Car MSRP Prediction with Multiple Linear Regression

CIS 4321

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Introduction

The problem for the manufacturers is to find a balance between what consumers want and pricing the particular vehicle

- Important to Know
    - which features and specs make the Manufacturer Suggested Retail Price
    - which features largely determine the price of the car
    - produce and sell cars that meet market demands for its target consumer group

The purpose of our group project is to figure out what features have an influence on a vehicle's Manufacturer Suggested Retail Price (MSRP) in the Car Features and MSRP dataset

- will be able to
    - know what features are most important to consumers by predicting an appropriate MSRP given a specific set of features
    - understand how those features affect the MSRP the most

Data Collection and Variable Description

Collecting Data:

- found our dataset on Kaggle
    - could not find the real source of the set
    - all the records were collected from Twitter and Edmunds

Dataset has 16 variables which are divided to 8 numerical and 8 categorical variables

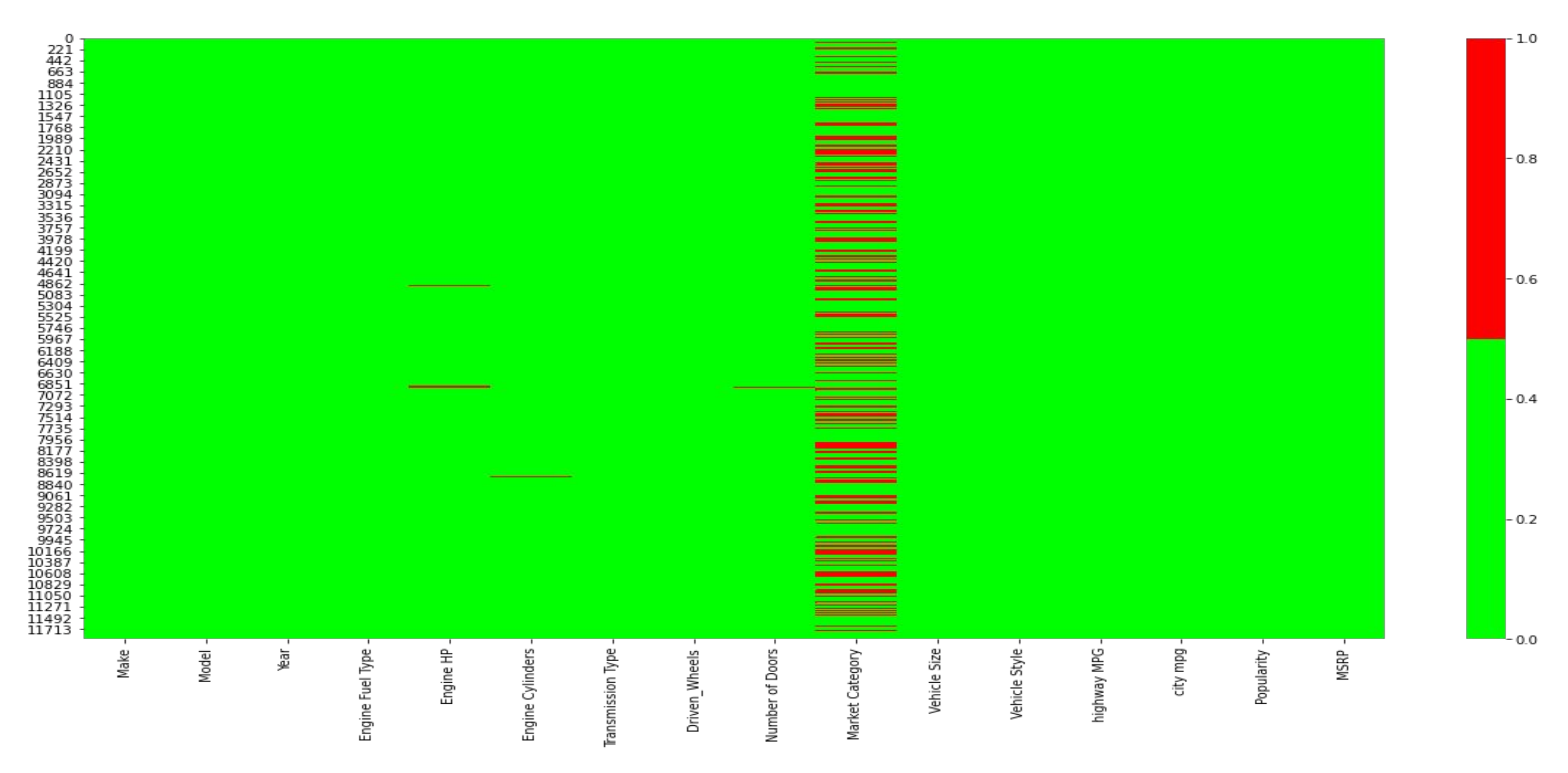
- numerical variables: Year, Engine HP, Engine Cylinders, Number of Doors, highway mpg, city mpg, Popularity, and MSRP
- categorical variables: Make, Model, Engine Fuel Type, Transmission type, Driven Wheels, Market Category, Vehicle Size, and Vehicle Style
    - categorical variables such as Transmission type, Vehicle Size, and Vehicle Style, are transformed to dummy variables

Data Collection and Variable Description

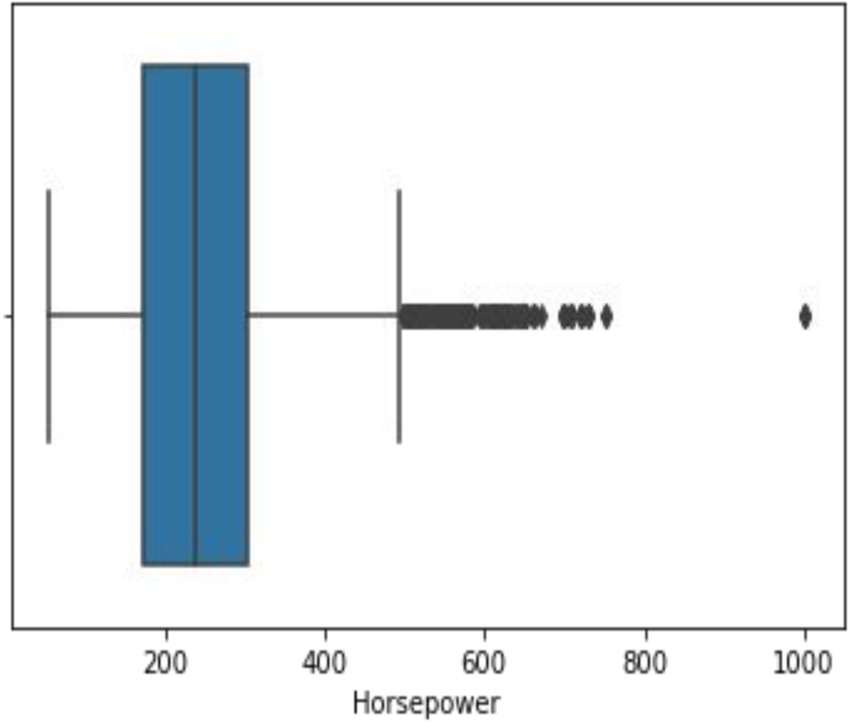
- Make : the brand of the vehicle
- Model : the model of the vehicle
- Year : the year of manufacture of the vehicle
- Engine fuel type : the type of you that the vehicle operates on
- Engine HP : the engine horsepower
- Engine cylinders :the number of cylinders in the combustion engine
- Transmission type: what kind of transmission the vehicle has
- Driven_Wheels : the amount of wheels that receive power directly from the engine
- Number of doors : how many doors the vehicle has

