Capstone Project : Used car price

HarvardX : Data Science Professional Certificate

Youssef Bougarrani

7/23/2021

Contents

N.b : All plots are built with theme_minimal to reduce ink when printing.

1 Introduction

This report is the second part of capstone for HarvardX Data Science Professional Certificate. Data set is from the British used car listing about 100,000 vehicles.

The goal of this analysis is to predict the price knowing other features of the car. We start by an initial exploration of data set and visualization. Then we perform machine learning models and display results.

1.1 Data description

Data set is about used cars listings 100,000 cars, which have been separated into files corresponding to each car manufacturer.

The cleaned data set contains information of price, transmission, mileage, fuel type, road tax, miles per gallon (mpg), and engine size.

1.2 Session information

```
## R version 4.1.0 (2021-05-18)
## Platform: x86_64-pc-linux-gnu (64-bit)
## Running under: Ubuntu 20.04.2 LTS
##
## Matrix products: default
## BLAS:   /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.9.0
## LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.9.0
##
## locale:
##  [1] LC_CTYPE=en_US.UTF-8       LC_NUMERIC=C
##  [3] LC_TIME=en_CA.UTF-8        LC_COLLATE=en_US.UTF-8
##  [5] LC_MONETARY=en_CA.UTF-8    LC_MESSAGES=en_US.UTF-8
##  [7] LC_PAPER=en_CA.UTF-8       LC_NAME=C
##  [9] LC_ADDRESS=C               LC_TELEPHONE=C
## [11] LC_MEASUREMENT=en_CA.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## loaded via a namespace (and not attached):
##  [1] compiler_4.1.0    magrittr_2.0.1    tools_4.1.0       htmltools_0.5.1.1
##  [5] yaml_2.2.1        stringi_1.6.2     rmarkdown_2.8     knitr_1.33
##  [9] stringr_1.4.0     xfun_0.23         digest_0.6.27     rlang_0.4.11
## [13] evaluate_0.14
```

Load libraries and install them if require

Load data
From kaggle "100,000 UK Used Car Data set".

```
## Warning in unzip("cars.zip"): error -1 in extracting from zip file
```

```
##  [1] "brand"        "model"        "year"         "price"        "transmission"
##  [6] "mileage"      "fuelType"     "tax(£)"       "mpg"          "engineSize"
```

```
## Warning in fread("vw.csv"): Discarded single-line footer: <<Tiguan
## Allspace,2019,27495,Automatic>>
```

```
##  [1] TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE TRUE
```

2 Analysis

2.1 Initial data exploration and visualization

Dimension of the data set

```
## [1] 98926    10
```

Search for duplicated rows

```
## [1] 1475
```

1475 rows are duplicated.
Remove them.

Look for NAs

	.
brand	0
model	0
year	0
price	0
transmission	0
mileage	0
fuelType	0
tax	0
mpg	0
engineSize	0

There are no NAs.

The structure

```
## Classes 'data.table' and 'data.frame':   97451 obs. of  10 variables:
##  $ brand       : chr  "audi" "audi" "audi" "audi" ...
##  $ model       : chr  "A1" "A6" "A1" "A4" ...
##  $ year        : int  2017 2016 2016 2017 2019 2016 2016 2016 2015 2016 ...
##  $ price       : int  12500 16500 11000 16800 17300 13900 13250 11750 10200 12000 ...
##  $ transmission: chr  "Manual" "Automatic" "Manual" "Automatic" ...
##  $ mileage     : int  15735 36203 29946 25952 1998 32260 76788 75185 46112 22451 ...
##  $ fuelType    : chr  "Petrol" "Diesel" "Petrol" "Diesel" ...
##  $ tax         : int  150 20 30 145 145 30 30 20 20 30 ...
##  $ mpg         : num  55.4 64.2 55.4 67.3 49.6 58.9 61.4 70.6 60.1 55.4 ...
##  $ engineSize  : num  1.4 2 1.4 2 1 1.4 2 2 1.4 1.4 ...
```

```
##    brand model year price transmission mileage fuelType tax  mpg engineSize
## 1:  audi    A1 2017 12500       Manual   15735   Petrol 150 55.4        1.4
## 2:  audi    A6 2016 16500    Automatic   36203   Diesel  20 64.2        2.0
## 3:  audi    A1 2016 11000       Manual   29946   Petrol  30 55.4        1.4
## 4:  audi    A4 2017 16800    Automatic   25952   Diesel 145 67.3        2.0
## 5:  audi    A3 2019 17300       Manual    1998   Petrol 145 49.6        1.0
## 6:  audi    A1 2016 13900    Automatic   32260   Petrol  30 58.9        1.4
```

The price is in British Pound £.
mileage is in mile. And mile = 1.609 km.
tax is in British Pound £.
mpg is the "miles per gallon". And UK gallon ~ 4.5 liter.
engineSize is in liter.

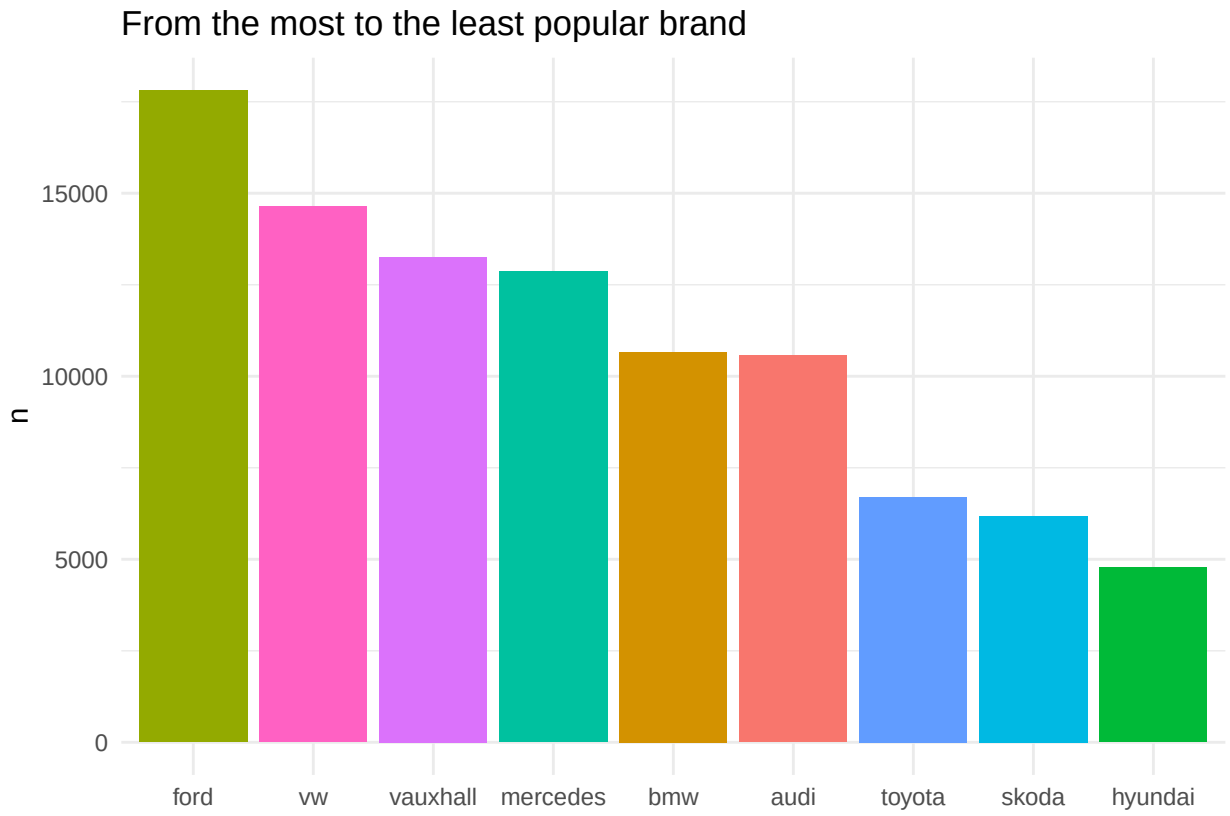
Brand

unique(brand)
audi
bmw
mercedes
ford
hyundai
skoda
toyota
vauxhall
vw

There are 9 brands

Distribution of brands

brand	n
ford	17811
vw	14632
vauxhall	13258
mercedes	12860
bmw	10664
audi	10565
toyota	6699
skoda	6188
hyundai	4774



Total of model

```
##     n
## 1 186
```

model	median(price)	n
180	10799.0	1
200	19495.0	1
220	19995.0	1
230	4500.0	1
A2	2490.0	1
Accent	1295.0	1
Amica	1750.0	1
Escort	3000.0	1
Ranger	14495.0	1
RS7	33490.0	1
Transit Tourneo	12450.0	1
R Class	9474.5	2
Streetka	1924.5	2
Terracan	3092.5	2
Ampera	11400.0	3
CLC Class	5880.0	3
Kadjar	15100.0	3
S5	17495.0	3
Tigra	2499.0	3
Veloster	6495.0	3
Verso-S	5795.0	3

model	median(price)	n
Cascada	9993.0	4
S8	33120.0	4
Urban Cruiser	4740.0	4
Vectra	1595.0	4
Getz	1992.5	6
CLK	3376.0	7
Z3	3995.0	7
IQ	4422.0	8
M6	33823.5	8
SQ7	47470.0	8
Camry	26491.0	11
S4	40425.0	12
Supra	49990.5	12
G Class	99850.0	15
PROACE VERSO	27990.0	15
Fusion	2443.0	16
SQ5	32419.0	16
i8	57870.0	17
Roomster	5495.0	17
GLB Class	37197.5	18
S3	19965.0	18
M2	44990.0	21
Vivaro	14900.0	21
Agila	4599.0	22
M3	31975.0	26
Antara	6500.0	27
R8	111490.0	28
RS5	54250.0	28
M5	63980.0	29

There are 50 over 186 models with less than 30 observations per model.

