

Lab 6

AA 501

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Question 1

This dataset has variables pertaining to fuel economy of various cars. Do not create a training and test set. Just use the whole cars2010 dataset for the following analysis. The cars2011 and cars2012 datasets will be used at late time periods.

Part (a)

Run a regression predicting the FE variable using all the remaining variables. Some of these predictor variables are coded as numeric, but should be treated as categorical. The only numeric variables in your dataset should be `EngDispl`. All remaining variables are categorical.

a. Perform a Global F-test. What is your conclusion?

Solution: We find a global F-stat of 95.55 with a p-value $< 2.2e-16$. Thus, we know that at least one variable is useful in predicting the FE.

```
cars.mlr <- lm(FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +  
              NumGears + TransLockup + TransCreeperGear + DriveDesc +  
              IntakeValvePerCyl + ExhaustValvesPerCyl + CarlineClassDesc +  
              VarValveTiming + VarValveLift, data = cars2010)  
  
summary(cars.mlr)
```

```
##  
## Call:  
## lm(formula = FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
```

```

##      NumGears + TransLockup + TransCreeperGear + DriveDesc + IntakeValvePerCyl +
##      ExhaustValvesPerCyl + CarlineClassDesc + VarValveTiming +
##      VarValveLift, data = cars2010)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -10.6399  -1.6583   0.0582   1.5708  21.6002
##
## Coefficients: (5 not defined because of singularities)
##
##              Estimate Std. Error t value
## (Intercept)      35.95655      3.34991  10.734
## EngDispl         -2.24571      0.26269  -8.549
## NumCyl3           15.88136      5.11001   3.108
## NumCyl4            7.76711      3.94430   1.969
## NumCyl5            4.89858      3.97620   1.232
## NumCyl6            4.19528      3.94208   1.064
## NumCyl8            2.51528      3.98438   0.631
## NumCyl10          -0.01541      4.13445  -0.004
## NumCyl12          -1.02329      4.11855  -0.248
## NumCyl16          -0.31250      5.42018  -0.058
## TransmissionA4    -6.93754      2.27354  -3.051
## TransmissionA5    -6.53146      2.27928  -2.866
## TransmissionA6    -4.88712      2.27829  -2.145
## TransmissionA7      5.70476      2.44239   2.336
## TransmissionAM6   -9.48575      2.46325  -3.851
## TransmissionAM7     0.59731      2.65233   0.225
## TransmissionAV    -4.40251      2.28451  -1.927
## TransmissionAVS6  -6.72835      2.41754  -2.783
## TransmissionM5    -7.00105      2.27746  -3.074
## TransmissionM6    -7.03693      2.26627  -3.105
## TransmissionS4   -10.42310      2.42863  -4.292
## TransmissionS5    -7.17879      2.30519  -3.114
## TransmissionS6    -5.09671      2.26315  -2.252
## TransmissionS7      4.08689      2.51141   1.627
## TransmissionS8    -4.61764      4.02547  -1.147
## AirAspirationMethodSupercharged -1.66003      0.78945  -2.103
## AirAspirationMethodTurbocharged -1.12911      0.32214  -3.505
## NumGears4           NA           NA      NA
## NumGears5           NA           NA      NA
## NumGears6           NA           NA      NA
## NumGears7    -10.74200      3.27897  -3.276
## NumGears8      1.78308      3.19710   0.558
## TransLockup1     -0.89442      0.35715  -2.504
## TransCreeperGear1 -1.04006      0.49553  -2.099
## DriveDescFourWheelDrive -0.45145      0.43461  -1.039
## DriveDescParttimeFourWheelDrive -0.29399      1.06503  -0.276
## DriveDescTwoWheelDriveFront  4.31845      0.37701  11.455
## DriveDescTwoWheelDriveRear   1.19634      0.37255   3.211
## IntakeValvePerCyl1  6.33644      3.32150   1.908
## IntakeValvePerCyl2  4.88952      3.21060   1.523
## IntakeValvePerCyl3           NA           NA      NA
## ExhaustValvesPerCyl1  1.54229      0.75433   2.045
## ExhaustValvesPerCyl2           NA           NA      NA
## CarlineClassDesc2Seaters  2.85693      1.17833   2.425

