Regression Models Course Project

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1 Executive Summary - 1974 Motor Trend Data in Review

This report was requested to enable a review of the 1974 magazine data on past car mpg performance and changes in vehicle efficiency. It addresses two core quesitons:

1. Is an automatic or manual transmission better for MPG?
2. Quantify the MPG difference between automatic and manual transmissions.

Based upon our analysis we conclude that in 1974:

1. ***Manual tranmisssions were better for MPG***.
2. Transmission, weight and quarter mile time significantly influenced mpg effienciency.
3. Manual transmissions were on average ***7.24 miles per gallon*** more efficient that automatics.
4. The model developed is estimated to explain about **88%** of the variance of the MPG variable in the **mtcars** data set.

Conclusion: In 1974, cars that were lighter in weight with a manual transmission and cars that were heavier in weight with an automatic transmission had higher MPG values. See: Appendix A, Figure 2.

Note: The report source code is available via **GitHub** for deeper review.

1.1 Data Set Description

The Motor Trend magazine data was extracted in 1974, it coverered gasoline mileage in miles per gallon (MPG), and ten aspects of vehicle design and performance for 32 vehicles (1973-74 models), the sample includes 32 vehicles and has a bias to exotic, non-US., automobiles: it includes seven Mercedes, a Porsche, a Ferrari, a Maserati and offers us us an amazing view of vehicle effiency and performance from 1974.

1.2 Basic exploratory data analyses

Our initial goal was to test the hypothesis that cars in 1974 with an automatic transmission used more fuel than cars with a manual transmission. The box plot (**Appendix A, Figure 1.**) provides a simple yet clear indication that automatic cars from the 1974 data set had lower mpg effienciency (Automatic Transmission Median: 17.15 mpg) than the manual cars reviewed (Manual Transmission Median: 24.39 mpg). Based on figure 1, we appear to have a clear hypothesis that automatic cars had a lower miles per gallon, and therefore a lower fuel efficiency, than manual cars did. i.e (**24.39mpg - 17.15mpg creates a 7.24mpg manual transmission advantage**).

	P.Value	Confidence	Lower.Bound	Upper.Bound
MPG ~ Transmission	0.001374	95%	-11.28	-3.21

Did lower automatic transmission mpg efficiency occur in the data by random chance? To try to confirm, we performed a `t.test(mpg ~ am, data=mtcars)`. The t-test **p-value** result of **0.0013736** in combination with a confidence value of **95%**, indicate that we can be confident that the probability of chance is low. We conclude that automatic transmissions **did** have lower **MPG** in 1974 than manuals.

We checked to see if automobile weight in 1974 ***correlated*** with ***MPG*** efficiency. **Appendix A, Figure 2** shows that in 1974 automobile weight did correlate with MPG for both manual and automatic cars. We used a linear model to depict the manual and automatic trend lines.

```
baseline <- lm(mpg ~ ., data=mtcars)
prefferedModel <- step(baseline, k=log(nrow(mtcars)))
```

Appendix A, Figure 3 shows our final exploratory chart which gives a strong indication that weight was a key driving factor in 1974. However, the predictors (Weight, Cylinder Size, and Displacement) could potentially be confounded. To determine which predictors were significant, and to select the preferred model to use, we performed an Akaike information criterion (AIC) model selection ***(Ref: The R Book, Chapter 9.17)*** against the `baseline` linear model using the `step()` function; the smaller the AIC, the better the fit. The `prefferedModel` model selected has the Residual standard error as **2.084** on **27** degrees of freedom and has an Adjusted R-squared value of **0.8804**, which means that the model can explain about **88%** of the variance of the MPG variable.

```
selectedModel <- aov(mpg ~ wt*qsec*am, data=mtcars)
summary(selectedModel)
finalModel <- lm(mpg ~ wt + qsec + am + wt:am, data=mtcars)
summary(finalModel)$coef
```

Based on the result we picked **weight**, **quarter mile** and **transmission** as the predictors of most value based on the lowest **aic()** result of **AIC of 67.17**. Our final check was to see if the predictors interact using `aov`. We noted that `wt` and `am` do appear to interact **(Sum Sq 52.0)**, hence we specified to `lm()` that weight and transmission interact `wt:am`.