Summary of year

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1970    2016    2017    2017    2019    2060
```

Search for non-logic value

```
##    brand  model year price transmission mileage fuelType tax  mpg engineSize
## 1:  ford Fiesta 2060  6495    Automatic   54807   Petrol 205 42.8        1.4
```

There is a max value year = 2060 for a Ford Fiesta.
We find identical metrics for this model and change the year.

There are 11 Ford Fiesta with roughly same metrics and median year = 2010.
We replace 2060 by 2010.

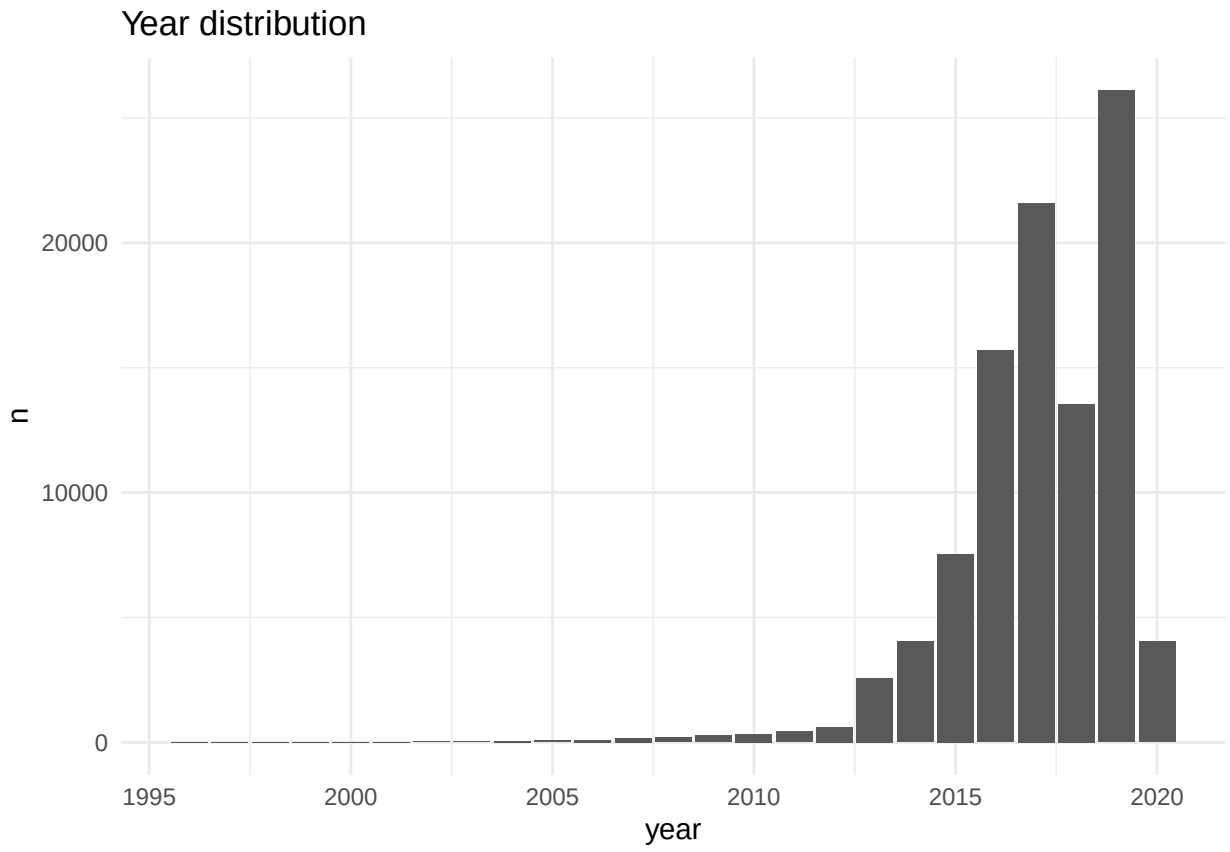
Check the range of year now :

```
## [1] 1970 2020
```

Table of year distribution

year	n
1970	2
1996	2
1997	4
1998	8
1999	6
2000	9
2001	20
2002	31
2003	34
2004	52
2005	69
2006	84
2007	161
2008	195
2009	276
2010	341
2011	428
2012	624
2013	2572
2014	4033
2015	7546
2016	15683
2017	21599
2018	13537
2019	26105
2020	4030

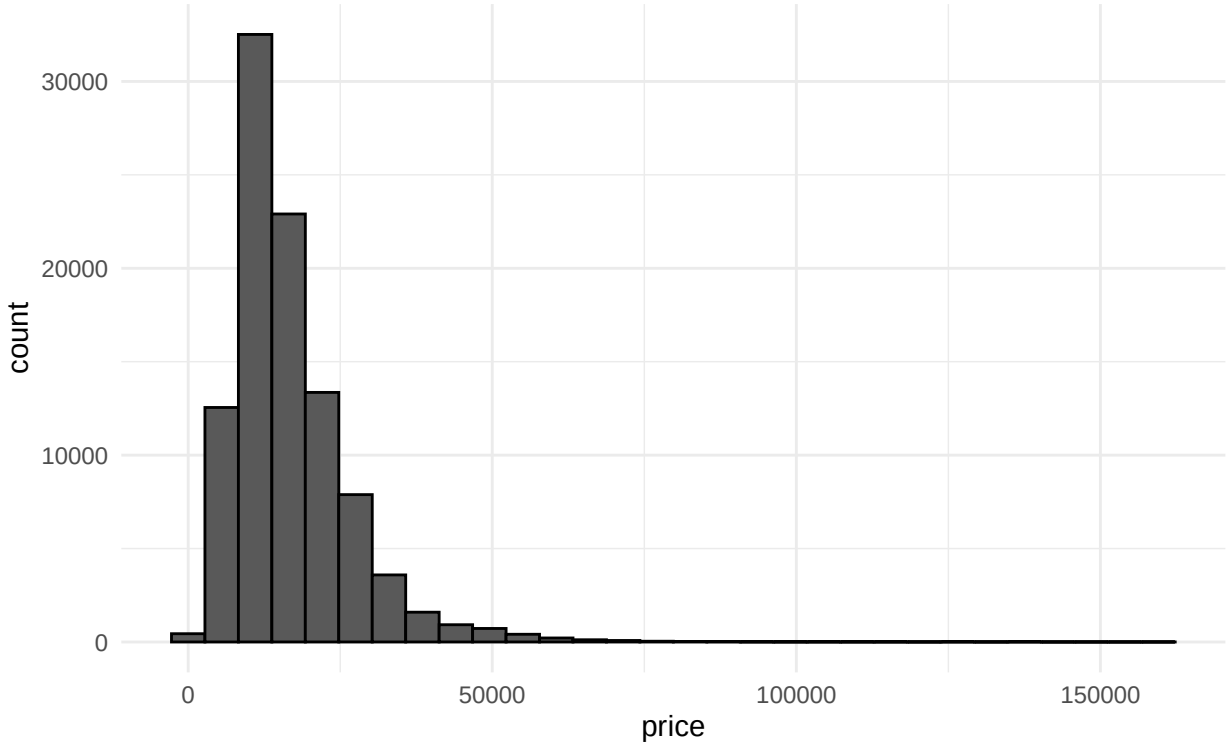
There are 2 vehicles with year = 1970 and these models are not from this period.
We replace 1970 by the median.



Only 953 cars have year < 2010.

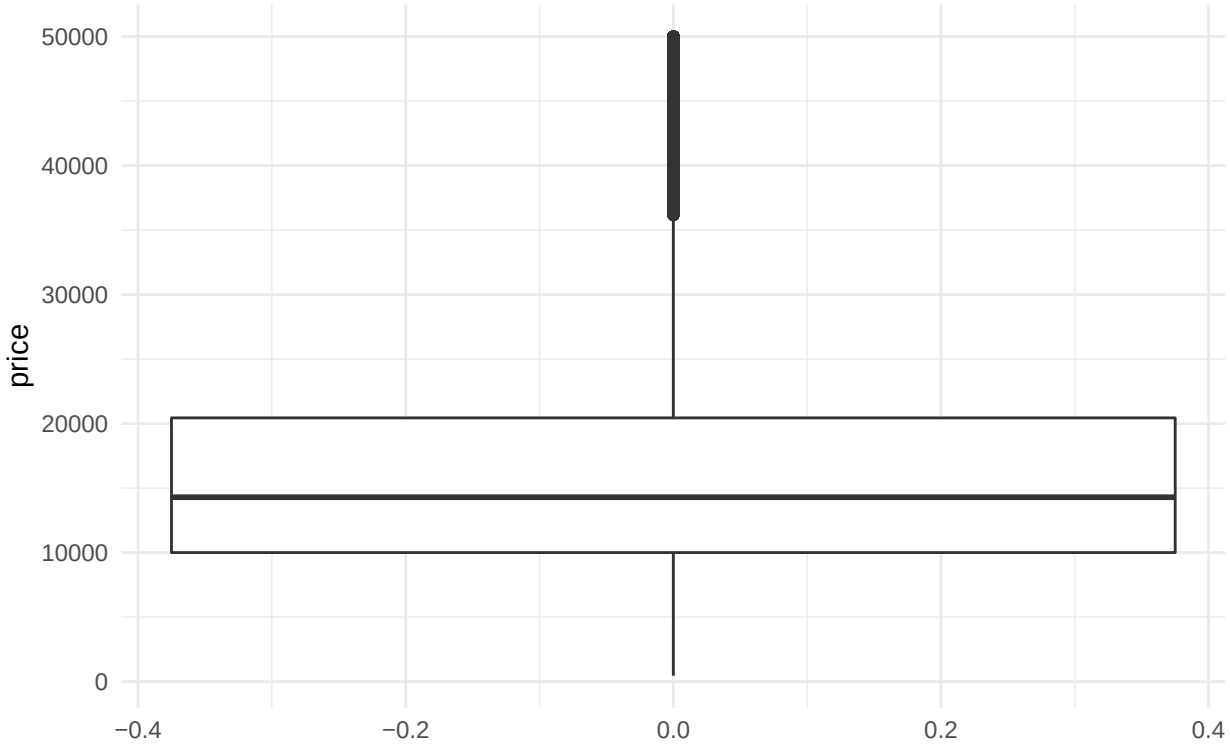
Summary of price

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     450    9999   14480   16769   20750  159999
```



Very few cars have price $> 50{,}000$ £

1135 cars are, it's roughly 1% of all vehicles.



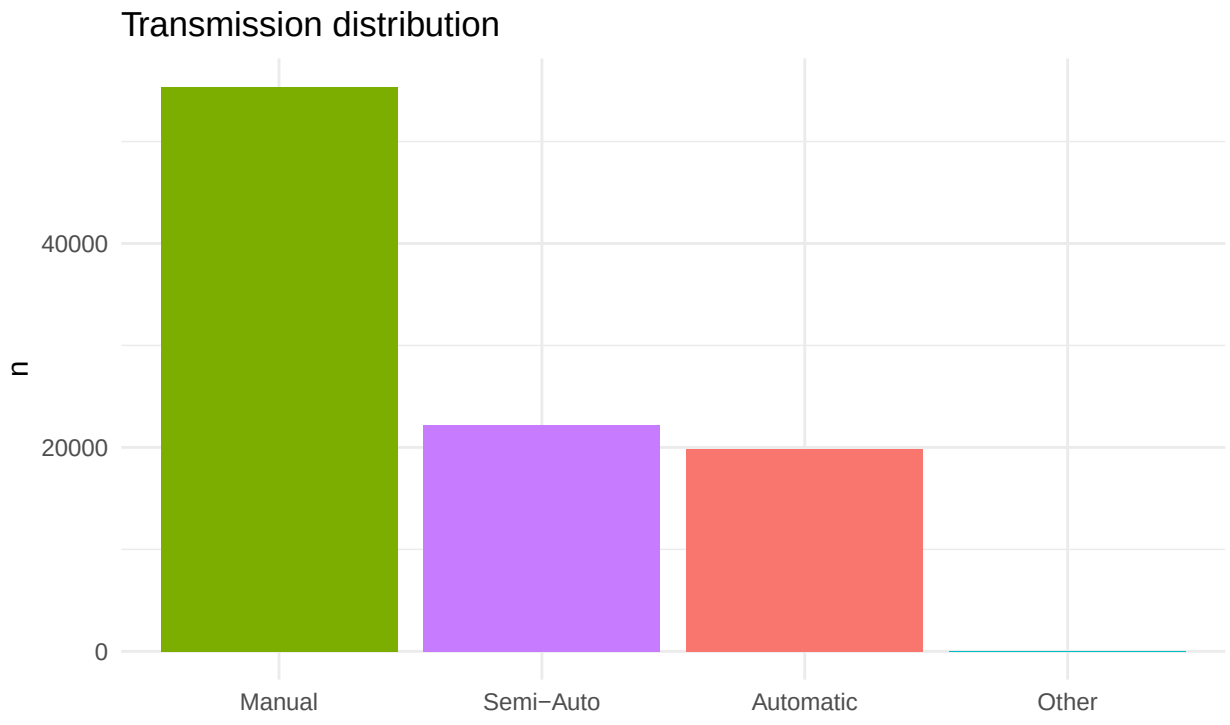
50% of total cars have price between 10,000 and 20,000 £.