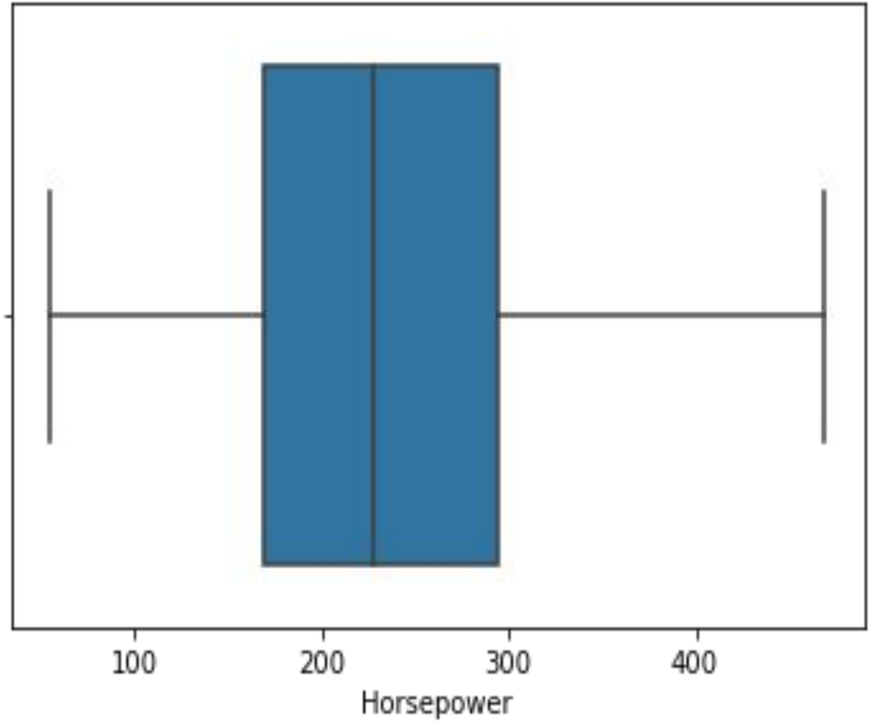
- Market category : the market category to which the vehicle belongs
- Vehicle size : the size of the vehicle based on its volume capacity
- Vehicle style : the style of the vehicle based on its physical shape
- Highway MPG : the number of miles the vehicle drives per gallon at highway speed
- City MPG : the number of miles the vehicle drives per gallon at a city speed
- Popularity : how popular the car is among people
- MSRP :the manufacturer’s suggested retail price of a vehicle