```

## CarlineClassDescCompactCars	3.78908	1.09963	3.446
## CarlineClassDescLargeCars	2.56219	1.13079	2.266
## CarlineClassDescMidsizeCars	3.39390	1.09686	3.094
## CarlineClassDescMinicompactCars	3.63416	1.19375	3.044
## CarlineClassDescSmallPickupTrucks2WD	-1.85140	1.25181	-1.479
## CarlineClassDescSmallPickupTrucks4WD	-0.95072	1.35268	-0.703
## CarlineClassDescSmallStationWagons	2.20724	1.13608	1.943
## CarlineClassDescSpecialPurposeVehicleminivan2WD	-2.07995	1.36307	-1.526
## CarlineClassDescSpecialPurposeVehicleSUV2WD	-1.51997	1.10807	-1.372
## CarlineClassDescSpecialPurposeVehicleSUV4WD	-0.56991	1.12243	-0.508
## CarlineClassDescStandardPickupTrucks2WD	-1.74467	1.27006	-1.374
## CarlineClassDescStandardPickupTrucks4WD	-1.94205	1.30286	-1.491
## CarlineClassDescSubcompactCars	3.43057	1.11242	3.084
## CarlineClassDescVansCargoTypes	-4.07446	1.51702	-2.686
## CarlineClassDescVansPassengerType	-4.27396	1.95092	-2.191
## VarValveTiming1	0.15943	0.29071	0.548
## VarValveLift1	0.82579	0.30704	2.690
##	Pr(> t)		
## (Intercept)	< 2e-16	***	
## EngDispl	< 2e-16	***	
## NumCyl3	0.001935	**	
## NumCyl4	0.049193	*	
## NumCyl5	0.218234		
## NumCyl6	0.287469		
## NumCyl8	0.527992		
## NumCyl10	0.997028		
## NumCyl12	0.803827		
## NumCyl16	0.954034		
## TransmissionA4	0.002335	**	
## TransmissionA5	0.004245	**	
## TransmissionA6	0.032175	*	
## TransmissionA7	0.019693	*	
## TransmissionAM6	0.000125	***	
## TransmissionAM7	0.821867		
## TransmissionAV	0.054234	.	
## TransmissionAVS6	0.005480	**	
## TransmissionM5	0.002166	**	
## TransmissionM6	0.001953	**	
## TransmissionS4	1.94e-05	***	
## TransmissionS5	0.001894	**	
## TransmissionS6	0.024526	*	
## TransmissionS7	0.103967		
## TransmissionS8	0.251599		
## AirAspirationMethodSupercharged	0.035723	*	
## AirAspirationMethodTurbocharged	0.000476	***	
## NumGears4	NA		
## NumGears5	NA		
## NumGears6	NA		
## NumGears7	0.001087	**	
## NumGears8	0.577155		
## TransLockup1	0.012420	*	
## TransCreeperGear1	0.036067	*	
## DriveDescFourWheelDrive	0.299167		
## DriveDescParttimeFourWheelDrive	0.782571		

```

## DriveDescTwoWheelDriveFront          < 2e-16 ***
## DriveDescTwoWheelDriveRear           0.001362 **
## IntakeValvePerCyl1                    0.056702 .
## IntakeValvePerCyl2                    0.128077
## IntakeValvePerCyl3                     NA
## ExhaustValvesPerCyl1                   0.041146 *
## ExhaustValvesPerCyl2                     NA
## CarlineClassDesc2Seaters                0.015495 *
## CarlineClassDescCompactCars             0.000592 ***
## CarlineClassDescLargeCars               0.023664 *
## CarlineClassDescMidsizeCars             0.002026 **
## CarlineClassDescMinicompactCars         0.002390 **
## CarlineClassDescSmallPickupTrucks2WD    0.139447
## CarlineClassDescSmallPickupTrucks4WD    0.482307
## CarlineClassDescSmallStationWagons      0.052300 .
## CarlineClassDescSpecialPurposeVehicleminivan2WD 0.127330
## CarlineClassDescSpecialPurposeVehicleSUV2WD 0.170443
## CarlineClassDescSpecialPurposeVehicleSUV4WD 0.611738
## CarlineClassDescStandardPickupTrucks2WD 0.169828
## CarlineClassDescStandardPickupTrucks4WD 0.136365
## CarlineClassDescSubcompactCars          0.002097 **
## CarlineClassDescVansCargoTypes          0.007349 **
## CarlineClassDescVansPassengerType       0.028690 *
## VarValveTiming1                        0.583517
## VarValveLift1                          0.007269 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.14 on 1051 degrees of freedom
## Multiple R-squared:  0.8333, Adjusted R-squared:  0.8246
## F-statistic: 95.55 on 55 and 1051 DF, p-value: < 2.2e-16

