FE590. Assignment #4.

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2017-12-12

Instructions

When you have completed the assignment, knit the document into a PDF file, and upload *both* the .pdf and .Rmd files to Canvas.

Note that you must have LaTeX installed in order to knit the equations below. If you do not have it installed, simply delete the questions below.

Question 1:

In this assignment, you will be required to find a set of data to run regression on. This data set should be financial in nature, and of a type that will work with the models we have discussed this semester (hint: we didn't look at time series) You may not use any of the data sets in the ISLR package that we have been looking at all semester. Your data set that you choose should have both qualitative and quantitative variables. (or has variables that you can transform)

Provide a description of the data below, where you obtained it, what the variable names are and what it is describing.

Answer 1:

The dataset is view of the interest rates across from the Federal Reserve of the United States. The information provides daily interest rate information for a variety of core interest rates, such as T-bills and the federal funds rate. For some rates, this dataset extends all the way back to 1954 but as we're looking at the dataset overall, some of those rates will not be used as it's an incomplete view across the data set. It was downloaded from the Federal Reserve (https://www.federalreserve.gov/releases/h15/) and the variables are as follows:

time_period - This is the date of the recorded data points federal_funds - Federal funds, often referred to as fed funds, are excess reserves that commercial banks and other financial institutions deposit at regional Federal Reserve banks; these funds can be lent, then, to other market participants with insufficient cash on hand to meet their lending and reserve needs. *financial and nonfinancial commercial paper - Commercial paper is an unsecured, short-term debt instrument issued by a corporation, typically for the financing of accounts receivable, inventories and meeting short-term liabilities.* prime_rate - The prime rate is the interest rate that commercial banks charge their most credit-worthy customers. Generally, a bank's best customers consist of large corporations. The prime interest rate, or prime lending rate, is largely determined by the federal funds rate, which is the overnight rate that banks use to lend to one another; the prime rate is also important for individual borrowers, as the prime rate directly affects the lending rates available for a mortgage, small business loan or personal loan. *discount_rate - The discount rate is the interest rate charged to commercial banks and other depository institutions for loans received from the Federal Reserve's discount window. The discount rate also refers to the interest rate used in discounted cash flow analysis to determine the present value of future cash flows.* treasury_bill - A Treasury bill (T-Bill) is a short-term debt obligation backed by the Treasury Dept. of the U.S. government with a maturity of less than one year, sold in denominations of $1,000 up to a maximum purchase of $5 million. T-bills have various maturities and are issued at a discount from par. *treasury_constant_maturity - Constant maturity is an adjustment for equivalent maturity, used by the Federal Reserve Board to compute an index based on the average yield of various Treasury securities* *maturing at different periods. Constant maturity yields on Treasuries are obtained by the U.S. Treasury on a daily basis through interpolation of the Treasury yield curve, which in turn is based on closing bid-yields of actively-traded Treasury securities.* inflation_indexed_treasury_constant_maturity - An adjustment for equivalent maturity, used by the Federal Reserve Board to compute an index based on the average inflation. *inflation_indexed_long_term_average - This is the average value of the inflation over time.

Question 2:

Pick a quantitative variable and fit at least four different models in order to predict that variable using the other predictors. Determine which of the models is the best fit. You will need to provide strong reason why the particular model you chose is the best one. You will need to confirm the model you have selected provides the best fit and that you have obtained the best version of that particular model (i.e. subset selection or validation for example). You need to convince the grader that you have chosen the best model.

```r
library(boot)
library(leaps)
```

```
## Warning: package 'leaps' was built under R version 3.4.2
```

```r
library(glmnet)
```

```
## Warning: package 'glmnet' was built under R version 3.4.2
## Loading required package: Matrix
## Loading required package: foreach
## Warning: package 'foreach' was built under R version 3.4.2
## Loaded glmnet 2.0-13
```

```r
library(caTools)
library(pls)
```

```
## Warning: package 'pls' was built under R version 3.4.2
##
## Attaching package: 'pls'
## The following object is masked from 'package:stats':
##
##     loadings
```

```r
library(tree)
```

```
## Warning: package 'tree' was built under R version 3.4.2
```

```r
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 3.4.2
## randomForest 4.6-12
## Type rfNews() to see new features/changes/bug fixes.
```

```r
library(gbm)
```

```
## Warning: package 'gbm' was built under R version 3.4.2
## Loading required package: survival
```

```
##
## Attaching package: 'survival'
## The following object is masked from 'package:boot':
##
##     aml
## Loading required package: lattice
##
## Attaching package: 'lattice'
## The following object is masked from 'package:boot':
##
##     melanoma
## Loading required package: splines
## Loading required package: parallel
## Loaded gbm 2.1.3
```

```r
library(gam)
```

```
## Warning: package 'gam' was built under R version 3.4.2
## Loaded gam 1.14-4
```

```r
library(splines)
library(MASS)
library(class)
```

```r
setwd("C:/Users/gang.ping.m.zhu/OneDrive - Accenture/Stevens/FE 590/A4")
int.rate.df <- read.csv("data.csv", header=TRUE, na.strings=-9999)
names(int.rate.df)
```

```
##  [1] "time_period"
##  [2] "federal_funds"
##  [3] "month_1_nonfinancial_commercial_paper"
##  [4] "month_2_nonfinancial_commercial_paper"
##  [5] "month_3_nonfinancial_commercial_paper"
##  [6] "month_1_financial_commercial_paper"
##  [7] "month_2_financial_commercial_paper"
##  [8] "month_3_financial_commercial_paper"
##  [9] "prime_rate"
## [10] "discount_rate"
## [11] "week_4_treasury_bill"
## [12] "month_3_treasury_bill"
## [13] "month_6_treasury_bill"
## [14] "year_1_treasury_bill"
## [15] "month_1_treasury_constant_maturity"
## [16] "month_3_treasury_constant_maturity"
## [17] "month_6_treasury_constant_maturity"
## [18] "year_1_treasury_constant_maturity"
## [19] "year_2_treasury_constant_maturity"
## [20] "year_3_treasury_constant_maturity"
## [21] "year_5_treasury_constant_maturity"
## [22] "year_7_treasury_constant_maturity"
## [23] "year_10_treasury_constant_maturity"
## [24] "year_20_treasury_constant_maturity"
```

```
## [25] "year_30_treasury_constant_maturity"
## [26] "year_5_inflation_indexed_treasury_constant_maturity"
## [27] "year_7_inflation_indexed_treasury_constant_maturity"
## [28] "year_10_inflation_indexed_treasury_constant_maturity"
## [29] "year_20_inflation_indexed_treasury_constant_maturity"
## [30] "year_30_inflation_indexed_treasury_constant_maturity"
## [31] "inflation_indexed_long_term_average"
```

```
int.rate.clean.df <- int.rate.df[, c("month_1_nonfinancial_commercial_paper",
                                     "month_2_nonfinancial_commercial_paper",
                                     "month_3_nonfinancial_commercial_paper",
                                     "month_1_financial_commercial_paper",
                                     "month_2_financial_commercial_paper",
                                     "month_3_financial_commercial_paper",
                                     "prime_rate",
                                     "week_4_treasury_bill",
                                     "month_3_treasury_bill",
                                     "month_6_treasury_bill",
                                     "year_1_treasury_bill",
                                     "month_1_treasury_constant_maturity" ,
                                     "month_3_treasury_constant_maturity",
                                     "month_6_treasury_constant_maturity" ,
                                     "year_1_treasury_constant_maturity",
                                     "year_2_treasury_constant_maturity",
                                     "year_3_treasury_constant_maturity",
                                     "year_5_treasury_constant_maturity",
                                     "year_7_treasury_constant_maturity",
                                     "year_10_treasury_constant_maturity",
                                     "year_20_treasury_constant_maturity",
                                     "year_30_treasury_constant_maturity",
                                     "year_5_inflation_indexed_treasury_constant_maturity",
                                     "year_7_inflation_indexed_treasury_constant_maturity",
                                     "year_10_inflation_indexed_treasury_constant_maturity",
                                     "year_20_inflation_indexed_treasury_constant_maturity",
                                     "year_30_inflation_indexed_treasury_constant_maturity",
                                     "inflation_indexed_long_term_average")]
int.rate.clean.df <- na.omit(int.rate.clean.df)
head(int.rate.clean.df)
```

```
##   month_1_nonfinancial_commercial_paper
## 1                                  1.10
## 2                                  1.12
## 3                                  1.12
## 6                                  1.12
## 7                                  1.09
## 8                                  1.10
##   month_2_nonfinancial_commercial_paper
## 1                                  1.14
## 2                                  1.15
## 3                                  1.15
## 6                                  1.14
## 7                                  1.14
## 8                                  1.13
##   month_3_nonfinancial_commercial_paper month_1_financial_commercial_paper
## 1                                  1.19                               1.19
```

```
## 2                                1.18                                  1.10
## 3                                1.19                                  1.14
## 6                                1.18                                  1.20
## 7                                1.18                                  1.21
## 8                                1.15                                  1.13
##   month_2_financial_commercial_paper month_3_financial_commercial_paper
## 1                               1.22                               1.26
## 2                               1.15                               1.21
## 3                               1.18                               1.22
## 6                               1.24                               1.27
## 7                               1.24                               1.28
## 8                               1.17                               1.22
##   prime_rate week_4_treasury_bill month_3_treasury_bill
## 1       4.25                 0.99                  1.04
## 2       4.25                 0.98                  1.04
## 3       4.25                 0.97                  1.01
## 6       4.25                 0.98                  1.06
## 7       4.25                 0.98                  1.06
## 8       4.25                 1.00                  1.06
##   month_6_treasury_bill year_1_treasury_bill
## 1                  1.13                 1.18
## 2                  1.14                 1.21
## 3                  1.12                 1.19
## 6                  1.12                 1.20
## 7                  1.11                 1.19
## 8                  1.13                 1.21
##   month_1_treasury_constant_maturity month_3_treasury_constant_maturity
## 1                               1.01                               1.06
## 2                               1.00                               1.06
## 3                               0.99                               1.02
## 6                               1.00                               1.08
## 7                               1.00                               1.08
## 8                               1.02                               1.08
##   month_6_treasury_constant_maturity year_1_treasury_constant_maturity
## 1                               1.15                              1.21
## 2                               1.16                              1.24
## 3                               1.14                              1.22
## 6                               1.14                              1.23
## 7                               1.13                              1.22
## 8                               1.15                              1.24
##   year_2_treasury_constant_maturity year_3_treasury_constant_maturity
## 1                              1.33                              1.50
## 2                              1.36                              1.53
## 3                              1.36                              1.52
## 6                              1.36                              1.51
## 7                              1.34                              1.49
## 8                              1.36                              1.52
##   year_5_treasury_constant_maturity year_7_treasury_constant_maturity
## 1                              1.81                              2.06
## 2                              1.84                              2.10
## 3                              1.81                              2.07
## 6                              1.82                              2.08
## 7                              1.79                              2.05
## 8                              1.82                              2.08
```

```
##   year_10_treasury_constant_maturity year_20_treasury_constant_maturity
## 1                               2.24                               2.59
## 2                               2.29                               2.63
## 3                               2.26                               2.60
## 6                               2.27                               2.61
## 7                               2.24                               2.56
## 8                               2.27                               2.60
##   year_30_treasury_constant_maturity
## 1                               2.82
## 2                               2.86
## 3                               2.84
## 6                               2.84
## 7                               2.81
## 8                               2.85
##   year_5_inflation_indexed_treasury_constant_maturity
## 1                                                0.11
## 2                                                0.15
## 3                                                0.16
## 6                                                0.17
## 7                                                0.17
## 8                                                0.19
##   year_7_inflation_indexed_treasury_constant_maturity
## 1                                                0.31
## 2                                                0.37
## 3                                                0.37
## 6                                                0.38
## 7                                                0.38
## 8                                                0.39
##   year_10_inflation_indexed_treasury_constant_maturity
## 1                                                 0.42
## 2                                                 0.46
## 3                                                 0.46
## 6                                                 0.47
## 7                                                 0.46
## 8                                                 0.48
##   year_20_inflation_indexed_treasury_constant_maturity
## 1                                                 0.73
## 2                                                 0.77
## 3                                                 0.76
## 6                                                 0.78
## 7                                                 0.76
## 8                                                 0.78
##   year_30_inflation_indexed_treasury_constant_maturity
## 1                                                 0.92
## 2                                                 0.96
## 3                                                 0.96
## 6                                                 0.97
## 7                                                 0.96
## 8                                                 0.98
##   inflation_indexed_long_term_average
## 1                                0.77
## 2                                0.81
## 3                                0.81
## 6                                0.82
```

```
## 7                                0.81
## 8                                0.83
```

```
#Running a model variable selection in order to determine which of the explanatory variables to use. I'
regfit.full <- regsubsets(prime_rate~.,data=int.rate.clean.df, nvmax = 15, really.big = T)
t(summary(regfit.full)$which)
```

```
##                                                          1     2     3
## (Intercept)                                           TRUE  TRUE  TRUE
## month_1_nonfinancial_commercial_paper                FALSE FALSE FALSE
## month_2_nonfinancial_commercial_paper                FALSE FALSE FALSE
## month_3_nonfinancial_commercial_paper                FALSE FALSE FALSE
## month_1_financial_commercial_paper                    TRUE  TRUE  TRUE
## month_2_financial_commercial_paper                   FALSE FALSE FALSE
## month_3_financial_commercial_paper                   FALSE FALSE FALSE
## week_4_treasury_bill                                 FALSE FALSE FALSE
## month_3_treasury_bill                                FALSE FALSE FALSE
## month_6_treasury_bill                                FALSE FALSE FALSE
## year_1_treasury_bill                                 FALSE FALSE FALSE
## month_1_treasury_constant_maturity                   FALSE FALSE  TRUE
## month_3_treasury_constant_maturity                   FALSE FALSE FALSE
## month_6_treasury_constant_maturity                   FALSE FALSE FALSE
## year_1_treasury_constant_maturity                    FALSE FALSE FALSE
## year_2_treasury_constant_maturity                    FALSE FALSE FALSE
## year_3_treasury_constant_maturity                    FALSE FALSE FALSE
## year_5_treasury_constant_maturity                    FALSE FALSE FALSE
## year_7_treasury_constant_maturity                    FALSE FALSE FALSE
## year_10_treasury_constant_maturity                   FALSE FALSE FALSE
## year_20_treasury_constant_maturity                   FALSE FALSE FALSE
## year_30_treasury_constant_maturity                   FALSE FALSE  TRUE
## year_5_inflation_indexed_treasury_constant_maturity  FALSE FALSE FALSE
## year_7_inflation_indexed_treasury_constant_maturity  FALSE FALSE FALSE
## year_10_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_20_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_30_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## inflation_indexed_long_term_average                  FALSE  TRUE FALSE
##                                                          4     5     6
## (Intercept)                                           TRUE  TRUE  TRUE
## month_1_nonfinancial_commercial_paper                FALSE FALSE  TRUE
## month_2_nonfinancial_commercial_paper                FALSE FALSE FALSE
## month_3_nonfinancial_commercial_paper                FALSE FALSE FALSE
## month_1_financial_commercial_paper                    TRUE  TRUE  TRUE
## month_2_financial_commercial_paper                   FALSE FALSE FALSE
## month_3_financial_commercial_paper                   FALSE FALSE FALSE
## week_4_treasury_bill                                 FALSE FALSE FALSE
## month_3_treasury_bill                                FALSE FALSE FALSE
## month_6_treasury_bill                                FALSE FALSE FALSE
## year_1_treasury_bill                                 FALSE FALSE FALSE
## month_1_treasury_constant_maturity                   FALSE  TRUE  TRUE
## month_3_treasury_constant_maturity                   FALSE FALSE FALSE
## month_6_treasury_constant_maturity                   FALSE FALSE FALSE
## year_1_treasury_constant_maturity                    FALSE FALSE FALSE
## year_2_treasury_constant_maturity                    FALSE FALSE FALSE
## year_3_treasury_constant_maturity                    FALSE FALSE  TRUE
## year_5_treasury_constant_maturity                    FALSE FALSE  TRUE
```

```
## year_7_treasury_constant_maturity                      FALSE FALSE  TRUE
## year_10_treasury_constant_maturity                     FALSE FALSE FALSE
## year_20_treasury_constant_maturity                     FALSE FALSE FALSE
## year_30_treasury_constant_maturity                      TRUE  TRUE FALSE
## year_5_inflation_indexed_treasury_constant_maturity     TRUE  TRUE FALSE
## year_7_inflation_indexed_treasury_constant_maturity     TRUE  TRUE FALSE
## year_10_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_20_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_30_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## inflation_indexed_long_term_average                    FALSE FALSE FALSE
##                                                            7     8     9
## (Intercept)                                             TRUE  TRUE  TRUE
## month_1_nonfinancial_commercial_paper                   TRUE  TRUE  TRUE
## month_2_nonfinancial_commercial_paper                  FALSE FALSE FALSE
## month_3_nonfinancial_commercial_paper                  FALSE FALSE FALSE
## month_1_financial_commercial_paper                      TRUE  TRUE  TRUE
## month_2_financial_commercial_paper                     FALSE FALSE FALSE
## month_3_financial_commercial_paper                     FALSE FALSE FALSE
## week_4_treasury_bill                                   FALSE FALSE FALSE
## month_3_treasury_bill                                  FALSE FALSE FALSE
## month_6_treasury_bill                                  FALSE FALSE FALSE
## year_1_treasury_bill                                   FALSE FALSE FALSE
## month_1_treasury_constant_maturity                     FALSE  TRUE  TRUE
## month_3_treasury_constant_maturity                     FALSE FALSE FALSE
## month_6_treasury_constant_maturity                     FALSE FALSE FALSE
## year_1_treasury_constant_maturity                      FALSE FALSE FALSE
## year_2_treasury_constant_maturity                      FALSE FALSE  TRUE
## year_3_treasury_constant_maturity                       TRUE  TRUE  TRUE
## year_5_treasury_constant_maturity                       TRUE  TRUE  TRUE
## year_7_treasury_constant_maturity                      FALSE FALSE FALSE
## year_10_treasury_constant_maturity                     FALSE FALSE FALSE
## year_20_treasury_constant_maturity                     FALSE FALSE FALSE
## year_30_treasury_constant_maturity                      TRUE  TRUE  TRUE
## year_5_inflation_indexed_treasury_constant_maturity    FALSE FALSE FALSE
## year_7_inflation_indexed_treasury_constant_maturity    FALSE FALSE FALSE
## year_10_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_20_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_30_inflation_indexed_treasury_constant_maturity  TRUE  TRUE  TRUE
## inflation_indexed_long_term_average                     TRUE  TRUE  TRUE
##                                                           10    11    12
## (Intercept)                                             TRUE  TRUE  TRUE
## month_1_nonfinancial_commercial_paper                   TRUE  TRUE  TRUE
## month_2_nonfinancial_commercial_paper                  FALSE FALSE FALSE
## month_3_nonfinancial_commercial_paper                  FALSE FALSE FALSE
## month_1_financial_commercial_paper                      TRUE  TRUE  TRUE
## month_2_financial_commercial_paper                     FALSE FALSE FALSE
## month_3_financial_commercial_paper                     FALSE FALSE FALSE
## week_4_treasury_bill                                   FALSE FALSE FALSE
## month_3_treasury_bill                                  FALSE FALSE FALSE
## month_6_treasury_bill                                  FALSE FALSE FALSE
## year_1_treasury_bill                                   FALSE FALSE FALSE
## month_1_treasury_constant_maturity                      TRUE  TRUE  TRUE
## month_3_treasury_constant_maturity                     FALSE FALSE FALSE
## month_6_treasury_constant_maturity                     FALSE FALSE FALSE
```

```
## year_1_treasury_constant_maturity                         FALSE FALSE FALSE
## year_2_treasury_constant_maturity                         FALSE  TRUE  TRUE
## year_3_treasury_constant_maturity                          TRUE  TRUE  TRUE
## year_5_treasury_constant_maturity                          TRUE  TRUE  TRUE
## year_7_treasury_constant_maturity                         FALSE FALSE  TRUE
## year_10_treasury_constant_maturity                        FALSE FALSE FALSE
## year_20_treasury_constant_maturity                        FALSE FALSE FALSE
## year_30_treasury_constant_maturity                         TRUE  TRUE  TRUE
## year_5_inflation_indexed_treasury_constant_maturity        TRUE  TRUE  TRUE
## year_7_inflation_indexed_treasury_constant_maturity        TRUE  TRUE  TRUE
## year_10_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_20_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_30_inflation_indexed_treasury_constant_maturity  TRUE  TRUE  TRUE
## inflation_indexed_long_term_average                        TRUE  TRUE  TRUE
##                                                              13    14    15
## (Intercept)                                                TRUE  TRUE  TRUE
## month_1_nonfinancial_commercial_paper                      TRUE  TRUE  TRUE
## month_2_nonfinancial_commercial_paper                     FALSE FALSE FALSE
## month_3_nonfinancial_commercial_paper                     FALSE FALSE FALSE
## month_1_financial_commercial_paper                         TRUE  TRUE  TRUE
## month_2_financial_commercial_paper                        FALSE FALSE FALSE
## month_3_financial_commercial_paper                        FALSE  TRUE  TRUE
## week_4_treasury_bill                                      FALSE FALSE  TRUE
## month_3_treasury_bill                                     FALSE FALSE FALSE
## month_6_treasury_bill                                      TRUE  TRUE  TRUE
## year_1_treasury_bill                                      FALSE FALSE FALSE
## month_1_treasury_constant_maturity                         TRUE  TRUE  TRUE
## month_3_treasury_constant_maturity                        FALSE FALSE FALSE
## month_6_treasury_constant_maturity                         TRUE  TRUE  TRUE
## year_1_treasury_constant_maturity                         FALSE FALSE FALSE
## year_2_treasury_constant_maturity                          TRUE  TRUE  TRUE
## year_3_treasury_constant_maturity                          TRUE  TRUE  TRUE
## year_5_treasury_constant_maturity                          TRUE  TRUE  TRUE
## year_7_treasury_constant_maturity                         FALSE FALSE FALSE
## year_10_treasury_constant_maturity                        FALSE FALSE FALSE
## year_20_treasury_constant_maturity                        FALSE FALSE FALSE
## year_30_treasury_constant_maturity                         TRUE  TRUE  TRUE
## year_5_inflation_indexed_treasury_constant_maturity        TRUE  TRUE  TRUE
## year_7_inflation_indexed_treasury_constant_maturity        TRUE  TRUE  TRUE
## year_10_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_20_inflation_indexed_treasury_constant_maturity FALSE FALSE FALSE
## year_30_inflation_indexed_treasury_constant_maturity  TRUE  TRUE  TRUE
## inflation_indexed_long_term_average                        TRUE  TRUE  TRUE
```

```r
reg.summary <- summary(regfit.full)
reg.summary
```

```
## Subset selection object
## Call: regsubsets.formula(prime_rate ~ ., data = int.rate.clean.df,
##     nvmax = 15, really.big = T)
## 27 Variables  (and intercept)
##                                                      Forced in Forced out
## month_1_nonfinancial_commercial_paper                    FALSE      FALSE
## month_2_nonfinancial_commercial_paper                    FALSE      FALSE
## month_3_nonfinancial_commercial_paper                    FALSE      FALSE
```

```
## month_1_financial_commercial_paper                        FALSE      FALSE
## month_2_financial_commercial_paper                        FALSE      FALSE
## month_3_financial_commercial_paper                        FALSE      FALSE
## week_4_treasury_bill                                      FALSE      FALSE
## month_3_treasury_bill                                     FALSE      FALSE
## month_6_treasury_bill                                     FALSE      FALSE
## year_1_treasury_bill                                      FALSE      FALSE
## month_1_treasury_constant_maturity                        FALSE      FALSE
## month_3_treasury_constant_maturity                        FALSE      FALSE
## month_6_treasury_constant_maturity                        FALSE      FALSE
## year_1_treasury_constant_maturity                         FALSE      FALSE
## year_2_treasury_constant_maturity                         FALSE      FALSE
## year_3_treasury_constant_maturity                         FALSE      FALSE
## year_5_treasury_constant_maturity                         FALSE      FALSE
## year_7_treasury_constant_maturity                         FALSE      FALSE
## year_10_treasury_constant_maturity                        FALSE      FALSE
## year_20_treasury_constant_maturity                        FALSE      FALSE
## year_30_treasury_constant_maturity                        FALSE      FALSE
## year_5_inflation_indexed_treasury_constant_maturity       FALSE      FALSE
## year_7_inflation_indexed_treasury_constant_maturity       FALSE      FALSE
## year_10_inflation_indexed_treasury_constant_maturity      FALSE      FALSE
## year_20_inflation_indexed_treasury_constant_maturity      FALSE      FALSE
## year_30_inflation_indexed_treasury_constant_maturity      FALSE      FALSE
## inflation_indexed_long_term_average                       FALSE      FALSE
## 1 subsets of each size up to 15
## Selection Algorithm: exhaustive
##           month_1_nonfinancial_commercial_paper
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  "*"
## 7  ( 1 )  "*"
## 8  ( 1 )  "*"
## 9  ( 1 )  "*"
## 10  ( 1 ) "*"
## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           month_2_nonfinancial_commercial_paper
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
## 7  ( 1 )  " "
## 8  ( 1 )  " "
## 9  ( 1 )  " "
## 10  ( 1 ) " "
## 11  ( 1 ) " "
```

```
## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           month_3_nonfinancial_commercial_paper
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
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## 11  ( 1 ) " "
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## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           month_1_financial_commercial_paper
## 1  ( 1 )  "*"
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## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           month_2_financial_commercial_paper
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
## 7  ( 1 )  " "
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## 10  ( 1 ) " "
## 11  ( 1 ) " "
## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           month_3_financial_commercial_paper week_4_treasury_bill
## 1  ( 1 )  " "                                " "
```

