

Analysis on Transmission Effects vs. Fuel Efficiency ?

Executive Summary

You work for Motor Trend, a magazine about the automobile industry. Looking at a data set of a collection of cars, they are interested in exploring the relationship between a set of variables and miles per gallon (MPG) (outcome). They are particularly interested in the following two questions:

- “Is an automatic or manual transmission better for MPG”
- “Quantify the MPG difference between automatic and manual transmissions”

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).

Dataset details

The dataset contains of 32 rows on 11 variables name below :-

1. mpg: Miles per US gallon
2. cyl: Number of cylinders
3. disp: Displacement (cc)
4. hp: Raw Horsepower
5. drat: Rear axle ratio
6. wt: Weight (lb / 1000)
7. qsec: 1/4 mile time in sec
8. vs: V engine or Straight engine
9. am: Transmission (0 = automatic, 1 = manual)
10. gear: Number of gears
11. carb: Number of carburetors

Details records of the dataset

```
unique(mtcars)
```

##	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
## Mazda RX4	21.0	6	160.0	110	3.90	2.620	16.46	0	1	4	4
## Mazda RX4 Wag	21.0	6	160.0	110	3.90	2.875	17.02	0	1	4	4
## Datsun 710	22.8	4	108.0	93	3.85	2.320	18.61	1	1	4	1
## Hornet 4 Drive	21.4	6	258.0	110	3.08	3.215	19.44	1	0	3	1
## Hornet Sportabout	18.7	8	360.0	175	3.15	3.440	17.02	0	0	3	2
## Valiant	18.1	6	225.0	105	2.76	3.460	20.22	1	0	3	1
## Duster 360	14.3	8	360.0	245	3.21	3.570	15.84	0	0	3	4
## Merc 240D	24.4	4	146.7	62	3.69	3.190	20.00	1	0	4	2
## Merc 230	22.8	4	140.8	95	3.92	3.150	22.90	1	0	4	2
## Merc 280	19.2	6	167.6	123	3.92	3.440	18.30	1	0	4	4
## Merc 280C	17.8	6	167.6	123	3.92	3.440	18.90	1	0	4	4
## Merc 450SE	16.4	8	275.8	180	3.07	4.070	17.40	0	0	3	3
## Merc 450SL	17.3	8	275.8	180	3.07	3.730	17.60	0	0	3	3

## Merc 450SLC	15.2	8	275.8	180	3.07	3.780	18.00	0	0	3	3
## Cadillac Fleetwood	10.4	8	472.0	205	2.93	5.250	17.98	0	0	3	4
## Lincoln Continental	10.4	8	460.0	215	3.00	5.424	17.82	0	0	3	4
## Chrysler Imperial	14.7	8	440.0	230	3.23	5.345	17.42	0	0	3	4
## Fiat 128	32.4	4	78.7	66	4.08	2.200	19.47	1	1	4	1
## Honda Civic	30.4	4	75.7	52	4.93	1.615	18.52	1	1	4	2
## Toyota Corolla	33.9	4	71.1	65	4.22	1.835	19.90	1	1	4	1
## Toyota Corona	21.5	4	120.1	97	3.70	2.465	20.01	1	0	3	1
## Dodge Challenger	15.5	8	318.0	150	2.76	3.520	16.87	0	0	3	2
## AMC Javelin	15.2	8	304.0	150	3.15	3.435	17.30	0	0	3	2
## Camaro Z28	13.3	8	350.0	245	3.73	3.840	15.41	0	0	3	4
## Pontiac Firebird	19.2	8	400.0	175	3.08	3.845	17.05	0	0	3	2
## Fiat X1-9	27.3	4	79.0	66	4.08	1.935	18.90	1	1	4	1
## Porsche 914-2	26.0	4	120.3	91	4.43	2.140	16.70	0	1	5	2
## Lotus Europa	30.4	4	95.1	113	3.77	1.513	16.90	1	1	5	2
## Ford Pantera L	15.8	8	351.0	264	4.22	3.170	14.50	0	1	5	4
## Ferrari Dino	19.7	6	145.0	175	3.62	2.770	15.50	0	1	5	6
## Maserati Bora	15.0	8	301.0	335	3.54	3.570	14.60	0	1	5	8
## Volvo 142E	21.4	4	121.0	109	4.11	2.780	18.60	1	1	4	2

Research Questions

- “Is an automatic or manual transmission better for MPG”