```

b. What percent of variation in fuel economy (FE) is explained by these 13 variables?

Solution: We found that 83.33% of the variation in the model is explained by all 13 predictor variables.

Part (b)

Trying to evaluate categorical variables in traditional linear regression output can be difficult because the p-values are for each categorical dummy variable. To evaluate the inclusion of a variable as a whole, you need a global p-value for each categorical variable.

a. . Use the `car::Anova` function in R on your linear regression object to get the p-values for each categorical variable.

Solution:

```
car::Anova(cars.mlr)

## Note: model has aliased coefficients
##      sums of squares computed by model comparison

## Anova Table (Type II tests)
##
## Response: FE
##           Sum Sq   Df F value    Pr(>F)
## EngDispl      720.6    1 73.0842 < 2.2e-16 ***
## NumCyl        889.6    6 15.0374 < 2.2e-16 ***
## Transmission  707.7   12  5.9813 3.553e-10 ***
## AirAspirationMethod 151.2    2  7.6686 0.0004939 ***
## NumGears      109.2    2  5.5361 0.0040576 **
## TransLockup     61.8    1  6.2715 0.0124202 *
## TransCreeperGear  43.4    1  4.4052 0.0360667 *
## DriveDesc     1535.0    4 38.9205 < 2.2e-16 ***
## IntakeValvePerCyl   56.6    2  2.8720 0.0570315 .
## ExhaustValvesPerCyl  41.2    1  4.1803 0.0411460 *
## CarlineClassDesc 3495.4   16 22.1561 < 2.2e-16 ***
## VarValveTiming       3.0    1  0.3008 0.5835171
## VarValveLift       71.3    1  7.2336 0.0072685 **
## Residuals     10363.0 1051
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

b. Which of the variables has the highest p-value?

Solution: The variable `VarValveTiming` has the highest p-value.

Part (c)

Rerun the preceding model, but remove the variable with the highest p-value that you found with the “`car::Anova`” function. Compare the output with the preceding model.

a. Did the p-value for the model change notably?

Solution: No, model did not change notably. The F-statistic increased by less than 2.

```
cars.mlr2 <- lm(FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
               NumGears + TransLockup + TransCreeperGear + DriveDesc +
               IntakeValvePerCyl + ExhaustValvesPerCyl + CarlineClassDesc +
               VarValveLift, data = cars2010)

summary(cars.mlr2)