Thus, we conclude that when `wt` **(weight/1000lbs)** and `qsec` **(1/4 mile time)** are fixed, we can calculate the manual transmission advantage over an equivalent automatic transmission. For example, a hypetheical manual transmission car that weighs 2500 lbs has, with a qsec of 16.5 has a predicted mpg of **22.9mpg**. We can go futher an use the `finalmodel` to predict the mpg of all the vehicles in mtcars.

```
# We can now use predict() to predict the fuel economy of hypothetical cars...
newcar = data.frame(wt=2.5, qsec=16.5, am=1)
predict(finalModel, newcar)

# Alternatively, we can use predict() to show the predicted fuel economoy of mtcars
predict(finalModel)
```

1.3 Residual Analysis / Diagnostics

To wrap up, we ran a diagnostic model (Appendix A, Figure 4), (Ref: R CookBook, Section 11.15) enabling us to verify the following underlying assumptions:

1. The Residuals vs. Fitted plot shows no consistent pattern, in support of accuracy of the independence.
2. The Normal Q-Q plot indicates that the residuals are normally distributed to the line.
3. The Scale-Location plot confirms the constant variance assumption, points are randomly distributed.
4. The Residuals vs. Leverage implies no outliers are present, as all values fall well within the 0.5 bands.
5. We conclude that we do not have influential observations based on the `dfbetas` result of `0`. `dfbetas` is a measure of influence of the observations on the regression coefficients. The thumb rule for the 'dfbetas is that if their absolute value exceeds 1, the observations have significant influence on the covariates.