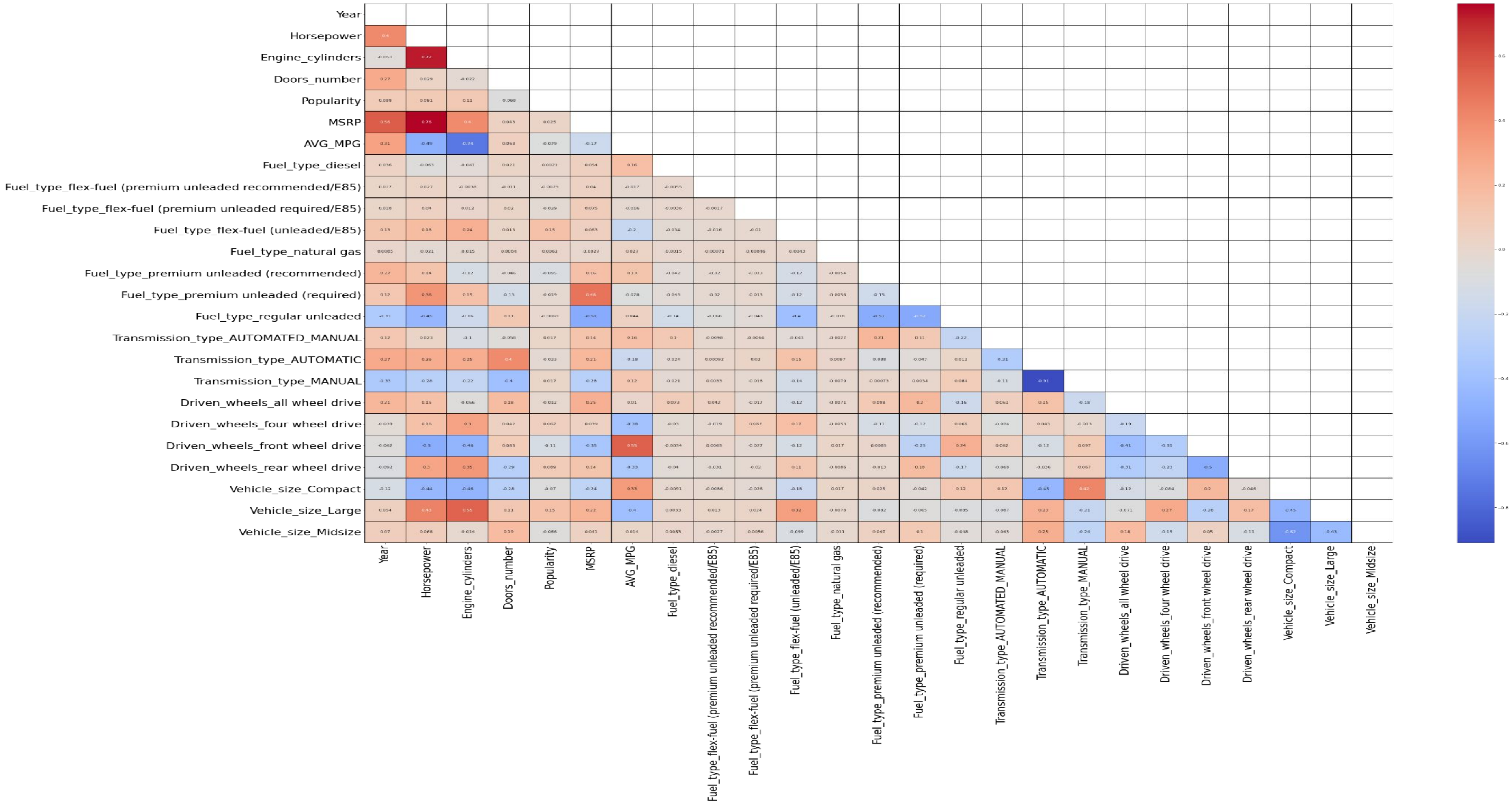
Descriptive Analysis

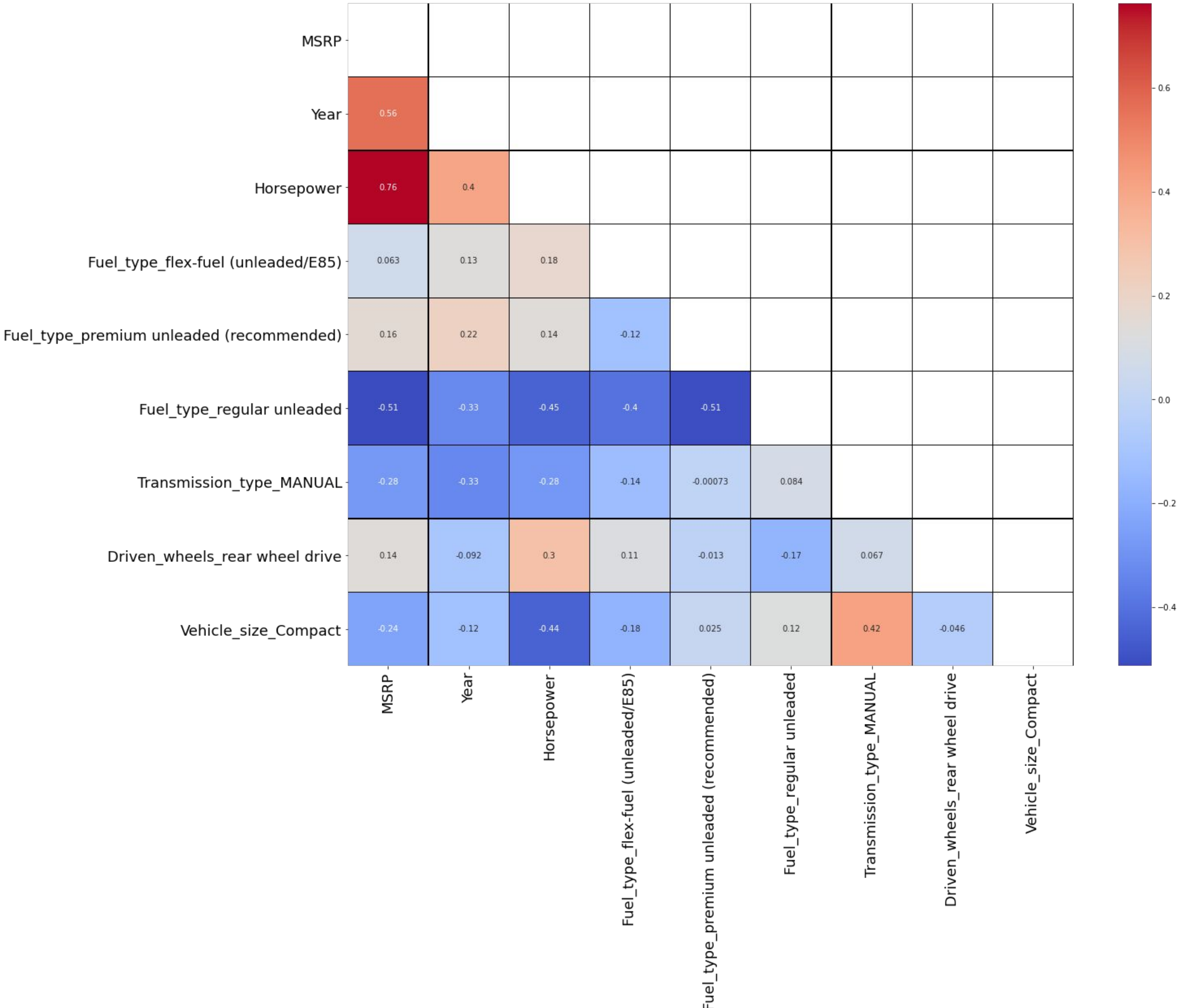


Descriptive Analysis






Year
Horsepower
0.4
Engine_cylinders
-0.051
0.72
Doors_number
0.27
0.029
-0.022
Popularity
0.088
0.091
0.11
-0.068
MSRP
0.56
0.76
0.4
0.043
0.025
AVG_MPG
0.31
-0.49
-0.74
0.063
-0.079
-0.17
Fuel_type_diesel
0.036
-0.063
-0.041
0.021
0.0021
0.054
0.16
Fuel_type_flex-fuel (premium unleaded recommended/E85)
0.017
0.027
-0.0038
-0.011
-0.0079
0.04
-0.017
-0.0055
Fuel_type_flex-fuel (premium unleaded required/E85)
0.018
0.04
0.012
0.02
-0.029
0.075
-0.016
-0.0036
-0.0017
Fuel_type_flex-fuel (unleaded/E85)
0.13
0.18
0.24
0.013
0.15
0.063
-0.2
-0.034
-0.016
-0.01
Fuel_type_natural gas
0.0085
-0.021
-0.015
0.0084
0.0062
-0.0027
0.027
-0.0015
-0.00071
-0.00046
-0.0043
Fuel_type_premium unleaded (recommended)
0.22
0.14
-0.12
-0.046
-0.095
0.16
0.13
-0.042
-0.02
-0.013
-0.12
-0.0054
Fuel_type_premium unleaded (required)
0.12
0.36
0.15
-0.13
-0.019
0.48
-0.078
-0.043
-0.02
-0.013
-0.12
-0.0056
-0.15
Fuel_type_regular unleaded
-0.33
-0.45
-0.16
0.11
-0.0069
-0.51
0.044
-0.14
-0.066
-0.043
-0.4
-0.018
-0.51
-0.52
Transmission_type_AUTOMATED_MANUAL
0.12
0.023
-0.1
-0.058
0.017
0.14
0.16
0.1
-0.0098
-0.0064
-0.043
-0.0027
0.21
0.11
-0.22
Transmission_type_AUTOMATIC
0.27
0.26
0.25
0.4
-0.023
0.21
-0.18
-0.024
0.00092
0.02
0.15
0.0087
-0.088
-0.047
0.012
-0.31
Transmission_type_MANUAL
-0.33
-0.28
-0.22
-0.4
0.017
-0.28
0.12
-0.021
0.0033
-0.018
-0.14
-0.0079
-0.00073
0.0034
0.084
-0.11
-0.91
Driven_wheels_all wheel drive
0.21
0.15
-0.066
0.18
-0.012
0.25
0.01
0.073
0.042
-0.017
-0.12
-0.0071
0.098
0.2
-0.16
0.061
0.15
-0.18
Driven_wheels_four wheel drive
-0.039
0.16
0.3
0.042
0.062
0.039
-0.38
-0.03
-0.019
0.087
0.17
-0.0053
-0.11
-0.12
0.066
-0.074
0.043
-0.013
-0.19
Driven_wheels_front wheel drive
-0.062
-0.5
-0.46
0.083
-0.11
-0.35
0.55
-0.0034
0.0065
-0.027
-0.12
0.017
0.0085
-0.25
0.24
0.062
-0.12
0.097
-0.41
-0.31