##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
##      NumGears + TransLockup + TransCreeperGear + DriveDesc + IntakeValvePerCyl +
##      ExhaustValvesPerCyl + CarlineClassDesc + VarValveLift, data = cars2010)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.6242  -1.6504   0.0541   1.5540  21.5852
##
## Coefficients: (5 not defined because of singularities)
##                                Estimate Std. Error t value
## (Intercept)                   35.99395    3.34810  10.751
## EngDispl                      -2.26003    0.26130  -8.649
## NumCyl3                       16.00965    5.10296   3.137
## NumCyl4                        7.91363    3.93394   2.012
## NumCyl5                        5.03429    3.96717   1.269
## NumCyl6                        4.35537    3.92996   1.108
## NumCyl8                        2.71420    3.96652   0.684
## NumCyl10                       0.18914    4.11622   0.046
## NumCyl12                      -0.81976    4.10043  -0.200
## NumCyl16                      -0.08503    5.40249  -0.016
## TransmissionA4                -6.98768    2.27095  -3.077
## TransmissionA5                -6.53850    2.27848  -2.870
## TransmissionA6                -4.90059    2.27740  -2.152
## TransmissionA7                 5.71566    2.44150   2.341
## TransmissionAM6               -9.49295    2.46240  -3.855
## TransmissionAM7                 0.59242    2.65143   0.223
## TransmissionAV               -4.40233    2.28375  -1.928
## TransmissionAVS6              -6.72853    2.41673  -2.784
## TransmissionM5                -7.01977    2.27644  -3.084
## TransmissionM6                -7.04911    2.26540  -3.112
## TransmissionS4              -10.51052    2.42259  -4.339
## TransmissionS5                -7.20354    2.30398  -3.127
## TransmissionS6                -5.10605    2.26234  -2.257
## TransmissionS7                 4.09144    2.51056   1.630
## TransmissionS8                -4.62893    4.02408  -1.150
## AirAspirationMethodSupercharged -1.67713    0.78857  -2.127
## AirAspirationMethodTurbocharged -1.13613    0.32177  -3.531
## NumGears4                      NA         NA      NA
## NumGears5                      NA         NA      NA
## NumGears6                      NA         NA      NA
```

## NumGears7	-10.74376	3.27788	-3.278
## NumGears8	1.79152	3.19600	0.561
## TransLockup1	-0.89373	0.35703	-2.503
## TransCreeperGear1	-1.09666	0.48450	-2.263
## DriveDescFourWheelDrive	-0.44026	0.43399	-1.014
## DriveDescParttimeFourWheelDrive	-0.25475	1.06227	-0.240
## DriveDescTwoWheelDriveFront	4.32752	0.37652	11.494
## DriveDescTwoWheelDriveRear	1.19041	0.37227	3.198
## IntakeValvePerCyl1	6.36976	3.31984	1.919
## IntakeValvePerCyl2	4.90088	3.20946	1.527
## IntakeValvePerCyl3	NA	NA	NA
## ExhaustValvesPerCyl1	1.49669	0.74949	1.997
## ExhaustValvesPerCyl2	NA	NA	NA
## CarlineClassDesc2Seaters	2.85888	1.17793	2.427
## CarlineClassDescCompactCars	3.77775	1.09907	3.437
## CarlineClassDescLargeCars	2.55092	1.13023	2.257
## CarlineClassDescMidsizeCars	3.38958	1.09647	3.091
## CarlineClassDescMinicompactCars	3.62150	1.19313	3.035
## CarlineClassDescSmallPickupTrucks2WD	-1.88501	1.24990	-1.508
## CarlineClassDescSmallPickupTrucks4WD	-0.99946	1.34930	-0.741
## CarlineClassDescSmallStationWagons	2.19864	1.13559	1.936
## CarlineClassDescSpecialPurposeVehicleminivan2WD	-2.14681	1.35716	-1.582
## CarlineClassDescSpecialPurposeVehicleSUV2WD	-1.52376	1.10769	-1.376
## CarlineClassDescSpecialPurposeVehicleSUV4WD	-0.58904	1.12151	-0.525
## CarlineClassDescStandardPickupTrucks2WD	-1.76375	1.26916	-1.390
## CarlineClassDescStandardPickupTrucks4WD	-1.97791	1.30079	-1.521
## CarlineClassDescSubcompactCars	3.42813	1.11204	3.083
## CarlineClassDescVansCargoTypes	-4.03720	1.51499	-2.665
## CarlineClassDescVansPassengerType	-4.21030	1.94682	-2.163
## VarValveLift1	0.82139	0.30683	2.677
##	Pr(> t)		
## (Intercept)	< 2e-16 ***		
## EngDispl	< 2e-16 ***		
## NumCyl3	0.001752 **		
## NumCyl4	0.044513 *		
## NumCyl5	0.204726		
## NumCyl6	0.268007		
## NumCyl8	0.493951		
## NumCyl10	0.963360		
## NumCyl12	0.841581		
## NumCyl16	0.987446		
## TransmissionA4	0.002145 **		
## TransmissionA5	0.004191 **		
## TransmissionA6	0.031638 *		
## TransmissionA7	0.019416 *		
## TransmissionAM6	0.000123 ***		
## TransmissionAM7	0.823240		
## TransmissionAV	0.054164 .		
## TransmissionAVS6	0.005463 **		
## TransmissionM5	0.002098 **		
## TransmissionM6	0.001911 **		
## TransmissionS4	1.57e-05 ***		
## TransmissionS5	0.001817 **		
## TransmissionS6	0.024214 *		

