (3520 lbs). In addition to car weight, there is a bias in the number of engine cylinders between manual and automatic transmissions (Table 1).

Transmission	4 cyl	6 cyl	8 cyl
Automatic	3	4	12
Manual	8	3	2

Constructing a new regression model factoring in car weight and number of cylinders now shows a fuel efficiency of 33.9 for manual transmissions and 33.8 for automatic transmissions.

```
##             Estimate Std. Error t value  Pr(>|t|)
## amAutomatic   33.754      2.813  11.997 2.496e-12
## amManual      33.904      2.065  16.420 1.413e-15
## wt            -3.150      0.908  -3.469 1.771e-03
## cyl6          -4.257      1.411  -3.017 5.515e-03
## cyl8          -6.079      1.684  -3.611 1.228e-03
```

This suggests that the differences observed from the initial regression model were primarily due to confounding caused by car weight and the number of cylinders. This new regression model also shows a decrease in the residuals, suggesting that they account for a portion of the variance missed by the initial model. In order to be certain that there are no other factors with an appreciable effect on the fuel efficiency we can construct a regression model using all available variables.

```
##          Estimate Std. Error t value Pr(>|t|)
## cyl4     23.87913   20.06582  1.1900  0.25253
## cyl6     21.23044   18.33416  1.1580  0.26498
## cyl8     23.54297   18.22250  1.2920  0.21592
## disp      0.03555    0.03190  1.1143  0.28267
## hp       -0.07051    0.03943 -1.7884  0.09393
## drat      1.18283    2.48348  0.4763  0.64074
## wt       -4.52978    2.53875 -1.7843  0.09462
## qsec      0.36784    0.93540  0.3933  0.69967
## vs1       1.93085    2.87126  0.6725  0.51151
## amManual  1.21212    3.21355  0.3772  0.71132
## gear4     1.11435    3.79952  0.2933  0.77332
## gear5     2.52840    3.73636  0.6767  0.50890
## carb2    -0.97935    2.31797 -0.4225  0.67865
## carb3     2.99964    4.29355  0.6986  0.49547
## carb4     1.09142    4.44962  0.2453  0.80956
## carb6     4.47757    6.38406  0.7014  0.49381
## carb8     7.25041    8.36057  0.8672  0.39948
```

Summary

The full regression model shows that many of the variables have some influence on fuel efficiency. Most notably the number of carburetors improves fuel efficiency dramatically, with 8 carburetors giving a 7.2 mpg boost and 6 carburetors giving a 4.5 mpg boost. This increase in fuel efficiency is somewhat misleading as only 2 cars have more than 4 carburetors with our dataset. Overall our regression model that factors in the car weight and number of cylinders is near optimal. Using only two factors it accounts for most of the residual variation and is comparable to the remaining residuals in the full regression model (Appx Fig 5).

Report Questions

Is an automatic or manual transmission better for MPG?

No

Quantify the MPG difference between automatic and manual transmissions

33.90 mpg (manual) - 33.75 mpg (automatic) = 0.15 mpg

Reproducibility

Note that for the purposes of this Course Project the R code was hidden to generate the final PDF. If you wish to see the R code used to generate this report a copy of the original R markdown file can be found on Github

Appendix

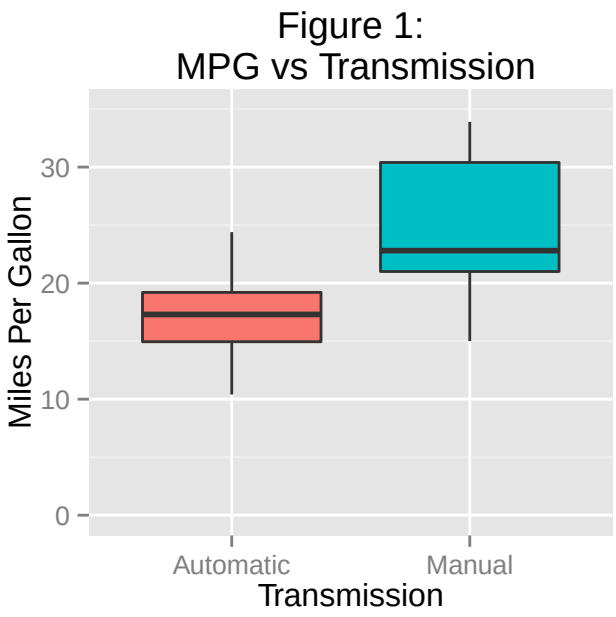
Figure 1:
MPG vs Transmission
Miles Per Gallon
30
20
10
0
Automatic
Manual
Transmission