Number of cars by transmission

```
##
## Automatic    Manual     Other Semi-Auto
##     19848     55378         9     22216
```

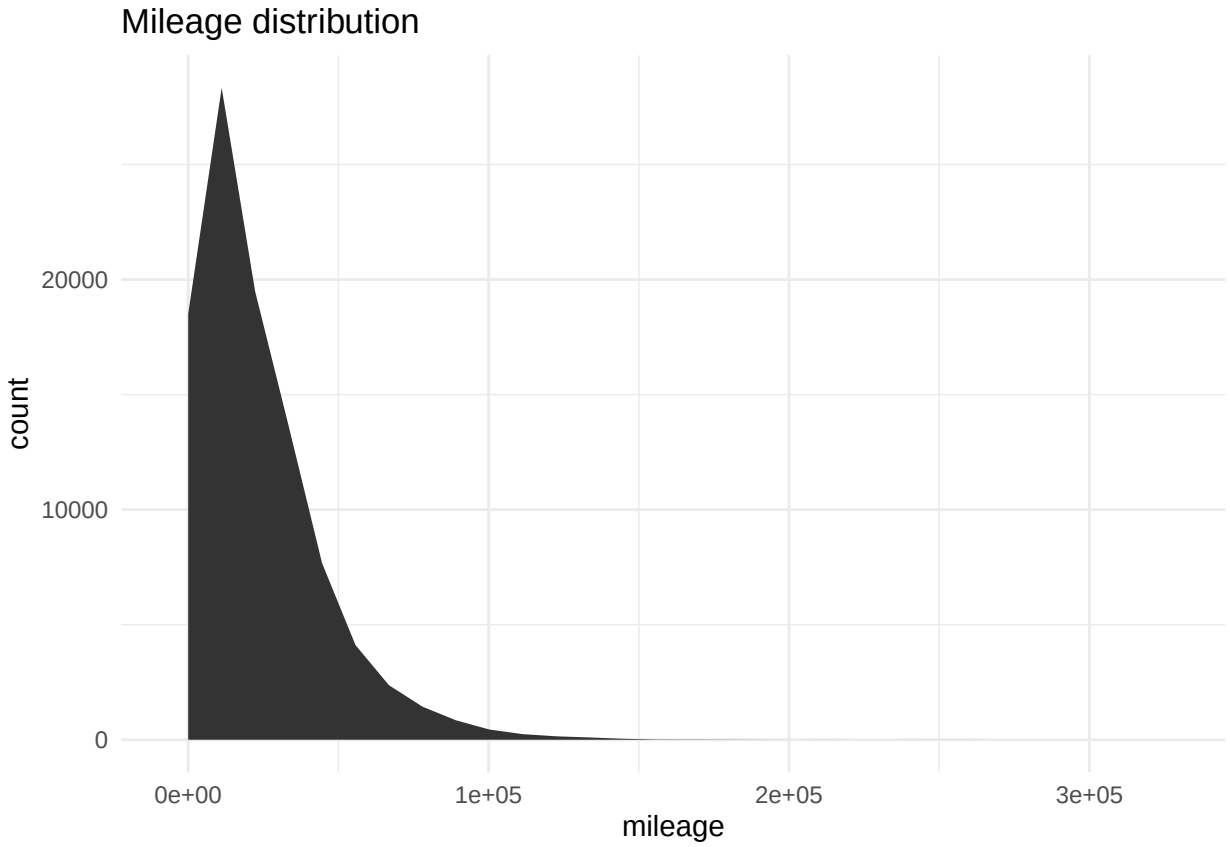
brand	model	year	price	transmission	mileage	fuelType	tax	mpg	engineSize
mercedes	GLA Class	2016	18700	Other	30895	Other	125	56.5	0.0
mercedes	SLK	2015	12995	Other	39000	Diesel	150	56.5	2.1
hyundai	Ioniq	2017	12495	Other	27779	Hybrid	0	78.5	1.6
hyundai	Tucson	2017	16995	Other	25915	Petrol	145	39.8	1.6
skoda	Scala	2019	15999	Other	3500	Petrol	145	47.1	1.0
toyota	Yaris	2015	12795	Other	16733	Hybrid	0	78.0	1.5
vauxhall	Mokka	2019	19995	Other	1450	Diesel	145	57.7	1.5
vauxhall	Mokka	2019	13499	Other	3000	Petrol	145	44.8	1.4
vauxhall	Mokka	2019	22499	Other	4500	Petrol	145	42.2	1.5

Only 9 cars have "Other" type of transmission.



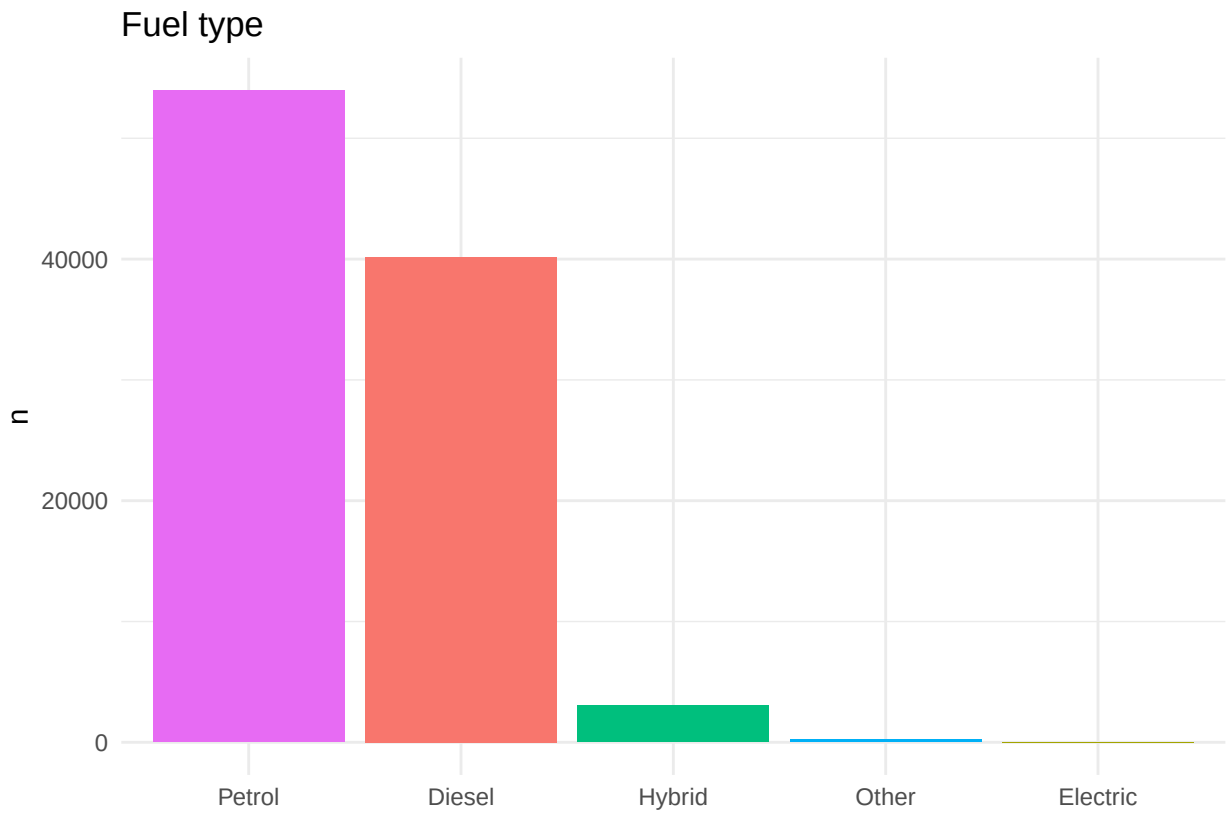
Summary of mileage

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##       1    7664   17663   23190   32463  323000
```



Distribution of fuelType

Var1	Freq
Diesel	40175
Electric	6
Hybrid	3059
Other	246
Petrol	53965

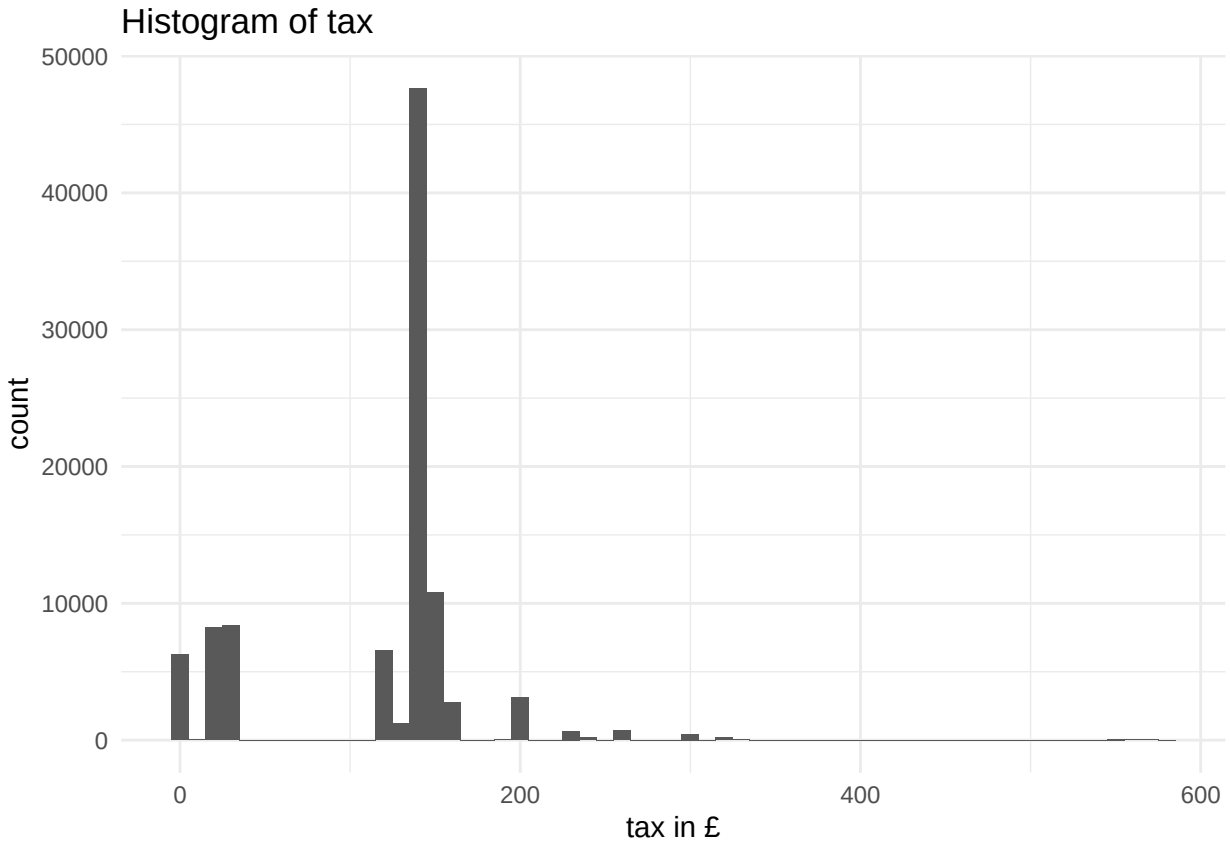


Summary of tax and total number of cars with small tax category

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.0   125.0   145.0   120.1   145.0   580.0
```

