Effect of the type of transmission on mpg car performance

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This report concerns with the possible effect the car transmission type can have on its performance, specifically on how many miles of travel per gallon of fuel (mpg) the car can have. The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (1973□74 models). There were 10 variables that might affect the mpg parameter for the car: weight, horsepower, number of cylinders, displacement, rear axle ratio, time to travel 1/4 of a mile, transmission type, number of forward gears, and number of carburetors. We performed the analysis of the influence of various factors and present our conclusion in this report.

It is sensible to asssume that weight of the car and its horsepower will all affect its mpg performance. Therefore, we chose the weight and gross horsepower as our predictors, and mpg is the outcome. First, we plotted the mpg as a function of weight and gross horsepower for cars with manual and automatic transmission and presented the results in Fig. 1.

From the Fig. 1. we can easily see that there are few outliers, which will have strong leverage on our analysis. Next figure presents the residual plot and some diagnostic plots.

Fig. 2. clearly indicates that our outliers correspond to Toyota Corolla, Chrysler Imperial, Fiat 128. and Maseratti Bora. Residuals versus leverage graph clearly indicates that these points have strong leverage and/or high residuals. Q-Q plot also shows that these points cause the errors distribution to deviate from normality. Based on these arguments, We decided to exclude those points from consideration. Next figure presents the same plot as in Fig. 2, but with four mentioned points excluded.

We first fitted the linear regression model using weight and gross horsepower as predictors and we added transmission type as a factor variable, in order to see if the fitting results will significantly change for different types of transmission. The results are presented in Table 1 below.

Table 1. Fitting results for the linear regression model:

```
##                    Estimate  Std. Error   t value     Pr(>|t|)
## (Intercept)    33.00665927 1.993143833 16.560099 6.602831e-14
## wt             -2.56364868 0.686798891 -3.732750 1.154810e-03
## hp             -0.04019263 0.009085691 -4.423728 2.142979e-04
## factor(am)1     9.65101103 3.053418049  3.160724 4.532060e-03
## wt:factor(am)1 -4.81140847 1.437540243 -3.346973 2.917629e-03
## hp:factor(am)1  0.02691486 0.014787324  1.820131 8.237267e-02
```

The marginal car performance for automatic transmission was determined to be 33 mpg, whereas the manual transmission cars will have marginal performance of 33+9.65~43 mpg. The standard errors are 2 and 4 mpg, correspondingly. The decrease in performance per 1000 lb increase of car's weight will be 2.56+-0.69 and 7.37+-2.1 mpg for the cars with automatic and manual transmission, respectively. The p-values are all small enough to indicate the significance of difference. At the same time, the decrease in car performance over the unit increase in horsepower is 0.04 and 0.014 for cars with automatic and manual transmission. However, the p-value for the transmission factor in this case is 0.082, which rejects the hypothesis that transmission type matters.

Overall, the manual transmission seems to provide better performance for the light cars, with weight less than 9.65 mpg/(4.81/1000 mpg/lb)=2000 lb, but automatic transmission works better for cars heavier than 2000 lb. The marginal gain in performance is about 9.65 mpg for the cars with manual transmission.

The last step we took was to check if our model is sufficient and no other confounders shall be added to it. We performed the analysis of variances of our model and models involving other confounders and presented the results in Table 2. Additional confounders were displacement volume, 1/4 mile time, and rear axle ratio.

Table 2. ANOVA results for comparing our model with models involving additional confounders.

```
## Analysis of Variance Table
##
## Model 1: mpg ~ wt + hp
## Model 2: mpg ~ wt + hp + disp
## Model 3: mpg ~ wt + hp + disp + drat
## Model 4: mpg ~ wt + hp + disp + drat + qsec
##   Res.Df    RSS Df Sum of Sq      F Pr(>F)
## 1     25 78.014
## 2     24 75.350  1    2.6645 0.8456 0.3678
## 3     23 70.926  1    4.4240 1.4039 0.2487
## 4     22 69.325  1    1.6012 0.5081 0.4834
```

All p-values are large enough and indicate the insignificance of addition of extra confounders.

In conclusion, we determined that manual transmission works better for the light cars, weighing less than 200 lb, with marginal gain in performace to be 9.65 mpg. However, heavy cars (heavier than 2000 lb) perform better with automatic transmission.