Driven_wheels_rear wheel drive
-0.092
0.3
0.35
-0.29
0.089
0.14
-0.33
-0.04
-0.031
-0.02
0.11
-0.0086
-0.013
0.18
-0.17
-0.068
-0.036
0.067
-0.31
-0.23
-0.5
Vehicle_size_Compact
-0.12
-0.44
-0.46
-0.28
-0.07
-0.24
0.33
-0.0091
-0.0086
-0.026
-0.18
0.017
0.025
-0.042
0.12
0.12
-0.45
0.42
-0.12
-0.084
0.2
-0.046
Vehicle_size_Large
0.054
0.43
0.55
0.11
0.15
0.22
-0.4
0.0033
0.013
0.024
0.32
-0.0078
-0.082
-0.065
-0.085
-0.087
0.23
-0.21
-0.071
0.27
-0.28
0.17
-0.45
Vehicle_size_Midsize
0.07
0.068
-0.014
0.19
-0.066
0.041
0.014
0.0063
-0.0027
0.0056
-0.099
-0.011
0.047
0.1
-0.048
-0.045
0.25
-0.24
0.18
-0.15
0.05
-0.11
-0.62
-0.43
Year
Horsepower
Engine_cylinders
Doors_number
Popularity
MSRP
AVG_MPG
Fuel_type_diesel
Fuel_type_flex-fuel (premium unleaded recommended/E85)
Fuel_type_flex-fuel (premium unleaded required/E85)
Fuel_type_flex-fuel (unleaded/E85)
Fuel_type_natural gas
Fuel_type_premium unleaded (recommended)
Fuel_type_premium unleaded (required)
Fuel_type_regular unleaded
Transmission_type_AUTOMATED_MANUAL
Transmission_type_AUTOMATIC
Transmission_type_MANUAL
Driven_wheels_all wheel drive
Driven_wheels_four wheel drive
Driven_wheels_front wheel drive
Driven_wheels_rear wheel drive
Vehicle_size_Compact
Vehicle_size_Large
Vehicle_size_Midsize
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8

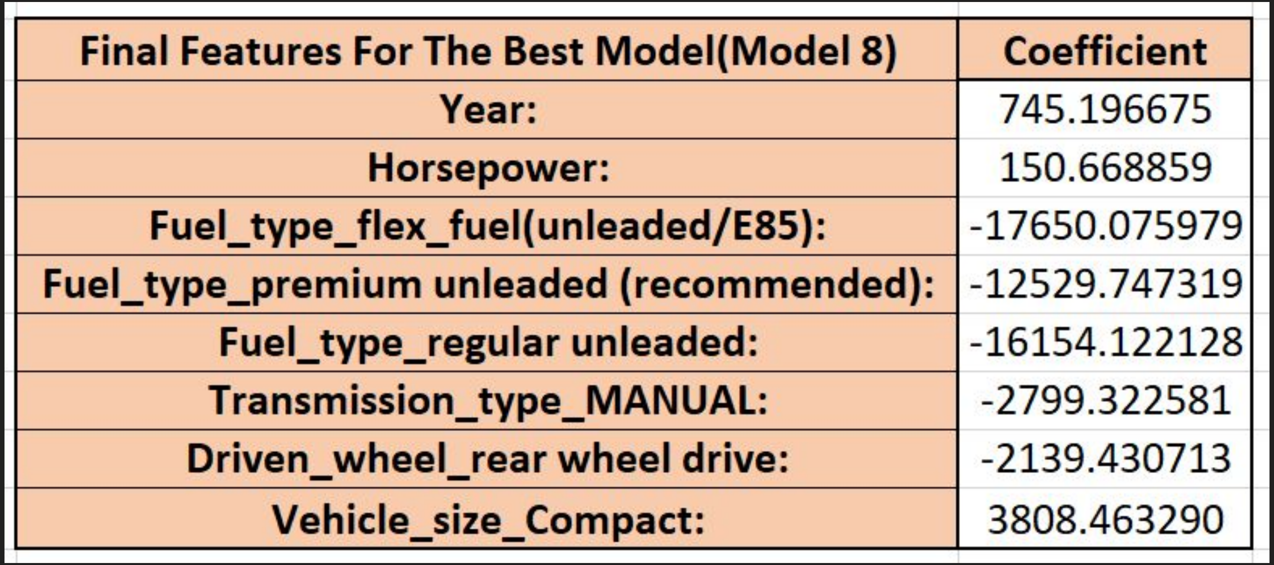

MSRP
Year
Horsepower
Fuel_type_flex-fuel (unleaded/E85)
Fuel_type_premium unleaded (recommended)
Fuel_type_regular unleaded
Transmission_type_MANUAL
Driven_wheels_rear wheel drive
Vehicle_size_Compact
0.56
0.76
0.4
0.063
0.13
0.18
0.16
0.22
0.14
-0.12
-0.51
-0.33
-0.45
-0.4
-0.51
-0.28
-0.33
-0.28
-0.14
-0.00073
0.084
0.14
-0.092
0.3
0.11
-0.013
-0.17
0.067
-0.24
-0.12
-0.44
-0.18
0.025
0.12
0.42
-0.046
MSRP
Year
Horsepower
Fuel_type_flex-fuel (unleaded/E85)
Fuel_type_premium unleaded (recommended)
Fuel_type_regular unleaded
Transmission_type_MANUAL
Driven_wheels_rear wheel drive
Vehicle_size_Compact
0.6
0.4
0.2
0.0
−0.2
−0.4