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## 2  ( 1 )  " "                                " "
## 3  ( 1 )  " "                                " "
## 4  ( 1 )  " "                                " "
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## 6  ( 1 )  " "                                " "
## 7  ( 1 )  " "                                " "
## 8  ( 1 )  " "                                " "
## 9  ( 1 )  " "                                " "
## 10  ( 1 ) " "                                " "
## 11  ( 1 ) " "                                " "
## 12  ( 1 ) " "                                " "
## 13  ( 1 ) " "                                " "
## 14  ( 1 ) "*"                                " "
## 15  ( 1 ) "*"                                "*"
##           month_3_treasury_bill month_6_treasury_bill year_1_treasury_bill
## 1  ( 1 )  " "                   " "                   " "
## 2  ( 1 )  " "                   " "                   " "
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## 4  ( 1 )  " "                   " "                   " "
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## 6  ( 1 )  " "                   " "                   " "
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## 11  ( 1 ) " "                   " "                   " "
## 12  ( 1 ) " "                   " "                   " "
## 13  ( 1 ) " "                   "*"                   " "
## 14  ( 1 ) " "                   "*"                   " "
## 15  ( 1 ) " "                   "*"                   " "
##           month_1_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  "*"
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## 15  ( 1 ) "*"
##           month_3_treasury_constant_maturity
## 1  ( 1 )  " "
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## 8  ( 1 )  " "
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## 11  ( 1 ) " "
## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           month_6_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
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## 10  ( 1 ) " "
## 11  ( 1 ) " "
## 12  ( 1 ) " "
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_1_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
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## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           year_2_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
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## 9  ( 1 )  "*"
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## 13  ( 1 ) "*"
```

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## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_3_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
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## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_5_treasury_constant_maturity
## 1  ( 1 )  " "
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## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_7_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  "*"
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## 10  ( 1 ) " "
## 11  ( 1 ) " "
## 12  ( 1 ) "*"
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           year_10_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
```

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## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
## 7  ( 1 )  " "
## 8  ( 1 )  " "
## 9  ( 1 )  " "
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## 11  ( 1 ) " "
## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           year_20_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
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## 11  ( 1 ) " "
## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           year_30_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  "*"
## 4  ( 1 )  "*"
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## 6  ( 1 )  " "
## 7  ( 1 )  "*"
## 8  ( 1 )  "*"
## 9  ( 1 )  "*"
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## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_5_inflation_indexed_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  "*"
## 5  ( 1 )  "*"
## 6  ( 1 )  " "
## 7  ( 1 )  " "
## 8  ( 1 )  " "
## 9  ( 1 )  " "
```

```
## 10  ( 1 ) "*"
## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_7_inflation_indexed_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  "*"
## 5  ( 1 )  "*"
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## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           year_10_inflation_indexed_treasury_constant_maturity
## 1  ( 1 )  " "
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## 5  ( 1 )  " "
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## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
##           year_20_inflation_indexed_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
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## 12  ( 1 ) " "
## 13  ( 1 ) " "
## 14  ( 1 ) " "
## 15  ( 1 ) " "
```

```
##           year_30_inflation_indexed_treasury_constant_maturity
## 1  ( 1 )  " "
## 2  ( 1 )  " "
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
## 7  ( 1 )  "*"
## 8  ( 1 )  "*"
## 9  ( 1 )  "*"
## 10  ( 1 ) "*"
## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
##           inflation_indexed_long_term_average
## 1  ( 1 )  " "
## 2  ( 1 )  "*"
## 3  ( 1 )  " "
## 4  ( 1 )  " "
## 5  ( 1 )  " "
## 6  ( 1 )  " "
## 7  ( 1 )  "*"
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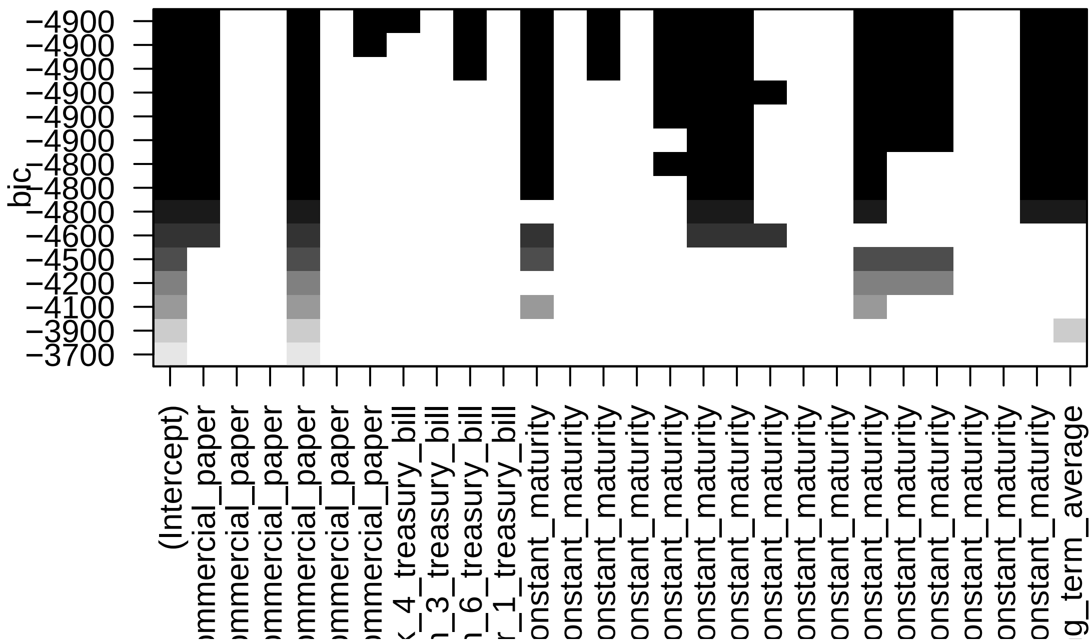
## 9  ( 1 )  "*"
## 10  ( 1 ) "*"
## 11  ( 1 ) "*"
## 12  ( 1 ) "*"
## 13  ( 1 ) "*"
## 14  ( 1 ) "*"
## 15  ( 1 ) "*"
```

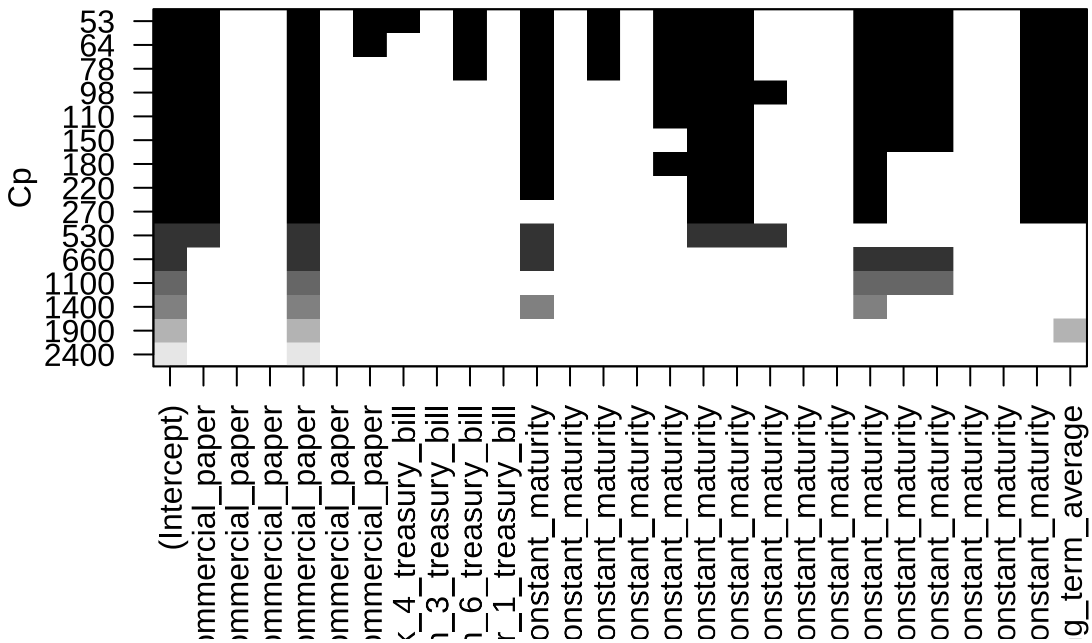
```
reg.summary$rsq
```