Summary for all cars

```
summary(mtcars)
```

##	mpg	cyl	disp	hp
##	Min. :10.40	Min. :4.000	Min. : 71.1	Min. : 52.0
##	1st Qu.:15.43	1st Qu.:4.000	1st Qu.:120.8	1st Qu.: 96.5
##	Median :19.20	Median :6.000	Median :196.3	Median :123.0
##	Mean :20.09	Mean :6.188	Mean :230.7	Mean :146.7
##	3rd Qu.:22.80	3rd Qu.:8.000	3rd Qu.:326.0	3rd Qu.:180.0
##	Max. :33.90	Max. :8.000	Max. :472.0	Max. :335.0
##	drat	wt	qsec	vs
##	Min. :2.760	Min. :1.513	Min. :14.50	Min. :0.0000
##	1st Qu.:3.080	1st Qu.:2.581	1st Qu.:16.89	1st Qu.:0.0000
##	Median :3.695	Median :3.325	Median :17.71	Median :0.0000
##	Mean :3.597	Mean :3.217	Mean :17.85	Mean :0.4375
##	3rd Qu.:3.920	3rd Qu.:3.610	3rd Qu.:18.90	3rd Qu.:1.0000
##	Max. :4.930	Max. :5.424	Max. :22.90	Max. :1.0000
##	am	gear	carb	
##	Min. :0.0000	Min. :3.000	Min. :1.000	
##	1st Qu.:0.0000	1st Qu.:3.000	1st Qu.:2.000	
##	Median :0.0000	Median :4.000	Median :2.000	
##	Mean :0.4062	Mean :3.688	Mean :2.812	
##	3rd Qu.:1.0000	3rd Qu.:4.000	3rd Qu.:4.000	
##	Max. :1.0000	Max. :5.000	Max. :8.000	

Summary for automatic type cars

```
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
## Min.       :2.760   Min.       :2.465   Min.       :15.41   Min.       :0.0000
## 1st Qu.:3.070   1st Qu.:3.438   1st Qu.:17.18   1st Qu.:0.0000
## Median :3.150   Median :3.520   Median :17.82   Median :0.0000
## Mean      :3.286   Mean      :3.769   Mean      :18.18   Mean      :0.3684
## 3rd Qu.:3.695   3rd Qu.:3.842   3rd Qu.:19.17   3rd Qu.:1.0000
## Max.      :3.920   Max.      :5.424   Max.      :22.90   Max.      :1.0000
##           am           gear           carb
## Min.       :0   Min.       :3.000   Min.       :1.000
## 1st Qu.:0   1st Qu.:3.000   1st Qu.:2.000
## Median :0   Median :3.000   Median :3.000
## Mean      :0   Mean      :3.211   Mean      :2.737
## 3rd Qu.:0   3rd Qu.:3.000   3rd Qu.:4.000
## Max.      :0   Max.      :4.000   Max.      :4.000
```

Summary for manual type cars

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

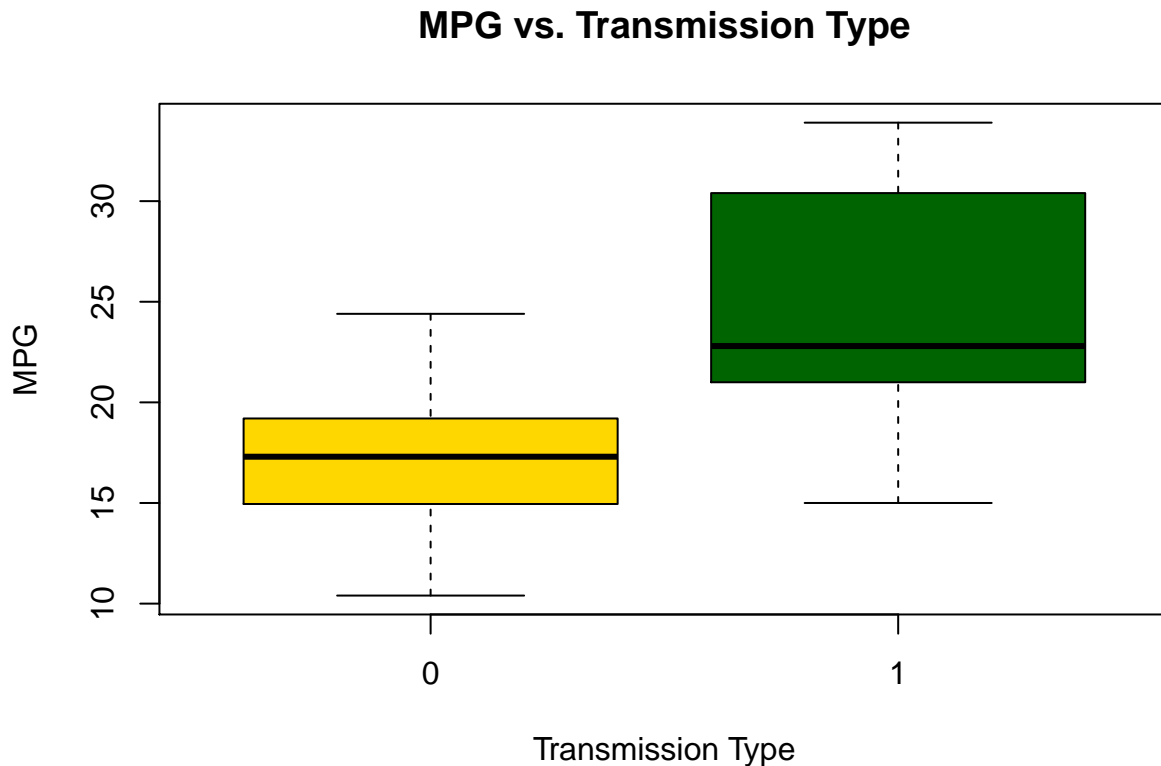
```
##           mpg           cyl           disp           hp
## Min.      :15.00   Min.      :4.000   Min.       : 71.1   Min.       : 52.0
## 1st Qu.:21.00   1st Qu.:4.000   1st Qu.: 79.0   1st Qu.: 66.0
## Median :22.80   Median :4.000   Median :120.3   Median :109.0
## Mean      :24.39   Mean  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

We found that the mean for MPG for manual cars is bigger than automatic which is [24.39 > 17.15]. Further investigation needed to be done to verify this .

- “Quantify the MPG difference between automatic and manual transmissions”

By plotting into BoxPlot we can have more info