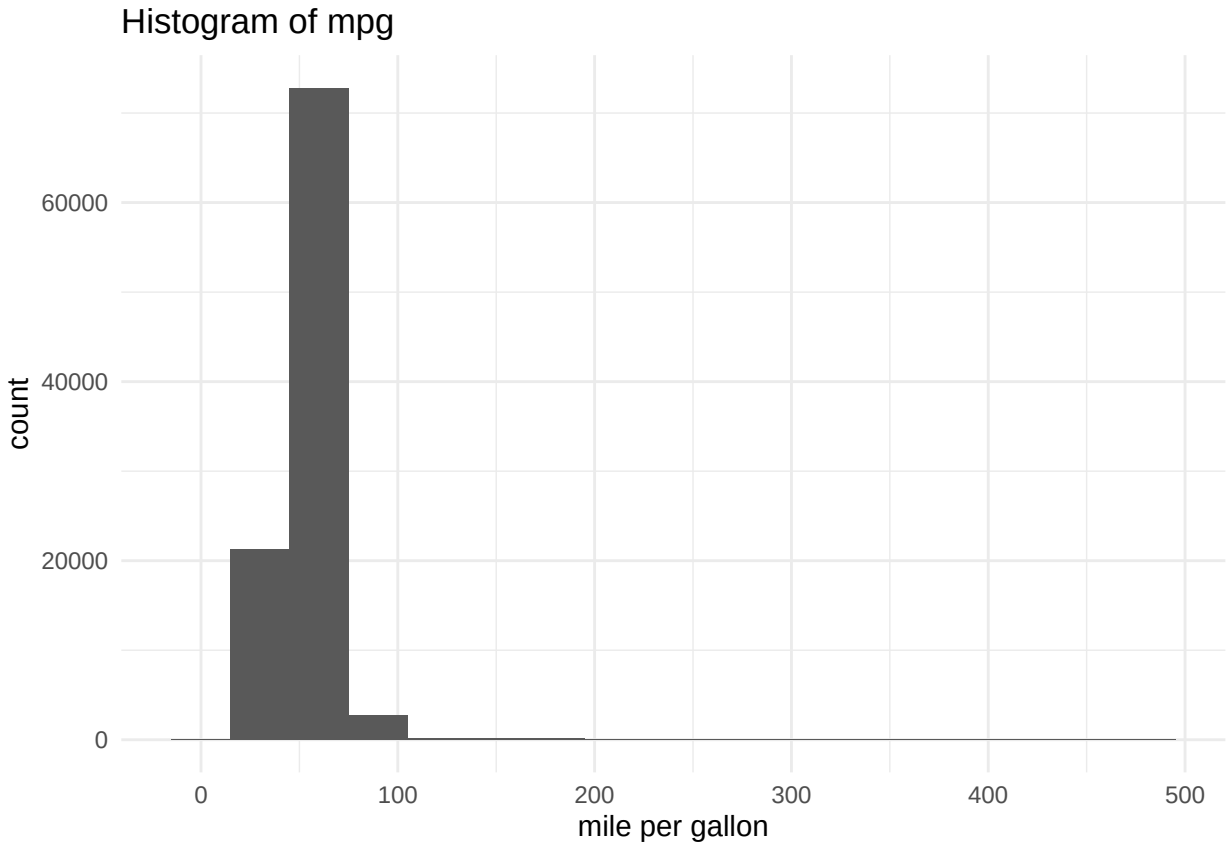
Var1	Freq
0	6259
10	25
20	8228
30	8381
110	2
115	12

6259 cars have 0£ on tax, and only 3065 cars are electric or hybrid. This can be a mistake because cars in UK payed tax for CO2 rejections.



Summary of mpg

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.30   47.10   54.30   55.22   62.80  470.80
```



Summary of engineSize and total number of cars with small engineSize

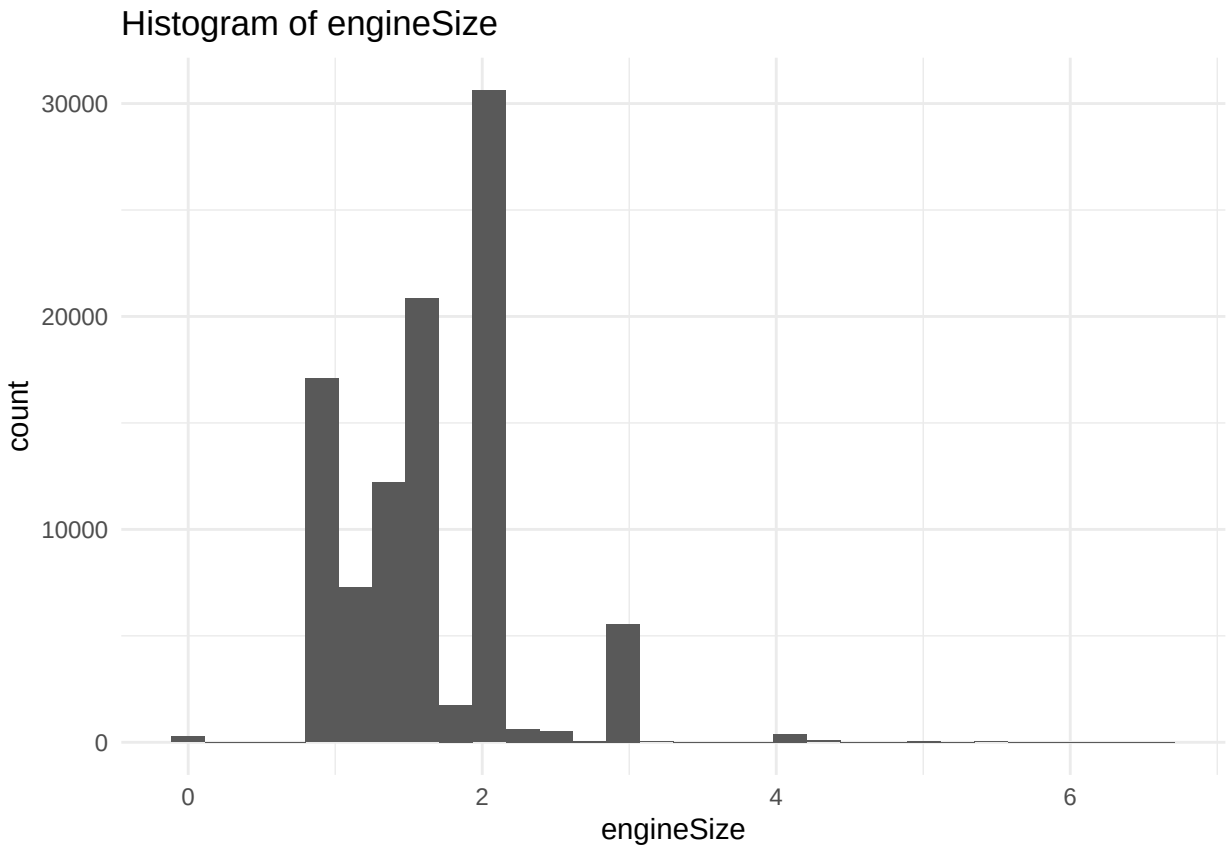
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.000   1.200   1.600   1.664   2.000   6.600
```

Var1	Freq
0	268
0.6	7
1	17083
1.1	558
1.2	6715
1.3	1307

273 vehicles have engine size = 0.
The assumption is electrical vehicles have enginSize = 0

brand	model	year	price	transmission	mileage	fuelType	tax	mpg	engineSize
bmw	i3	2017	18999	Automatic	20321	Electric	135	470.8	0.0
bmw	i3	2016	18999	Automatic	9990	Electric	0	470.8	0.0
bmw	i3	2015	17400	Automatic	29465	Electric	0	470.8	1.0
ford	Mondeo	2016	15975	Automatic	9396	Electric	0	67.3	2.0
ford	Mondeo	2016	15500	Automatic	24531	Electric	0	67.3	2.0
vauxhall	Ampera	2015	12999	Automatic	34461	Electric	0	235.4	1.4

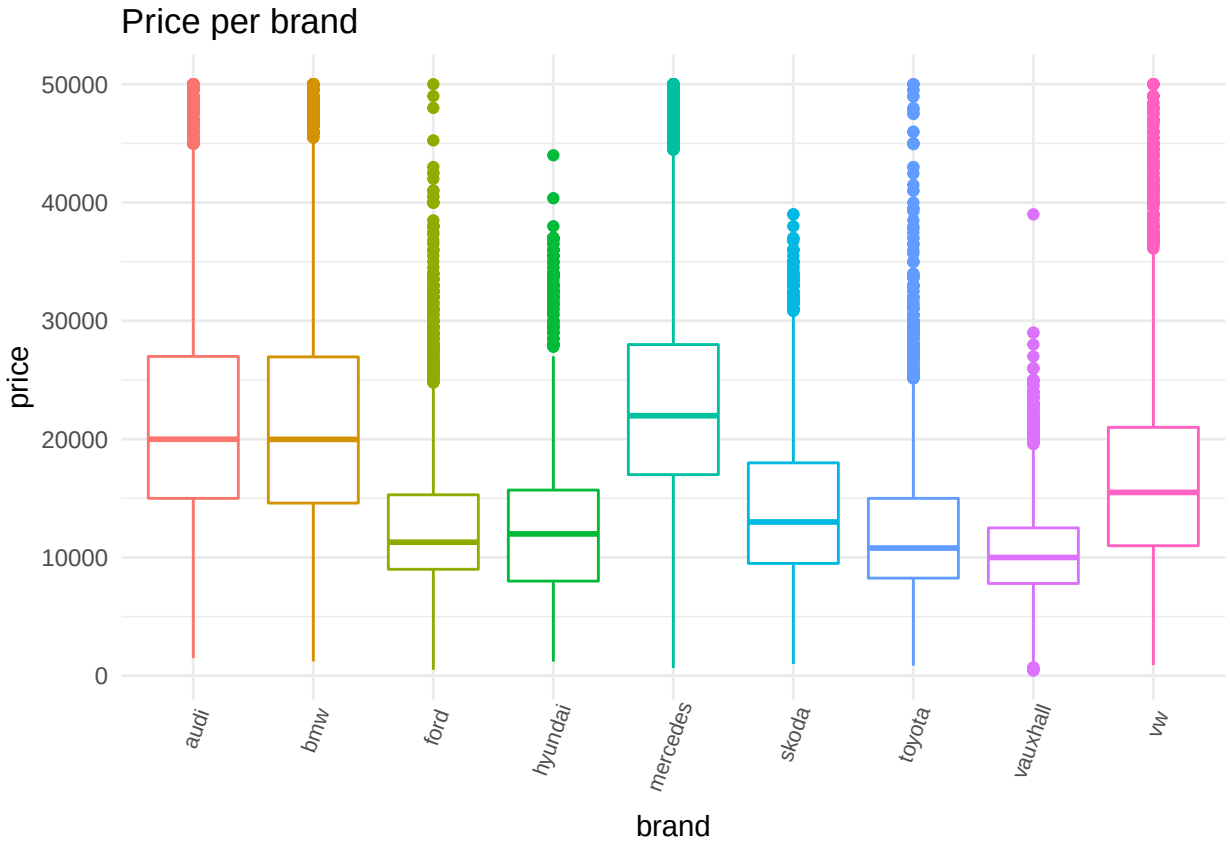
But only 2 of 6 electrical cars have engine size = 0, others are not.
We replace all non-electric cars by the median. The median engineSize is 1.6 liter.



