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```r
# In this question, we will predict the number of applications received
(Apps) using the other variables in the College data set (ISLR package).


library(ISLR)
library(leaps)
names(College)

##  [1] "Private"    "Apps"       "Accept"     "Enroll"     "Top10perc"
##  [6] "Top25perc"  "F.Undergrad" "P.Undergrad" "Outstate"   "Room.Board"
## [11] "Books"      "Personal"   "PhD"        "Terminal"   "S.F.Ratio"
## [16] "perc.alumni" "Expend"     "Grad.Rate"

dim(College)

## [1] 777  18

bss_fit <- regsubsets(Apps~., data = College, nvmax=17)
bss_summary = summary(bss_fit)

# (a) Perform best subset selection to the data. What is the best model
obtained according to Cp, BIC and adjusted R2? Show some plots to provide
evidence for your answer, and report the coefficients of the best model.


bss_summary$rsq

##  [1] 0.8900990 0.9157839 0.9183356 0.9212640 0.9237599 0.9247464 0.9257649
##  [8] 0.9268725 0.9276780 0.9283103 0.9288011 0.9289945 0.9291223 0.9291632
## [15] 0.9291878 0.9291885 0.9291887

par(mfrow =c(2,2))

#1
plot(bss_summary$cp ,xlab =" Number of Variables ",ylab="Cp", type="l")
points(which.min (bss_summary$cp), bss_summary$cp [which.min
(bss_summary$cp)], col ="red",cex =2, pch =20)

#2
plot(bss_summary$bic ,xlab=" Number of Variables ",ylab=" BIC", type="l")
points (which.min (bss_summary$bic ), bss_summary$bic [which.min
(bss_summary$bic )], col =" red",cex =2, pch =20)

#3
plot(bss_summary$adjr2 ,xlab =" Number of Variables ", ylab=" Adjusted
RSq",type="l")
```

```r
points (which.max(bss_summary$adjr2),
bss_summary$adjr2[which.max(bss_summary$adjr2)], col ="red",cex =2, pch =20)

coef(bss_fit , which.min (bss_summary$bic ))
```

```
##   (Intercept)     PrivateYes        Accept        Enroll      Top10perc
## -100.51668243 -575.07060789    1.58421887   -0.56220848   49.13908916
##     Top25perc       Outstate    Room.Board           PhD         Expend
##  -13.86531103    -0.09466457    0.16373674  -10.01608705    0.07273776
##     Grad.Rate
##     7.33268904
```
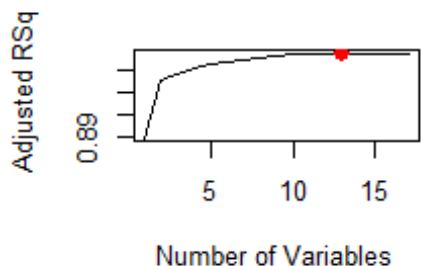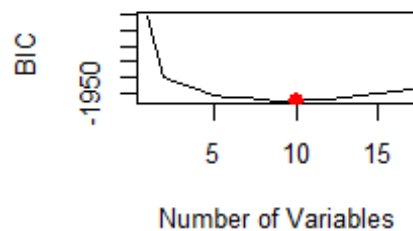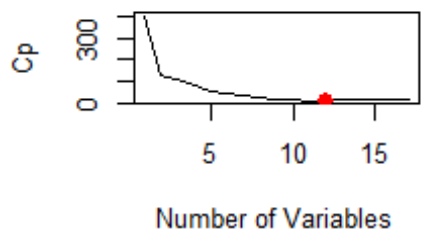


```r
# (b) Repeat (a) using forward stepwise selection and backwards stepwise
selection. How does your answer compare to the results in (a)?

#Forward stepwise selection
for_ss <- regsubsets(Apps~., data = College, nvmax=17, method = "forward")
for_ss_summary = summary(for_ss)

par(mfrow =c(2,2))

#1
plot(for_ss_summary$cp ,xlab =" Number of Variables ",ylab="Cp", type="l")
points(which.min (for_ss_summary$cp), for_ss_summary$cp [which.min
(for_ss_summary$cp)], col ="red",cex =2, pch =20)

#2
```
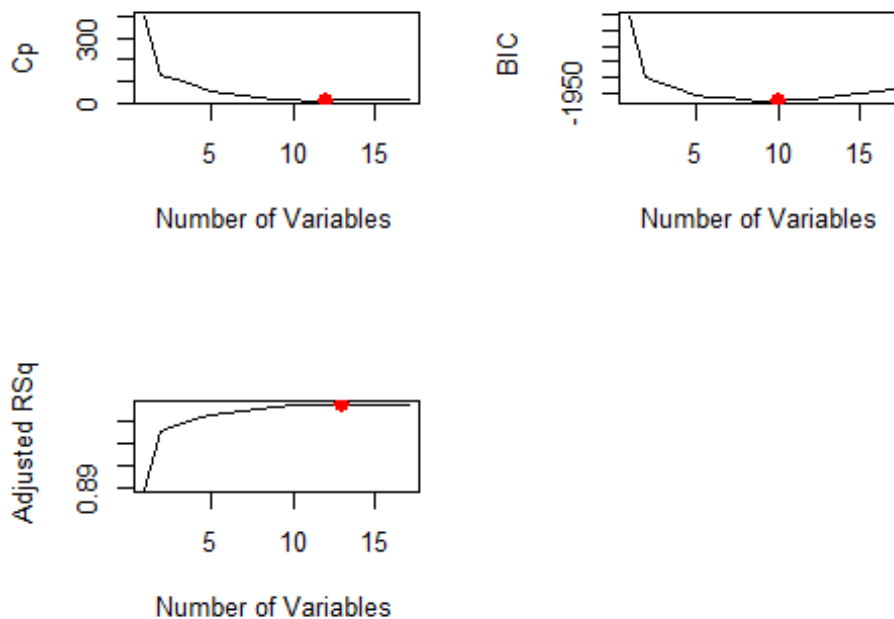
```r
plot(for_ss_summary$bic ,xlab=" Number of Variables ",ylab=" BIC", type="l")
points (which.min (for_ss_summary$bic ), for_ss_summary$bic [which.min
(for_ss_summary$bic )], col =" red",cex =2, pch =20)