```
##  [1] 0.9446447 0.9525775 0.9597990 0.9645022 0.9710287 0.9730322 0.9769872
##  [8] 0.9777627 0.9783930 0.9789155 0.9794389 0.9797032 0.9800374 0.9802671
## [15] 0.9804630
```

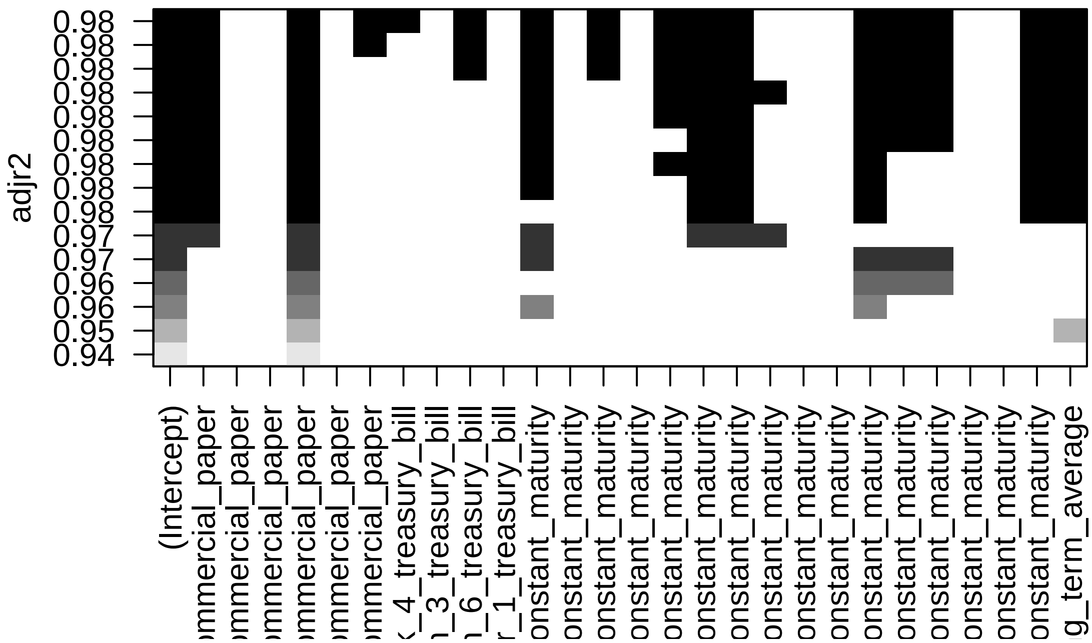
```
plot(regfit.full)
```



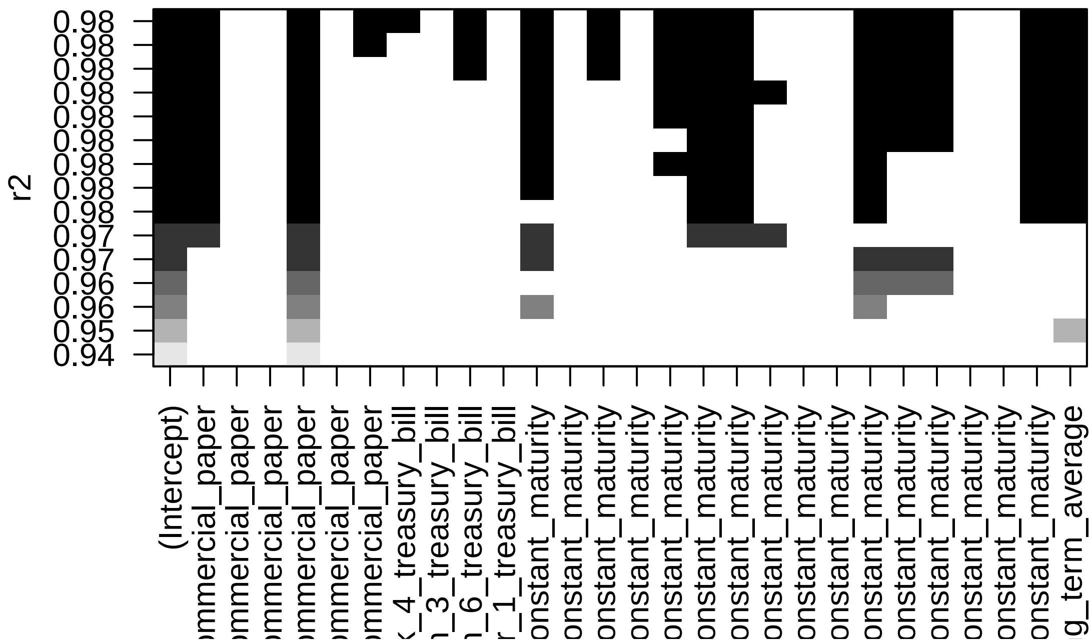

```r
plot(regfit.full, scale="Cp")
```




```r
plot(regfit.full, scale="adjr2")
```




```r
plot(regfit.full, scale="r2")
```




```r
#Model 1 for Prime Rate
set.seed(33)
glm.fit1 <- glm(prime_rate~
                  month_2_nonfinancial_commercial_paper+
                  month_1_financial_commercial_paper+
                  month_6_treasury_bill+
                  year_3_treasury_constant_maturity+
                  year_5_treasury_constant_maturity+
                  year_7_treasury_constant_maturity+
                  year_10_treasury_constant_maturity+
                  year_20_treasury_constant_maturity+
                  year_30_treasury_constant_maturity+
                  year_5_inflation_indexed_treasury_constant_maturity+
                  year_7_inflation_indexed_treasury_constant_maturity+
                  year_10_inflation_indexed_treasury_constant_maturity+
                  year_20_inflation_indexed_treasury_constant_maturity+
                  inflation_indexed_long_term_average, data=int.rate.clean.df)
cv.err1 <- cv.glm(int.rate.clean.df, glm.fit1)
cv.err1$delta
```

```
## [1] 0.001241602 0.001241588
```

```r
# 0.001241602 0.001241588
```

```r
#Model 2 for Prime Rate
glm.fit2 <- glm(prime_rate~
                  month_1_nonfinancial_commercial_paper+
```

```r
                  year_5_treasury_constant_maturity+
                  year_7_treasury_constant_maturity+
                  year_10_treasury_constant_maturity+
                  year_20_treasury_constant_maturity+
                  year_30_treasury_constant_maturity+
                  year_5_inflation_indexed_treasury_constant_maturity+
                  year_7_inflation_indexed_treasury_constant_maturity+
                  year_10_inflation_indexed_treasury_constant_maturity+
                  year_20_inflation_indexed_treasury_constant_maturity+
                  inflation_indexed_long_term_average, data=int.rate.clean.df)
cv.err2 <- cv.glm(int.rate.clean.df, glm.fit2)
cv.err2$delta
```

```
## [1] 0.001690060 0.001690047
```

```r
# 0.001690060 0.001690047
```

```r
# Model 3 for Prime Rate
glm.fit3 <- glm(prime_rate~
                  month_2_nonfinancial_commercial_paper+
                  month_1_financial_commercial_paper+
                  month_6_treasury_bill+
                  year_3_treasury_constant_maturity+
                  year_5_treasury_constant_maturity+
                  year_7_treasury_constant_maturity+
                  year_10_treasury_constant_maturity+
                  year_20_treasury_constant_maturity+
                  year_30_treasury_constant_maturity+
                  year_5_inflation_indexed_treasury_constant_maturity+
                  year_7_inflation_indexed_treasury_constant_maturity+
                  year_10_inflation_indexed_treasury_constant_maturity+
                  year_20_inflation_indexed_treasury_constant_maturity+
                  inflation_indexed_long_term_average+
                  poly(inflation_indexed_long_term_average, 2),data=int.rate.clean.df)
cv.err3 <- cv.glm(int.rate.clean.df, glm.fit3)
```

```
## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
## ifelse(type == : prediction from a rank-deficient fit may be misleading

## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
## ifelse(type == : prediction from a rank-deficient fit may be misleading

## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
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## ifelse(type == : prediction from a rank-deficient fit may be misleading

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## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
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## ifelse(type == : prediction from a rank-deficient fit may be misleading

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## Warning in predict.lm(object, newdata, se.fit, scale = 1, type =
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cv.err3$delta
```

```
## [1] 0.001186794 0.001186780
```

```
#0.001186794 0.001186780
```

```
# Model 4 for Prime Rate
glm.fit4<- glm(prime_rate~
                 month_2_nonfinancial_commercial_paper+
                 month_1_financial_commercial_paper+
                 month_6_treasury_bill+
                 year_3_treasury_constant_maturity+
                 year_5_treasury_constant_maturity+
                 year_7_treasury_constant_maturity+
                 year_10_treasury_constant_maturity+
                 year_20_treasury_constant_maturity+
                 year_30_treasury_constant_maturity+
                 year_5_inflation_indexed_treasury_constant_maturity+
                 year_7_inflation_indexed_treasury_constant_maturity+
                 year_10_inflation_indexed_treasury_constant_maturity+
                 year_20_inflation_indexed_treasury_constant_maturity+
```

```r
                 inflation_indexed_long_term_average+
                 poly(inflation_indexed_long_term_average, 2)+
                 poly(year_20_inflation_indexed_treasury_constant_maturity, 2),data=int.rate.clean.df)
cv.err4 <- cv.glm(int.rate.clean.df, glm.fit4)
```

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```

```
cv.err4$delta
```

```
## [1] 0.001153627 0.001153613
```

```
#0.001153627 0.001153613
```

```
anova(glm.fit1,glm.fit2,glm.fit3,glm.fit4)
```

```
## Analysis of Deviance Table
##
## Model 1: prime_rate ~ month_2_nonfinancial_commercial_paper + month_1_financial_commercial_paper +
##     month_6_treasury_bill + year_3_treasury_constant_maturity +
##     year_5_treasury_constant_maturity + year_7_treasury_constant_maturity +
##     year_10_treasury_constant_maturity + year_20_treasury_constant_maturity +
##     year_30_treasury_constant_maturity + year_5_inflation_indexed_treasury_constant_maturity +
##     year_7_inflation_indexed_treasury_constant_maturity + year_10_inflation_indexed_treasury_constant
##     year_20_inflation_indexed_treasury_constant_maturity + inflation_indexed_long_term_average
## Model 2: prime_rate ~ month_1_nonfinancial_commercial_paper + year_5_treasury_constant_maturity +
##     year_7_treasury_constant_maturity + year_10_treasury_constant_maturity +
##     year_20_treasury_constant_maturity + year_30_treasury_constant_maturity +
##     year_5_inflation_indexed_treasury_constant_maturity + year_7_inflation_indexed_treasury_constant_
##     year_10_inflation_indexed_treasury_constant_maturity + year_20_inflation_indexed_treasury_constan
##     inflation_indexed_long_term_average
## Model 3: prime_rate ~ month_2_nonfinancial_commercial_paper + month_1_financial_commercial_paper +
##     month_6_treasury_bill + year_3_treasury_constant_maturity +
##     year_5_treasury_constant_maturity + year_7_treasury_constant_maturity +
##     year_10_treasury_constant_maturity + year_20_treasury_constant_maturity +
##     year_30_treasury_constant_maturity + year_5_inflation_indexed_treasury_constant_maturity +
##     year_7_inflation_indexed_treasury_constant_maturity + year_10_inflation_indexed_treasury_constant
##     year_20_inflation_indexed_treasury_constant_maturity + inflation_indexed_long_term_average +
##     poly(inflation_indexed_long_term_average, 2)
## Model 4: prime_rate ~ month_2_nonfinancial_commercial_paper + month_1_financial_commercial_paper +
##     month_6_treasury_bill + year_3_treasury_constant_maturity +
##     year_5_treasury_constant_maturity + year_7_treasury_constant_maturity +
##     year_10_treasury_constant_maturity + year_20_treasury_constant_maturity +
##     year_30_treasury_constant_maturity + year_5_inflation_indexed_treasury_constant_maturity +
##     year_7_inflation_indexed_treasury_constant_maturity + year_10_inflation_indexed_treasury_constant
##     year_20_inflation_indexed_treasury_constant_maturity + inflation_indexed_long_term_average +
##     poly(inflation_indexed_long_term_average, 2) + poly(year_20_inflation_indexed_treasury_constant_
##     2)
##   Resid. Df Resid. Dev Df Deviance
## 1      1263     1.5434
## 2      1266     2.1166 -3 -0.57320
## 3      1262     1.4712  4  0.64547
## 4      1261     1.4274  1  0.04378
```

Based on the computed LOOCV errors, model 4 is the best.

Question 3:

Do the same approach as in question 2, but this time for a qualitative variable.