2 Appendix A

Figure 1: Miles per Gallon by Transmission Type

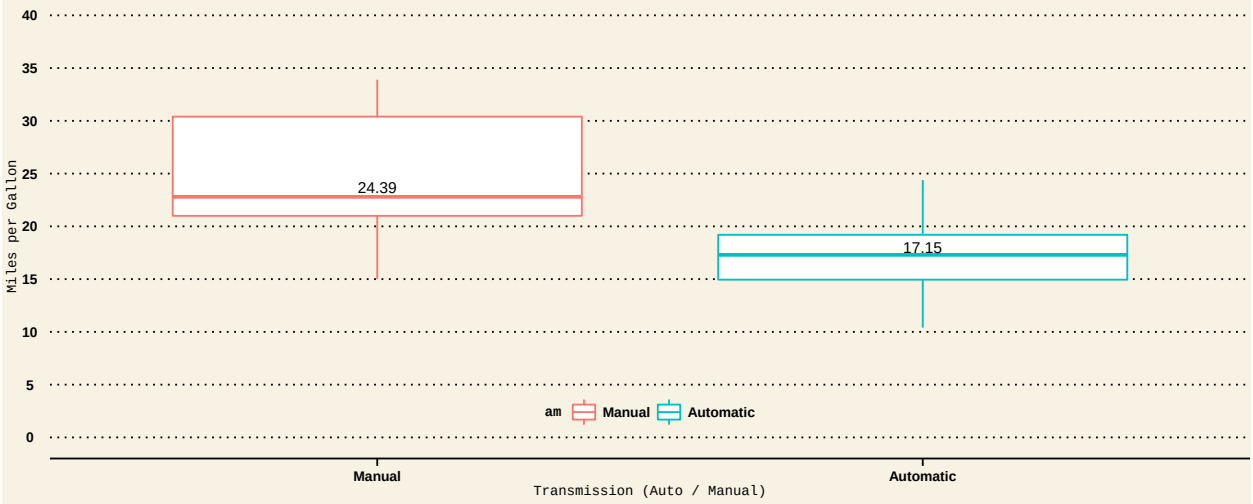


Figure 2: Miles per Gallon by Automobile Weight

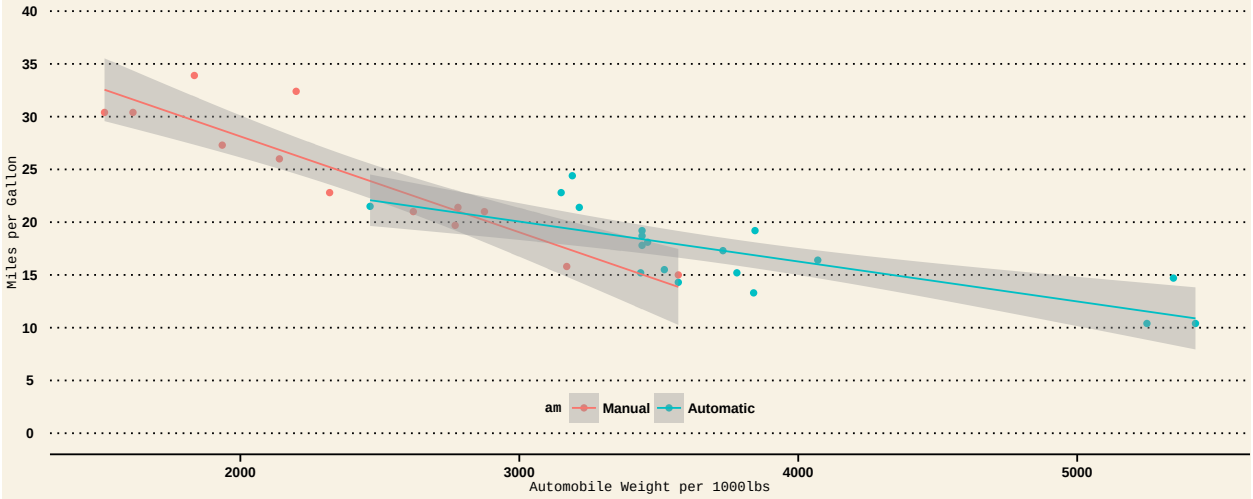