```
boxplot(mpg ~ am, data = mtcars, col=(c("gold","darkgreen")),
        xlab = "Transmission Type", ylab = "MPG",
        main="MPG vs. Transmission Type")
```



it proves that manual = 1 transmission is higher mpg mean than automatic = 0

We need to do the hypothesis testing to prove this

```
aggregate(mpg~am, data = mtcars, mean)
```

```
##   am      mpg
## 1  0 17.14737
## 2  1 24.39231
```

The mean transmission for manuals is 24.39 mpg which is 7.24 mpg higher than automatic which is 17.15 mpg

We want to test and to determine is there any significant between this. Student TTest can be used to achieve this.

```
a <- mtcars[mtcars$am == 0,]
m <- mtcars[mtcars$am == 1,]
t.test(a$mpg, m$mpg)
```

```
##
## Welch Two Sample t-test
##
## data: a$mpg and m$mpg
## 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 of x mean of y
## 17.14737 24.39231
```

With the $p\text{Value} = 0.001374$, we reject the NULL hypothesis. There is a difference between the mpg for auto and manual transmission.

We try to fit the data into the linear model to check the variance

```
m<-lm(mpg~am,data=mtcars)
summary(m)
```

```
##
## 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 ***
## am              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
```

We found that the $R\text{-Squared} = 0.3598$, so we can assume the model only can be trusted for 36% of variance.

We also want to analyze the differences between the group means and their association. We put the dataset into the model and compared it using Anova

```
model <- lm(mpg~am + wt + hp + cyl, data = mtcars)
anova(m,model)
```

```
## Analysis of Variance Table
##
## Model 1: mpg ~ am
## Model 2: mpg ~ am + wt + hp + cyl
##   Res.Df  RSS Df Sum of Sq    F    Pr(>F)
## 1      30 720.9
```

```
## 2      27 170.0  3      550.9 29.166 1.274e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The model finally can be summarized below :-

```
summary(model)
```

```
##
## Call:
## lm(formula = mpg ~ am + wt + hp + cyl, data = mtcars)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.4765 -1.8471 -0.5544  1.2758  5.6608
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  36.14654    3.10478   11.642 4.94e-12 ***
## am           1.47805    1.44115    1.026  0.3142
## wt          -2.60648    0.91984   -2.834  0.0086 **
## hp           -0.02495    0.01365   -1.828  0.0786 .
## cyl          -0.74516    0.58279   -1.279  0.2119
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.509 on 27 degrees of freedom
## Multiple R-squared:  0.849, Adjusted R-squared:  0.8267
## F-statistic: 37.96 on 4 and 27 DF, p-value: 1.025e-10
```

Conclusion

The model clearly explains with the 84.9% of variance that on average the manual transmission will have more 1.47805 more mpg than the automatic transmission.

We also found that the residuals were normally distributed.

Appendix

```
plot(model)
```