#3
plot(for_ss_summary$adjr2 ,xlab =" Number of Variables ", ylab=" Adjusted
RSq",type="l")
points (which.max(for_ss_summary$adjr2),
for_ss_summary$adjr2[which.max(for_ss_summary$adjr2)], col ="red",cex =2, pch
=20)

coef(for_ss , which.min (for_ss_summary$bic ))
```

```
##   (Intercept)     PrivateYes         Accept         Enroll      Top10perc
## -100.51668243 -575.07060789     1.58421887    -0.56220848    49.13908916
##      Top25perc       Outstate     Room.Board            PhD         Expend
##   -13.86531103    -0.09466457     0.16373674   -10.01608705     0.07273776
##      Grad.Rate
##      7.33268904
```



```r
#Backward stepwise selection

back_ss <- regsubsets(Apps~., data = College, nvmax=17, method = "backward")
back_ss_summary = summary(back_ss)

par(mfrow =c(2,2))
```

```
#1
plot(back_ss_summary$cp ,xlab =" Number of Variables ",ylab="Cp", type="l")
points(which.min (back_ss_summary$cp), back_ss_summary$cp [which.min
(back_ss_summary$cp)], col ="red",cex =2, pch =20)

#2
plot(back_ss_summary$bic ,xlab=" Number of Variables ",ylab=" BIC", type="l")
points (which.min (back_ss_summary$bic ), back_ss_summary$bic [which.min
(back_ss_summary$bic )], col =" red",cex =2, pch =20)

#3
plot(back_ss_summary$adjr2 ,xlab =" Number of Variables ", ylab=" Adjusted
RSq",type="l")
points (which.max(back_ss_summary$adjr2),
back_ss_summary$adjr2[which.max(back_ss_summary$adjr2)], col ="red",cex =2,
pch =20)


coef(back_ss , which.min (back_ss_summary$bic ))

##   (Intercept)    PrivateYes         Accept         Enroll      Top10perc
## -100.51668243 -575.07060789     1.58421887    -0.56220848    49.13908916
##      Top25perc      Outstate     Room.Board            PhD         Expend
##  -13.86531103    -0.09466457     0.16373674   -10.01608705     0.07273776
##      Grad.Rate
##     7.33268904
```
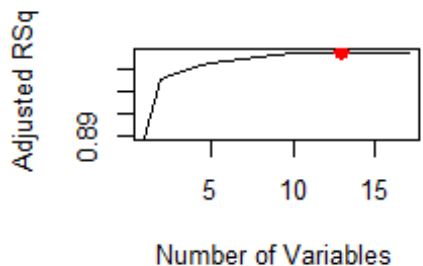

Number of Variables

Number of Variables

Number of Variables
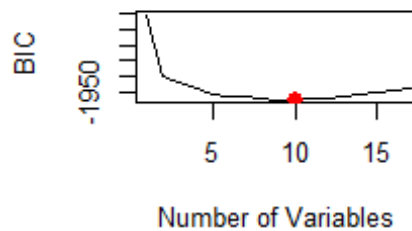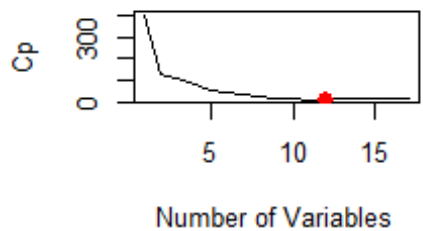
```
# (c) Fit a lasso model on the data. Use cross-validation to select the
optimal value of lambda. Create plots of the cross-validation error as a
function of 𝜆. Report the resulting coefficient estimates.

library(glmnet)

## Loading required package: Matrix

## Loading required package: foreach

## Loaded glmnet 2.0-16

x = model.matrix(Apps~.,College)[,-1]
y = College$Apps
grid = 10^seq (10,-2, length =100)
lasso.mod = glmnet(x,y,alpha =1, lambda =grid)
dim(coef(lasso.mod))

## [1]  18 100

cv.out = cv.glmnet(x,y,alpha =1)
plot(cv.out)
```
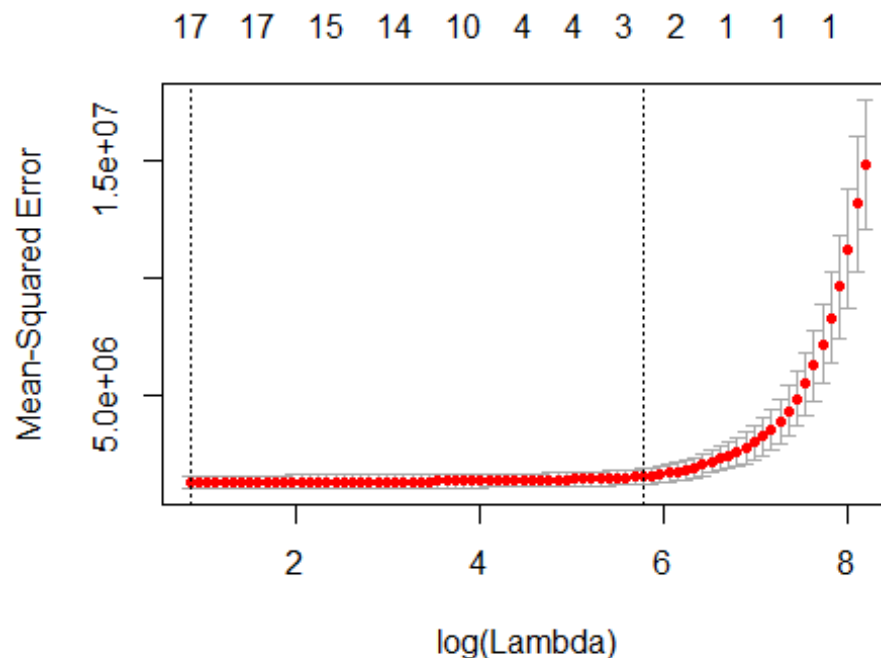