```

## TransmissionS7                0.103466
## TransmissionS8                0.250279
## AirAspirationMethodSupercharged 0.033668 *
## AirAspirationMethodTurbocharged 0.000432 ***
## NumGears4                     NA
## NumGears5                     NA
## NumGears6                     NA
## NumGears7                     0.001081 **
## NumGears8                     0.575223
## TransLockup1                  0.012458 *
## TransCreeperGear1             0.023808 *
## DriveDescFourWheelDrive       0.310604
## DriveDescParttimeFourWheelDrive 0.810521
## DriveDescTwoWheelDriveFront   < 2e-16 ***
## DriveDescTwoWheelDriveRear    0.001427 **
## IntakeValvePerCyl1            0.055293 .
## IntakeValvePerCyl2            0.127060
## IntakeValvePerCyl3            NA
## ExhaustValvesPerCyl1          0.046088 *
## ExhaustValvesPerCyl2          NA
## CarlineClassDesc2Seaters       0.015390 *
## CarlineClassDescCompactCars    0.000611 ***
## CarlineClassDescLargeCars      0.024213 *
## CarlineClassDescMidsizeCars    0.002045 **
## CarlineClassDescMinicompactCars 0.002462 **
## CarlineClassDescSmallPickupTrucks2WD 0.131822
## CarlineClassDescSmallPickupTrucks4WD 0.459026
## CarlineClassDescSmallStationWagons 0.053120 .
## CarlineClassDescSpecialPurposeVehicleminivan2WD 0.113986
## CarlineClassDescSpecialPurposeVehicleSUV2WD 0.169229
## CarlineClassDescSpecialPurposeVehicleSUV4WD 0.599543
## CarlineClassDescStandardPickupTrucks2WD 0.164913
## CarlineClassDescStandardPickupTrucks4WD 0.128675
## CarlineClassDescSubcompactCars 0.002105 **
## CarlineClassDescVansCargoTypes 0.007821 **
## CarlineClassDescVansPassengerType 0.030792 *
## VarValveLift1                 0.007544 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.139 on 1052 degrees of freedom
## Multiple R-squared:  0.8333, Adjusted R-squared:  0.8247
## F-statistic: 97.38 on 54 and 1052 DF, p-value: < 2.2e-16

```

b. Did the R-square and adjusted R-square values change notably?

Solution: No, they stayed nearly identical.

c. Did the p-values on other variables change notably?

Solution: No, they stayed nearly identical.

Part (d)

Again, rerun the preceding model (from question c), but eliminate the variable with the highest p-value. Repeat this process of eliminating one variable at a time and rerunning the regression until you only have variables significant at the 0.008 level. Remember to run the model after EACH variable you remove as the p-value might change by removing a variable.

a. Did the R-square and adjusted R-square values change notably?

Solution: No, they did not.

b. How many variables did you have left that were significant at the 0.008 level?

Solution: We have 9 variables left.