Data Analysis

- Use multiple linear regression
  - to predict one variable based on the known information about other variables, and
  - examine how multiple independent variables are related to one dependent variable
- Used recursive model elimination (RFE) to compare models with different sizes and selected Model 8* with highest adjusted R^2 of 0.75
- Compared the performance of the model using the training and test sets

Model 8* (Year, Horsepower, Fuel_type_flex-fuel (unleaded/E85), Fuel_type_premium unleaded (recommended), Fuel_type_regular unleaded, Transmission_type_MANUAL, Driven_wheels_rear wheel drive, Vehicle_size_Compact)

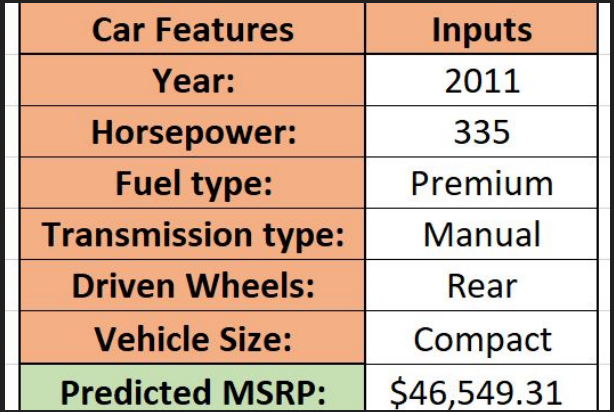
Model 8



Final Features For The Best Model(Model 8)	Coefficient
Year:	745.196675
Horsepower:	150.668859
Fuel_type_flex_fuel(unleaded/E85):	-17650.075979
Fuel_type_premium unleaded (recommended):	-12529.747319
Fuel_type_regular unleaded:	-16154.122128
Transmission_type_MANUAL:	-2799.322581
Driven_wheel_rear wheel drive:	-2139.430713
Vehicle_size_Compact:	3808.463290

Summary of Findings

- Result of the analysis: predict the MSRP of a car with a 75% accuracy
- We were able to predict a car’s MSRP with a given set of features
- We also concluded that the RFE is not the best model to predict a car’s MSRP based on the 75% accuracy that the RFE method yielded.
  - We were able to accurately predict a car's msrp after plugging in values for the features listed in Model 8



Car Features	Inputs
Year:	2011
Horsepower:	335
Fuel type:	Premium
Transmission type:	Manual
Driven Wheels:	Rear
Vehicle Size:	Compact
Predicted MSRP:	$46,549.31

Implications

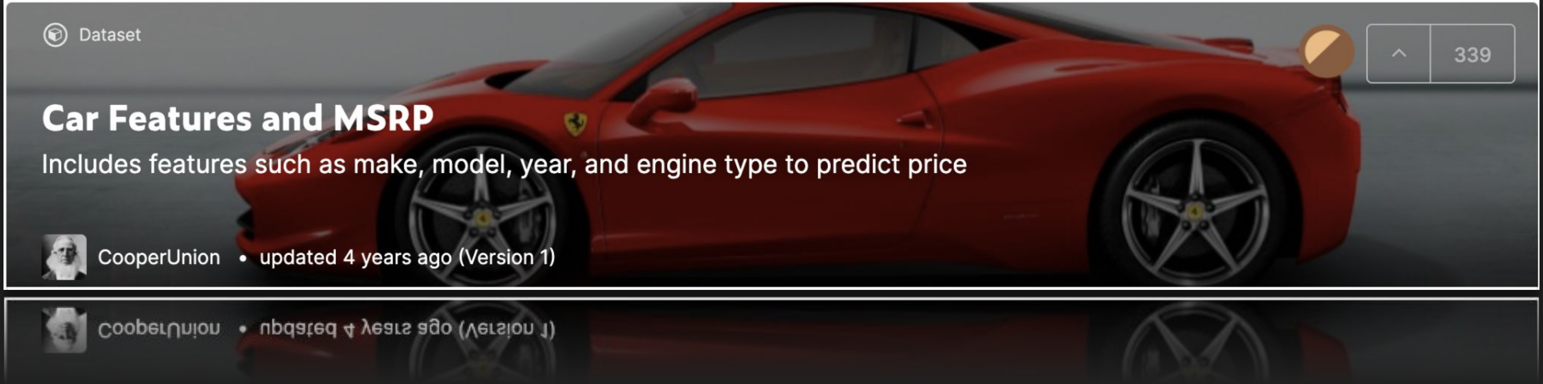
- At 75% accuracy in predicting MSRP, manufacturers can:
  - Adjust features and specs according to the preferred MSRP,
  - Budget early on,
  - Decide on how to market the car, and
  - Have a better understanding and control of the factors contributing to the MSRP

Limitations

- Lack of numerical variables
- Unknown values which needed to be dropped individually
- Irrelevant variables such as market category, vehicle style, and popularity.

Future steps

- Improve our results with a dataset that has more complete data and more relevant variables
- Use a different model for our prediction



Car Features and MSRP

Includes features such as make, model, year, and engine type to predict price

CooperUnion • updated 4 years ago (Version 1)