```
bestlam =cv.out$lambda.min
bestlam

## [1] 2.3456
```

```
predict(lasso.mod,s=bestlam,type="coefficients")[1:18,]

##   (Intercept)     PrivateYes         Accept         Enroll      Top10perc
## -471.91198713 -491.00658329     1.56900019    -0.75108809    47.98058884
##      Top25perc    F.Undergrad    P.Undergrad       Outstate     Room.Board
##   -12.73328855     0.04062555     0.04399959    -0.08298682     0.14925171
##          Books       Personal            PhD       Terminal      S.F.Ratio
##     0.01455346     0.02878410    -8.37861131    -3.25247875    14.44887626
##     perc.alumni         Expend      Grad.Rate
##     -0.05217050     0.07703557     8.25050995
```

(d) Fit a ridge regression model on the data. Use cross-validation to
select the optimal value of lambda. Create plots of the cross-validation
error as a function of lambda. Report the resulting coefficient estimates.

```
library(glmnet)
x=model.matrix(Apps~.,College)[,-1]
y=College$Apps
grid =10^seq (10,-2, length =100)
ridge.mod = glmnet(x,y,alpha =0, lambda =grid)
coef(ridge.mod)

## 18 x 100 sparse Matrix of class "dgCMatrix"

##    [[ suppressing 100 column names 's0', 's1', 's2' ... ]]

##
## (Intercept)  3.001624e+03  3.001619e+03  3.001613e+03  3.001605e+03
## PrivateYes  -1.451161e-03 -1.918346e-03 -2.535939e-03 -3.352359e-03
## Accept       5.761598e-07  7.616485e-07  1.006854e-06  1.331001e-06
## Enroll       1.364210e-06  1.803403e-06  2.383992e-06  3.151494e-06
## Top10perc    2.875188e-05  3.800824e-05  5.024462e-05  6.642037e-05
## Top25perc    2.657756e-05  3.513393e-05  4.644496e-05  6.139744e-05
## F.Undergrad  2.513585e-07  3.322809e-07  4.392555e-07  5.806695e-07
## P.Undergrad  3.915797e-07  5.176450e-07  6.842956e-07  9.045976e-07
## Outstate     1.866318e-08  2.467155e-08  3.261432e-08  4.311419e-08
## Room.Board   2.251252e-07  2.976019e-07  3.934120e-07  5.200671e-07
## Books        1.201804e-06  1.588712e-06  2.100182e-06  2.776315e-06
## Personal     3.951405e-07  5.223521e-07  6.905181e-07  9.128232e-07
## PhD          3.581707e-05  4.734801e-05  6.259123e-05  8.274182e-05
## Terminal     3.756761e-05  4.966213e-05  6.565035e-05  8.678579e-05
## S.F.Ratio    3.616432e-05  4.780710e-05  6.319812e-05  8.354411e-05
## perc.alumni -1.089892e-05 -1.440773e-05 -1.904617e-05 -2.517790e-05
## Expend       7.441500e-08  9.837219e-08  1.300422e-07  1.719079e-07
## Grad.Rate    1.278832e-05  1.690539e-05  2.234792e-05  2.954262e-05
##
## (Intercept)  3.001594e+03  3.001580e+03  3.001561e+03  3.001536e+03
## PrivateYes  -4.431617e-03 -5.858329e-03 -7.744351e-03 -1.023755e-02
## Accept       1.759503e-06  2.325957e-06  3.074774e-06  4.064662e-06
## Enroll       4.166086e-06  5.507313e-06  7.280330e-06  9.624145e-06
## Top10perc    8.780372e-05  1.160712e-04  1.534389e-04  2.028367e-04
```