```r
# Transforming the information into a quanitive variable
new.col.transform <- data.frame(int.rate.clean.df$inflation_indexed_long_term_average)
new.col.transform <- data.frame(new.col.transform[-1,])
new.col.transform <- rbind(new.col.transform, c(0))
int.rate.clean.df$inflation_indexed_long_term_average_previous <- new.col.transform
int.rate.clean.df$direction <- ifelse(int.rate.clean.df$inflation_indexed_long_term_average>=int.rate.cl
# int.rate.clean.df$inflation_indexed_long_term_average_previous <- NULL
```

```r
# Dividing into a training set and validation set
n = 1:floor(nrow(int.rate.clean.df)/2)
TrainingSet = int.rate.clean.df[n, ]
ValidationSet = int.rate.clean.df[ - n, ]
dim(TrainingSet)
```

```
## [1] 639  30
```

```r
names(TrainingSet)
```

```
##  [1] "month_1_nonfinancial_commercial_paper"
##  [2] "month_2_nonfinancial_commercial_paper"
##  [3] "month_3_nonfinancial_commercial_paper"
##  [4] "month_1_financial_commercial_paper"
##  [5] "month_2_financial_commercial_paper"
##  [6] "month_3_financial_commercial_paper"
##  [7] "prime_rate"
##  [8] "week_4_treasury_bill"
##  [9] "month_3_treasury_bill"
## [10] "month_6_treasury_bill"
## [11] "year_1_treasury_bill"
## [12] "month_1_treasury_constant_maturity"
## [13] "month_3_treasury_constant_maturity"
## [14] "month_6_treasury_constant_maturity"
## [15] "year_1_treasury_constant_maturity"
## [16] "year_2_treasury_constant_maturity"
## [17] "year_3_treasury_constant_maturity"
## [18] "year_5_treasury_constant_maturity"
## [19] "year_7_treasury_constant_maturity"
## [20] "year_10_treasury_constant_maturity"
## [21] "year_20_treasury_constant_maturity"
## [22] "year_30_treasury_constant_maturity"
## [23] "year_5_inflation_indexed_treasury_constant_maturity"
## [24] "year_7_inflation_indexed_treasury_constant_maturity"
## [25] "year_10_inflation_indexed_treasury_constant_maturity"
## [26] "year_20_inflation_indexed_treasury_constant_maturity"
## [27] "year_30_inflation_indexed_treasury_constant_maturity"
## [28] "inflation_indexed_long_term_average"
## [29] "inflation_indexed_long_term_average_previous"
## [30] "direction"
```

```r
dim(ValidationSet)
```

```
## [1] 639  30
```

```r
names(ValidationSet)
```

```
##  [1] "month_1_nonfinancial_commercial_paper"
##  [2] "month_2_nonfinancial_commercial_paper"
##  [3] "month_3_nonfinancial_commercial_paper"
##  [4] "month_1_financial_commercial_paper"
##  [5] "month_2_financial_commercial_paper"
##  [6] "month_3_financial_commercial_paper"
##  [7] "prime_rate"
##  [8] "week_4_treasury_bill"
##  [9] "month_3_treasury_bill"
## [10] "month_6_treasury_bill"
## [11] "year_1_treasury_bill"
## [12] "month_1_treasury_constant_maturity"
## [13] "month_3_treasury_constant_maturity"
## [14] "month_6_treasury_constant_maturity"
## [15] "year_1_treasury_constant_maturity"
## [16] "year_2_treasury_constant_maturity"
## [17] "year_3_treasury_constant_maturity"
## [18] "year_5_treasury_constant_maturity"
## [19] "year_7_treasury_constant_maturity"
## [20] "year_10_treasury_constant_maturity"
## [21] "year_20_treasury_constant_maturity"
## [22] "year_30_treasury_constant_maturity"
## [23] "year_5_inflation_indexed_treasury_constant_maturity"
## [24] "year_7_inflation_indexed_treasury_constant_maturity"
## [25] "year_10_inflation_indexed_treasury_constant_maturity"
## [26] "year_20_inflation_indexed_treasury_constant_maturity"
## [27] "year_30_inflation_indexed_treasury_constant_maturity"
## [28] "inflation_indexed_long_term_average"
## [29] "inflation_indexed_long_term_average_previous"
## [30] "direction"
```

```r
# Model 1 for Infation Indexed Long Term Average Direction (Quantative Variable)
# LDA for Inflaction Indexed Long Term Average Direction
inf.d.Val = ValidationSet$direction

inf.d.lda.fit1 <- lda(direction~
                  month_2_nonfinancial_commercial_paper+
                  month_1_financial_commercial_paper+
                  month_6_treasury_bill+
                  prime_rate+
                  year_3_treasury_constant_maturity+
                  year_5_treasury_constant_maturity+
                  year_7_treasury_constant_maturity+
                  year_10_treasury_constant_maturity+
                  year_20_treasury_constant_maturity+
                  year_30_treasury_constant_maturity+
                  year_5_inflation_indexed_treasury_constant_maturity+
                  year_7_inflation_indexed_treasury_constant_maturity+
                  year_10_inflation_indexed_treasury_constant_maturity+
                  year_20_inflation_indexed_treasury_constant_maturity+
                  inflation_indexed_long_term_average, data=TrainingSet)
```

```r
inf.d.lda.pred=predict(inf.d.lda.fit1,ValidationSet)
inf.d.lda.class=inf.d.lda.pred$class
table(inf.d.lda.class,inf.d.Val)
```

```
##                 inf.d.Val
## inf.d.lda.class Down  Up
##            Down  172 195
##            Up    127 145
```

```r
inf.d.LDA = round(mean(inf.d.lda.class==inf.d.Val)*100, 4)
inf.d.LDA
```

```
## [1] 49.6088
```

```r
#Success rate of 49.6088%

#QDA for Inflaction Indexed Long Term Average Direction
inf.d.qda.fit1 <- qda(direction~
                        month_2_nonfinancial_commercial_paper+
                        month_1_financial_commercial_paper+
                        month_6_treasury_bill+
                        prime_rate+
                        year_3_treasury_constant_maturity+
                        year_5_treasury_constant_maturity+
                        year_7_treasury_constant_maturity+
                        year_10_treasury_constant_maturity+
                        year_20_treasury_constant_maturity+
                        year_30_treasury_constant_maturity+
                        year_5_inflation_indexed_treasury_constant_maturity+
                        year_7_inflation_indexed_treasury_constant_maturity+
                        year_10_inflation_indexed_treasury_constant_maturity+
                        year_20_inflation_indexed_treasury_constant_maturity+
                        inflation_indexed_long_term_average, data=TrainingSet)

inf.d.qda.pred=predict(inf.d.qda.fit1,ValidationSet)
inf.d.qda.class=inf.d.qda.pred$class
table(inf.d.qda.class,inf.d.Val)
```

```
##                 inf.d.Val
## inf.d.qda.class Down  Up
##            Down   36  39
##            Up    263 301
```

```r
inf.d.QDA = round(mean(inf.d.qda.class==inf.d.Val)*100, 4)
inf.d.QDA
```

```
## [1] 52.7387
```

```r
#Success rate of 52.7387%

#KNN for Inflaction Indexed Long Term Average Direction

var1 <- c("month_2_nonfinancial_commercial_paper",
         "month_1_financial_commercial_paper",
         "month_6_treasury_bill",
         "prime_rate",
         "year_3_treasury_constant_maturity",
```

```r
         "year_5_treasury_constant_maturity",
         "year_7_treasury_constant_maturity",
         "year_10_treasury_constant_maturity",
         "year_20_treasury_constant_maturity",
         "year_30_treasury_constant_maturity",
         "year_5_inflation_indexed_treasury_constant_maturity",
         "year_7_inflation_indexed_treasury_constant_maturity",
         "year_10_inflation_indexed_treasury_constant_maturity",
         "year_20_inflation_indexed_treasury_constant_maturity",
         "inflation_indexed_long_term_average")
var2 <- c("direction")
train.var1 <- TrainingSet[var1]
test.var1 <- ValidationSet[var1]
test.var1 <- test.var1[var1]
train.dep1 <- TrainingSet[var2]
test.dep1 <- ValidationSet[var2]

KNN.Multi <- rep(NA,50)
for (i in 1:50){
  set.seed(1)
  inf.knn.pred <- knn(train.var1,test.var1,train.dep1$direction,k = i)
  KNN.Multi[i] <- mean(inf.knn.pred==test.dep1$direction)
}
KN <- c(1:50)
KNN.Multi.KN <- cbind(KNN.Multi,KN)
inf.knn <- KNN.Multi.KN[which.max(KNN.Multi), ]
inf.knn
```

```
## KNN.Multi        KN
## 0.5117371 6.0000000
```

```r
inf.knn.NoLag <- round(mean(inf.knn[1])*100, 4)
inf.knn.NoLag
```

```
## [1] 51.1737
```

```r
#Success rate of 51.1737% when K = 6
```

```r
# Model 2 for Infation Indexed Long Term Average Direction
# LDA for Inflaction Indexed Long Term Average Direction

inf.d.lda.fit2 <- lda(direction~
                        month_1_nonfinancial_commercial_paper+
                        month_2_nonfinancial_commercial_paper+
                        month_2_financial_commercial_paper+
                        month_3_financial_commercial_paper+
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_30_inflation_indexed_treasury_constant_maturity+
                        inflation_indexed_long_term_average, data=TrainingSet)
```

```r
inf.d.lda.pred2 <- predict(inf.d.lda.fit2,ValidationSet)
inf.d.lda.class2 <- inf.d.lda.pred2$class
table(inf.d.lda.class2,inf.d.Val)
```

```
##                  inf.d.Val
## inf.d.lda.class2 Down  Up
##             Down  140 170
##             Up    159 170
```

```r
inf.d.LDA2 = round(mean(inf.d.lda.class2==inf.d.Val)*100, 4)
inf.d.LDA2
```

```
## [1] 48.5133
```

```r
#Success rate of 48.5133%

#QDA for Inflaction Indexed Long Term Average Direction
inf.d.qda.fit2 <- qda(direction~
                        month_1_nonfinancial_commercial_paper+
                        month_2_nonfinancial_commercial_paper+
                        month_2_financial_commercial_paper+
                        month_3_financial_commercial_paper+
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_30_inflation_indexed_treasury_constant_maturity+
                        inflation_indexed_long_term_average, data=TrainingSet)

inf.d.qda.pred2 <- predict(inf.d.qda.fit2,ValidationSet)
inf.d.qda.class2 <- inf.d.qda.pred2$class
table(inf.d.qda.class2,inf.d.Val)
```

```
##                  inf.d.Val
## inf.d.qda.class2 Down  Up
##             Down  106 114
##             Up    193 226
```

```r
inf.d.QDA2 = round(mean(inf.d.qda.class2==inf.d.Val)*100, 4)
inf.d.QDA2
```

```
## [1] 51.9562
```

```r
#Success rate of 51.9562%

#KNN for Inflaction Indexed Long Term Average Direction

var1.2 <- c("month_1_nonfinancial_commercial_paper",
         "month_2_nonfinancial_commercial_paper",
         "month_2_financial_commercial_paper",
         "month_3_financial_commercial_paper",
         "prime_rate",
         "week_4_treasury_bill",
         "month_3_treasury_bill",
         "month_1_treasury_constant_maturity",
```

```r
         "month_3_treasury_constant_maturity",
         "month_6_treasury_constant_maturity",
         "year_30_inflation_indexed_treasury_constant_maturity",
         "inflation_indexed_long_term_average")

var2.2 <- c("direction")

train.var1.2 <- TrainingSet[var1.2]
test.var1.2 <- ValidationSet[var1.2]
test.var1.2 <- test.var1.2[var1.2]
train.dep1.2 <- TrainingSet[var2.2]
test.dep1.2 <- ValidationSet[var2.2]

KNN.Multi.2 <- rep(NA,50)
for (i in 1:50){
  set.seed(1)
  inf.knn.pred <- knn(train.var1.2,test.var1.2,train.dep1.2$direction,k = i)
  KNN.Multi.2[i] <- mean(inf.knn.pred==test.dep1.2$direction)
}
KN2 <- c(1:50)
KNN.Multi.KN2 <- cbind(KNN.Multi.2,KN2)
inf.knn2 <- KNN.Multi.KN2[which.max(KNN.Multi.2), ]
inf.knn2
```

```
## KNN.Multi.2         KN2
##   0.5179969  32.0000000
```

```r
inf.knn.NoLag2 <- round(mean(inf.knn2[1])*100, 4)
inf.knn.NoLag2
```

```
## [1] 51.7997
```

```r
#Success rate of 51.7997% when K = 32
```

```r
# Model 3 for Infation Indexed Long Term Average Direction
# LDA for Inflaction Indexed Long Term Average Direction

inf.d.lda.fit3 <- lda(direction~
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_6_treasury_bill+
                        year_1_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_1_treasury_constant_maturity+
                        year_2_treasury_constant_maturity+
                        year_3_treasury_constant_maturity+
                        year_5_treasury_constant_maturity+
                        year_7_treasury_constant_maturity+
                        year_10_treasury_constant_maturity+
                        year_20_treasury_constant_maturity+
                        year_30_treasury_constant_maturity+
                        year_5_inflation_indexed_treasury_constant_maturity+
```

```
                        year_7_inflation_indexed_treasury_constant_maturity+
                        year_10_inflation_indexed_treasury_constant_maturity+
                        year_20_inflation_indexed_treasury_constant_maturity+
                        year_30_inflation_indexed_treasury_constant_maturity+
                        inflation_indexed_long_term_average, data=TrainingSet)

inf.d.lda.pred3 <- predict(inf.d.lda.fit3,ValidationSet)
inf.d.lda.class3 <- inf.d.lda.pred3$class
table(inf.d.lda.class3,inf.d.Val)
```

```
##                   inf.d.Val
## inf.d.lda.class3 Down  Up
##             Down  189 203
##             Up    110 137
```

```
inf.d.LDA3 <- round(mean(inf.d.lda.class3==inf.d.Val)*100, 4)
inf.d.LDA3
```

```
## [1] 51.0172
```

```
#Success rate of 51.0172%

#QDA for Inflaction Indexed Long Term Average Direction
inf.d.qda.fit3 <- qda(direction~
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_6_treasury_bill+
                        year_1_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_1_treasury_constant_maturity+
                        year_2_treasury_constant_maturity+
                        year_3_treasury_constant_maturity+
                        year_5_treasury_constant_maturity+
                        year_7_treasury_constant_maturity+
                        year_10_treasury_constant_maturity+
                        year_20_treasury_constant_maturity+
                        year_30_treasury_constant_maturity+
                        year_5_inflation_indexed_treasury_constant_maturity+
                        year_7_inflation_indexed_treasury_constant_maturity+
                        year_10_inflation_indexed_treasury_constant_maturity+
                        year_20_inflation_indexed_treasury_constant_maturity+
                        year_30_inflation_indexed_treasury_constant_maturity+
                        inflation_indexed_long_term_average, data=TrainingSet)

inf.d.qda.pred3 <- predict(inf.d.qda.fit3,ValidationSet)
inf.d.qda.class3 <- inf.d.qda.pred3$class
table(inf.d.qda.class3,inf.d.Val)
```

```
##                   inf.d.Val
## inf.d.qda.class3 Down  Up
##             Down  111 129
##             Up    188 211
```

```r
inf.d.QDA3 = round(mean(inf.d.qda.class3==inf.d.Val)*100, 4)
inf.d.QDA3
```

```
## [1] 50.3912
```

```r
#Success rate of 50.3912%

#KNN for Inflaction Indexed Long Term Average Direction

var1.3 <- c("prime_rate",
             "week_4_treasury_bill",
             "month_3_treasury_bill",
             "month_6_treasury_bill",
             "year_1_treasury_bill",
             "month_1_treasury_constant_maturity" ,
             "month_3_treasury_constant_maturity",
             "month_6_treasury_constant_maturity" ,
             "year_1_treasury_constant_maturity",
             "year_2_treasury_constant_maturity",
             "year_3_treasury_constant_maturity",
             "year_5_treasury_constant_maturity",
             "year_7_treasury_constant_maturity",
             "year_10_treasury_constant_maturity",
             "year_20_treasury_constant_maturity",
             "year_30_treasury_constant_maturity",
             "year_5_inflation_indexed_treasury_constant_maturity",
             "year_7_inflation_indexed_treasury_constant_maturity",
             "year_10_inflation_indexed_treasury_constant_maturity",
             "year_20_inflation_indexed_treasury_constant_maturity",
             "year_30_inflation_indexed_treasury_constant_maturity",
             "inflation_indexed_long_term_average")

var2.3 <- c("direction")
train.var1.3 <- TrainingSet[var1.3]
test.var1.3 <- ValidationSet[var1.3]
test.var1.3 <- test.var1.3[var1.3]
train.dep1.3 <- TrainingSet[var2.3]
test.dep1.3 <- ValidationSet[var2.3]

KNN.Multi.3 <- rep(NA,50)
for (i in 1:50){
  set.seed(1)
  inf.knn.pred <- knn(train.var1.3,test.var1.3,train.dep1.3$direction,k = i)
  KNN.Multi.3[i] <- mean(inf.knn.pred==test.dep1.3$direction)
}
KN3 <- c(1:50)
KNN.Multi.KN3 <- cbind(KNN.Multi.3,KN3)
inf.knn3 <- KNN.Multi.KN3[which.max(KNN.Multi.3), ]
inf.knn3
```

```
## KNN.Multi.3         KN3
##    0.514867   15.000000
```

```r
inf.knn.NoLag3 <- round(mean(inf.knn3[1])*100, 4)
inf.knn.NoLag3
```

```
## [1] 51.4867
```

```r
#Success rate of 51.4867% when K = 15
```

```r
# Model 4 for Infation Indexed Long Term Average Direction
# LDA for Inflaction Indexed Long Term Average Direction

inf.d.lda.fit4 <- lda(direction~
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_6_treasury_bill+
                        year_1_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_1_treasury_constant_maturity+
                        year_2_treasury_constant_maturity+
                        year_3_treasury_constant_maturity+
                        year_5_treasury_constant_maturity+
                        year_7_treasury_constant_maturity+
                        year_10_treasury_constant_maturity+
                        year_20_treasury_constant_maturity+
                        year_30_treasury_constant_maturity, data=TrainingSet)

inf.d.lda.pred4 <- predict(inf.d.lda.fit4,ValidationSet)
inf.d.lda.class4 <- inf.d.lda.pred4$class
table(inf.d.lda.class4,inf.d.Val)
```

```
##                   inf.d.Val
## inf.d.lda.class4 Down  Up
##             Down  158 201
##             Up    141 139
```