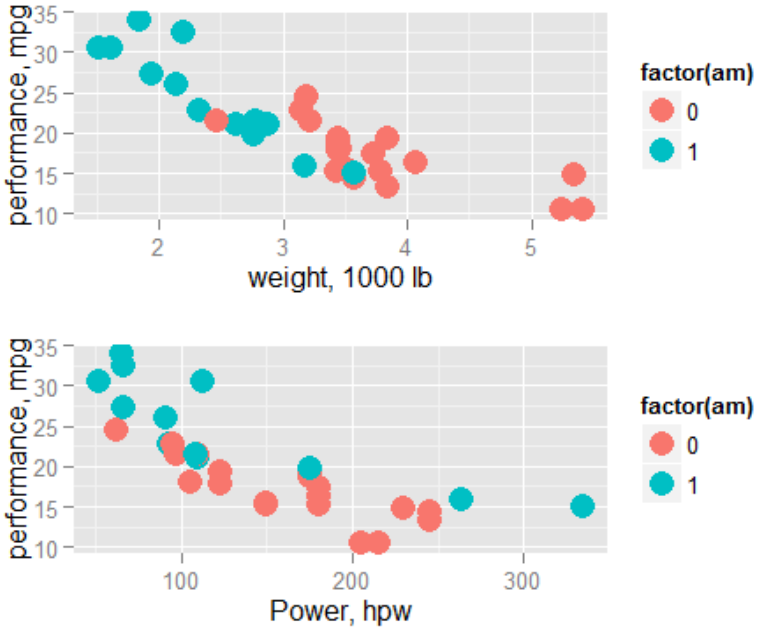

Fig. 1. mpg as a function of weight or gross horsepower. Blue circles represent cars with manual transmission, salmon ones present cars with automatic transmission.

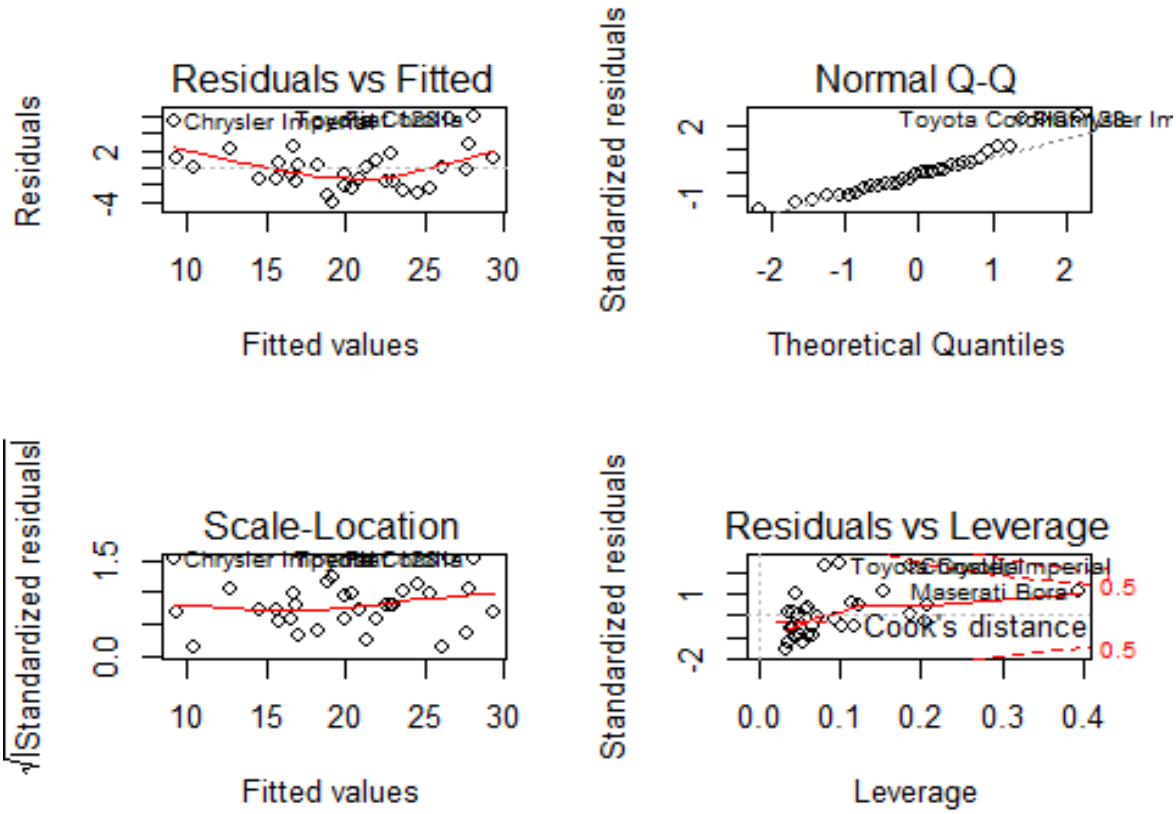

Fig. 2. Residuals and diagnostic plots.