```
## Top25perc     8.116369e-05  1.072934e-04  1.418353e-04  1.874973e-04
## F.Undergrad   7.676100e-07  1.014734e-06  1.341415e-06  1.773268e-06
## P.Undergrad   1.195823e-06  1.580805e-06  2.089726e-06  2.762485e-06
## Outstate      5.699438e-08  7.534314e-08  9.959906e-08  1.316639e-07
## Room.Board    6.874975e-07  9.088300e-07  1.201418e-06  1.588200e-06
## Books         3.670119e-06  4.851673e-06  6.413610e-06  8.478387e-06
## Personal      1.206697e-06  1.595179e-06  2.108726e-06  2.787601e-06
## PhD           1.093796e-04  1.445931e-04  1.911431e-04  2.526790e-04
## Terminal      1.147255e-04  1.516600e-04  2.004851e-04  2.650284e-04
## S.F.Ratio     1.104402e-04  1.459952e-04  1.929967e-04  2.551294e-04
## perc.alumni  -3.328367e-05 -4.399901e-05 -5.816401e-05 -7.688925e-05
## Expend        2.272519e-07  3.004131e-07  3.971276e-07  5.249778e-07
## Grad.Rate     3.905356e-05  5.162644e-05  6.824699e-05  9.021829e-05
##
## (Intercept)   3.001503e+03  3.001460e+03  3.001402e+03  3.001326e+03
## PrivateYes   -1.353340e-02 -1.789027e-02 -2.364975e-02 -3.126334e-02
## Accept        5.373230e-06  7.103069e-06  9.389796e-06  1.241268e-05
## Enroll        1.272251e-05  1.681834e-05  2.223273e-05  2.939015e-05
## Top10perc     2.681372e-04  3.544599e-04  4.685722e-04  6.194198e-04
## Top25perc     2.478594e-04  3.276538e-04  4.331360e-04  5.725749e-04
## F.Undergrad   2.344147e-06  3.098810e-06  4.096420e-06  5.415182e-06
## P.Undergrad   3.651827e-06  4.827473e-06  6.381587e-06  8.435998e-06
## Outstate      1.740515e-07  2.300851e-07  3.041578e-07  4.020766e-07
## Room.Board    2.099501e-06  2.775406e-06  3.668904e-06  4.850042e-06
## Books         1.120788e-05  1.481607e-05  1.958583e-05  2.589105e-05
## Personal      3.685027e-06  4.871357e-06  6.439591e-06  8.512663e-06
## PhD           3.340251e-04  4.415587e-04  5.837096e-04  7.716211e-04
## Terminal      3.503502e-04  4.631391e-04  6.122372e-04  8.093319e-04
## S.F.Ratio     3.372647e-04  4.458416e-04  5.893720e-04  7.791076e-04
## perc.alumni  -1.016428e-04 -1.343654e-04 -1.776223e-04 -2.348049e-04
## Expend        6.939872e-07  9.174057e-07  1.212748e-06  1.603168e-06
## Grad.Rate     1.192629e-04  1.576579e-04  2.084133e-04  2.755082e-04
##
## (Intercept)   3.001226e+03  3.001093e+03  3.000917e+03  3.000685e+03
## PrivateYes   -4.132789e-02 -5.463231e-02 -7.221943e-02 -9.546761e-02
## Accept        1.640870e-05  2.169111e-05  2.867397e-05  3.790460e-05
## Enroll        3.885167e-05  5.135896e-05  6.789237e-05  8.974770e-05
## Top10perc     8.188276e-04  1.082426e-03  1.430876e-03  1.891486e-03
## Top25perc     7.569010e-04  1.000562e-03  1.322656e-03  1.748423e-03
## F.Undergrad   7.158475e-06  9.462948e-06  1.250923e-05  1.653605e-05
## P.Undergrad   1.115175e-05  1.474169e-05  1.948720e-05  2.576015e-05
## Outstate      5.315179e-07  7.026289e-07  9.288227e-07  1.227829e-06
## Room.Board    6.411413e-06  8.475410e-06  1.120382e-05  1.481048e-05
## Books         3.422599e-05  4.524395e-05  5.980845e-05  7.906082e-05
## Personal      1.125307e-05  1.487560e-05  1.966414e-05  2.599393e-05
## PhD           1.020022e-03  1.348383e-03  1.782437e-03  2.356195e-03
## Terminal      1.069872e-03  1.414279e-03  1.869542e-03  2.471334e-03
## S.F.Ratio     1.029921e-03  1.361472e-03  1.799746e-03  2.379089e-03
## perc.alumni  -3.103958e-04 -4.103208e-04 -5.424126e-04 -7.170248e-04
## Expend        2.119270e-06  2.801507e-06  3.703354e-06  4.895487e-06
```

