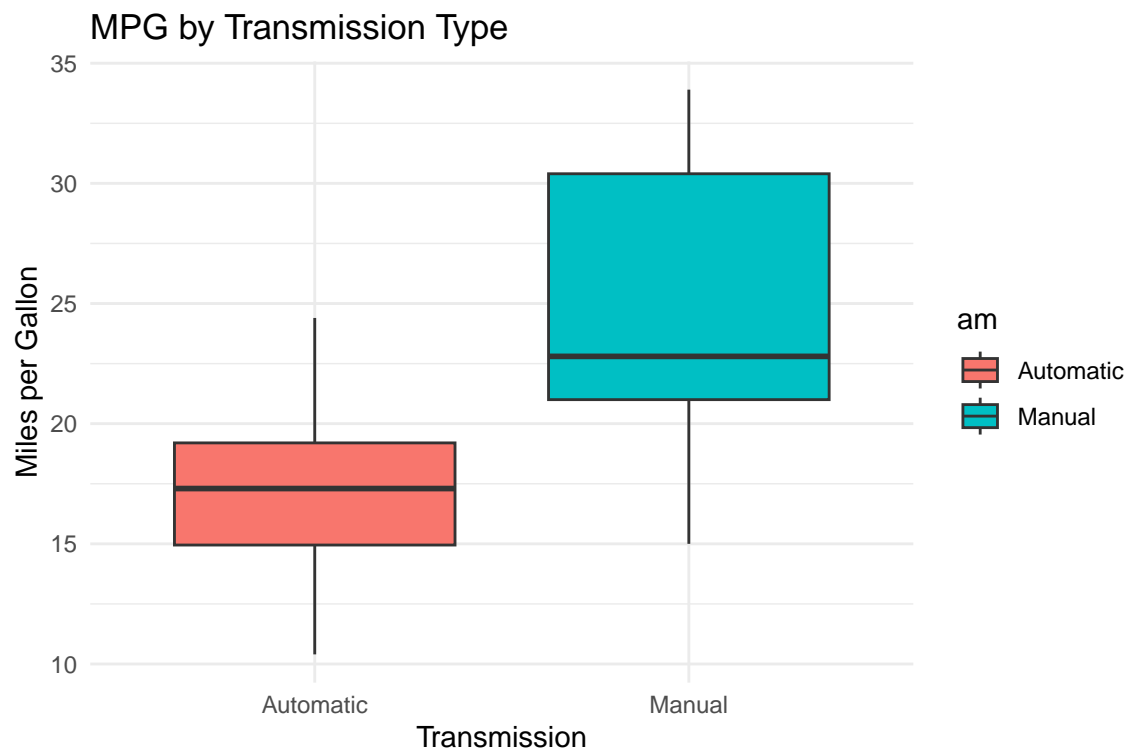# Motor Trend MPG Analysis

Bharat Dogra

2025-03-28

Executive Summary

This report investigates whether automatic or manual transmission results in better fuel efficiency, measured in miles per gallon (MPG), using the `mtcars` dataset. A simple linear regression suggests manual transmission cars achieve 7.25 more MPG than automatic cars. However, after adjusting for car weight and horsepower, the difference reduces to 2.08 MPG and is not statistically significant.

Exploratory Data Analysis

MPG vs Weight by Transmission

Simple Linear Regression

```
##
## Call:
## lm(formula = mpg ~ am, data = mtcars)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.3923 -3.0923 -0.2974  3.2439  9.5077
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   17.147      1.125  15.247 1.13e-15 ***
## amManual       7.245      1.764   4.106 0.000285 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.902 on 30 degrees of freedom
## Multiple R-squared:  0.3598, Adjusted R-squared:  0.3385
## F-statistic: 16.86 on 1 and 30 DF,  p-value: 0.000285
```

Interpretation: Manual transmission cars are estimated to have **7.25 MPG higher** fuel efficiency than automatic ones ($p < 0.001$) before accounting for other factors.

Adjusted Regression Model

```
## 
## Call:
## lm(formula = mpg ~ am + wt + hp, data = mtcars)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -3.4221 -1.7924 -0.3788  1.2249  5.5317 
## 
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)    
## (Intercept) 34.002875   2.642659  12.867 2.82e-13 ***
## amManual     2.083710   1.376420   1.514 0.141268    
## wt          -2.878575   0.904971  -3.181 0.003574 ** 
## hp          -0.037479   0.009605  -3.902 0.000546 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 2.538 on 28 degrees of freedom
## Multiple R-squared:  0.8399, Adjusted R-squared:  0.8227 
## F-statistic: 48.96 on 3 and 28 DF,  p-value: 2.908e-11
```

Interpretation: After adjusting for weight and horsepower, the estimated benefit of manual transmission reduces to **2.08 MPG** (p = 0.14), which is not statistically significant.