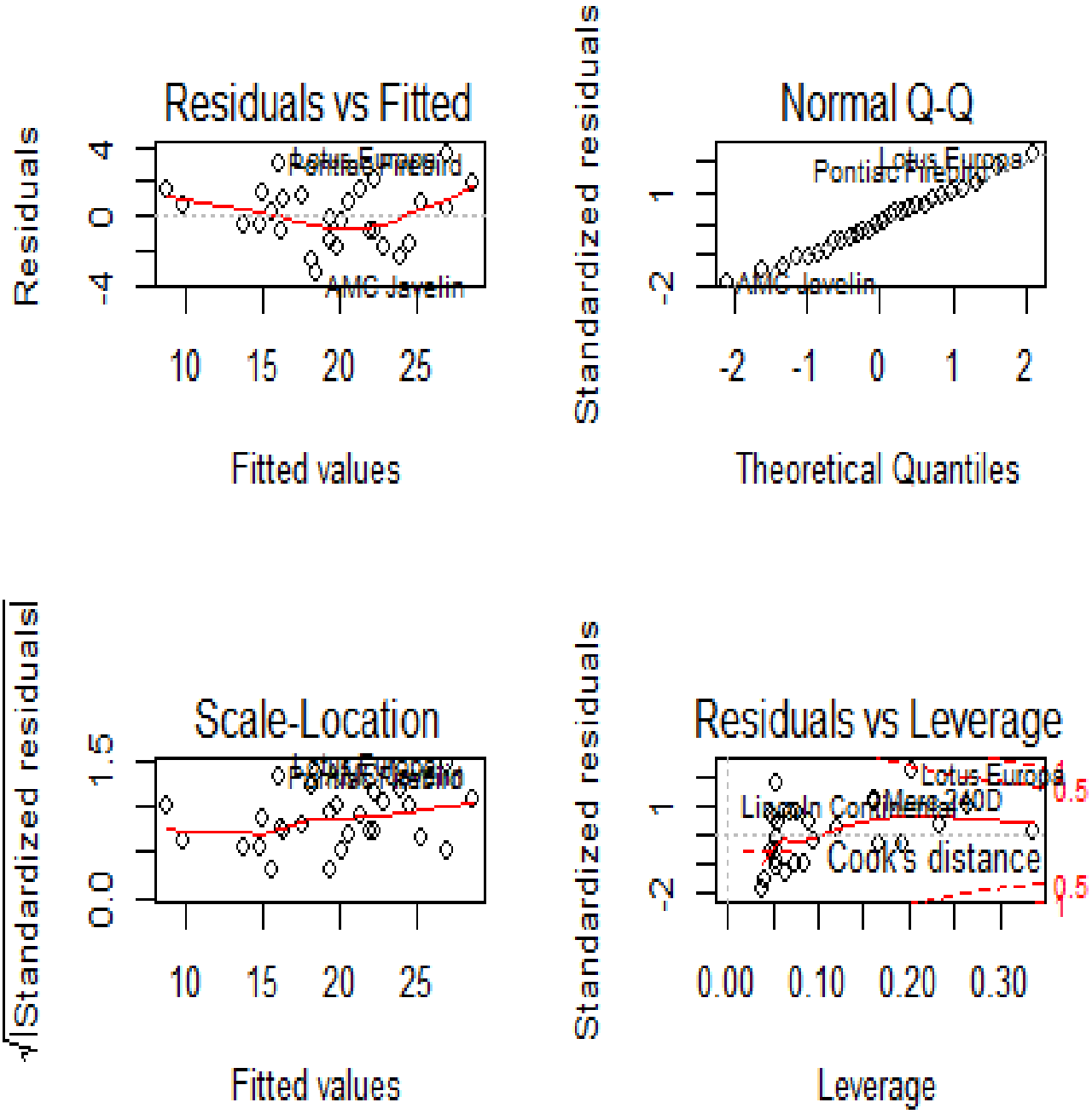

Fig. 3. Residuals and diagnostic plots, outliers excluded.