```
## Grad.Rate      3.642021e-04   4.814477e-04   6.364350e-04   8.413111e-04
##
## (Intercept)    3.000378e+03   2.999972e+03   2.999436e+03   2.998728e+03
## PrivateYes    -1.261987e-01  -1.668205e-01  -2.205150e-01  -2.914872e-01
## Accept         5.010642e-05   6.623559e-05   8.755580e-05   1.157371e-04
## Enroll         1.186377e-04   1.568258e-04   2.073038e-04   2.740246e-04
## Top10perc      2.500350e-03   3.305170e-03   4.368985e-03   5.775095e-03
## Top25perc      2.311225e-03   3.055152e-03   4.038464e-03   5.338147e-03
## F.Undergrad    2.185897e-05   2.889502e-05   3.819533e-05   5.048815e-05
## P.Undergrad    3.405202e-05   4.501237e-05   5.949950e-05   7.864750e-05
## Outstate       1.623083e-06   2.145560e-06   2.836199e-06   3.749103e-06
## Room.Board     1.957804e-05   2.588008e-05   3.421030e-05   4.522114e-05
## Books          1.045095e-04   1.381480e-04   1.826106e-04   2.413779e-04
## Personal       3.436086e-05   4.542027e-05   6.003807e-05   7.935833e-05
## PhD            3.114610e-03   4.117083e-03   5.442109e-03   7.193391e-03
## Terminal       3.266802e-03   4.318245e-03   5.707987e-03   7.544785e-03
## S.F.Ratio      3.144893e-03   4.157149e-03   5.495133e-03   7.263589e-03
## perc.alumni   -9.478422e-04  -1.252952e-03  -1.656261e-03  -2.189360e-03
## Expend         6.471320e-06   8.554309e-06   1.130760e-05   1.494678e-05
## Grad.Rate      1.112132e-03   1.470116e-03   1.943308e-03   2.568767e-03
##
## (Intercept)    2.997791e+03   2.996553e+03   2.994917e+03   2.992756e+03
## PrivateYes    -3.852928e-01  -5.092713e-01  -6.731164e-01  -8.896277e-01
## Accept         1.529861e-04   2.022187e-04   2.672862e-04   3.532756e-04
## Enroll         3.622115e-04   4.787650e-04   6.327988e-04   8.363477e-04
## Top10perc      7.633556e-03   1.008975e-02   1.333568e-02   1.762483e-02
## Top25perc      7.055903e-03   9.326068e-03   1.232603e-02   1.628995e-02
## F.Undergrad    6.673569e-05   8.820898e-05   1.165867e-04   1.540852e-04
## P.Undergrad    1.039545e-04   1.373994e-04   1.815948e-04   2.399893e-04
## Outstate       4.955772e-06   6.550676e-06   8.658624e-06   1.144447e-05
## Room.Board     5.977467e-05   7.900985e-05   1.044311e-04   1.380250e-04
## Books          3.190478e-04   4.216934e-04   5.573333e-04   7.365512e-04
## Personal       1.048922e-04   1.386355e-04   1.832228e-04   2.421309e-04
## PhD            9.507918e-03   1.256660e-02   1.660827e-02   2.194811e-02
## Terminal       9.972299e-03   1.318024e-02   1.741903e-02   2.301913e-02
## S.F.Ratio      9.600896e-03   1.268983e-02   1.677172e-02   2.216514e-02
## perc.alumni   -2.893997e-03  -3.825329e-03  -5.056223e-03  -6.682916e-03
## Expend         1.975666e-05   2.611346e-05   3.451403e-05   4.561430e-05
## Grad.Rate      3.395458e-03   4.488071e-03   5.932048e-03   7.840215e-03
##
## (Intercept)    2.989901e+03   2.986129e+03   2.981149e+03   2.974575e+03
## PrivateYes    -1.175699e+00  -1.553617e+00  -2.052764e+00  -2.711842e+00
## Accept         4.669028e-04   6.170317e-04   8.153543e-04   1.077282e-03
## Enroll         1.105296e-03   1.460603e-03   1.929898e-03   2.549582e-03
## Top10perc      2.329173e-02   3.077762e-02   4.066407e-02   5.371687e-02
## Top25perc      2.152679e-02   2.844392e-02   3.757810e-02   4.963573e-02
## F.Undergrad    2.036293e-04   2.690773e-04   3.555148e-04   4.696386e-04
## P.Undergrad    3.171323e-04   4.190218e-04   5.535581e-04   7.311360e-04
## Outstate       1.512592e-05   1.999033e-05   2.641689e-05   3.490560e-05
## Room.Board     1.824143e-04   2.410594e-04   3.185240e-04   4.208216e-04
```