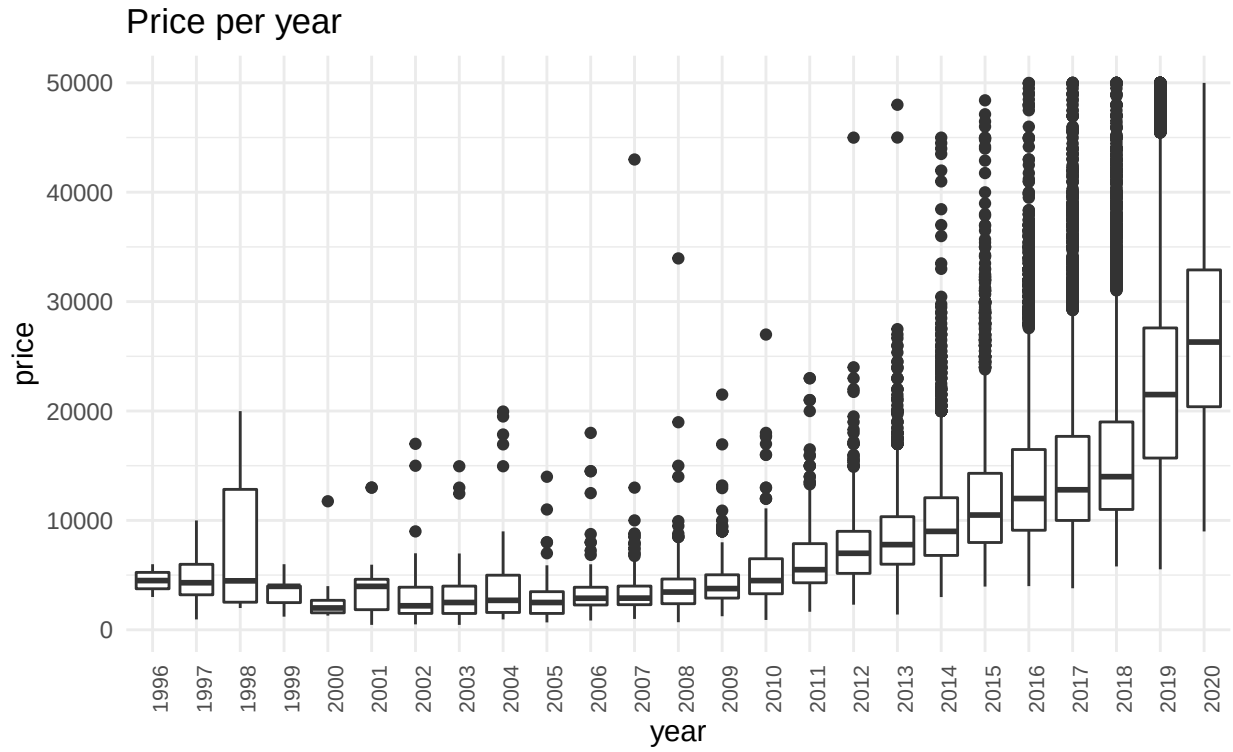
Most vehicles have less than 1; 1.6; 2; or 2.5 liter.

