

Motor Trend Analysis | Relationship between a set of variables and miles per gallon (MPG) (outcome).

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Motor Trend is looking at a data set of a collection of cars, they want to explore the relationship between a set of variables and miles per gallon (MPG) (outcome) by answering: A. Is an automatic or manual transmission better for MPG? B. Quantify the MPG difference between automatic and manual transmissions. In this research, we are clarifying those questions.

1. Processing Data and Exploring Data

1.1 Headers of MTCARS data

```
# [, 1] mpg Miles/(US) gallon
# [, 2] cyl Number of cylinders
# [, 3] disp Displacement (cu.in.)
# [, 4] hp Gross horsepower
# [, 5] drat Rear axle ratio
# [, 6] wt Weight (1000 lbs)
# [, 7] qsec 1/4 mile time
# [, 8] vs Engine (0 = V-shaped, 1 = straight)
# [, 9] am Transmission (0 = automatic, 1 = manual)
# [,10] gear Number of forward gears
```

1.2 Internal Structure of MTCARS

2. Questions

IS AN AUTOMATIC OR MANUAL TRANSMISSION BETTER FOR MPG?

Analyzing the transmission performance of MTCARS

By using SUMMARY function we are analyzing the statistical results of MTCARS.

```
# A. Checking data from summary.
#      0 = automatic
summary(mtcars[mtcars$am==0,])
```

```
##      mpg      cyl      disp      hp
## Min.   :10.40  Min.   :4.000  Min.   :120.1  Min.   : 62.0
## 1st Qu.:14.95  1st Qu.:6.000  1st Qu.:196.3  1st Qu.:116.5
## Median :17.30  Median :8.000  Median :275.8  Median :175.0
## Mean   :17.15  Mean   :6.947  Mean   :290.4  Mean   :160.3
## 3rd Qu.:19.20  3rd Qu.:8.000  3rd Qu.:360.0  3rd Qu.:192.5
## Max.   :24.40  Max.   :8.000  Max.   :472.0  Max.   :245.0
##      drat      wt      qsec      vs      am
## Min.   :2.760  Min.   :2.465  Min.   :15.41  Min.   :0.0000  Min.   :0
## 1st Qu.:3.070  1st Qu.:3.438  1st Qu.:17.18  1st Qu.:0.0000  1st Qu.:0
## Median :3.150  Median :3.520  Median :17.82  Median :0.0000  Median :0
## Mean   :3.286  Mean   :3.769  Mean   :18.18  Mean   :0.3684  Mean   :0
## 3rd Qu.:3.695  3rd Qu.:3.842  3rd Qu.:19.17  3rd Qu.:1.0000  3rd Qu.:0
## Max.   :3.920  Max.   :5.424  Max.   :22.90  Max.   :1.0000  Max.   :0
##      gear      carb
## Min.   :3.000  Min.   :1.000
## 1st Qu.:3.000  1st Qu.:2.000
## Median :3.000  Median :3.000
## Mean   :3.211  Mean   :2.737
## 3rd Qu.:3.000  3rd Qu.:4.000
## Max.   :4.000  Max.   :4.000
```

```
#      1 = manual
summary(mtcars[mtcars$am==1,])
```

```
##      mpg      cyl      disp      hp      drat
## Min.   :15.00  Min.   :4.000  Min.   : 71.1  Min.   : 52.0  Min.   :3.54
## 1st Qu.:21.00  1st Qu.:4.000  1st Qu.: 79.0  1st Qu.: 66.0  1st Qu.:3.85
## Median :22.80  Median :4.000  Median :120.3  Median :109.0  Median :4.08
## Mean   :24.39  Mean   :5.077  Mean   :143.5  Mean   :126.8  Mean   :4.05
## 3rd Qu.:30.40  3rd Qu.:6.000  3rd Qu.:160.0  3rd Qu.:113.0  3rd Qu.:4.22
## Max.   :33.90  Max.   :8.000  Max.   :351.0  Max.   :335.0  Max.   :4.93
##      wt      qsec      vs      am      gear
## Min.   :1.513  Min.   :14.50  Min.   :0.0000  Min.   :1  Min.   :4.000
## 1st Qu.:1.935  1st Qu.:16.46  1st Qu.:0.0000  1st Qu.:1  1st Qu.:4.000
## Median :2.320  Median :17.02  Median :1.0000  Median :1  Median :4.000
## Mean   :2.411  Mean   :17.36  Mean   :0.5385  Mean   :1  Mean   :4.385
## 3rd Qu.:2.780  3rd Qu.:18.61  3rd Qu.:1.0000  3rd Qu.:1  3rd Qu.:5.000
## Max.   :3.570  Max.   :19.90  Max.   :1.0000  Max.   :1  Max.   :5.000
##      carb
## Min.   :1.000
## 1st Qu.:1.000
## Median :2.000
## Mean   :2.923
## 3rd Qu.:4.000
## Max.   :8.000
```

Testing the hypothesis: *Manual transmission is better than automatic transmission for MPG*