```
## Books        9.733094e-04  1.286015e-03  1.698915e-03  2.243908e-03
## Personal     3.199451e-04  4.227080e-04  5.583750e-04  7.374059e-04
## PhD          2.900181e-02  3.831720e-02  5.061558e-02  6.684535e-02
## Terminal     3.041632e-02  4.018479e-02  5.308040e-02  7.009669e-02
## S.F.Ratio    2.929038e-02  3.870160e-02  5.112883e-02  6.753273e-02
## perc.alumni -8.832477e-03 -1.167262e-02 -1.542458e-02 -2.038004e-02
## Expend       6.027981e-05  7.965214e-05  1.052357e-04  1.390111e-04
## Grad.Rate    1.036150e-02  1.369241e-02  1.809202e-02  2.390169e-02
##
## (Intercept)  2.965902e+03  2.954465e+03  2.939425e+03  2.919615e+03
## PrivateYes  -3.581768e+00 -4.729432e+00 -6.233352e+00 -8.219727e+00
## Accept       1.423113e-03  1.879542e-03  2.479281e-03  3.271232e-03
## Enroll       3.367556e-03  4.446752e-03  5.865580e-03  7.737187e-03
## Top10perc    7.094314e-02  9.366509e-02  1.234633e-01  1.627915e-01
## Top25perc    6.554521e-02  8.652428e-02  1.140658e-01  1.503747e-01
## F.Undergrad  6.202569e-04  8.189357e-04  1.080537e-03  1.425229e-03
## P.Undergrad  9.654103e-04  1.274283e-03  1.680920e-03  2.216118e-03
## Outstate     4.611527e-05  6.091304e-05  8.010652e-05  1.056102e-04
## Room.Board   5.558679e-04  7.340686e-04  9.681769e-04  1.277205e-03
## Books        2.962898e-03  3.910821e-03  5.157797e-03  6.799542e-03
## Personal     9.735283e-04  1.284717e-03  1.694603e-03  2.233476e-03
## PhD          8.825141e-02  1.164640e-01  1.535431e-01  2.023430e-01
## Terminal     9.253728e-02  1.221084e-01  1.610165e-01  2.121783e-01
## S.F.Ratio    8.917556e-02  1.177127e-01  1.554149e-01  2.049711e-01
## perc.alumni -2.692313e-02 -3.555925e-02 -4.699018e-02 -6.203821e-02
## Expend       1.835826e-04  2.423682e-04  3.198170e-04  4.218074e-04
## Grad.Rate    3.157065e-02  4.168924e-02  5.503211e-02  7.261216e-02
##
## (Intercept)  2.893589e+03  2.859464e+03  2.814835e+03  2.756666e+03
## PrivateYes  -1.083054e+01 -1.425580e+01 -1.873878e+01 -2.458760e+01
## Accept       4.313543e-03  5.683450e-03  7.480629e-03  9.832733e-03
## Enroll       1.019896e-02  1.343185e-02  1.766852e-02  2.320551e-02
## Top10perc    2.144716e-01  2.822545e-01  3.709371e-01  4.865871e-01
## Top25perc    1.980678e-01  2.605879e-01  3.423264e-01  4.488189e-01
## F.Undergrad  1.878546e-03  2.473743e-03  3.253545e-03  4.272338e-03
## P.Undergrad  2.919218e-03  3.841059e-03  5.046534e-03  6.617502e-03
## Outstate     1.391149e-04  1.830451e-04  2.404990e-04  3.153944e-04
## Room.Board   1.683756e-03  2.217793e-03  2.917902e-03  3.833352e-03
## Books        8.955991e-03  1.178274e-02  1.547823e-02  2.029249e-02
## Personal     2.940897e-03  3.867519e-03  5.077710e-03  6.652156e-03
## PhD          2.663877e-01  3.502451e-01  4.597107e-01  6.020334e-01
## Terminal     2.793131e-01  3.671995e-01  4.818947e-01  6.309656e-01
## S.F.Ratio    2.701274e-01  3.556459e-01  4.676333e-01  6.138398e-01
## perc.alumni -8.187126e-02 -1.079857e-01 -1.423270e-01 -1.874110e-01
## Expend       5.559164e-04  7.319621e-04  9.625494e-04  1.263709e-03
## Grad.Rate    9.575097e-02  1.261645e-01  1.660685e-01  2.183030e-01
##
## (Intercept)  2.681184e+03  2.583797e+03  2.459083e+03  2.300896e+03
## PrivateYes  -3.218693e+01 -4.200761e+01 -5.461044e+01 -7.063796e+01
## Accept       1.290158e-02  1.688954e-02  2.204524e-02  2.866700e-02
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## Enroll        3.041616e-02   3.976299e-02   5.180667e-02   6.720679e-02
## Top10perc     6.367677e-01   8.307198e-01   1.079430e+00   1.395473e+00
## Top25perc     5.869311e-01   7.649916e-01   9.927957e-01   1.281364e+00
## F.Undergrad   5.598483e-03   7.316479e-03   9.528407e-03   1.235378e-02
## P.Undergrad   8.655572e-03   1.128410e-02   1.464823e-02   1.891113e-02
## Outstate      4.126165e-04   5.381488e-04   6.991516e-04   9.039448e-04
## Room.Board    5.026378e-03   6.574448e-03   8.572188e-03   1.113233e-02
## Books         2.653542e-02   3.458251e-02   4.487442e-02   5.790499e-02
## Personal      8.690125e-03   1.131056e-02   1.465064e-02   1.885968e-02
## PhD           7.861062e-01   1.022544e+00   1.323529e+00   1.702228e+00
## Terminal      8.236776e-01   1.071060e+00   1.385717e+00   1.781174e+00
## S.F.Ratio     8.039645e-01   1.049912e+00   1.365901e+00   1.768257e+00
## perc.alumni  -2.464668e-01  -3.235980e-01  -4.239498e-01  -5.538557e-01
## Expend        1.655575e-03   2.163013e-03   2.816057e-03   3.649908e-03
## Grad.Rate     2.864733e-01   3.750986e-01   4.897532e-01   6.371694e-01
##
## (Intercept)   2.102699e+03   1.858193e+03   1.562357e+03   1.212892e+03
## PrivateYes   -9.078521e+01  -1.157402e+02  -1.460801e+02  -1.821231e+02
## Accept        3.710153e-02   4.773555e-02   6.097600e-02   7.721862e-02
## Enroll        8.670785e-02   1.111015e-01   1.411562e-01   1.775092e-01
## Top10perc     1.792445e+00   2.283925e+00   2.881583e+00   3.592695e+00
## Top25perc     1.642289e+00   2.086509e+00   2.622293e+00   3.252482e+00
## F.Undergrad   1.592648e-02   2.038706e-02   2.586886e-02   3.247677e-02
## P.Undergrad   2.424391e-02   3.080575e-02   3.871160e-02   4.798583e-02
## Outstate      1.161831e-03   1.482801e-03   1.876995e-03   2.354183e-03
## Room.Board    1.438485e-02   1.847328e-02   2.354723e-02   2.975085e-02
## Books         7.418981e-02   9.420610e-02   1.182961e-01   1.465317e-01
## Personal      2.408536e-02   3.044880e-02   3.800512e-02   4.668916e-02
## PhD           2.171534e+00   2.741839e+00   3.417595e+00   4.192702e+00
## Terminal      2.270499e+00   2.863871e+00   3.564872e+00   4.365507e+00
## S.F.Ratio     2.274636e+00   2.902360e+00   3.665465e+00   4.570278e+00
## perc.alumni  -7.209162e-01  -9.339432e-01  -1.202659e+00  -1.537056e+00
## Expend        4.704175e-03   6.020961e-03   7.641498e-03   9.601295e-03
## Grad.Rate     8.252645e-01   1.063036e+00   1.360278e+00   1.727082e+00
##
## (Intercept)   8.119302e+02   3.676396e+02  -1.048738e+02  -5.840186e+02
## PrivateYes   -2.237438e+02  -2.701898e+02  -3.199612e+02  -3.708258e+02
## Accept        9.680577e-02   1.199816e-01   1.468575e-01   1.774035e-01
## Enroll        2.205249e-01   2.701413e-01   3.257407e-01   3.860895e-01
## Top10perc     4.417174e+00   5.344901e+00   6.354404e+00   7.413996e+00
## Top25perc     3.971227e+00   4.760922e+00   5.590446e+00   6.415854e+00
## F.Undergrad   4.025977e-02   4.918130e-02   5.909490e-02   6.973446e-02
## P.Undergrad   5.850527e-02   6.994230e-02   8.172671e-02   9.305006e-02
## Outstate      2.923321e-03   3.592227e-03   4.366961e-03   5.249677e-03
## Room.Board    3.720795e-02   4.600595e-02   5.618143e-02   6.770887e-02
## Books         1.785530e-01   2.134149e-01   2.494996e-01   2.845599e-01
## Personal      5.625145e-02   6.619958e-02   7.577062e-02   8.396591e-02
## PhD           5.045248e+00   5.932914e+00   6.791138e+00   7.536361e+00
## Terminal      5.240559e+00   6.142699e+00   7.000602e+00   7.722594e+00
## S.F.Ratio     5.609676e+00   6.757072e+00   7.962231e+00   9.151880e+00
```