Classification

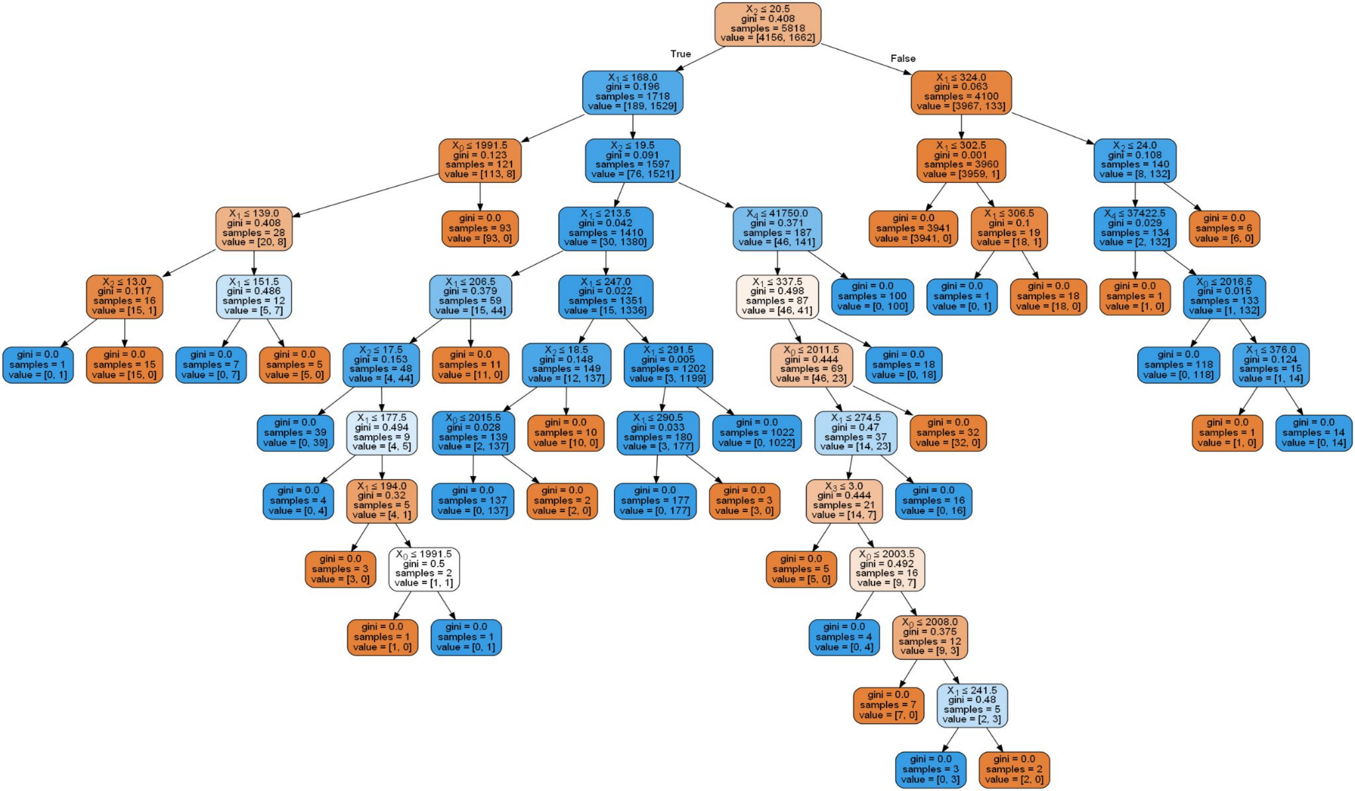
The problem: Filling a missing Engine Cylinder value on a car shopping website.

The approach: Using 3 different Binary Classification methods to solve this problem.

Used Methods: Decision Tree, Random Forest, and Naive Bayes

Results: All Methods yielded impressive Classification abilities of 97% and above accuracy scores.