Confidence Interval

```
##                  2.5 %      97.5 %
## (Intercept) 28.58963286 39.41611738
## amManual    -0.73575874  4.90317900
## wt          -4.73232353 -1.02482730
## hp          -0.05715454 -0.01780291
```

Interpretation: The 95% confidence interval for the manual transmission effect is [**-0.74, 4.90**], meaning we cannot confidently conclude that transmission type alone has a meaningful impact after adjustment.

Model Diagnostics

Residuals vs Fitted

Q–Q Residuals

Scale–Location

Residuals vs Leverage
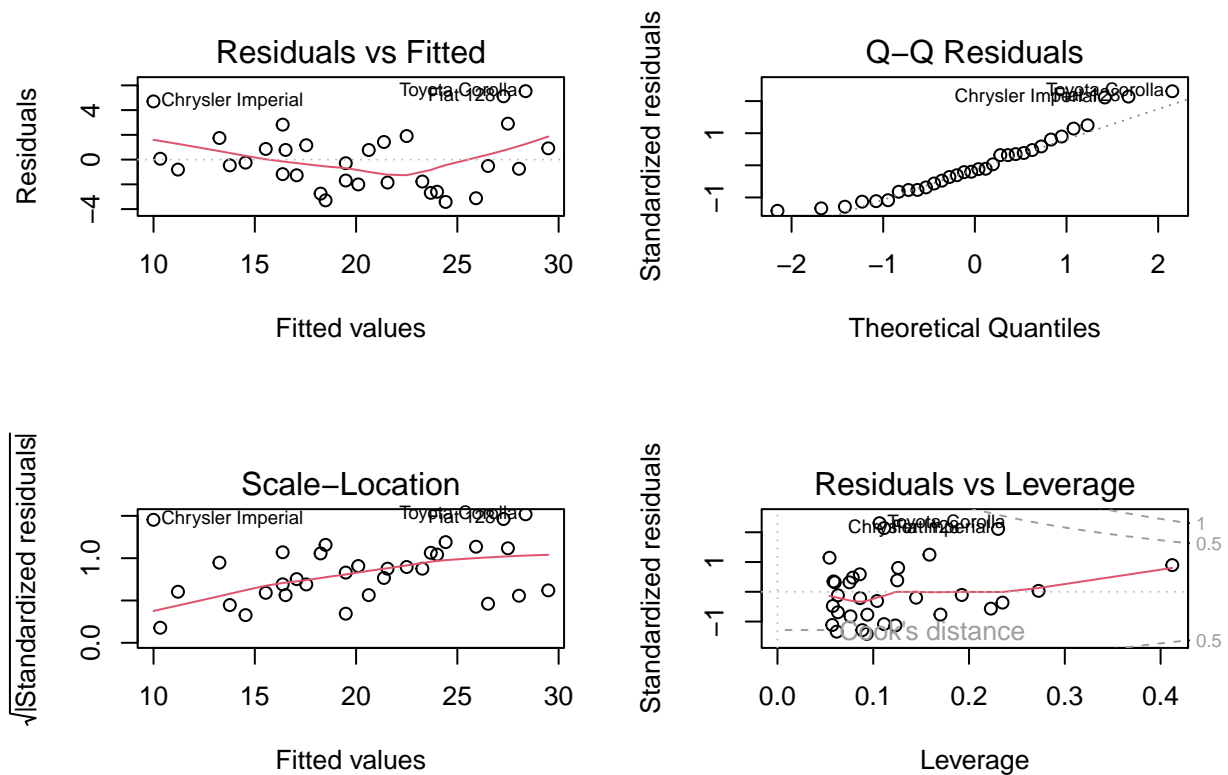
Interpretation: - **Residuals vs Fitted**: No pattern → linearity assumption holds - **Q-Q Plot**: Mostly straight line → residuals approximately normal - **Scale-Location**: Consistent spread → homoscedasticity acceptable - **Residuals vs Leverage**: Chrysler Imperial shows some influence, but not extreme

----

Conclusion

Manual transmission vehicles appear more fuel efficient at first glance. However, once weight and horsepower are accounted for, the advantage nearly disappears and is not statistically significant. The original difference is likely explained by those other variables, not the transmission alone.