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## perc.alumni -1.946351e+00 -2.437586e+00 -3.014132e+00 -3.674509e+00
## Expend        1.192436e-02  1.461787e-02  1.766922e-02  2.104743e-02
## Grad.Rate     2.173117e+00  2.706728e+00  3.333853e+00  4.056757e+00
##
## (Intercept) -1.043992e+03 -1.458263e+03 -1.804182e+03 -2.066353e+03
## PrivateYes   -4.200536e+02 -4.648071e+02 -5.025740e+02 -5.318671e+02
## Accept        2.114821e-01  2.489066e-01  2.894948e-01  3.332152e-01
## Enroll        4.494218e-01  5.134601e-01  5.757010e-01  6.336451e-01
## Top10perc     8.483925e+00  9.530257e+00  1.052380e+01  1.144745e+01
## Top25perc     7.184314e+00  7.841425e+00  8.337870e+00  8.636505e+00
## F.Undergrad   8.072989e-02  9.162011e-02  1.019144e-01  1.111174e-01
## P.Undergrad   1.029346e-01  1.103401e-01  1.143603e-01  1.143717e-01
## Outstate      6.236439e-03  7.305875e-03  8.407063e-03  9.454535e-03
## Room.Board    8.050435e-02  9.438862e-02  1.091033e-01  1.243056e-01
## Books         3.159534e-01  3.409711e-01  3.573767e-01  3.637870e-01
## Personal      8.965814e-02  9.181531e-02  8.971699e-02  8.312910e-02
## PhD           8.076269e+00  8.323631e+00  8.216664e+00  7.731740e+00
## Terminal      8.207483e+00  8.360791e+00  8.115584e+00  7.447622e+00
## S.F.Ratio     1.023339e+01  1.112056e+01  1.174331e+01  1.205718e+01
## perc.alumni  -4.410776e+00 -5.211799e+00 -6.060334e+00 -6.930192e+00
## Expend        2.470949e-02  2.860713e-02  3.269798e-02  3.694744e-02
## Grad.Rate     4.872354e+00  5.769915e+00  6.729143e+00  7.718258e+00
##
## (Intercept) -2.239443e+03 -2.326351e+03 -2.339483e+03 -2.293252e+03
## PrivateYes   -5.518657e+02 -5.634574e+02 -5.672886e+02 -5.651963e+02
## Accept        3.800196e-01  4.302041e-01  4.838692e-01  5.415447e-01
## Enroll        6.844843e-01  7.257911e-01  7.549247e-01  7.696982e-01
## Top10perc     1.231498e+01  1.314437e+01  1.399350e+01  1.492178e+01
## Top25perc     8.719261e+00  8.579376e+00  8.233177e+00  7.693607e+00
## F.Undergrad   1.187470e-01  1.243525e-01  1.275520e-01  1.279847e-01
## P.Undergrad   1.101826e-01  1.020863e-01  9.089490e-02  7.777716e-02
## Outstate      1.030837e-02  1.077920e-02  1.065072e-02  9.652874e-03
## Room.Board    1.395062e-01  1.541583e-01  1.676565e-01  1.793774e-01
## Books         3.599089e-01  3.465923e-01  3.255758e-01  2.990406e-01
## Personal      7.253859e-02  5.891017e-02  4.376305e-02  2.867105e-02
## PhD           6.894306e+00  5.767155e+00  4.452005e+00  3.046101e+00
## Terminal      6.386378e+00  5.007848e+00  3.424575e+00  1.760167e+00
## S.F.Ratio     1.209978e+01  1.191289e+01  1.163805e+01  1.139402e+01
## perc.alumni  -7.799258e+00 -8.622008e+00 -9.368269e+00 -9.984593e+00
## Expend        4.131960e-02  4.578365e-02  5.027078e-02  5.471620e-02
## Grad.Rate     8.693721e+00  9.606567e+00  1.040288e+01  1.104309e+01
##
## (Intercept) -2.202704e+03 -2.084290e+03 -1.949206e+03 -1.805760e+03
## PrivateYes   -5.606455e+02 -5.533251e+02 -5.465423e+02 -5.407085e+02
## Accept        6.037569e-01  6.707425e-01  7.422987e-01  8.176940e-01
## Enroll        7.673029e-01  7.460597e-01  7.046287e-01  6.449477e-01
## Top10perc     1.596728e+01  1.723459e+01  1.872919e+01  2.048255e+01
## Top25perc     6.972337e+00  6.084209e+00  5.044212e+00  3.869387e+00
## F.Undergrad   1.254490e-01  1.199131e-01  1.117175e-01  1.012262e-01
## P.Undergrad   6.407257e-02  5.125971e-02  4.038183e-02  3.212733e-02
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## Outstate      7.599283e-03  4.210320e-03 -4.361216e-04 -6.268056e-03
## Room.Board    1.889080e-01  1.957722e-01  2.001440e-01  2.022578e-01
## Books         2.696155e-01  2.391602e-01  2.098600e-01  1.827551e-01
## Personal      1.497891e-02  4.003623e-03 -3.891415e-03 -8.631141e-03
## PhD           1.643095e+00  3.111222e-01 -8.959688e-01 -1.964431e+00
## Terminal      1.490101e-01 -1.316956e+00 -2.554886e+00 -3.538636e+00
## S.F.Ratio     1.120432e+01  1.126906e+01  1.145528e+01  1.172025e+01
## perc.alumni -1.039968e+01 -1.060097e+01 -1.052992e+01 -1.017522e+01
## Expend        5.904154e-02  6.315135e-02  6.690717e-02  7.017382e-02
## Grad.Rate     1.150245e+01  1.178011e+01  1.187639e+01  1.180568e+01
##
## (Intercept) -1.660613e+03 -1.517138e+03 -1.378126e+03 -1.246208e+03
## PrivateYes  -5.348672e+02 -5.299185e+02 -5.259011e+02 -5.225365e+02
## Accept       8.963028e-01  9.763456e-01  1.055837e+00  1.132347e+00
## Enroll       5.658504e-01  4.699828e-01  3.594529e-01  2.392115e-01
## Top10perc    2.256065e+01  2.491605e+01  2.748685e+01  3.017251e+01
## Top25perc    2.547772e+00  1.099547e+00 -4.520017e-01 -2.060498e+00
## F.Undergrad  8.924180e-02  7.672094e-02  6.482096e-02  5.441166e-02
## P.Undergrad  2.690040e-02  2.446828e-02  2.434292e-02  2.583796e-02
## Outstate    -1.328091e-02 -2.108063e-02 -2.927710e-02 -3.746180e-02
## Room.Board   2.019966e-01  1.999132e-01  1.964290e-01  1.920703e-01
## Books        1.579315e-01  1.357697e-01  1.162840e-01  9.935594e-02
## Personal    -1.012061e-02 -9.031903e-03 -6.037431e-03 -1.891095e-03
## PhD         -2.913702e+00 -3.755372e+00 -4.506115e+00 -5.176592e+00
## Terminal    -4.251564e+00 -4.706505e+00 -4.934534e+00 -4.983937e+00
## S.F.Ratio    1.220338e+01  1.276267e+01  1.333607e+01  1.386374e+01
## perc.alumni -9.602712e+00 -8.838767e+00 -7.939901e+00 -6.967000e+00
## Expend       7.294585e-02  7.515295e-02  7.680655e-02  7.795251e-02
## Grad.Rate    1.162342e+01  1.135576e+01  1.104009e+01  1.070623e+01
##
## (Intercept) -1.123888e+03 -1.012783e+03 -913.94835456 -826.99736562
## PrivateYes  -5.195540e+02 -5.167427e+02 -514.02650361 -511.46633915
## Accept       1.203749e+00  1.268440e+00    1.32554820    1.37516661
## Enroll       1.131081e-01 -1.298535e-02   -0.13479022   -0.24930224
## Top10perc    3.285961e+01  3.544319e+01   37.83907977   40.00784506
## Top25perc   -3.672347e+00 -5.228199e+00   -6.67978792   -8.00010082
## F.Undergrad  4.631037e-02  4.062809e-02    0.03728163    0.03586360
## P.Undergrad  2.826309e-02  3.103741e-02    0.03375669    0.03620796
## Outstate    -4.526283e-02 -5.239849e-02   -0.05869930   -0.06411550
## Room.Board   1.872442e-01  1.823499e-01    0.17764696    0.17327607
## Books        8.485524e-02  7.253803e-02    0.06219630    0.05355615
## Personal     2.759499e-03  7.404768e-03    0.01171931    0.01556643
## PhD         -5.771209e+00 -6.294093e+00   -6.74729818   -7.13727588
## Terminal    -4.905766e+00 -4.749943e+00   -4.55665726   -4.35364685
## S.F.Ratio    1.432001e+01  1.468453e+01   14.95828735   15.14733557
## perc.alumni -5.983495e+00 -5.038068e+00   -4.16612125   -3.38214013
## Expend       7.868238e-02  7.907562e-02    0.07922345    0.07918792
## Grad.Rate    1.038301e+01  1.008311e+01    9.81592001    9.58026314
##
## (Intercept) -753.28822577 -692.11373494 -640.86788169 -599.03612139
```