Analyzing the data of MTCARS and trying to proof the hypothesis.

```
t.test(mtcars$mpg~mtcars$am)
```

```
##
## Welch Two Sample t-test
##
## data: mtcars$mpg by mtcars$am
## t = -3.7671, df = 18.332, p-value = 0.001374
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -11.280194 -3.209684
## sample estimates:
## mean in group 0 mean in group 1
## 17.14737 24.39231
```

CONCLUSIONS:

1. The mean of mpg is greater for manual (at 24.4) than automatic (at 17.1).
2. Null hypothesis rejected. Based on the results, **p-value** = 0.001374 < 0.05, therefore,
 - a. We reject the null hypothesis that there is no difference in MPG,
 - b. Conclude that:
 - Manual transmission is better than automatic transmission for MPG,
 - Assumption that all other conditions remain unchanged. By analyzing the mean of MPG, the general conclusion is that manual vehicles have better MPG performance than Automatic vehicles. But by how much? In the following analysis we will investigate the reason why manual is better than automatic by quantifying the difference.

QUANTIFY THE MPG DIFFERENCE BETWEEN AUTOMATIC AND MANUAL TRANSMISSIONS

Analyzing the transmission performance of MTCARS graphically.

By visualizing the data of the MTCARS.

Manual has a higher mean for mpg than automatic. ### Analyzing the linear model

Our model has included three variables:

- **wt** - Weight (1000 lbs)
- **qsec** - qsec 1/4 mile time
- **am** - Transmission (0 = automatic, 1 = manual)

This model explains 85% of the variance. It may be concluded that on average, manual transmissions have 1.478 more mpg than automatic. To optimize the model, let's examine the model with $\text{mpg} \sim \text{wt} + \text{qsec}$ correlation with **am**.

This model has a 89.5% total variance with an adjusted variance of 88%. By adding the coefficients, we have the following conclusions:

- When the weight increased by 1000 lbs, the mpg decreased by -3.176 for automatic transmission cars, and -6.09 for manual transmission cars

- By increasing car weight, the proper transmission to choose is: Manual.
- When the acceleration speed dropped and 1/4 mile time increased by 1 sec:
 - The mpg factor increased by 0.834 miles for automatic transmission cars.
 - And, 1.446 miles for manual transmission cars.
- Lowering acceleration speed, but same weight, manual transmission cars are better for mpg.

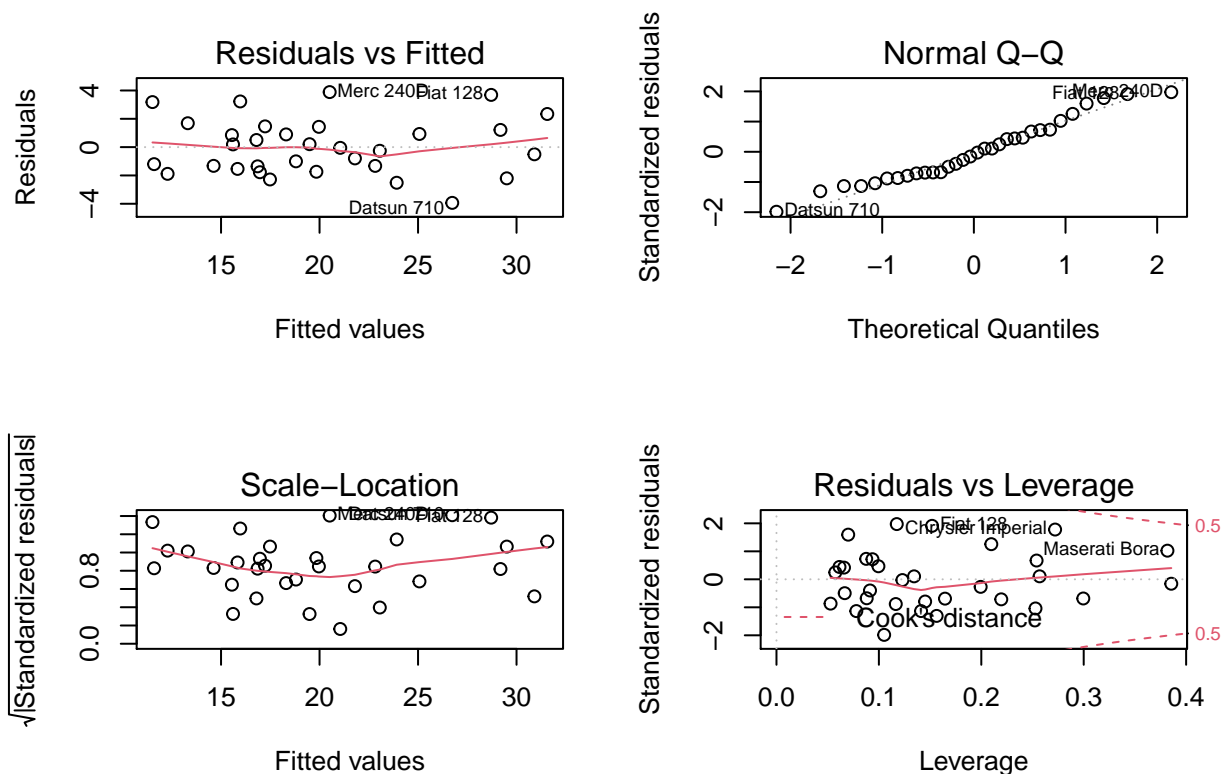
MAIN CONCLUSION

The mpg is determined by the interaction among: weight, acceleration and transmission. Given the above analysis, the original question (automatic transmission vs manual transmission) is not answered, and we should consider the context of weight and acceleration speed (clarified in question 2).