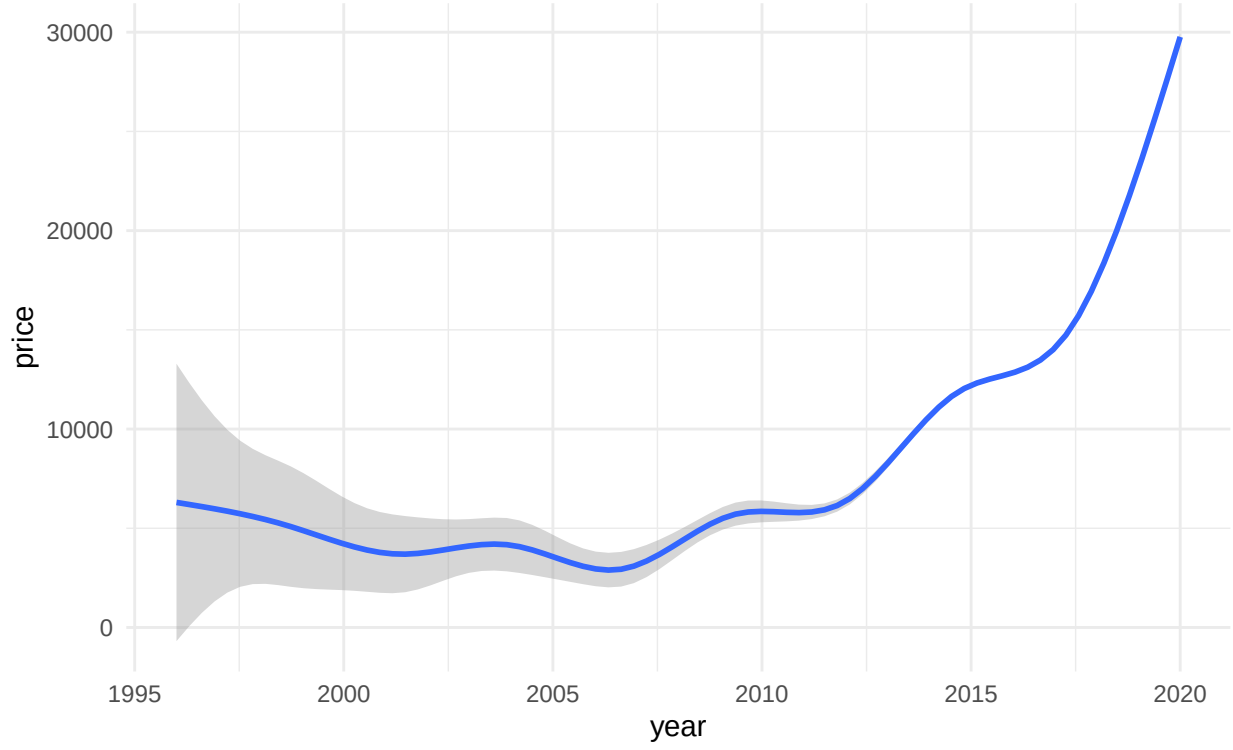
2.2 Exploratory Data Analysis

2.2.1 Search price correlation

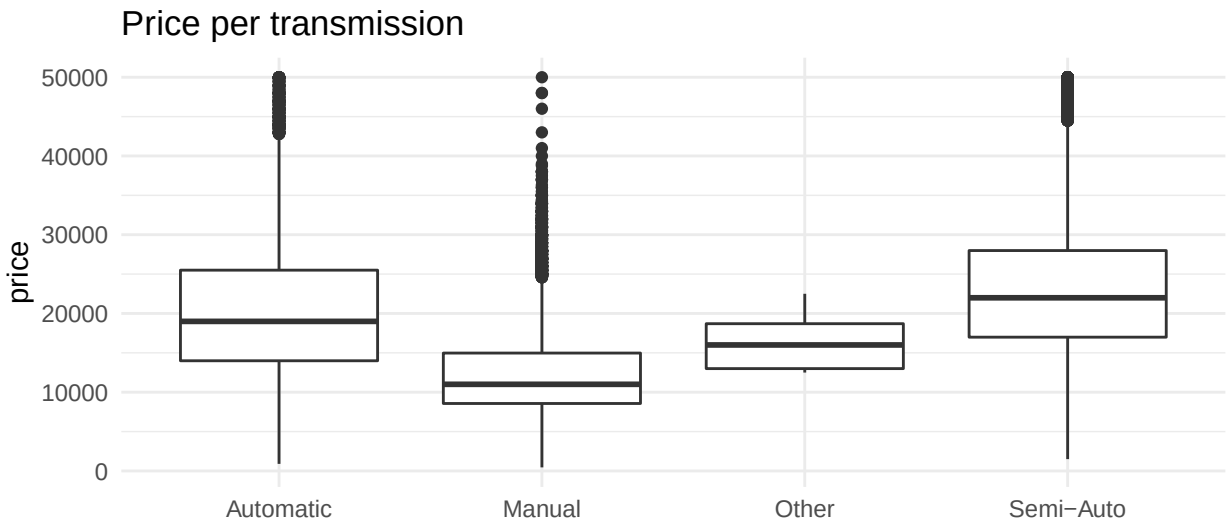


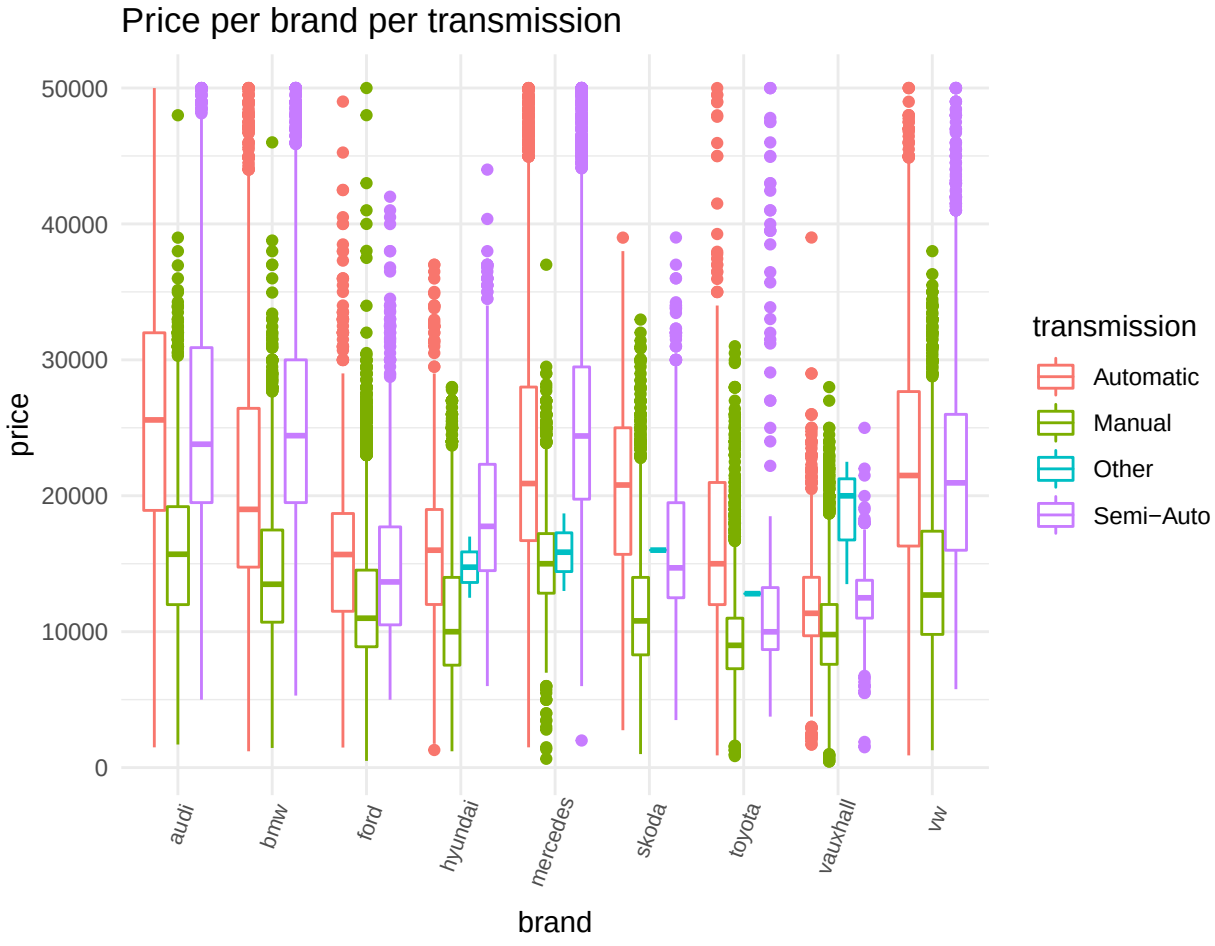
Some brand are more expensive in general.



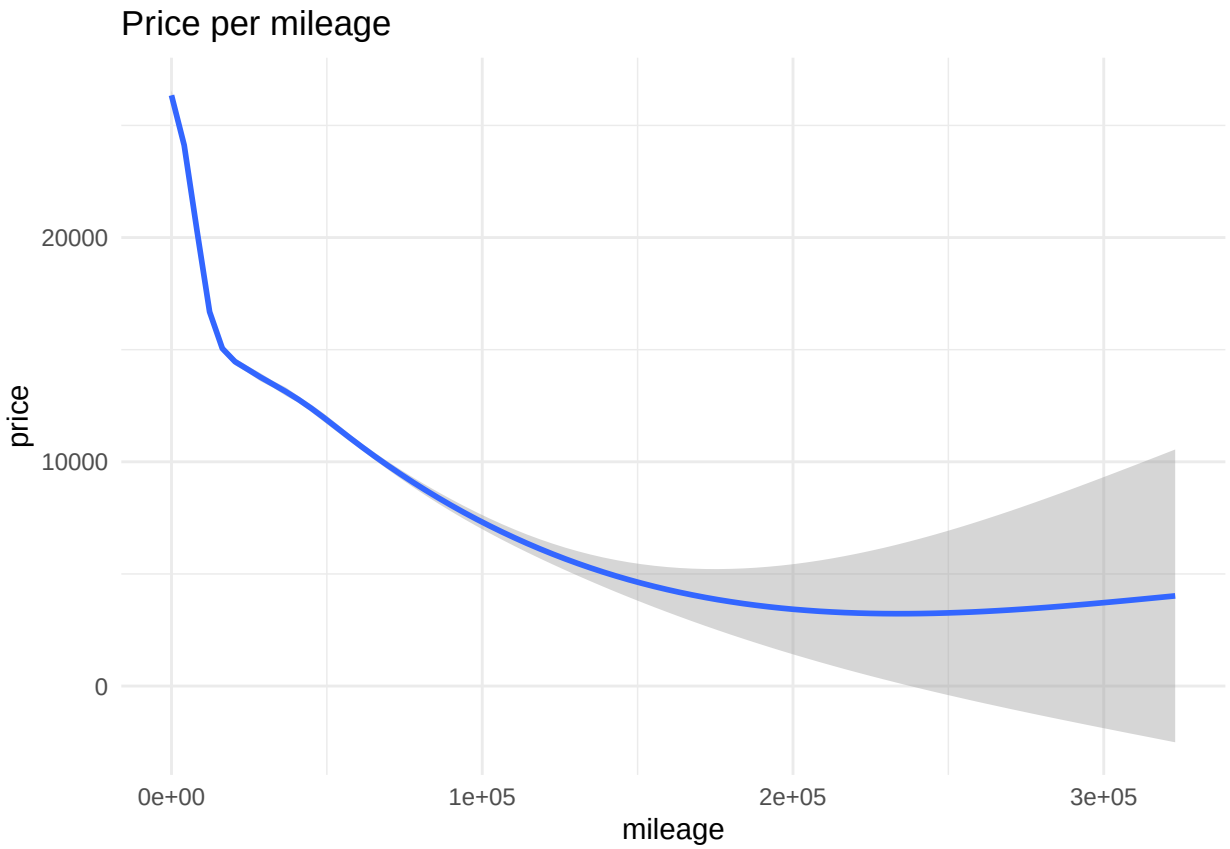


There is an obvious trend of price per year.

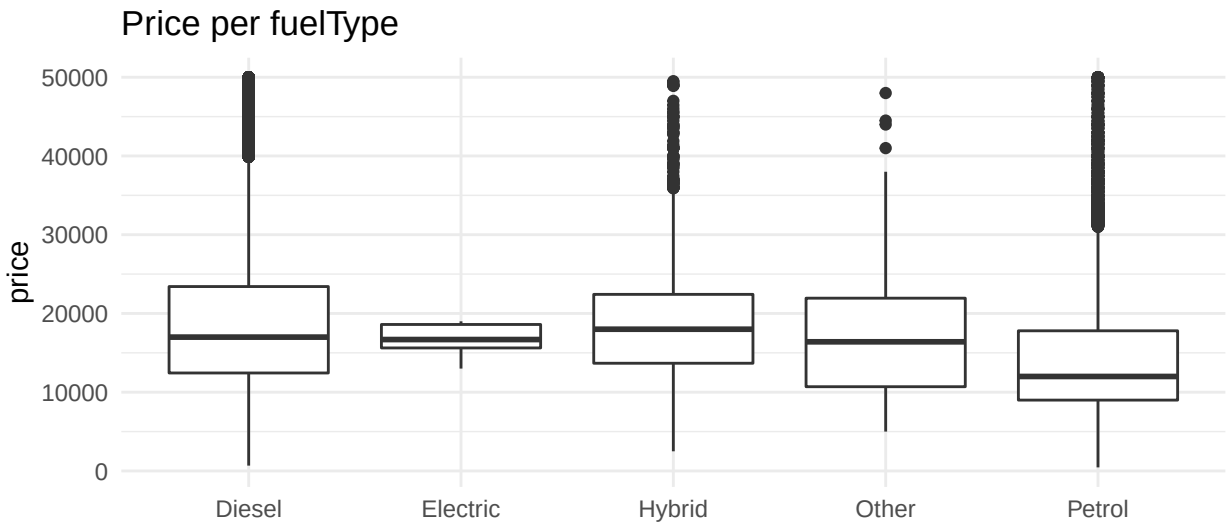


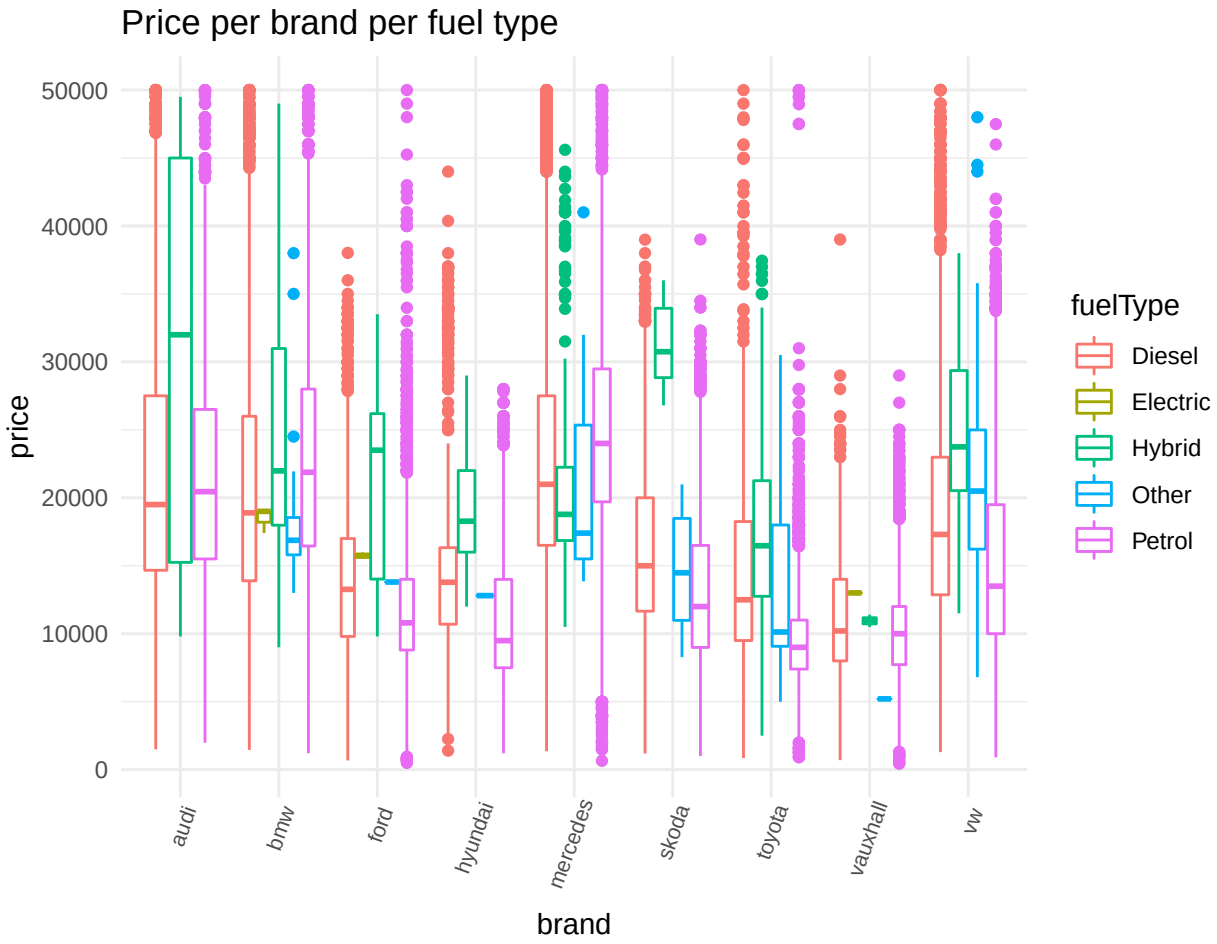


Generally, Automatic and Semi-Auto transmission are more expensive than Manual.

