Transmission Type Fuel Effieciency Analysis

2014-10-26

Executive Summary

Using the Motor Trends data this report endeavours to find out whether automatic or manual transmission is better for MPG. This report will further more attempt to quantify the MPG difference between automatic and manual transmissions. In an effort to keep the report concise most of the R code is not shown, please feel free to visit this GitHub Repository for the complete R Markdown code.

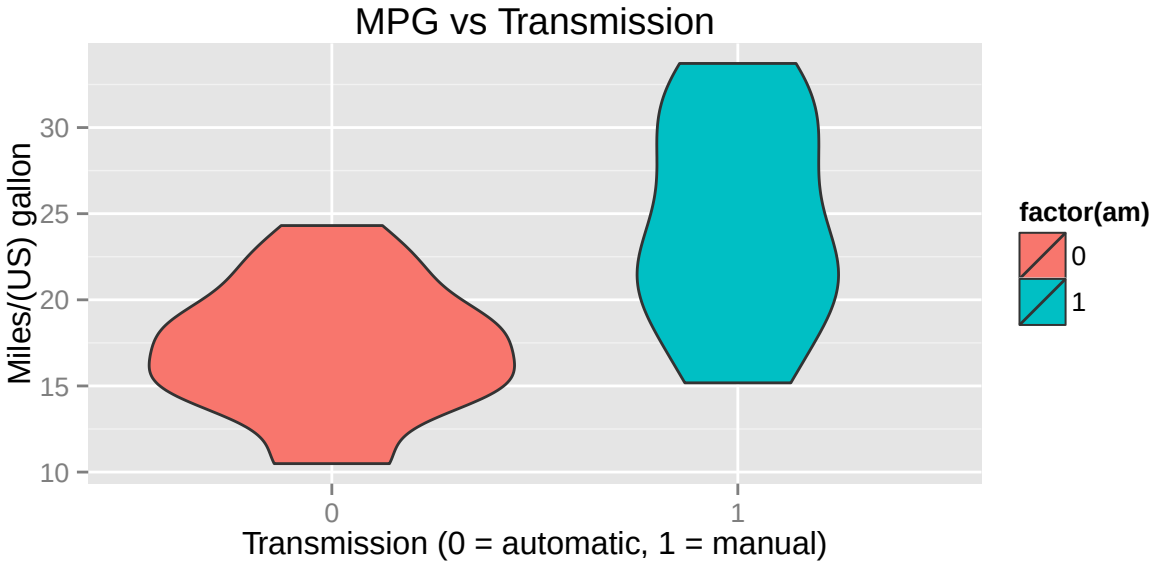
Data Dictionary

The Motor Trends data consists of 32 observations spanning 11 variables. For a full description of the data definition please refer to the Motor Trends Data Documentation.

Field	Definition	Field	Definition
mpg	Miles/(US) gallon	cyl	Number of cylinders
disp	Displacement (cu.in.)	hp	Gross horsepower
drat	Rear axle ratio	wt	Weight (lb/1000)
qsec	1/4 mile time in seconds	vs	V/S (0 = V-engine, 1 = straight engine)
am	Transmission (0 = automatic, 1 = manual)	gear	Number of forward gears
carb	Number of carburetors		

Exploring the Data

We start with a violin plot of `MPG vs Transmission` to explore the relatioship between transmission type and MPG. Next we run `summary()` on a few of the more interesting fields in the data to get a feel of what the data is telling us.



```
##     cars.mpg        cars.cyl      cars.disp        cars.hp
##  Min.   :10.4   Min.   :4.00   Min.   : 71.1   Min.   : 52.0
##  1st Qu.:15.4   1st Qu.:4.00   1st Qu.:120.8   1st Qu.: 96.5
##  Median :19.2   Median :6.00   Median :196.3   Median :123.0
##  Mean   :20.1   Mean   :6.19   Mean   :230.7   Mean   :146.7
##  3rd Qu.:22.8   3rd Qu.:8.00   3rd Qu.:326.0   3rd Qu.:180.0
##  Max.   :33.9   Max.   :8.00   Max.   :472.0   Max.   :335.0
##    cars.drat       cars.wt       cars.qsec      cars.carb
##  Min.   :2.76   Min.   :1.51   Min.   :14.5   Min.   :1.00
##  1st Qu.:3.08   1st Qu.:2.58   1st Qu.:16.9   1st Qu.:2.00
##  Median :3.69   Median :3.33   Median :17.7   Median :2.00
##  Mean   :3.60   Mean   :3.22   Mean   :17.8   Mean   :2.81
##  3rd Qu.:3.92   3rd Qu.:3.61   3rd Qu.:18.9   3rd Qu.:4.00
##  Max.   :4.93   Max.   :5.42   Max.   :22.9   Max.   :8.00
```

We find that the mean MPG for our Automatic transmissions is 17.1474 and for Manual transmissions is 24.3923. This is a mean MPG difference of 7.2449 with the Automatic transmission being less efficient. This extremely simple comparison is just the beginning of our journey.