Appendix

Appendix 1: Residual check and diagnostics

```
par(mfrow=c(2,2))
plot(model)
```



Appendix 2: Regression Model Results

```
full.model <- lm(mpg ~ ., data = mtcars)
best.model <- step(full.model, direction = "backward")
```

```
## Start: AIC=70.9
## mpg ~ cyl + disp + hp + drat + wt + qsec + vs + am + gear + carb
##
##           Df Sum of Sq    RSS    AIC
## - cyl      1    0.0799 147.57 68.915
## - vs       1    0.1601 147.66 68.932
## - carb     1    0.4067 147.90 68.986
## - gear     1    1.3531 148.85 69.190
## - drat     1    1.6270 149.12 69.249
## - disp     1    3.9167 151.41 69.736
## - hp       1    6.8399 154.33 70.348
## - qsec     1    8.8641 156.36 70.765
## <none>                147.49 70.898
## - am       1   10.5467 158.04 71.108
## - wt       1   27.0144 174.51 74.280
##
## Step: AIC=68.92
## mpg ~ disp + hp + drat + wt + qsec + vs + am + gear + carb
##
##           Df Sum of Sq    RSS    AIC
## - vs       1    0.2685 147.84 66.973
## - carb     1    0.5201 148.09 67.028
## - gear     1    1.8211 149.40 67.308
## - drat     1    1.9826 149.56 67.342
## - disp     1    3.9009 151.47 67.750
## - hp       1    7.3632 154.94 68.473
## <none>                147.57 68.915
## - qsec     1   10.0933 157.67 69.032
## - am       1   11.8359 159.41 69.384
## - wt       1   27.0280 174.60 72.297
##
## Step: AIC=66.97
## mpg ~ disp + hp + drat + wt + qsec + am + gear + carb
##
##           Df Sum of Sq    RSS    AIC
## - carb     1    0.6855 148.53 65.121
## - gear     1    2.1437 149.99 65.434
## - drat     1    2.2139 150.06 65.449
## - disp     1    3.6467 151.49 65.753
## - hp       1    7.1060 154.95 66.475
## <none>                147.84 66.973
## - am       1   11.5694 159.41 67.384
## - qsec     1   15.6830 163.53 68.200
## - wt       1   27.3799 175.22 70.410
##
## Step: AIC=65.12
## mpg ~ disp + hp + drat + wt + qsec + am + gear
##
```

```

##           Df Sum of Sq    RSS    AIC
## - gear    1      1.565 150.09 63.457
## - drat    1      1.932 150.46 63.535
## <none>                148.53 65.121
## - disp    1     10.110 158.64 65.229
## - am      1     12.323 160.85 65.672
## - hp      1     14.826 163.35 66.166
## - qsec    1     26.408 174.94 68.358
## - wt      1     69.127 217.66 75.350
##
## Step:  AIC=63.46
## mpg ~ disp + hp + drat + wt + qsec + am
##
##           Df Sum of Sq    RSS    AIC
## - drat    1      3.345 153.44 62.162
## - disp    1      8.545 158.64 63.229
## <none>                150.09 63.457
## - hp      1     13.285 163.38 64.171
## - am      1     20.036 170.13 65.466
## - qsec    1     25.574 175.67 66.491
## - wt      1     67.572 217.66 73.351
##
## Step:  AIC=62.16
## mpg ~ disp + hp + wt + qsec + am
##
##           Df Sum of Sq    RSS    AIC
## - disp    1      6.629 160.07 61.515
## <none>                153.44 62.162
## - hp      1     12.572 166.01 62.682
## - qsec    1     26.470 179.91 65.255
## - am      1     32.198 185.63 66.258
## - wt      1     69.043 222.48 72.051
##
## Step:  AIC=61.52
## mpg ~ hp + wt + qsec + am
##
##           Df Sum of Sq    RSS    AIC
## - hp      1      9.219 169.29 61.307
## <none>                160.07 61.515
## - qsec    1     20.225 180.29 63.323
## - am      1     25.993 186.06 64.331
## - wt      1     78.494 238.56 72.284
##
## Step:  AIC=61.31
## mpg ~ wt + qsec + am
##
##           Df Sum of Sq    RSS    AIC
## <none>                169.29 61.307
## - am      1     26.178 195.46 63.908
## - qsec    1    109.034 278.32 75.217
## - wt      1    183.347 352.63 82.790

```