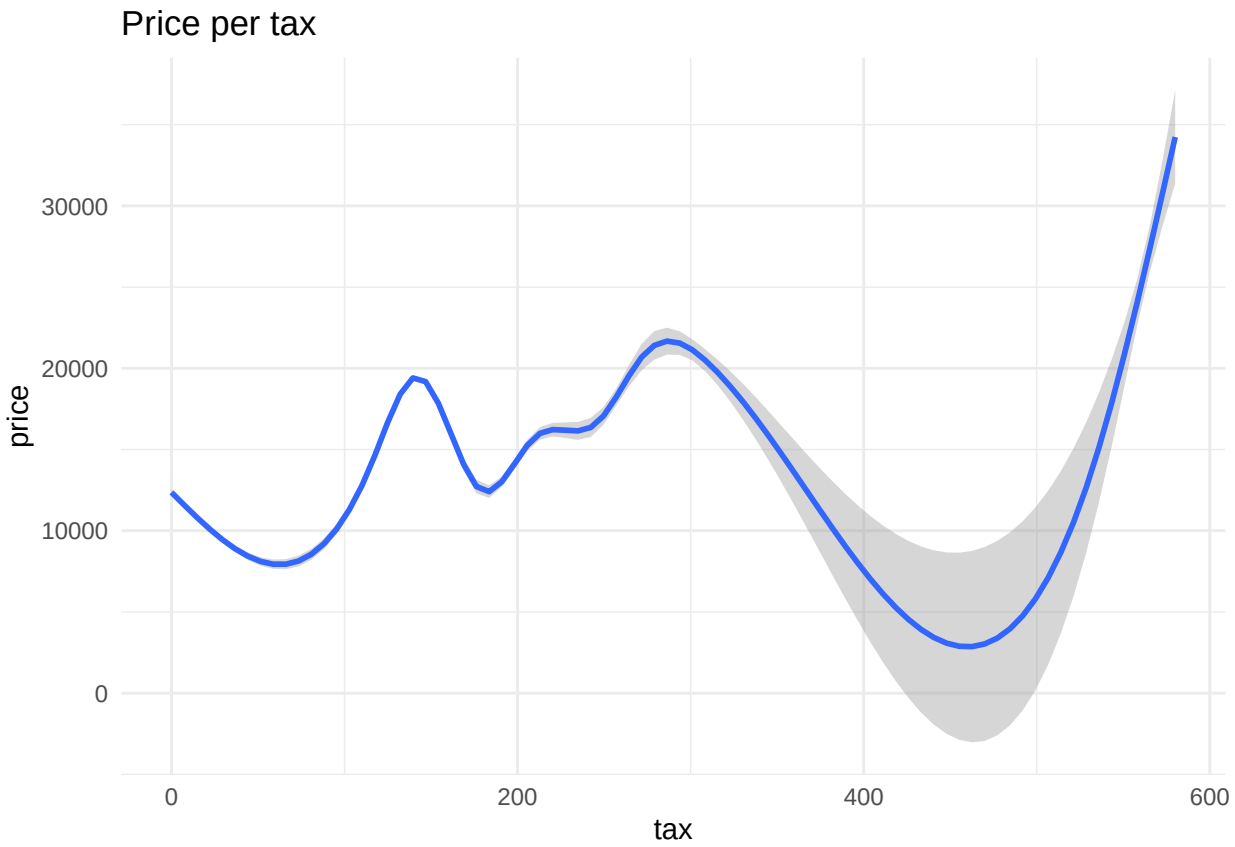


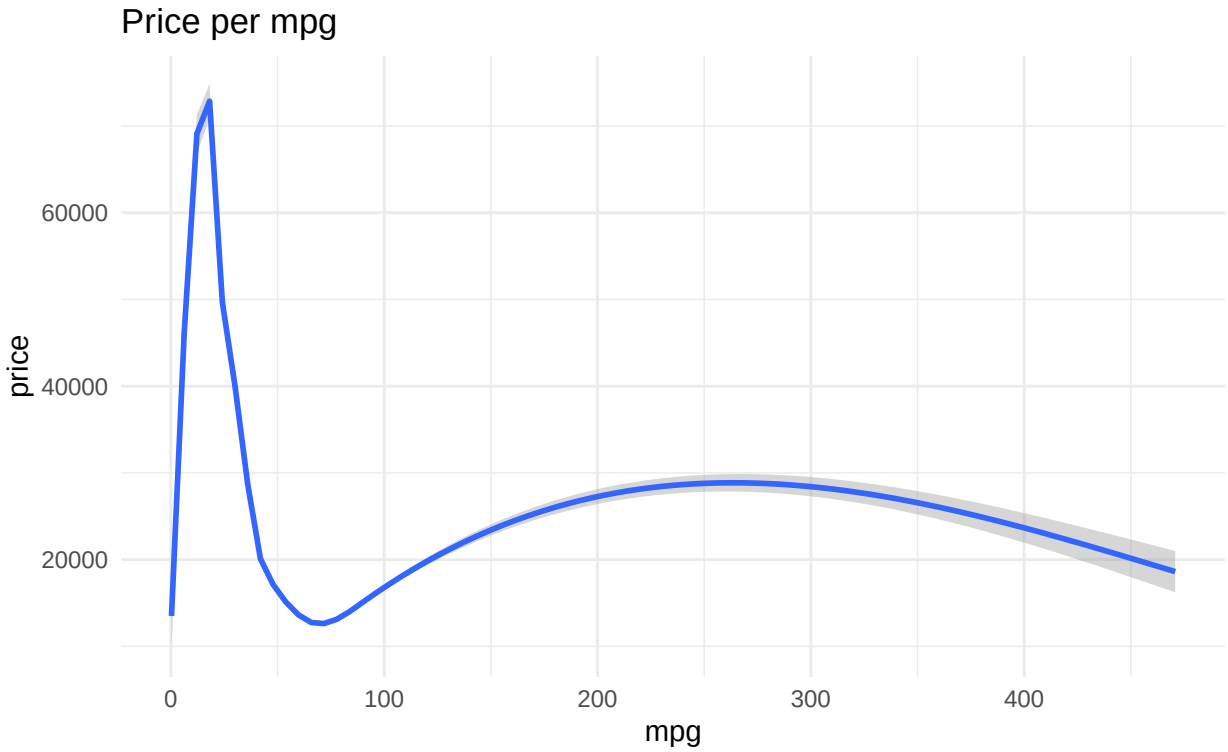
There is an inverse trend between mileage and price.

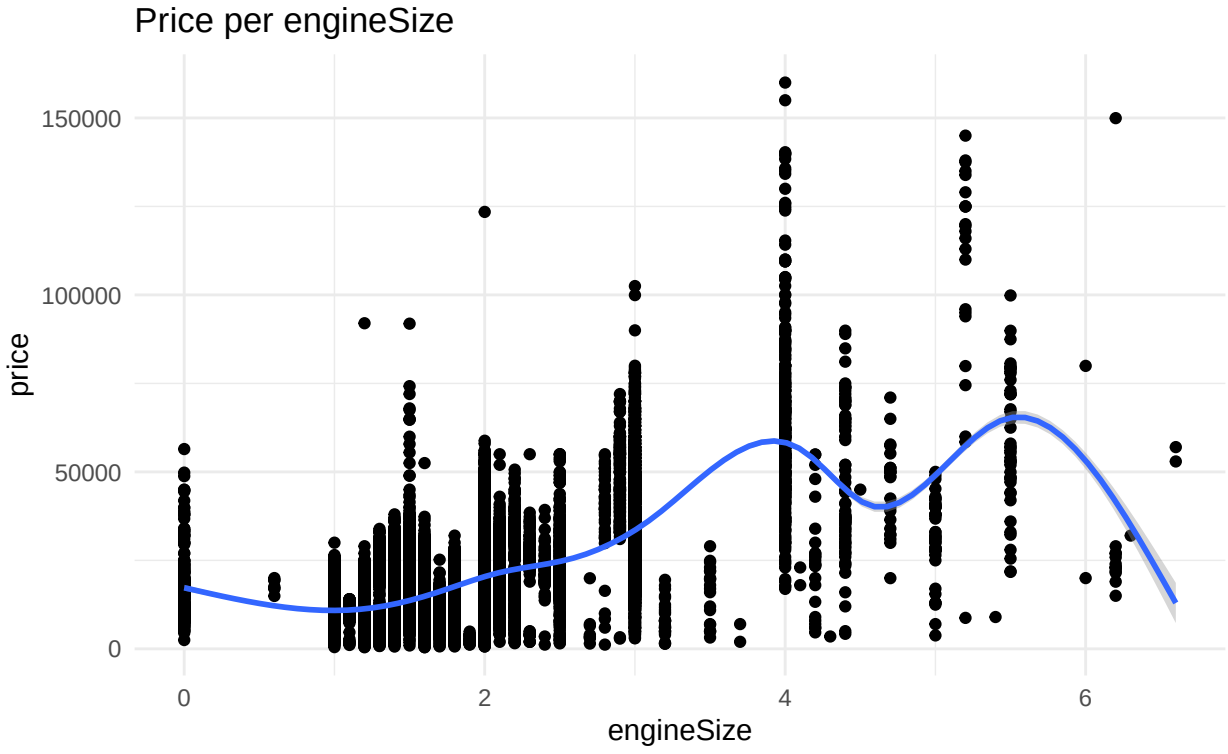




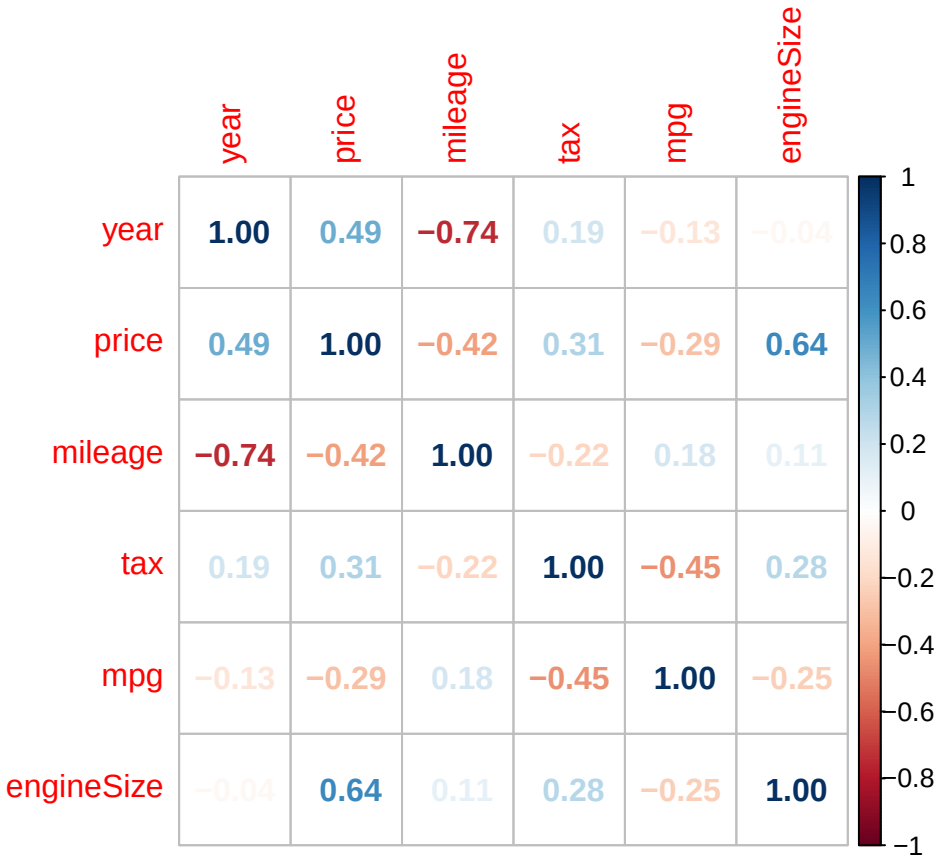
Petrol is less expensive than Diesel. But Mercedes and BMW are exceptions.