```r
inf.d.LDA4 <- round(mean(inf.d.lda.class4==inf.d.Val)*100, 4)
inf.d.LDA4
```

```
## [1] 46.4789
```

```r
#Success rate of 46.4789%

#QDA for Inflaction Indexed Long Term Average Direction
inf.d.qda.fit4 <- qda(direction~
                        prime_rate+
                        week_4_treasury_bill+
                        month_3_treasury_bill+
                        month_6_treasury_bill+
                        year_1_treasury_bill+
                        month_1_treasury_constant_maturity+
                        month_3_treasury_constant_maturity+
                        month_6_treasury_constant_maturity+
                        year_1_treasury_constant_maturity+
                        year_2_treasury_constant_maturity+
                        year_3_treasury_constant_maturity+
                        year_5_treasury_constant_maturity+
                        year_7_treasury_constant_maturity+
```

```r
                        year_10_treasury_constant_maturity+
                        year_20_treasury_constant_maturity+
                        year_30_treasury_constant_maturity, data=TrainingSet)

inf.d.qda.pred4 <- predict(inf.d.qda.fit4,ValidationSet)
inf.d.qda.class4 <- inf.d.qda.pred4$class
table(inf.d.qda.class4,inf.d.Val)
```

```
##                 inf.d.Val
## inf.d.qda.class4 Down  Up
##             Down  191 222
##             Up    108 118
```

```r
inf.d.QDA4 = round(mean(inf.d.qda.class4==inf.d.Val)*100, 4)
inf.d.QDA4
```

```
## [1] 48.3568
```

```r
#Success rate of 48.3568%

#KNN for Inflaction Indexed Long Term Average Direction

var1.4 <- c("prime_rate",
            "week_4_treasury_bill",
            "month_3_treasury_bill",
            "month_6_treasury_bill",
            "year_1_treasury_bill",
            "month_1_treasury_constant_maturity" ,
            "month_3_treasury_constant_maturity",
            "month_6_treasury_constant_maturity" ,
            "year_1_treasury_constant_maturity",
            "year_2_treasury_constant_maturity",
            "year_3_treasury_constant_maturity",
            "year_5_treasury_constant_maturity",
            "year_7_treasury_constant_maturity",
            "year_10_treasury_constant_maturity",
            "year_20_treasury_constant_maturity",
            "year_30_treasury_constant_maturity")

var2.4 <- c("direction")
train.var1.4 <- TrainingSet[var1.4]
test.var1.4 <- ValidationSet[var1.4]
test.var1.4 <- test.var1.4[var1.4]
train.dep1.4 <- TrainingSet[var2.4]
test.dep1.4 <- ValidationSet[var2.4]

KNN.Multi.4 <- rep(NA,50)
for (i in 1:50){
  set.seed(1)
  inf.knn.pred <- knn(train.var1.4,test.var1.4,train.dep1.4$direction,k = i)
  KNN.Multi.4[i] <- mean(inf.knn.pred==test.dep1.4$direction)
}
KN4 <- c(1:50)
KNN.Multi.KN4 <- cbind(KNN.Multi.4,KN4)
inf.knn4 <- KNN.Multi.KN4[which.max(KNN.Multi.4), ]
```

```r
inf.knn4
```

```
## KNN.Multi.4         KN4
##   0.4992175  18.0000000
```

```r
inf.knn.NoLag4 <- round(mean(inf.knn4[1])*100, 4)
inf.knn.NoLag4
```

```
## [1] 49.9218
```

```r
#Success rate of 49.9218% when K = 18
```

It appears that model 3 performs the best overall when running the LDA, QDA, and KNN on all of the models. It has the highest average percentage across the 4 models based on the training and validation that was run.

Question 4:

(Based on ISLR Chapter 9 #7) In this problem, you will use support vector approaches in order to predict whether a given car gets high or low gas mileage based on the Auto data set.

(a)

Create a binary variable that takes on a 1 for cars with gas mileage above the median, and a 0 for cars with gas mileage below the median.

```r
library(ISLR)
```

```
## Warning: package 'ISLR' was built under R version 3.4.2
```

```r
gsmed <- median(Auto$mpg)
Auto$mpglevel <- as.factor(ifelse(Auto$mpg > gsmed, 1, 0))
Auto$mpglevel
```

```
##   [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 1 0 0 0 0 0 1 1 1 0 0 0
##  [36] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0
##  [71] 0 0 0 0 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0
## [106] 0 0 0 0 0 0 0 0 1 0 0 1 1 0 0 0 1 0 0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1
## [141] 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 1 0 1 0
## [176] 1 1 0 1 1 1 1 1 1 1 0 0 0 0 0 0 1 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0
## [211] 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1
## [246] 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 1 0 0 0 0 1 1 0 0
## [281] 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## [316] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## [351] 1 1 1 1 1 1 1 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
## [386] 1 1 1 1 1 1 1
## Levels: 0 1
```

(b)

Fit a support vector classifier to the data with various values of cost, in order to predict whether a car gets high or low gas mileage. Report the cross-validation errors associated with different values of this parameter. Comment on your results.

```r
library(e1071)
```

```
## Warning: package 'e1071' was built under R version 3.4.3
```

```r
set.seed(333)
tuning <- tune(svm, mpglevel ~ ., data = Auto, kernel = "linear", ranges = list(cost = c(0.01,
    0.1, 1, 5, 10, 100)))
summary(tuning)
```

```
##
## Parameter tuning of 'svm':
##
## - sampling method: 10-fold cross validation
##
## - best parameters:
##  cost
##     1
##
## - best performance: 0.01269231
##
## - Detailed performance results:
##    cost      error dispersion
## 1 1e-02 0.07397436 0.04229172
## 2 1e-01 0.05615385 0.04121130
## 3 1e+00 0.01269231 0.01783081
## 4 5e+00 0.02288462 0.02505026
## 5 1e+01 0.02801282 0.03036301
## 6 1e+02 0.03564103 0.02727721
```

(c)

Now repeat for (b), this time using SVMs with radial and polynomial basis kernels, with different values of gamma and degree and cost. Comment on your results.

```r
set.seed(333)
tuning1 <- tune(svm, mpglevel ~ ., data = Auto, kernel = "polynomial", ranges = list(cost = c(0.1,
    1, 5, 10), degree = c(2, 3, 4)))
summary(tuning1)
```

```
##
## Parameter tuning of 'svm':
##
## - sampling method: 10-fold cross validation
##
## - best parameters:
##  cost degree
##    10      2
##
## - best performance: 0.5560897
##
## - Detailed performance results:
##    cost degree     error dispersion
## 1   0.1      2 0.5637179 0.03750983
## 2   1.0      2 0.5637179 0.03750983
```

```
## 3   5.0      2 0.5637179 0.03750983
## 4  10.0      2 0.5560897 0.04720748
## 5   0.1      3 0.5637179 0.03750983
## 6   1.0      3 0.5637179 0.03750983
## 7   5.0      3 0.5637179 0.03750983
## 8  10.0      3 0.5637179 0.03750983
## 9   0.1      4 0.5637179 0.03750983
## 10  1.0      4 0.5637179 0.03750983
## 11  5.0      4 0.5637179 0.03750983
## 12 10.0      4 0.5637179 0.03750983
```

```r
set.seed(463)
tuning2 <- tune(svm, mpglevel ~ ., data = Auto, kernel = "radial", ranges = list(cost = c(0.1,
    1, 5, 10), gamma = c(0.01, 0.1, 1, 5, 10, 100)))
summary(tuning2)
```

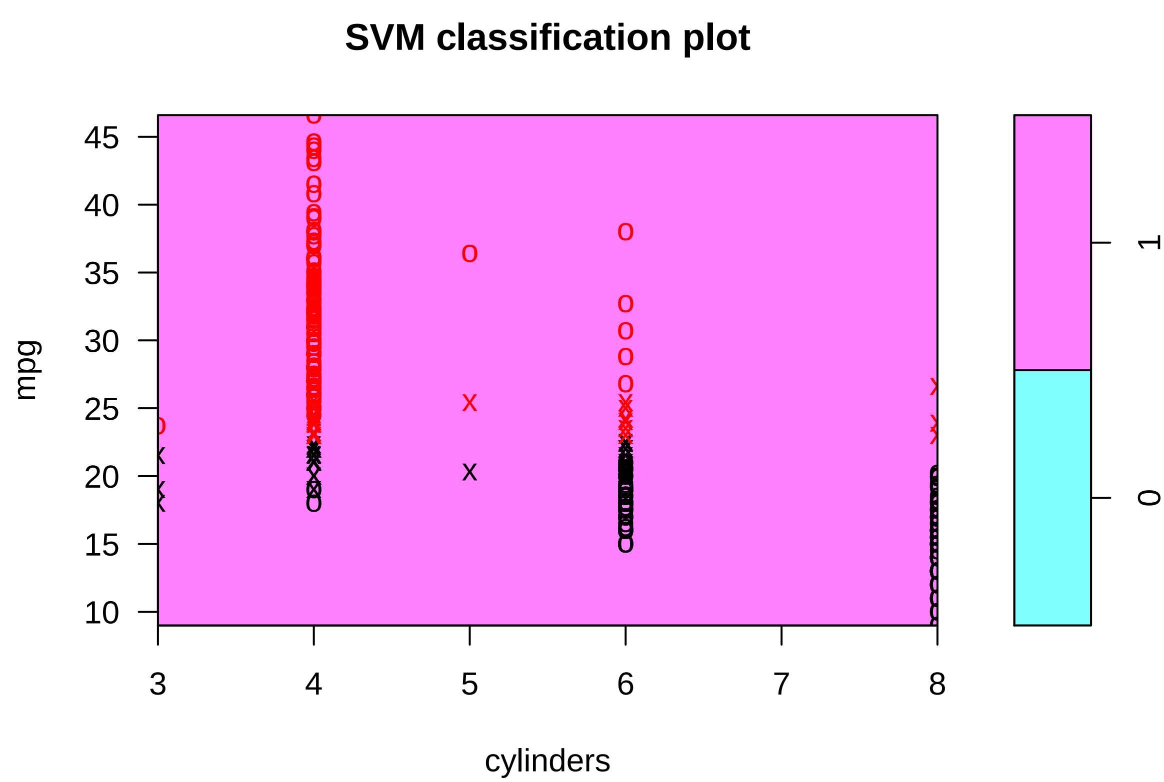
```
##
## Parameter tuning of 'svm':
##
## - sampling method: 10-fold cross validation
##
## - best parameters:
##  cost gamma
##    10  0.01
##
## - best performance: 0.02288462
##
## - Detailed performance results:
##    cost gamma      error dispersion
## 1   0.1 1e-02 0.08916667 0.04526330
## 2   1.0 1e-02 0.07397436 0.03896185
## 3   5.0 1e-02 0.05102564 0.03813274
## 4  10.0 1e-02 0.02288462 0.03286718
## 5   0.1 1e-01 0.07903846 0.04724112
## 6   1.0 1e-01 0.05602564 0.03950993
## 7   5.0 1e-01 0.02801282 0.02231663
## 8  10.0 1e-01 0.02551282 0.02093755
## 9   0.1 1e+00 0.55102564 0.03813274
## 10  1.0 1e+00 0.06365385 0.04199145
## 11  5.0 1e+00 0.06108974 0.04358351
## 12 10.0 1e+00 0.06108974 0.04358351
## 13  0.1 5e+00 0.55102564 0.03813274
## 14  1.0 5e+00 0.48717949 0.03963085
## 15  5.0 5e+00 0.49224359 0.04525523
## 16 10.0 5e+00 0.49224359 0.04525523
## 17  0.1 1e+01 0.55102564 0.03813274
## 18  1.0 1e+01 0.50506410 0.04235779
## 19  5.0 1e+01 0.49993590 0.04269277
## 20 10.0 1e+01 0.49993590 0.04269277
## 21  0.1 1e+02 0.55102564 0.03813274
## 22  1.0 1e+02 0.55102564 0.03813274
## 23  5.0 1e+02 0.55102564 0.03813274
## 24 10.0 1e+02 0.55102564 0.03813274
```

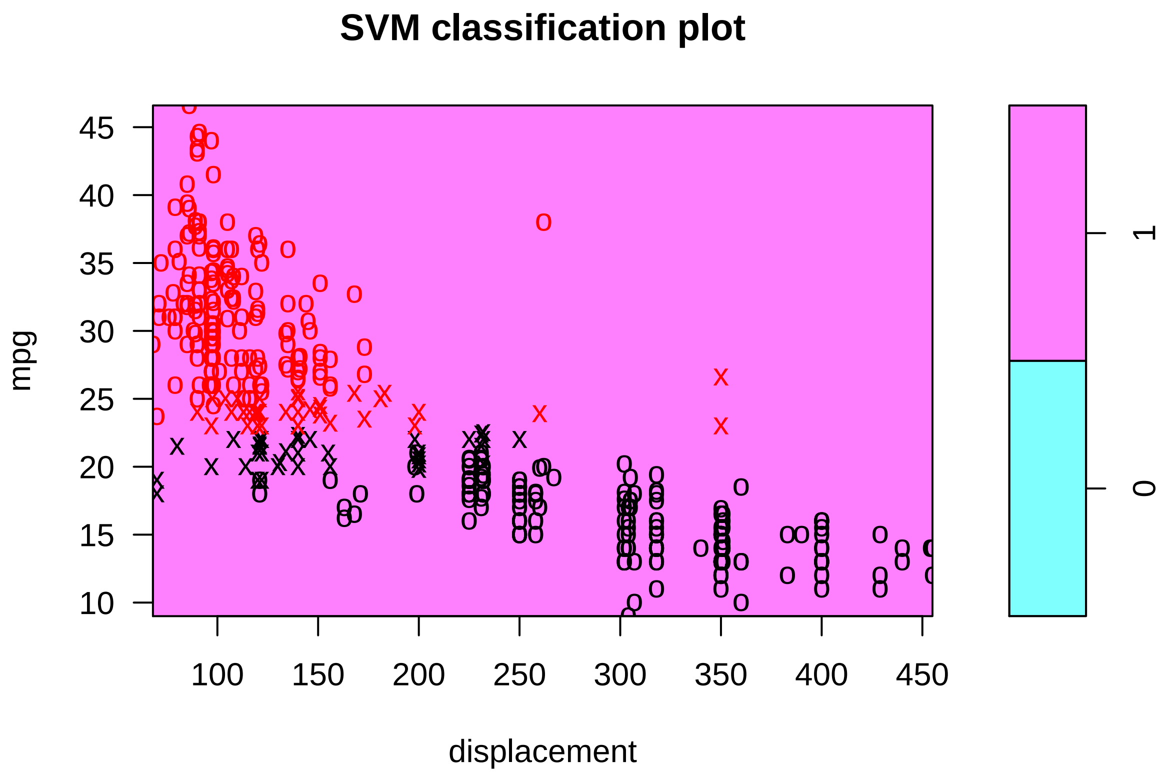
(d)

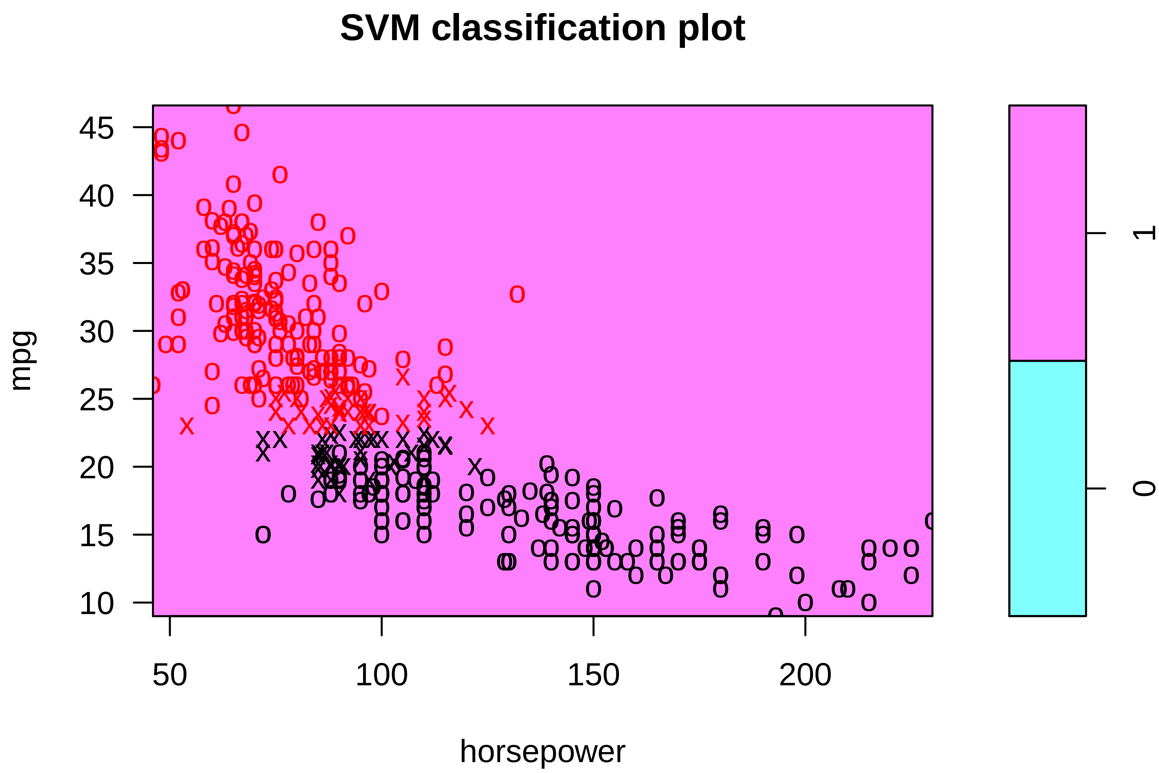
Make some plots to back up your assertions in (b) and (c). Hint: In the lab, we used the plot() function for svm objects only in cases with p=2 When p>2,you can use the plot() function to create plots displaying pairs of variables at a time. Essentially, instead of typing plot(svmfit , dat) where svmfit contains your fitted model and dat is a data frame containing your data, you can type plot(svmfit , dat, x1???x4) in order to plot just the first and fourth variables. However, you must replace x1 and x4 with the correct variable names. To find out more, type ?plot.svm.

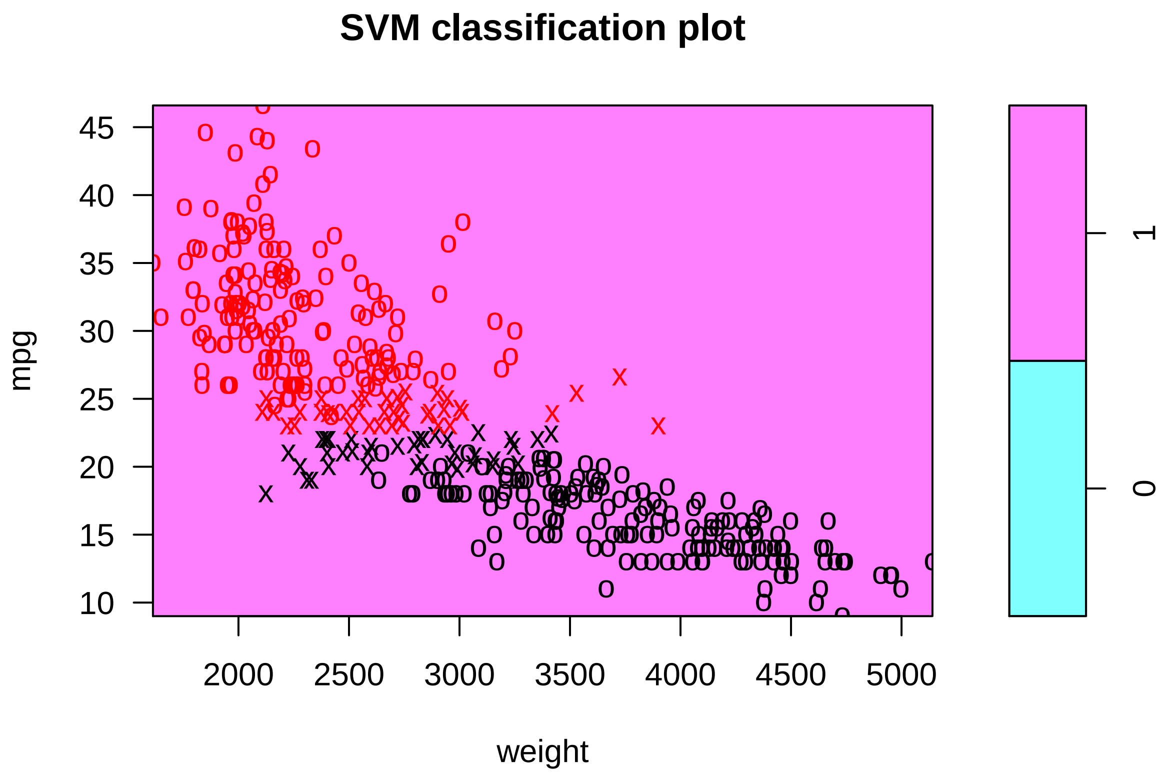
```
svmrad <- svm(mpglevel ~ ., data = Auto, kernel = "radial", cost = 10, gamma = 0.01)
svmlin <- svm(mpglevel ~ ., data = Auto, kernel = "linear", cost = 1)
svmpol <- svm(mpglevel ~ ., data = Auto, kernel = "polynomial", cost = 10, degree = 2)