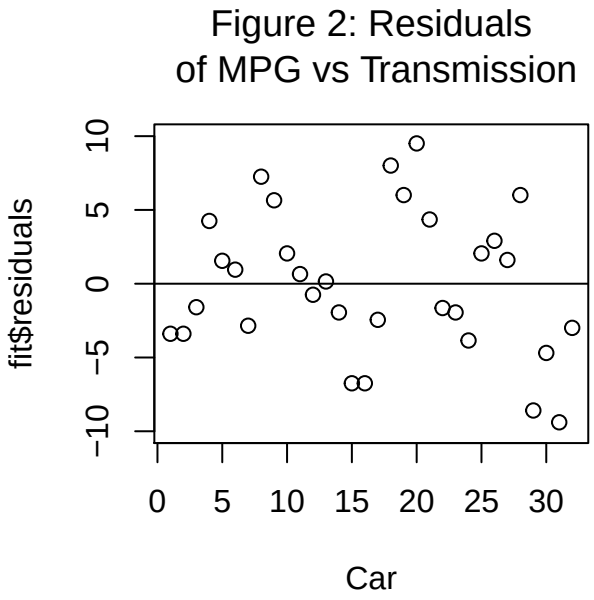
Figure 2: Residuals
of MPG vs Transmission
fit$residuals
10
5
0
−5
−10
0
5
10
15
20
25
30
Car

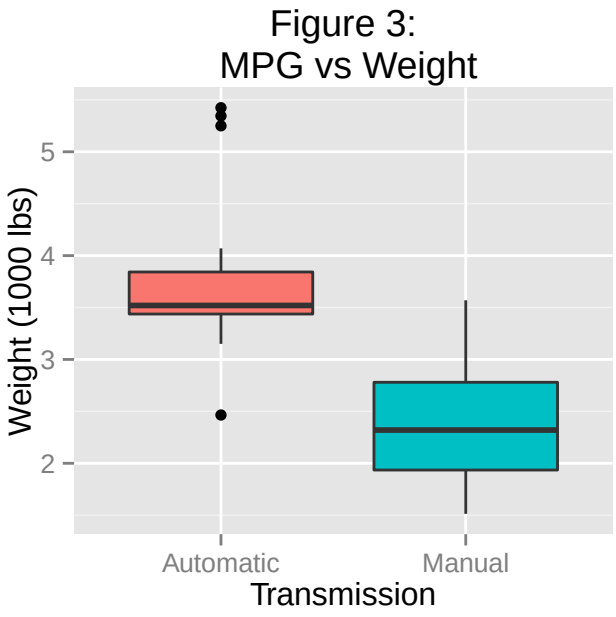
Figure 3:
MPG vs Weight
Weight (1000 lbs)
5
4
3
2
Automatic
Manual
Transmission

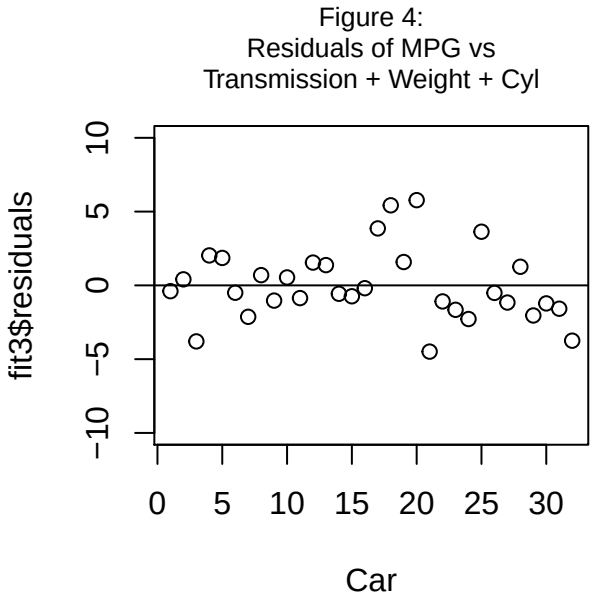
Figure 4:
Residuals of MPG vs
Transmission + Weight + Cyl
fit3$residuals
10
5
0
−5
−10
0
5
10
15
20
25
30
Car

Figure 5:
Residuals of MPG vs
Full Regression Model