Regression Modelling

We iteratively run linear regressions starting with `summary(lm(mpg ~ cyl + disp + hp + drat + wt + qsec + vs + am + gear + carb, data = cars))$coef`, in each subsequent run we remove the entry (field) with the largest `Pr(>|t|)` score until we have only one left, namely `wt`. Next we use the `anova()` function to find the cut-off point in terms regression variables. We find that including the `gear` is not beneficial to our regression model and when it is not specified the Transmission type `am` scrapes in just under 5%.

Field	Pr(>F) for (mpg ~ wt, qsec, am)	Pr(>F) for (mpg ~ wt, qsec, am, gear)
wt	NA	NA
qsec	9.2862 × 10-4	0.0011
am	0.0467	0.0508
gear		0.8897

The fields `wt`, `qsec` and `am` feel like the right set of variables to be looking at but a linear coefficient against `qsec` seems odd. One would expect diminishing returns for the fuel consumed as the `qsec` gets smaller (i.e. increased acceleration). In an effort to model these diminishing returns I introduce a new variable named `qsec.2.I` which represents the inverse of the square of `qsec` ($1/qsec^2$). The following two tables detail the coefficients of the respective linear regression models. We see that using the variable `qsec.2.I` as opposed to `qsec` yields a tighter fit to our data as evidenced by every single `Pr(>|t|)` being almost halved.

```
##             Estimate Std. Error t value  Pr(>|t|)
## (Intercept)    9.618     6.9596   1.382 1.779e-01
## wt            -3.917     0.7112  -5.507 6.953e-06
## qsec           1.226     0.2887   4.247 2.162e-04
## am             2.936     1.4109   2.081 4.672e-02
```

```
##              Estimate Std. Error t value  Pr(>|t|)
## (Intercept)    42.806     2.6020  16.451 6.347e-16
## wt             -3.845     0.6806  -5.649 4.719e-06
```

```
## qsec.2.I    -3603.694   767.4360  -4.696 6.370e-05
## am              3.191     1.3612   2.344 2.639e-02
```

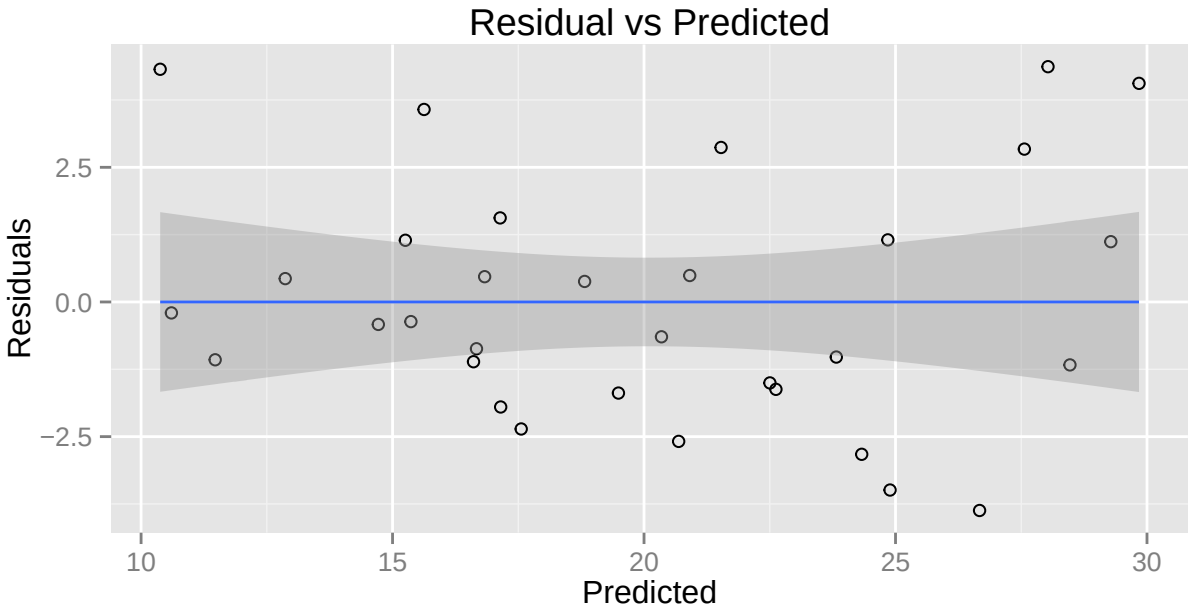
Interpreting the Coefficients

Using the `qsec` based regression we arrive at following model. For each additional `wt` (1000 lb) our MPG decreases by 3.9165. For each additional second needed to complete `qsec` (1/4 mile time in seconds) our MPG increases by 1.2259. Lastly, Manual transmissions yield a 2.9358 MPG benefit (increase) over Automatic transmissions.

Confidence

The R^2 for the `qsec` and `qsec.2.I` regression models are 0.8497 and 0.8617 respectively. The R^2 for the `qsec.2.I` based regression model is marginally stronger (by 0.0121) and with this model explaining 0.8617 of the variability it is a highly predictive model. We opt to use the `qsec.2.I` based regression model going forward.

Residuals



The Residuals vs. Predicted look good for this model and I believe we can in good conscience use it.

Conclusion

Using our `qsec.2.I` based regression model we find that Manual transmissions yield better MPG in the amount of 3.1909 MPG.