plotpairs = function(fit) {
    for (name in names(Auto)[!(names(Auto) %in% c("mpg", "mpglevel", "name"))]) {
        plot(fit, Auto, as.formula(paste("mpg~", name, sep = "")))
    }
}
```

```
plotpairs(svmrad)
```




SVM classification plot
mpg
45
40
35
30
25
20
15
10
100
150
200
250
300
350
400
450
displacement
1
0


SVM classification plot
mpg
horsepower
45
40
35
30
25
20
15
10
50
100
150
200
1
0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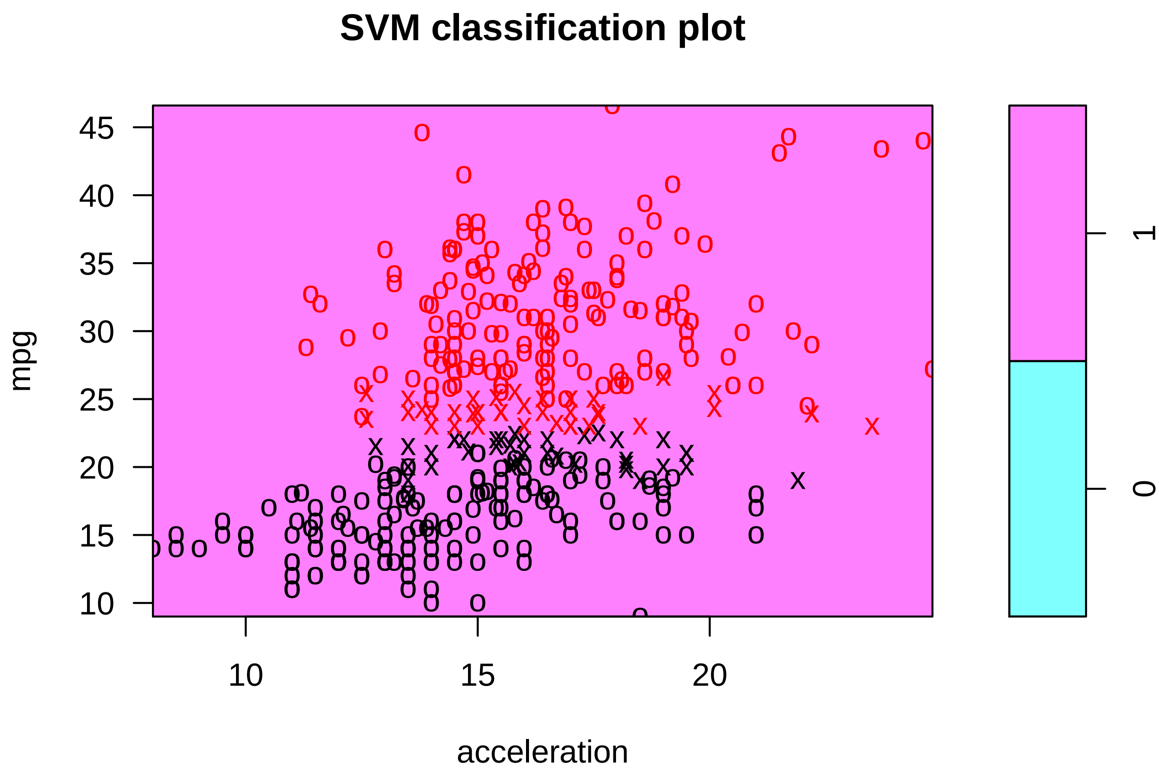
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SVM classification plot
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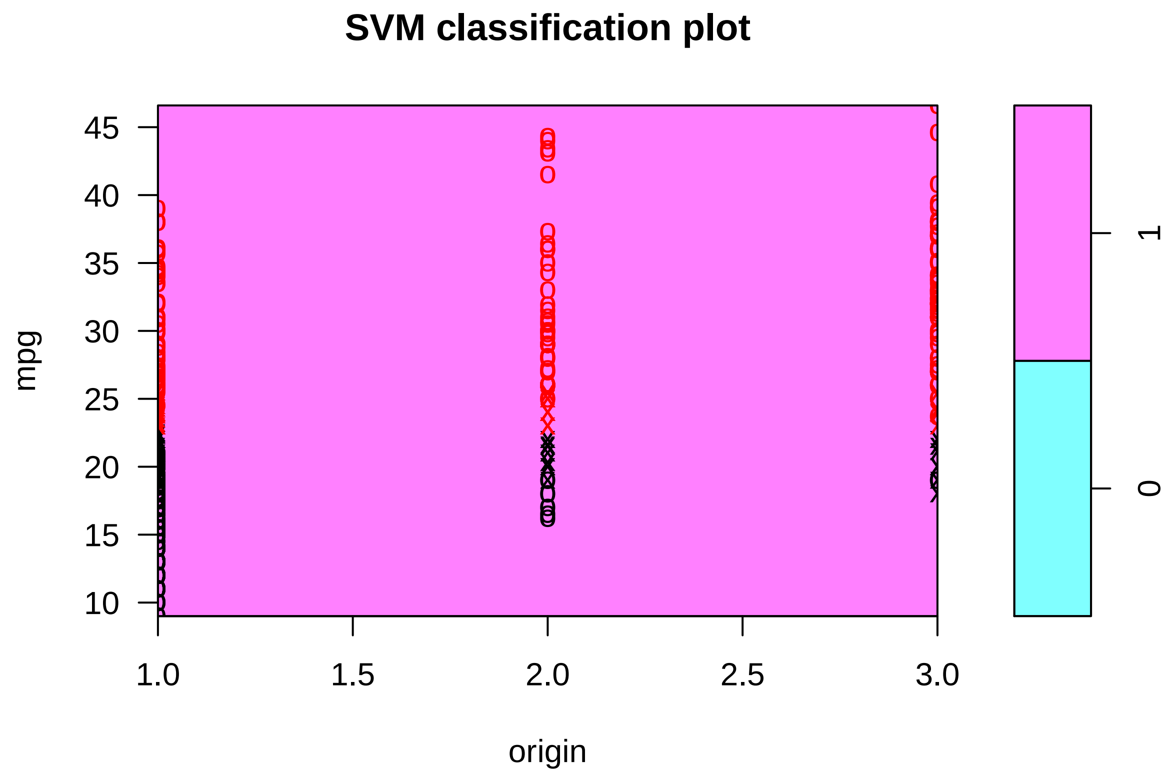


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plotpairs(svmlin)
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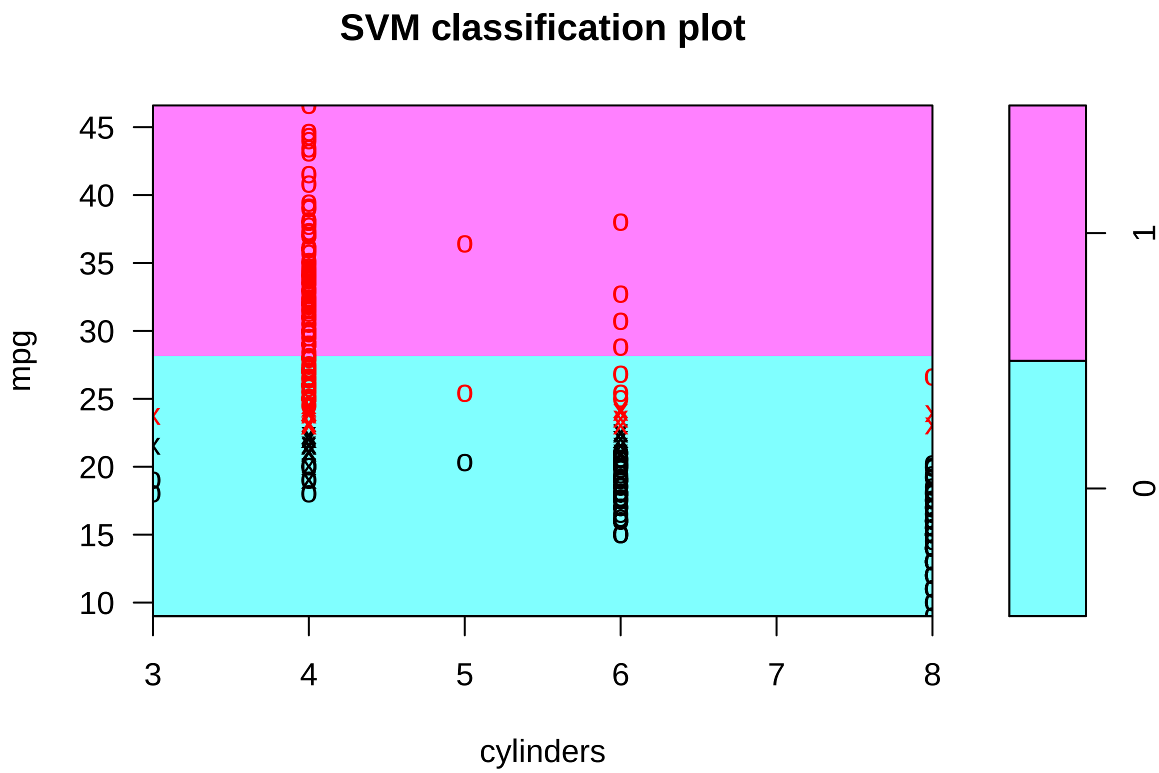
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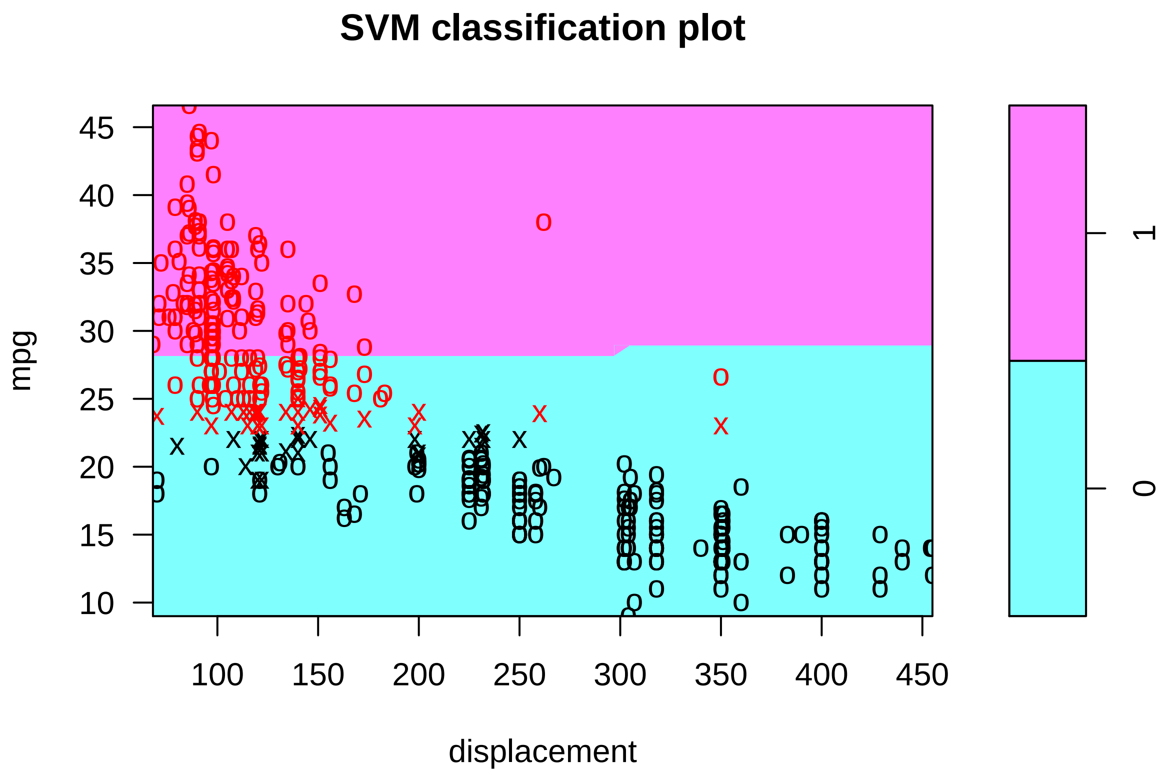