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## PrivateYes   -508.95287354 -506.54977167 -504.41689891 -502.53082427
## Accept          1.41686360    1.45118499    1.47959696    1.50259631
## Enroll         -0.35373409   -0.44604226   -0.52706158   -0.59621253
## Top10perc      41.88632597   43.46814236   44.80196206   45.89581751
## Top25perc      -9.15553164  -10.13809652  -10.97066941  -11.65784920
## F.Undergrad     0.03616475    0.03760631    0.03968098    0.04205273
## P.Undergrad     0.03823363    0.03982386    0.04106082    0.04198650
## Outstate       -0.06863348   -0.07232103   -0.07530760   -0.07768552
## Room.Board      0.16938050    0.16601715    0.16311030    0.16067042
## Books           0.04655094    0.04095334    0.03644576    0.03288578
## Personal        0.01879932    0.02142721    0.02358055    0.02529262
## PhD            -7.45949941   -7.72008191   -7.93307674   -8.10262469
## Terminal       -4.16370623   -3.99761613   -3.85556809   -3.73904265
## S.F.Ratio      15.27689427   15.36155302   15.40751864   15.43027045
## perc.alumni    -2.70716550   -2.14083469   -1.66401003   -1.27310742
## Expend          0.07907971    0.07894462    0.07877944    0.07862053
## Grad.Rate       9.38772754    9.23438255    9.10753698    9.00682496
##
## (Intercept)  -565.93241041 -539.61642150 -518.83668369 -503.09448370
## PrivateYes   -500.87592417 -499.48621216 -498.34469883 -497.40998332
## Accept          1.52071649    1.53504316    1.54630392    1.55483604
## Enroll         -0.65317376   -0.69987628   -0.73770495   -0.76699616
## