Motor Trends mtcars analysis

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Executive Summary

A list of 32 cars have been submitted to me for examination of the relationship between Miles Per Gallon and the transmission type. I am asked:

- Is automatic transmission better than manual transmission?
- Can we quantify this difference?

A set of models where attempted on the data set taking account each and all variables. Each variable was explored in-depth both as mathematical quantities and as physics aspects of a car design, including its engine, gasoline displacement and other aspects, not explicitly included in the original dataset, such as power-to-weight ratio, were calculated and explored.

Power loading is the most important variable of this result, so its important to define it explicitly:

$$w2p = power\_loading = Weight/HorsePower$$

Refer to the variable table in de appendix for further information this and other measures.

Preliminary analysis

The first attempt is to compare the difference in the average cars in both manual and automatic cars, assuming this dataset represents the whole car industry, that is, this sample of 32 cars is randomly selected and sufficiently large, these are the results:

- Cars with manual tranmission range in consumption from 21.6 to 27.16 miles per gallon while the average automatic transmission car ranges from 10.8 to 23.5 miles per gallon, with 95% confidence.
- As for the “can we quantify this”, the answer is partially yes: most automatic and manual cars lie within that range, but its obvious that some automatic cars give more miles per gallon than manual cars and viceversa: some manual cars give less miles per gallon than some automatic cars. Speciffically, in this dataset, this cars are:

row_number	Model	mpg	transmission	power_loading	carb
3	Datsun 710	22.8	M	0.4921482	1
9	Merc 230	22.8	A	8.7038064	2

Which you can immediatly see give exactly the same MPG, but are of auto and manual transmissions. If these two cars represent whole classes of cars in the market, then its possible that attempting to explain MPG only by transmission is misguided. A full exploration of the many possible other variables in the dataset that might help explain MPG additionally to transmission is available in the appendix. Here, I list only the final conclussion:

Conclusion

After a length exploration of the data and several models, I arrived at this conclusion:

- Many factors other than transmission affect MPG. It is a more complex question than what one would think.
- The main factor I included is the weight-to-power ratio, also called the power loading, which divides the car's weight in pounds over the cars horse powers.
- Therefore, taking into account the power loading and the transmission type, I have 95% confidence that:
  - Manual cars:
    - The average power loading manual transmission car will travel 22.7 to 27.2 miles per gallon.
  - Automatic cars:
    - The average power loading automatic transmission car will travel 11.5 to 21.9 miles per gallon.

This does not tell the whole story. For each 1 unit of

$$w2p = power\_loading = Weight/HorsePower$$

ratio that the car goes over the average power loading, any of this cars will travel from 0.2 to 0.57 additional miles per gallon spent.

This might seem anti climatic for a magazzine, but please refer to the figures in the appendix for a suggestion on how to publish this results. Cars can be classified as better or worse in power loading and that position of the cars with respect to power loading and mpg is what tells the rest of the story.

Due to this document's size constraint, I cannot put here all the exploration necessary. Please refer to the github repo for all the glorious analysis you might wish to see.

Suffice it to say that ANOVA suggests power loading is a great variable to include and it doesnt have much impact in variance inflation:

```
## [1] "ANOVA"

## Analysis of Variance Table
##
## Model 1: mpg ~ transmission
## Model 2: mpg ~ transmission + power_loading
##   Res.Df   RSS Df Sum of Sq      F    Pr(>F)
## 1     30 720.9
## 2     29 451.0  1     269.9 17.355 0.0002545 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## [1] "Variance Inflation Factor"

##  transmission power_loading
##       1.02892       1.02892
```

Appendix

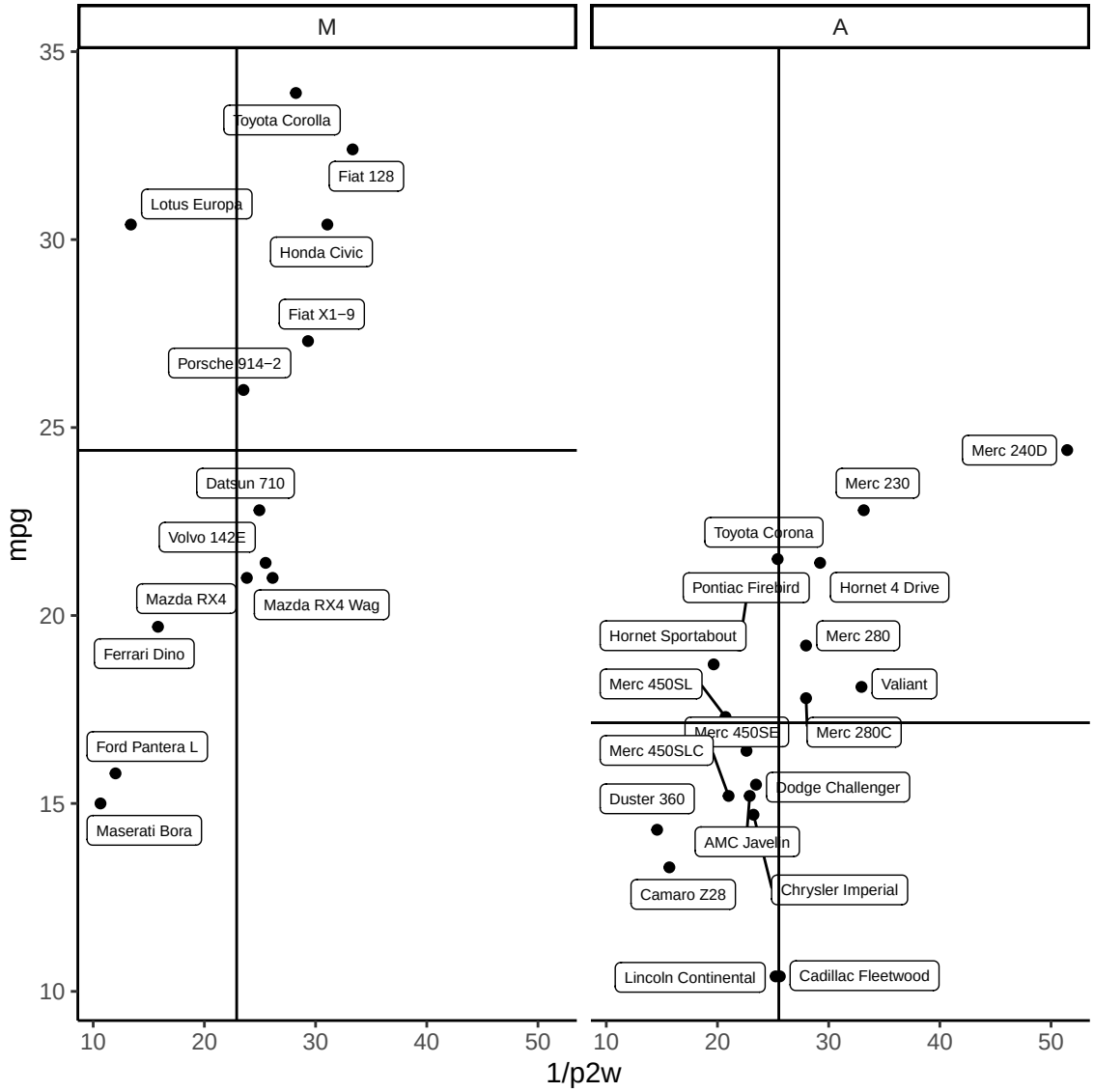

Figure 1: How i would explain this results to people: cuadrantize both groups by mean mpg and mean power loading

Other explorations

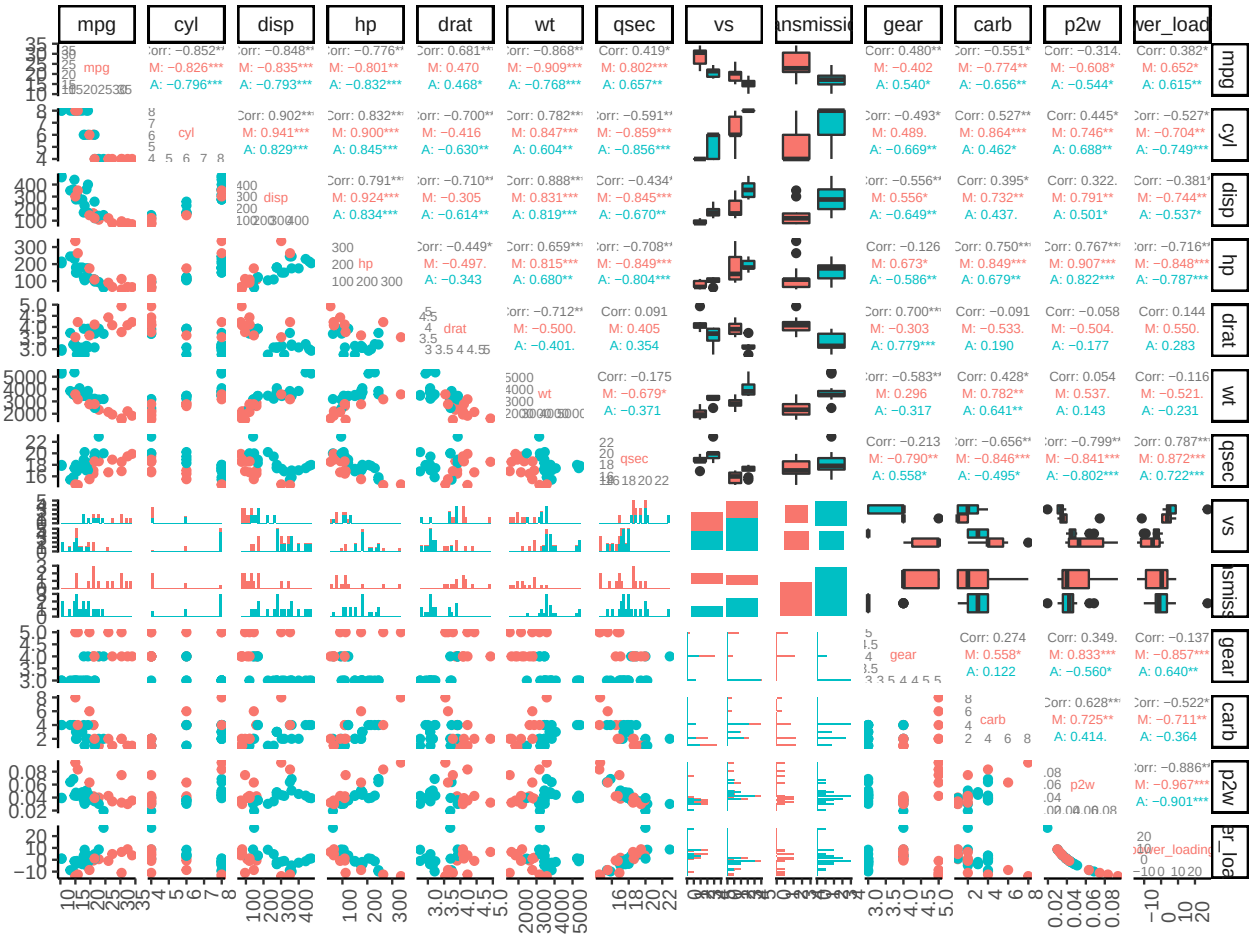

Table 2: The variables themselves, with research links

Var	Doc	Note	Source	f(?)
mpg	M iles/(US) gallon			
cyl	Number of cylinders			
disp	Dis placement (cu.in.)	How much gas/air mix passes through the cylinders in total	<https :// www.yourm ech anic.com/ art icle/what -is -engine-d ispl acement>	f(cyl,volcyl)=cyl*VolCyl
hp	Gross h orsepower		< ww. wikihow.c om/ Calculate -Hor sepower>	f(Torque, RPM)=T*RPM+e

Var	Doc	Note	Source	f(?)
drat	Rear axle ratio	Motor revs/rear axle revs (kind of a measure of efficiency)	< https:/ /ww w.autolis t.c om/guides /axl e-ratio>	f(RPMaxlefron t,RPMaxleback)=RPMaxelfron t/RPMaxleback
wt	Weight (1000 lbs)			f(car)
qsec	1/4 mile time			
vs	Engine (0 V-shaped, 1 = straight)	V: classic, can have more cylinders, Straight: more efficient, normally less cylinders	<ht tp: //www.why hig hend.com/ inl ine-vs-v- engi ne.html>	f(cyl)
am	Tra nsmission (0 = a utomatic, 1 = manual)			
gear	Number of forward gears			
carb	Number of ca rburetors			
p2w	hp/(wt*1000)			
power_ loading	1/p2w-(mean(1/p2w))	https://en .wikipedia.org/wiki/Powe r-to-weight_ratio)		

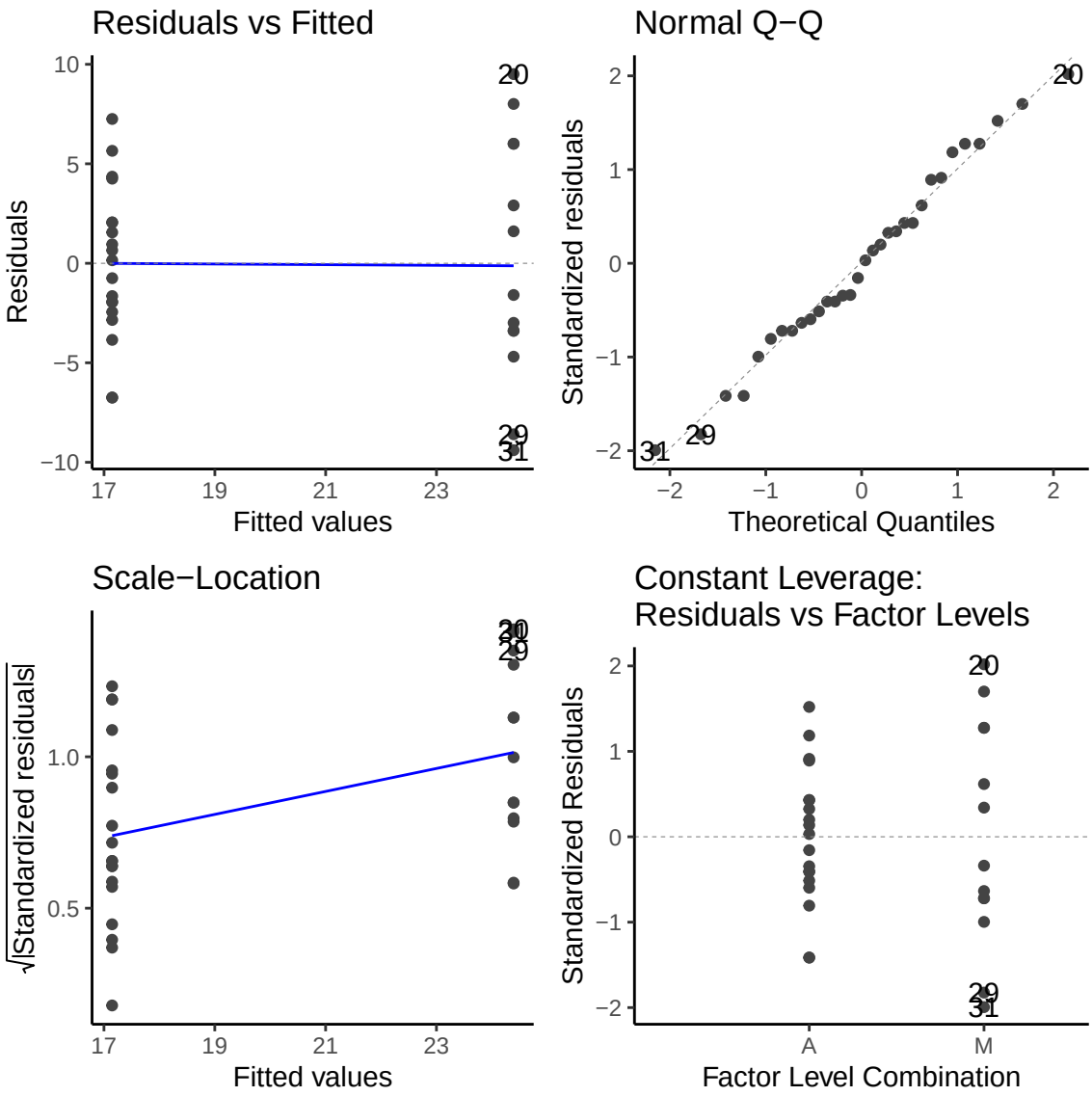

Figure 2: Model:lm(mpg~transmission,thecars)

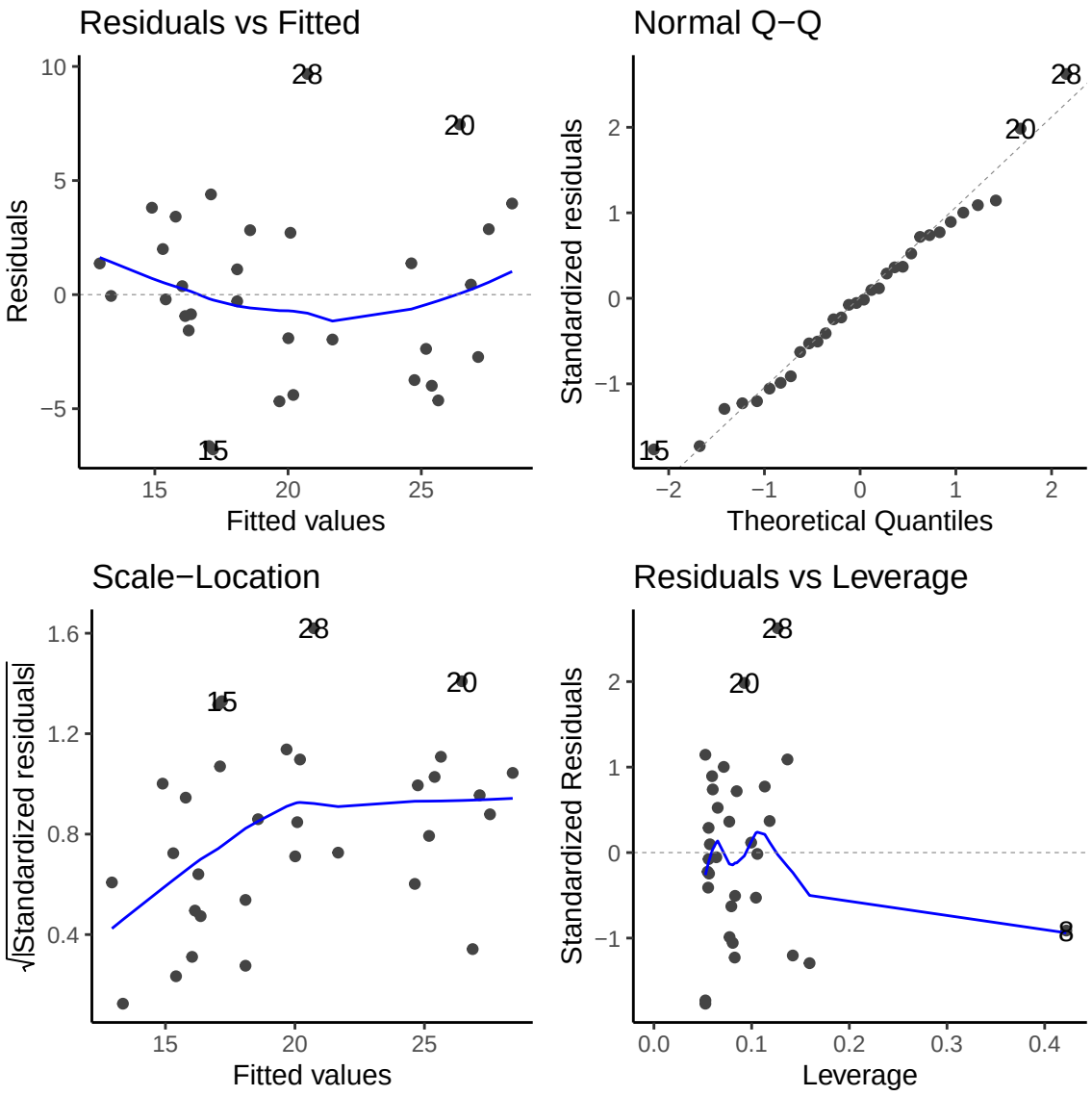

Figure 3: Model:lm(mpg~transmission+power_loading,thecars)