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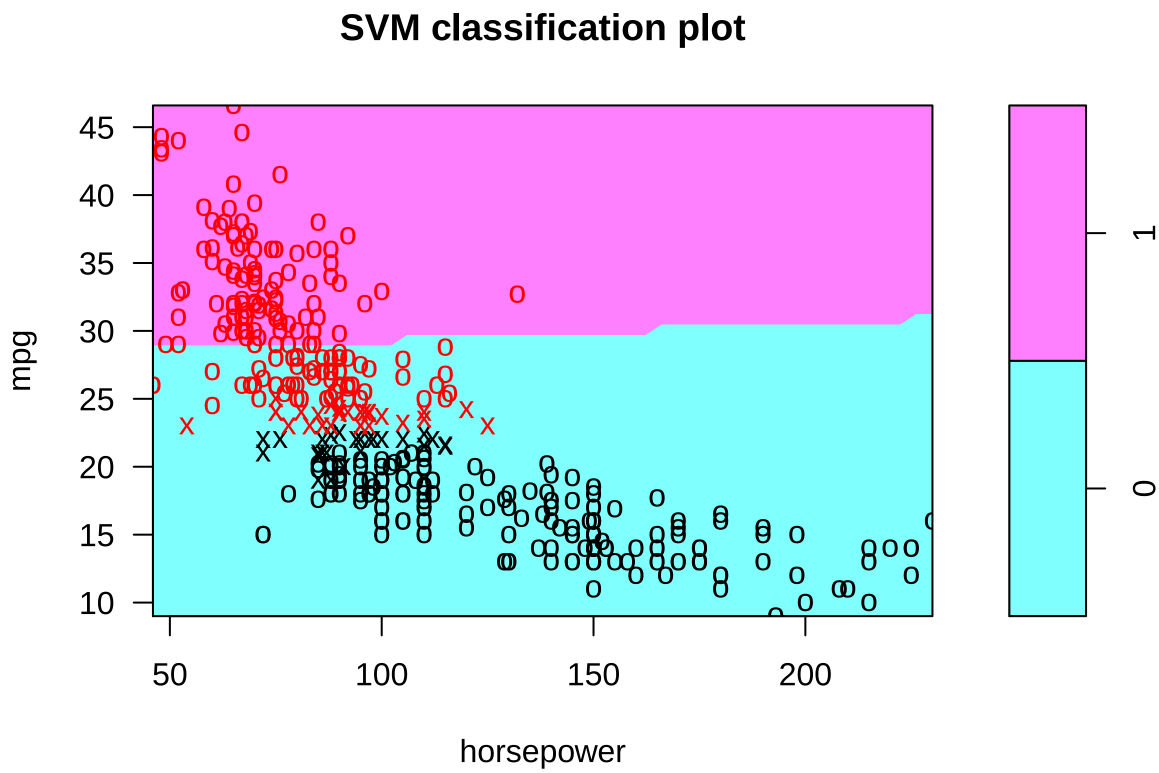

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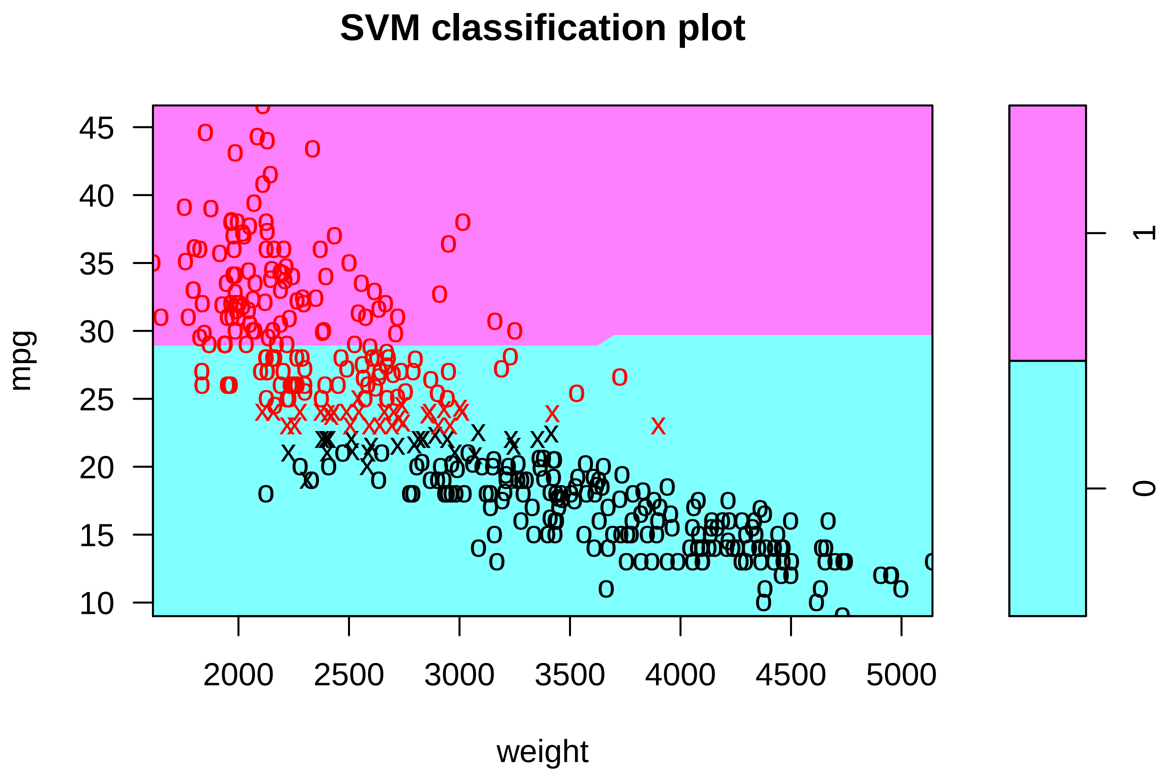
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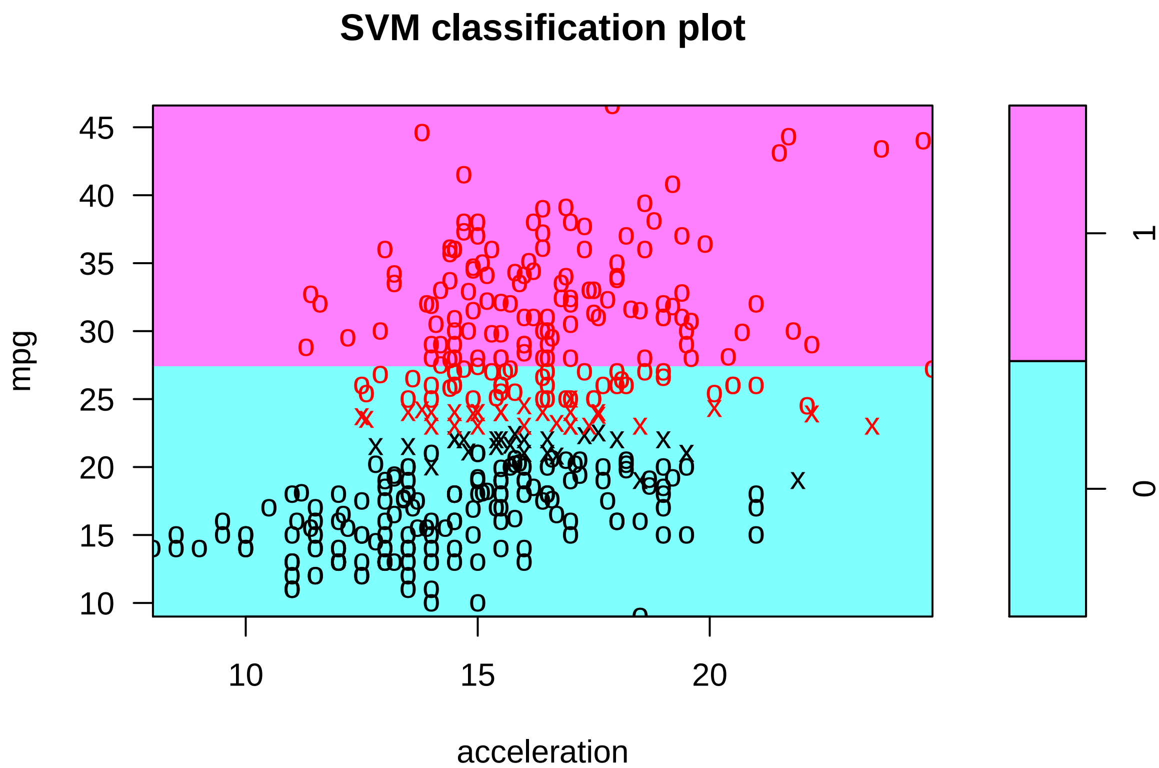
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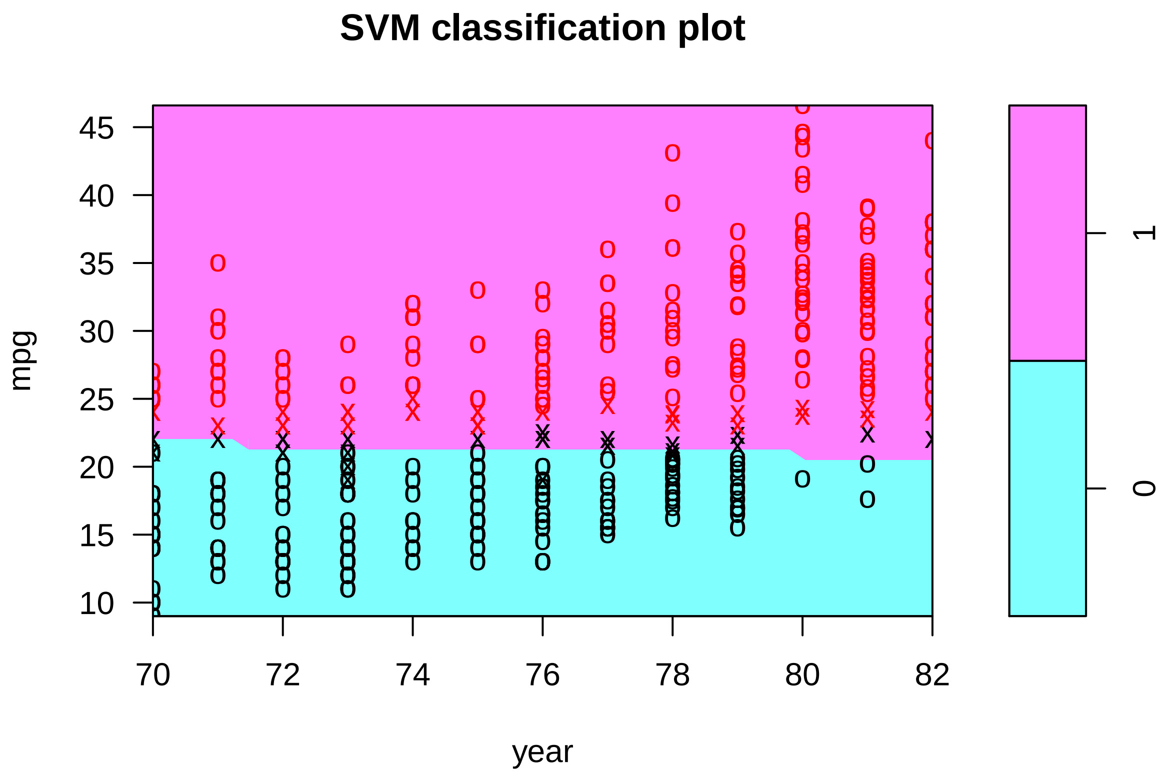
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80
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1
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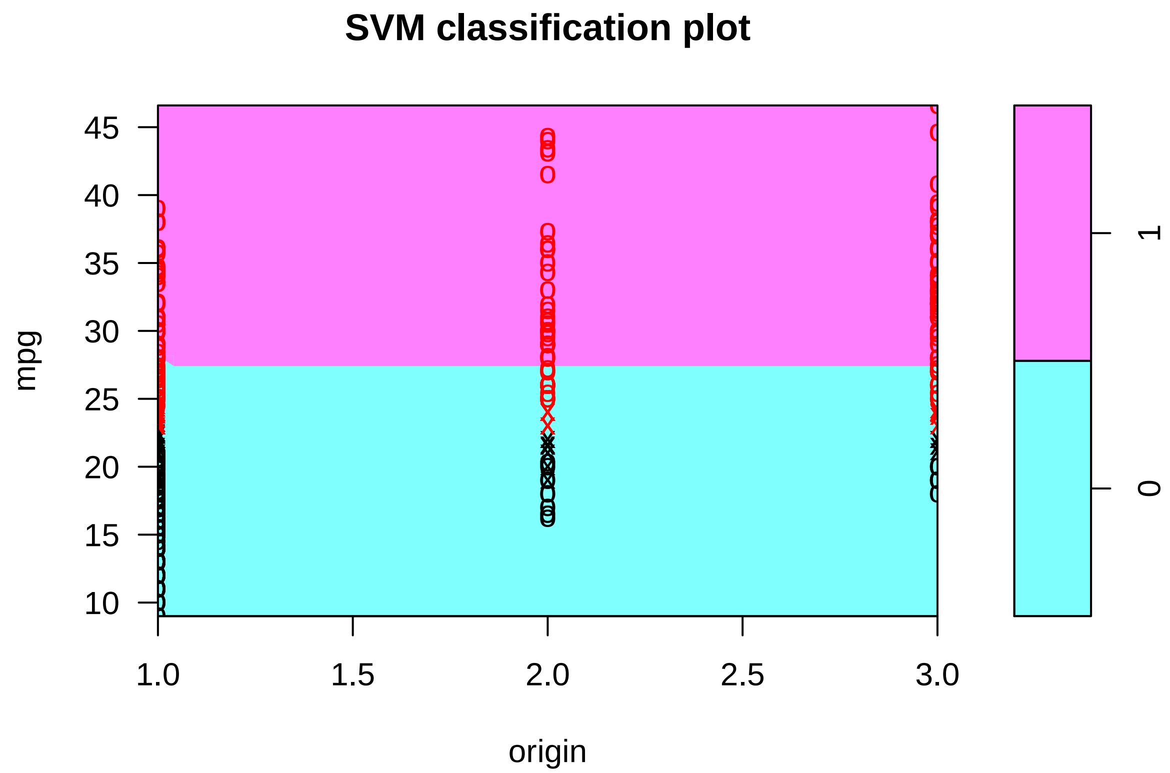


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plotpairs(svmpol)
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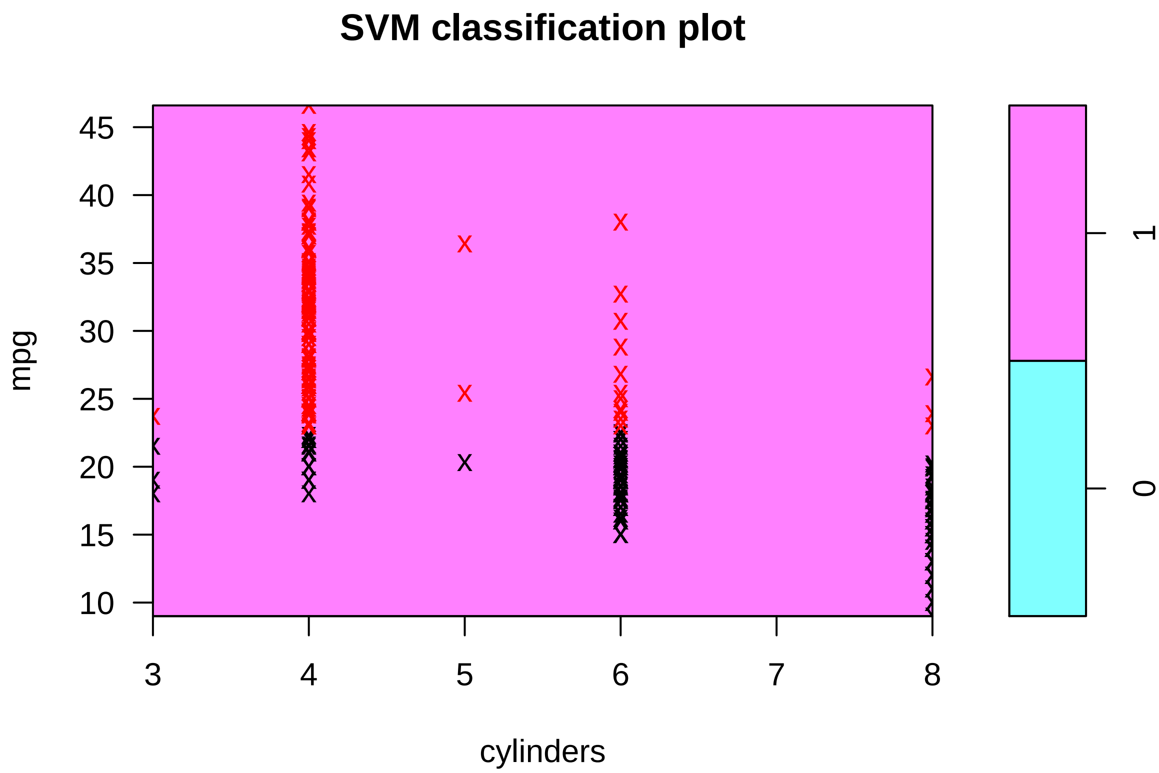
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cylinders
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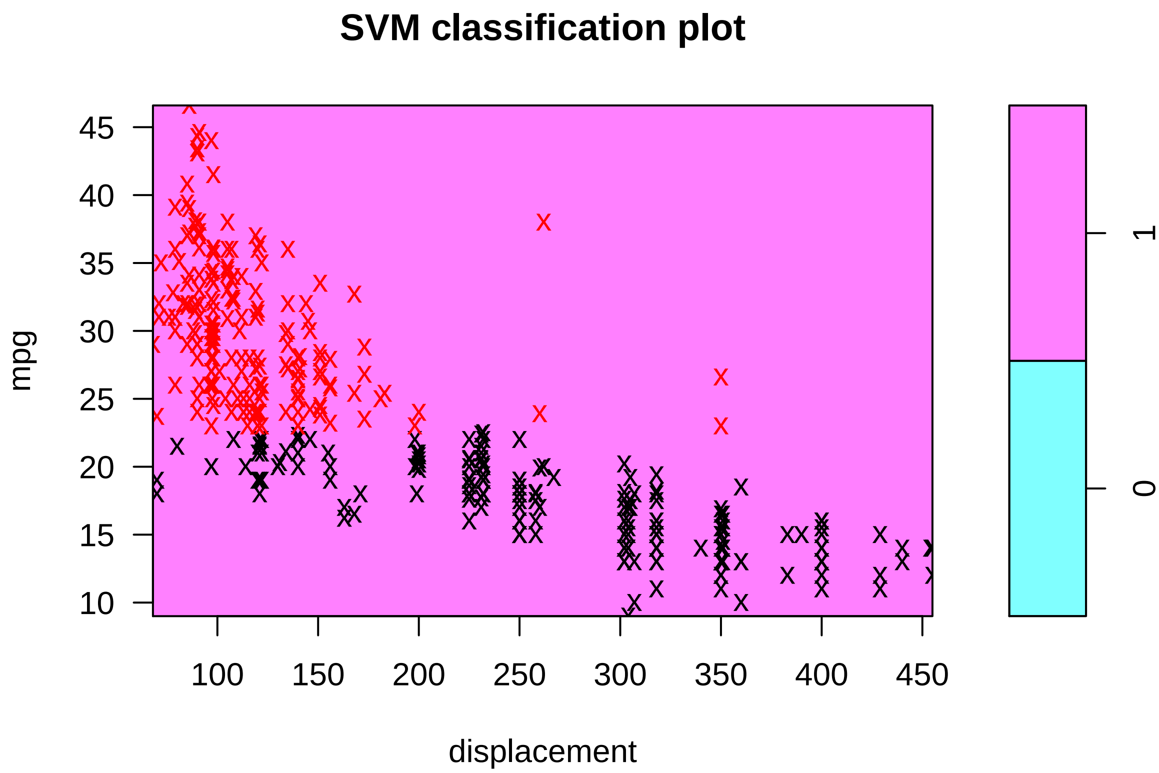