```
car::Anova(cars.mlr2)

## Note: model has aliased coefficients
##      sums of squares computed by model comparison

## Anova Table (Type II tests)
##
## Response: FE
##
##      Sum Sq   Df F value    Pr(>F)
## EngDispl    737.1    1 74.8066 < 2.2e-16 ***
## NumCyl      887.9    6 15.0181 < 2.2e-16 ***
## Transmission 712.6   12  6.0266 2.849e-10 ***
## AirAspirationMethod 153.8    2  7.8053 0.0004316 ***
## NumGears    109.2    2  5.5431 0.0040294 **
## TransLockup   61.7    1  6.2661 0.0124578 *
## TransCreeperGear 50.5    1  5.1234 0.0238082 *
## DriveDesc   1545.6    4 39.2146 < 2.2e-16 ***
## IntakeValvePerCyl 57.9    2  2.9386 0.0533736 .
## ExhaustValvesPerCyl 39.3    1  3.9878 0.0460877 *
## CarlineClassDesc 3504.2   16 22.2267 < 2.2e-16 ***
## VarValveLift   70.6    1  7.1663 0.0075441 **
## Residuals    10366.0 1052
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cars.mlr3 <- lm(FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
               NumGears + TransLockup + TransCreeperGear + DriveDesc +
               ExhaustValvesPerCyl + CarlineClassDesc +
               VarValveLift, data = cars2010)

car::Anova(cars.mlr3)
```

```
## Note: model has aliased coefficients
##      sums of squares computed by model comparison
```

```
## Anova Table (Type II tests)
##
## Response: FE
##
```

	Sum Sq	Df	F value	Pr(>F)
EngDispl	688.9	1	69.6604	< 2.2e-16 ***
NumCyl	1000.0	6	16.8523	< 2.2e-16 ***
Transmission	699.4	12	5.8935	5.430e-10 ***
AirAspirationMethod	169.7	2	8.5817	0.0002009 ***
NumGears	106.5	2	5.3833	0.0047196 **
TransLockup	63.6	1	6.4299	0.0113653 *
TransCreeperGear	67.4	1	6.8201	0.0091419 **
DriveDesc	1559.4	4	39.4183	< 2.2e-16 ***
ExhaustValvesPerCyl	474.2	1	47.9516	7.583e-12 ***
CarlineClassDesc	3489.4	16	22.0517	< 2.2e-16 ***
VarValveLift	68.0	1	6.8807	0.0088387 **
Residuals	10423.9	1054		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cars.mlr4 <- lm(FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
               NumGears + TransCreeperGear + DriveDesc +
               ExhaustValvesPerCyl + CarlineClassDesc +
               VarValveLift, data = cars2010)

car::Anova(cars.mlr4)
```

```
## Note: model has aliased coefficients
##      sums of squares computed by model comparison
```

```
## Anova Table (Type II tests)
##
## Response: FE
##
```

	Sum Sq	Df	F value	Pr(>F)
EngDispl	663.5	1	66.7421	8.786e-16 ***
NumCyl	1037.6	6	17.3966	< 2.2e-16 ***
Transmission	638.4	12	5.3520	7.426e-09 ***
AirAspirationMethod	155.0	2	7.7971	0.000435 ***
NumGears	101.0	2	5.0780	0.006385 **
TransCreeperGear	71.0	1	7.1376	0.007665 **
DriveDesc	1586.1	4	39.8882	< 2.2e-16 ***
ExhaustValvesPerCyl	492.7	1	49.5606	3.460e-12 ***
CarlineClassDesc	3548.8	16	22.3123	< 2.2e-16 ***
VarValveLift	67.4	1	6.7819	0.009338 **
Residuals	10487.5	1055		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cars.mlr4 <- lm(FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
               NumGears + TransCreeperGear + DriveDesc +
               ExhaustValvesPerCyl + CarlineClassDesc, data = cars2010)

car::Anova(cars.mlr4)
```

```
## Note: model has aliased coefficients
##      sums of squares computed by model comparison