Price per tax
price
30000
20000
10000
0
0
200
400
600
tax


Price per mpg
price
60000
40000
20000
0
100
200
300
400
mpg


Price per engineSize
price
150000
100000
50000
0
0
2
4
6
engineSize

2.2.2 Corrplot



We will use most correlated variables to build a machine learning model step-by-step.

3 Results

3.1 Data preparation for a step-by-step approch

We add a column of mile_interval depending on mileage quartile from 1 to 4.

After that, we split cars data set to train_set and test_set. test_set will be 20% of cars.

Make sure car's model in test_set are also in train_set

brand	model	year	price	transmission	mileage	mile_interval	fuelType	tax	mpg	engineSize
audi	A2	2003	2490	Manual	1e+05	4	Diesel	30	65.7	1.4

Remove this entry from test_set.

And add it to train_set.

3.2 First model

If we predicted all cars with the mean. The RMSE will be :

method	rmse
just the average	9638.289

model effect

If we group_by model after using "just the average" for predicting.

method	rmse
just the average	9638.289
model_effect	5918.040

year effect

If we group_by year after using "just the average" and model for predicting.

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738

engineSize effect

If we group_by engineSize after using "just the average", model and year for predicting.

method	rmse
just the average	9638.289
model_effect	5918.040

method	rmse
year_effect	4413.738
engineSize_effect	4074.205

mile_interval effect

If we group_by mile_interval after using "just the average", model, year and engineSize for predicting.

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738
engineSize_effect	4074.205
mile_interval_effect	4030.722

3.3 Data processing

We modify the structure of the data to accurate next machine learning models.
Numeric columns :

```
## [1] "year"       "price"      "mileage"    "tax"        "mpg"
## [6] "engineSize"
```

3.3.1 Transform categorical variables to binary

We add 4 columns for transmission :

```
##  [1] "model"      "year"       "price"      "mileage"    "fuelType"
##  [6] "tax"        "mpg"        "engineSize" "Automatic"  "Manual"
## [11] "Other"      "Semi-Auto"
```

We add 5 columns for FuelType :

```
##  [1] "model"      "year"       "price"      "mileage"    "tax"
##  [6] "mpg"        "engineSize" "Automatic"  "Manual"     "Semi-Auto"
## [11] "Diesel"     "Electric"   "Hybrid"     "Other"      "Petrol"
```

And we add 186 columns for model. It can make execution slower.

3.3.2 Scale continuous variables

```
##          year price    mileage        tax         mpg engineSize
## 1 -0.03281208 12500 -0.3546856  0.4716854  0.01112298 -0.4721660
## 2 -0.50778249 16500  0.6183849 -1.5800019  0.55474553  0.6011733
## 3 -0.50778249 11000  0.3209205 -1.4221798  0.01112298 -0.4721660
## 4 -0.03281208 16800  0.1310415  0.3927743  0.74624893  0.6011733
## 5  0.91712874 17300 -1.0077571  0.3927743 -0.34717371 -1.1877255
## 6 -0.50778249 13900  0.4309305 -1.4221798  0.22733649 -0.4721660
```

3.4 Linear model with caret

We will train the model. It take 3 minutes to execute !

Then predict the outcomes.

And finally calculate RMSE.

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738
engineSize_effect	4074.205
mile_interval_effect	4030.722
lm	3817.487

Until now, linear model is more accurate than all previous.

3.5 rpart model

We will train the model.

Then predict the outcomes.

And finally calculate RMSE.

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738
engineSize_effect	4074.205
mile_interval_effect	4030.722
lm	3817.487
rpart	7545.082

rpart looks doesn't work good.

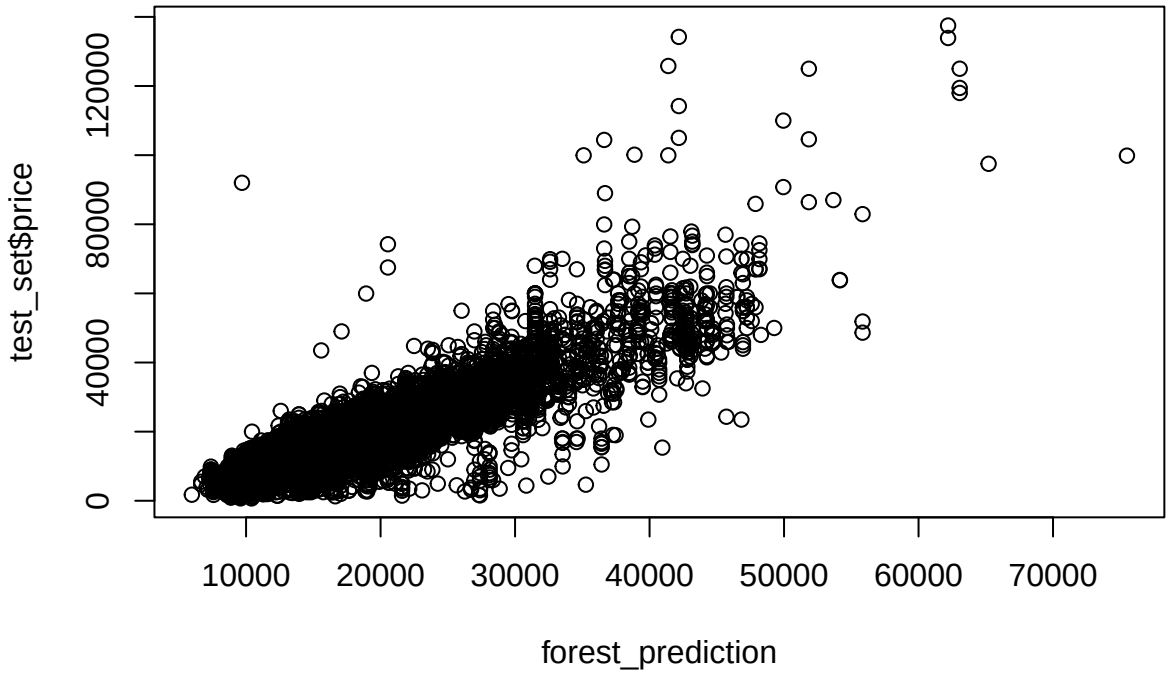
3.6 random forest

Another time, We will train the model. It take about 7 minutes !!

Then predict the outcomes.

And calculate RMSE.

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738
engineSize_effect	4074.205
mile_interval_effect	4030.722
lm	3817.487
rpart	7545.082
random_forest	5056.867



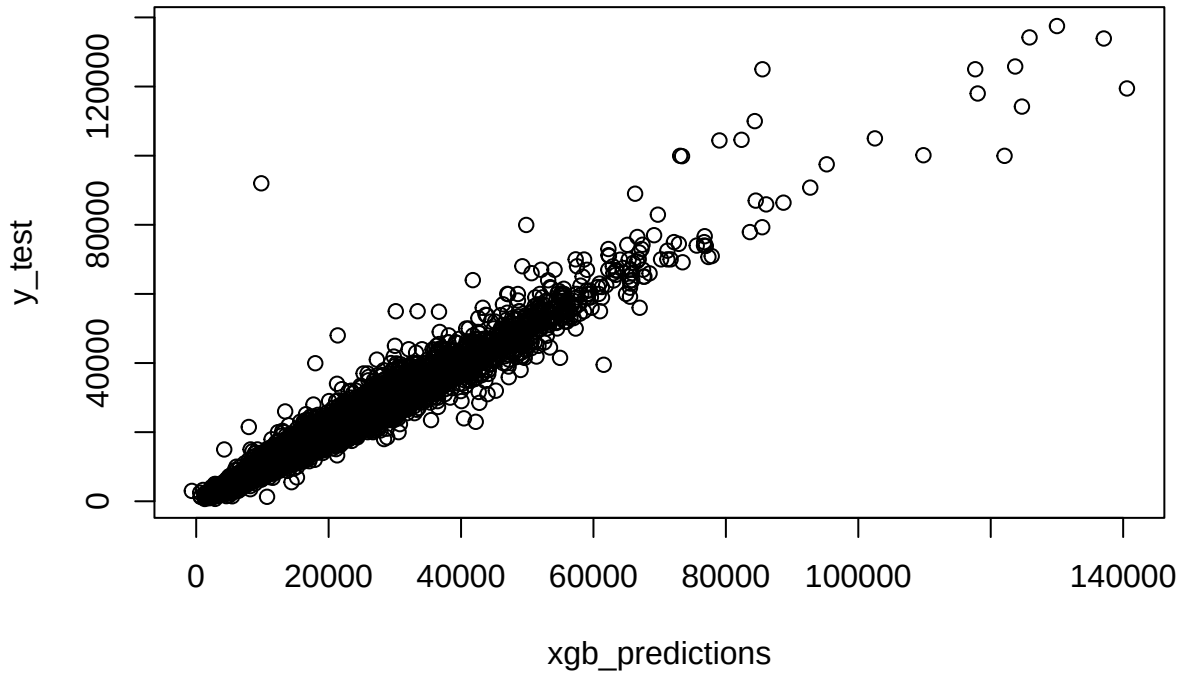
3.7 xgboost

We will train the model.

Then predict the outcomes.

And finally calculate RMSE (the Root Mean Square Error).

method	rmse
just the average	9638.289
model_effect	5918.040
year_effect	4413.738
engineSize_effect	4074.205
mile_interval_effect	4030.722
lm	3817.487
rpart	7545.082
random_forest	5056.867
xgboost	2022.158



4 Conclusion

xgboost is the most accurate, let's compare true_price ans predicted_price :

true_price	predicted_price	absolute_difference
12500	13640	1140
16500	16881	381
12000	13214	1214
16400	17466	1066
17300	19541	2241
20200	21987	1787
19400	18705	695
15700	17921	2221
16600	20576	3976
12750	13661	911
16000	17229	1229
10200	11008	808
16000	14849	1151
11700	10794	906
16900	16873	27

true_price	predicted_price	absolute_difference
30700	34418	3718
26991	32074	5083
15995	15005	990
24495	24532	37
23999	27688	3689
25495	27328	1833
26350	26149	201
30895	30571	324
32493	30737	1756
29990	24259	5731
22950	19549	3401
27990	24916	3074
32562	28541	4021
31291	27545	3746
21900	22079	179

The hope is to find info such as when is the ideal time to sell certain cars (i.e. at what age and mileage are there significant drops in resale value).