SVM classification plot
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300
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450
displacement
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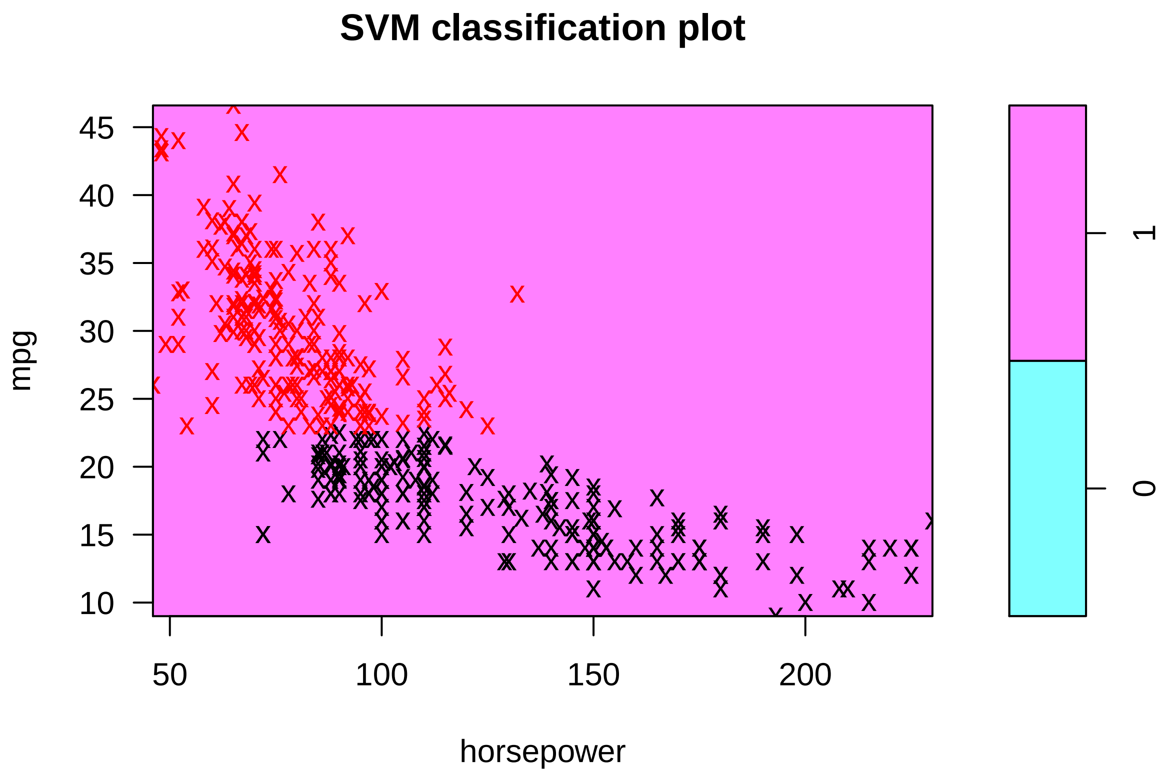
0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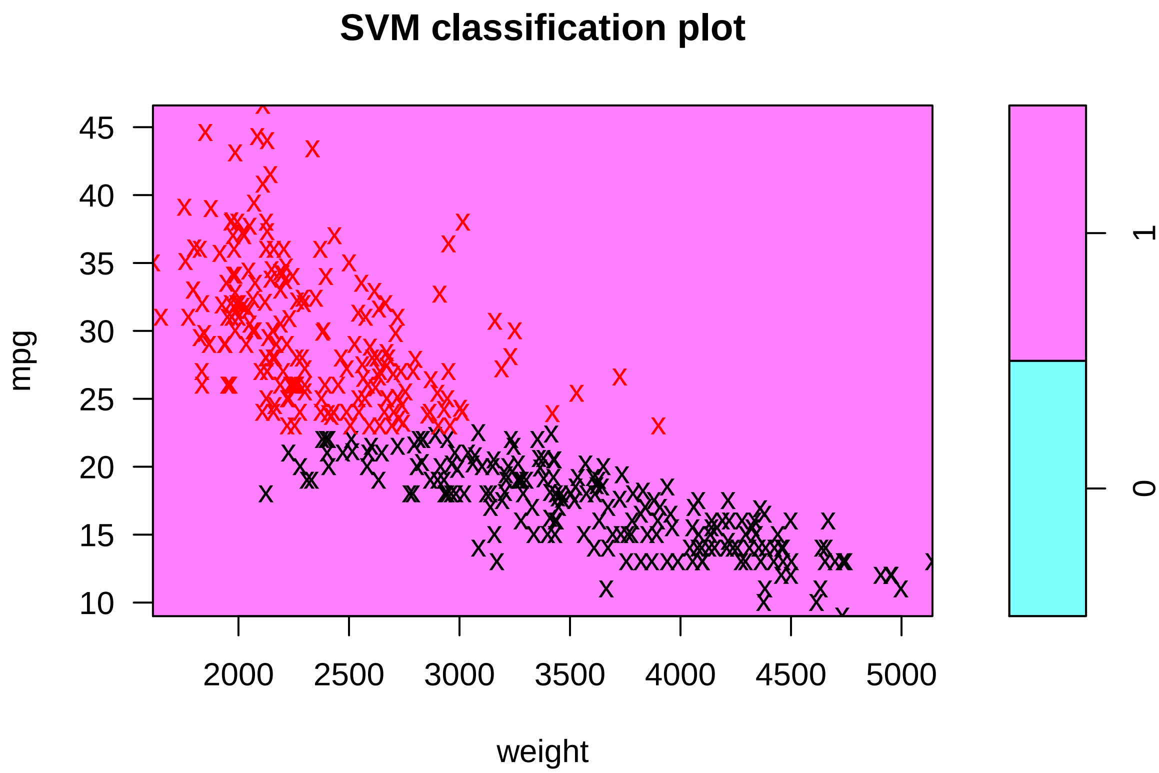

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mpg
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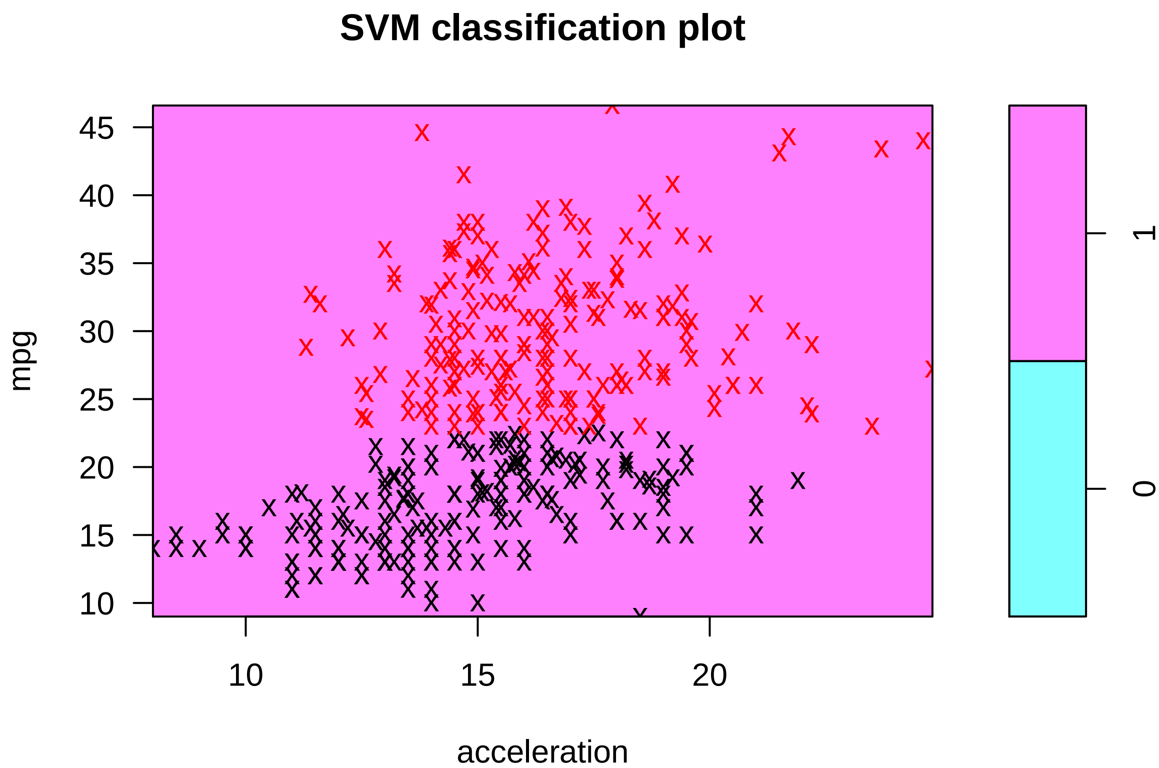
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10
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20
acceleration
1
0

SVM classification plot
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72
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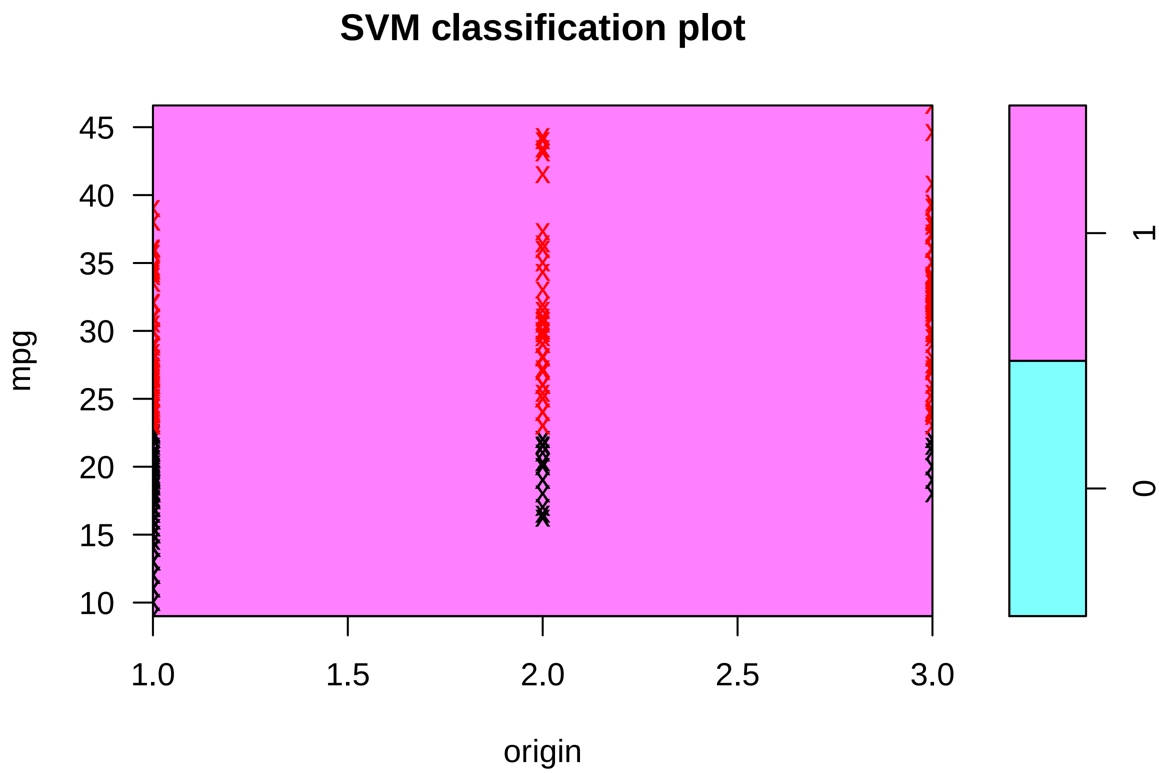
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2.0
2.5
3.0
1
0