## Anova Table (Type II tests)
##
## Response: FE
##
```

	Sum Sq	Df	F value	Pr(>F)
EngDispl	679.8	1	68.0122	4.791e-16 ***
NumCyl	1043.7	6	17.4026	< 2.2e-16 ***
Transmission	613.6	12	5.1154	2.307e-08 ***
AirAspirationMethod	202.9	2	10.1494	4.305e-05 ***
NumGears	108.9	2	5.4475	0.004429 **
TransCreeperGear	81.3	1	8.1365	0.004423 **
DriveDesc	1537.5	4	38.4558	< 2.2e-16 ***
ExhaustValvesPerCyl	487.9	1	48.8110	4.982e-12 ***
CarlineClassDesc	3715.0	16	23.2300	< 2.2e-16 ***
Residuals	10554.9	1056		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(cars.mlr4)
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + Transmission + AirAspirationMethod +
##      NumGears + TransCreeperGear + DriveDesc + ExhaustValvesPerCyl +
##      CarlineClassDesc, data = cars2010)
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-10.7951	-1.7259	0.0248	1.6395	22.0010

```
##
## Coefficients: (4 not defined because of singularities)
##
```

	Estimate	Std. Error	t value
(Intercept)	35.6506	3.3670	10.588
EngDispl	-2.0915	0.2536	-8.247
NumCyl3	20.1462	3.9256	5.132
NumCyl4	12.9901	2.2977	5.653
NumCyl5	9.9691	2.3716	4.204
NumCyl6	9.2880	2.3213	4.001
NumCyl8	7.1931	2.4355	2.953
NumCyl10	4.2902	2.6392	1.626
NumCyl12	2.9960	2.6229	1.142
NumCyl16	4.2509	4.3950	0.967
TransmissionA4	-7.9263	2.2748	-3.484
TransmissionA5	-7.4632	2.2831	-3.269
TransmissionA6	-5.9012	2.2815	-2.587
TransmissionA7	4.9316	2.4383	2.023
TransmissionAM6	-10.0571	2.4744	-4.064
TransmissionAM7	0.4535	2.6700	0.170
TransmissionAV	-4.8272	2.2967	-2.102
TransmissionAVS6	-7.2674	2.4264	-2.995
TransmissionM5	-7.0899	2.2822	-3.107

## TransmissionM6	-7.0372	2.2764	-3.091
## TransmissionS4	-11.2013	2.4291	-4.611
## TransmissionS5	-8.0730	2.3091	-3.496
## TransmissionS6	-5.7943	2.2722	-2.550
## TransmissionS7	3.4280	2.5065	1.368
## TransmissionS8	-5.5848	4.0379	-1.383
## AirAspirationMethodSupercharged	-1.9893	0.7821	-2.544
## AirAspirationMethodTurbocharged	-1.2457	0.3184	-3.912
## NumGears4	NA	NA	NA
## NumGears5	NA	NA	NA
## NumGears6	NA	NA	NA
## NumGears7	-10.6500	3.2928	-3.234
## NumGears8	2.0751	3.2121	0.646
## TransCreeperGear1	-1.3661	0.4789	-2.852
## DriveDescFourWheelDrive	-0.6841	0.4308	-1.588
## DriveDescParttimeFourWheelDrive	-0.7039	1.0622	-0.663
## DriveDescTwoWheelDriveFront	4.1905	0.3747	11.185
## DriveDescTwoWheelDriveRear	0.9965	0.3717	2.681
## ExhaustValvesPerCyl1	2.7810	0.3980	6.986
## ExhaustValvesPerCyl2	NA	NA	NA
## CarlineClassDesc2Seaters	3.0982	1.1801	2.625
## CarlineClassDescCompactCars	3.8878	1.1062	3.515
## CarlineClassDescLargeCars	2.6874	1.1366	2.364
## CarlineClassDescMidsizeCars	3.4001	1.1033	3.082
## CarlineClassDescMinicompactCars	4.3247	1.1802	3.664
## CarlineClassDescSmallPickupTrucks2WD	-1.8684	1.2587	-1.484
## CarlineClassDescSmallPickupTrucks4WD	-0.9067	1.3575	-0.668
## CarlineClassDescSmallStationWagons	2.2224	1.1434	1.944
## CarlineClassDescSpecialPurposeVehicleminivan2WD	-2.1858	1.3662	-1.600
## CarlineClassDescSpecialPurposeVehicleSUV2WD	-1.5070	1.1148	-1.352
## CarlineClassDescSpecialPurposeVehicleSUV4WD	-0.4822	1.1274	-0.428
## CarlineClassDescStandardPickupTrucks2WD	-1.6614	1.2778	-1.300
## CarlineClassDescStandardPickupTrucks4WD	-1.8270	1.3081	-1.397
## CarlineClassDescSubcompactCars	3.6375	1.1160	3.259
## CarlineClassDescVansCargoTypes	-3.8763	1.5246	-2.542
## CarlineClassDescVansPassengerType	-4.0117	1.9595	-2.047
##	Pr(> t)		
## (Intercept)	< 2e-16	***	
## EngDispl	4.79e-16	***	
## NumCyl3	3.41e-07	***	
## NumCyl4	2.02e-08	***	
## NumCyl5	2.85e-05	***	
## NumCyl6	6.74e-05	***	
## NumCyl8	0.003212	**	
## NumCyl10	0.104342		
## NumCyl12	0.253614		
## NumCyl16	0.333656		
## TransmissionA4	0.000513	***	
## TransmissionA5	0.001115	**	
## TransmissionA6	0.009827	**	
## TransmissionA7	0.043374	*	
## TransmissionAM6	5.17e-05	***	
## TransmissionAM7	0.865169		
## TransmissionAV	0.035807	*	