Figure 3: MPG by Automobile Weight, Cyclinder Size and Displacement

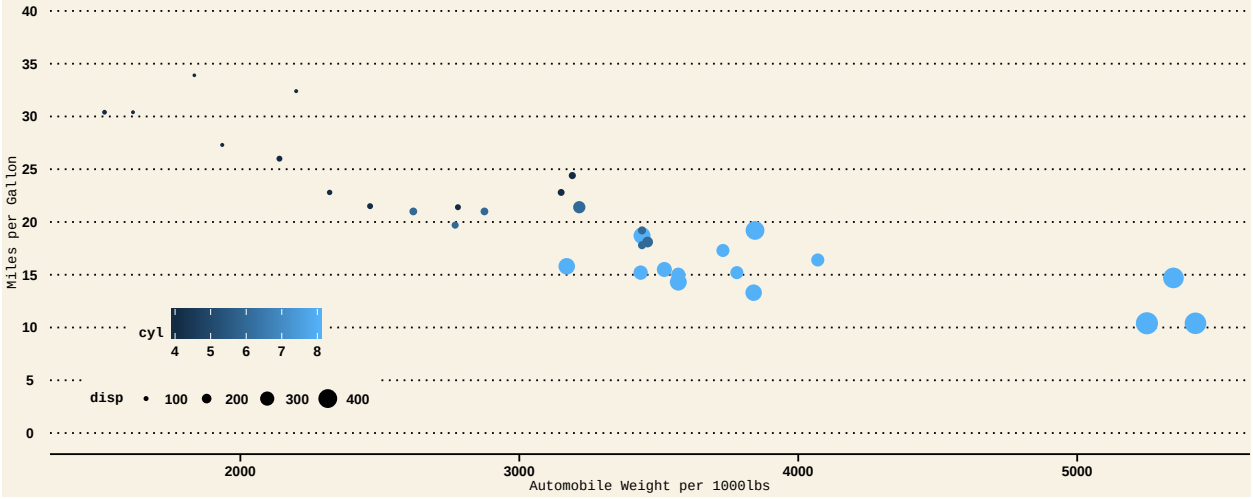
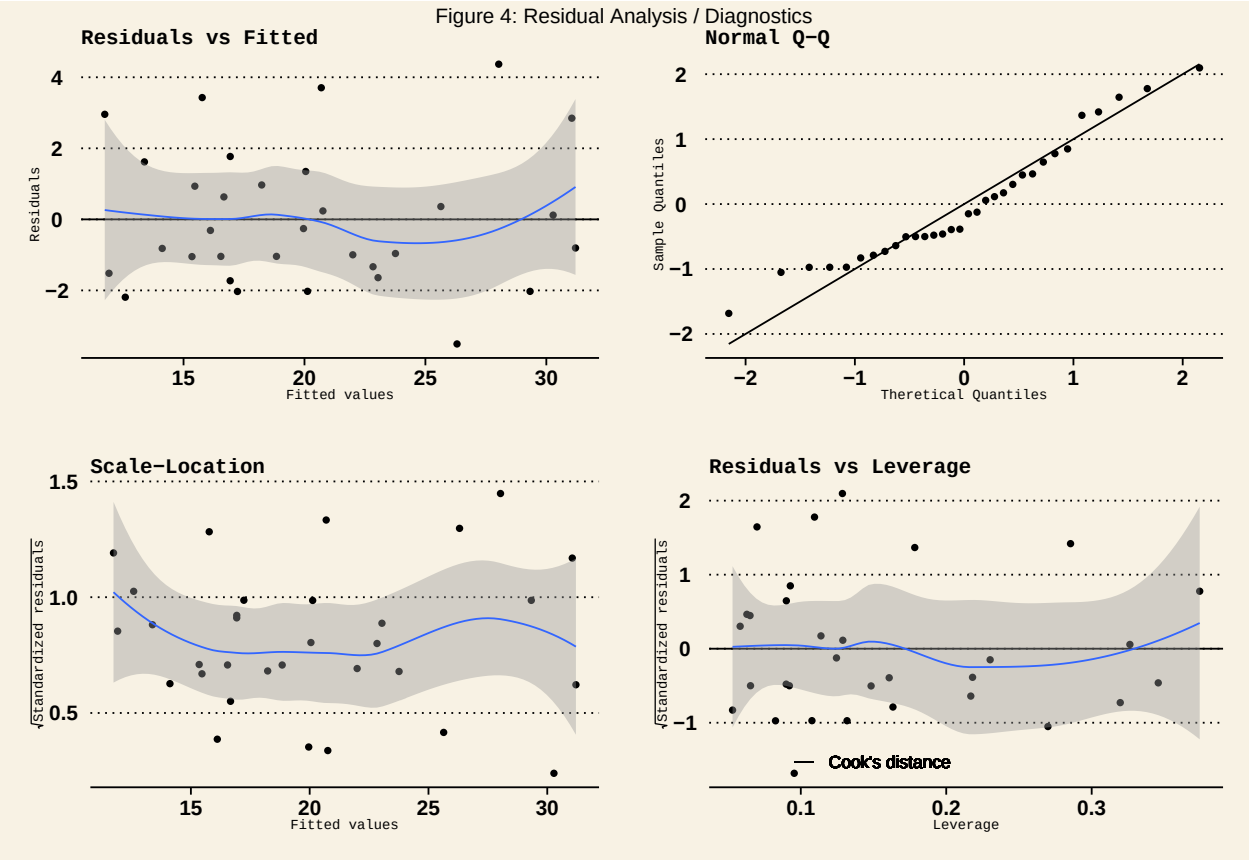


Figure 4: Residual Analysis / Diagnostics



3 References

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