Analysis and Results



$X_2 \leq 20.5$ gini = 0.408 samples = 5818 value = [4156, 1662]
True
False
$X_1 \leq 168.0$ gini = 0.196 samples = 1718 value = [189, 1529]
$X_1 \leq 324.0$ gini = 0.063 samples = 4100 value = [3967, 133]
$X_0 \leq 1991.5$ gini = 0.123 samples = 121 value = [113, 8]
$X_2 \leq 19.5$ gini = 0.091 samples = 1597 value = [76, 1521]
$X_1 \leq 302.5$ gini = 0.001 samples = 3960 value = [3959, 1]
$X_2 \leq 24.0$ gini = 0.108 samples = 140 value = [8, 132]
$X_1 \leq 139.0$ gini = 0.408 samples = 28 value = [20, 8]
gini = 0.0 samples = 93 value = [93, 0]
$X_1 \leq 213.5$ gini = 0.042 samples = 1410 value = [30, 1380]
$X_4 \leq 41750.0$ gini = 0.371 samples = 187 value = [46, 141]
gini = 0.0 samples = 3941 value = [3941, 0]
$X_1 \leq 306.5$ gini = 0.1 samples = 19 value = [18, 1]
$X_4 \leq 37422.5$ gini = 0.029 samples = 134 value = [2, 132]
gini = 0.0 samples = 6 value = [6, 0]
$X_2 \leq 13.0$ gini = 0.117 samples = 16 value = [15, 1]
$X_1 \leq 151.5$ gini = 0.486 samples = 12 value = [5, 7]
$X_1 \leq 206.5$ gini = 0.379 samples = 59 value = [15, 44]
$X_1 \leq 247.0$ gini = 0.022 samples = 1351 value = [15, 1336]
$X_1 \leq 337.5$ gini = 0.498 samples = 87 value = [46, 41]
gini = 0.0 samples = 100 value = [0, 100]
gini = 0.0 samples = 1 value = [0, 1]
gini = 0.0 samples = 18 value = [18, 0]
gini = 0.0 samples = 1 value = [1, 0]
$X_0 \leq 2016.5$ gini = 0.015 samples = 133 value = [1, 132]
gini = 0.0 samples = 1 value = [0, 1]
gini = 0.0 samples = 15 value = [15, 0]
gini = 0.0 samples = 7 value = [0, 7]
gini = 0.0 samples = 5 value = [5, 0]
$X_2 \leq 17.5$ gini = 0.153 samples = 48 value = [4, 44]
gini = 0.0 samples = 11 value = [11, 0]
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gini = 0.0 samples = 18 value = [0, 18]
gini = 0.0 samples = 118 value = [0, 118]
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gini = 0.0 samples = 39 value = [0, 39]
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gini = 0.0 samples = 10 value = [10, 0]
$X_1 \leq 290.5$ gini = 0.033 samples = 180 value = [3, 177]
gini = 0.0 samples = 1022 value = [0, 1022]
$X_1 \leq 274.5$ gini = 0.47 samples = 37 value = [14, 23]
gini = 0.0 samples = 32 value = [32, 0]
gini = 0.0 samples = 1 value = [1, 0]
gini = 0.0 samples = 14 value = [0, 14]
gini = 0.0 samples = 4 value = [0, 4]
$X_1 \leq 194.0$ gini = 0.32 samples = 5 value = [4, 1]
gini = 0.0 samples = 137 value = [0, 137]
gini = 0.0 samples = 2 value = [2, 0]
gini = 0.0 samples = 177 value = [0, 177]
gini = 0.0 samples = 3 value = [3, 0]
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gini = 0.0 samples = 16 value = [0, 16]
gini = 0.0 samples = 3 value = [3, 0]
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gini = 0.0 samples = 5 value = [5, 0]
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gini = 0.0 samples = 1 value = [1, 0]
gini = 0.0 samples = 1 value = [0, 1]
gini = 0.0 samples = 4 value = [0, 4]
$X_0 \leq 2008.0$ gini = 0.375 samples = 12 value = [9, 3]
gini = 0.0 samples = 7 value = [7, 0]
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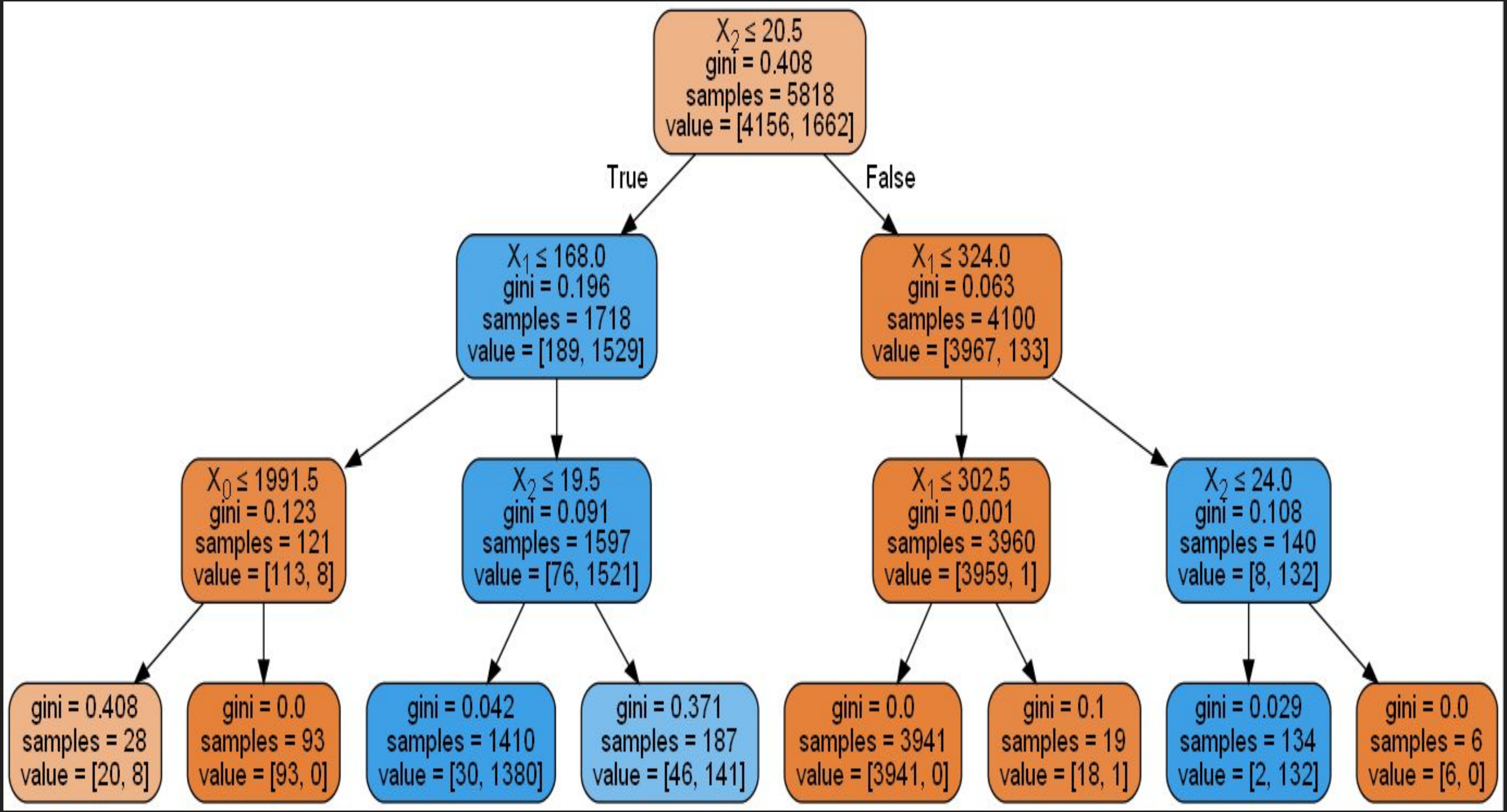
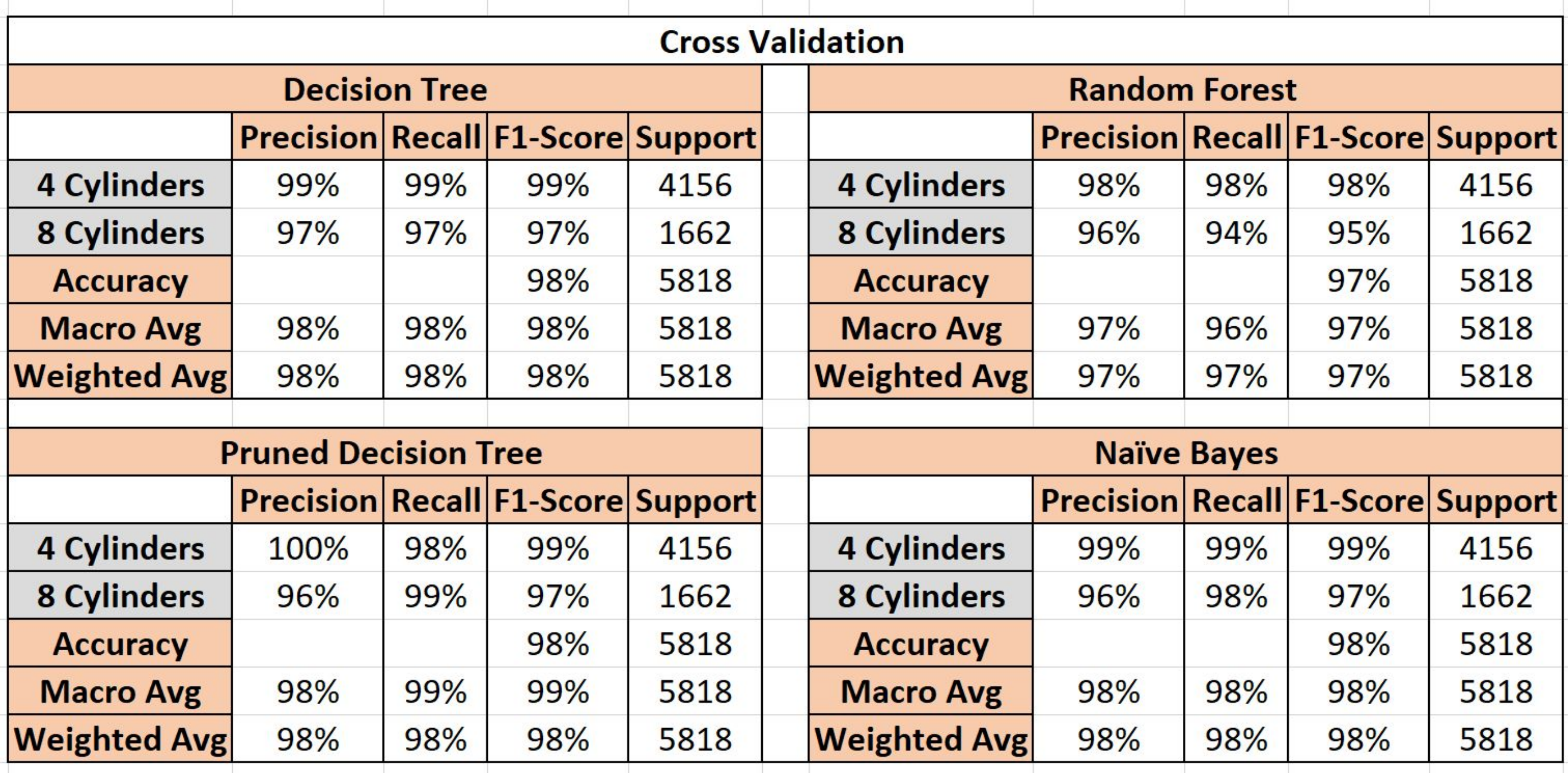
gini = 0.0 samples = 2 value = [2, 0]

Full Decision Tree



Pruned Decision Tree



Cross Validation

Decision Tree

	Precision	Recall	F1-Score	Support
4 Cylinders	99%	99%	99%	4156
8 Cylinders	97%	97%	97%	1662
Accuracy			98%	5818
Macro Avg	98%	98%	98%	5818
Weighted Avg	98%	98%	98%	5818

Random Forest

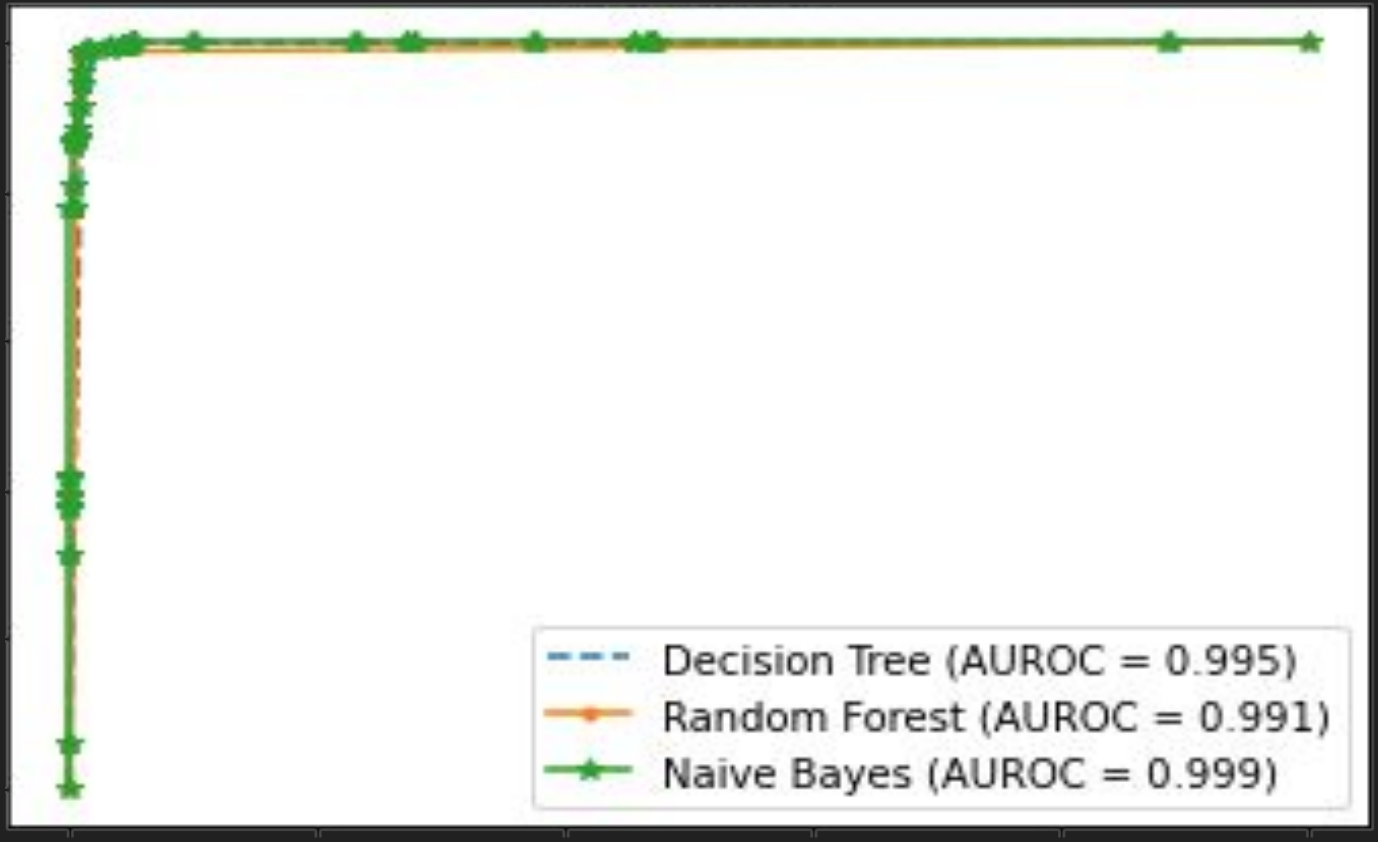
	Precision	Recall	F1-Score	Support
4 Cylinders	98%	98%	98%	4156
8 Cylinders	96%	94%	95%	1662
Accuracy			97%	5818
Macro Avg	97%	96%	97%	5818
Weighted Avg	97%	97%	97%	5818

Pruned Decision Tree

	Precision	Recall	F1-Score	Support
4 Cylinders	100%	98%	99%	4156
8 Cylinders	96%	99%	97%	1662
Accuracy			98%	5818
Macro Avg	98%	99%	99%	5818
Weighted Avg	98%	98%	98%	5818

Naïve Bayes

	Precision	Recall	F1-Score	Support
4 Cylinders	99%	99%	99%	4156
8 Cylinders	96%	98%	97%	1662
Accuracy			98%	5818
Macro Avg	98%	98%	98%	5818
Weighted Avg	98%	98%	98%	5818


Decision Tree (AUROC = 0.995)
Random Forest (AUROC = 0.991)
Naive Bayes (AUROC = 0.999)

ROC Curve