```

## TransmissionAVS6                0.002807 **
## TransmissionM5                   0.001944 **
## TransmissionM6                   0.002044 **
## TransmissionS4                   4.49e-06 ***
## TransmissionS5                   0.000492 ***
## TransmissionS6                   0.010908 *
## TransmissionS7                   0.171715
## TransmissionS8                   0.166927
## AirAspirationMethodSupercharged  0.011113 *
## AirAspirationMethodTurbocharged  9.74e-05 ***
## NumGears4                        NA
## NumGears5                        NA
## NumGears6                        NA
## NumGears7                        0.001257 **
## NumGears8                        0.518403
## TransCreeperGear1               0.004423 **
## DriveDescFourWheelDrive         0.112532
## DriveDescParttimeFourWheelDrive 0.507654
## DriveDescTwoWheelDriveFront     < 2e-16 ***
## DriveDescTwoWheelDriveRear      0.007448 **
## ExhaustValvesPerCyl1            4.98e-12 ***
## ExhaustValvesPerCyl2            NA
## CarlineClassDesc2Seaters         0.008782 **
## CarlineClassDescCompactCars      0.000459 ***
## CarlineClassDescLargeCars        0.018235 *
## CarlineClassDescMidsizeCars      0.002111 **
## CarlineClassDescMinicompactCars  0.000260 ***
## CarlineClassDescSmallPickupTrucks2WD 0.137996
## CarlineClassDescSmallPickupTrucks4WD 0.504354
## CarlineClassDescSmallStationWagons 0.052206 .
## CarlineClassDescSpecialPurposeVehicleminivan2WD 0.109914
## CarlineClassDescSpecialPurposeVehicleSUV2WD 0.176714
## CarlineClassDescSpecialPurposeVehicleSUV4WD 0.668970
## CarlineClassDescStandardPickupTrucks2WD 0.193828
## CarlineClassDescStandardPickupTrucks4WD 0.162813
## CarlineClassDescSubcompactCars   0.001152 **
## CarlineClassDescVansCargoTypes    0.011149 *
## CarlineClassDescVansPassengerType 0.040873 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.162 on 1056 degrees of freedom
## Multiple R-squared:  0.8303, Adjusted R-squared:  0.8222
## F-statistic: 103.3 on 50 and 1056 DF, p-value: < 2.2e-16

```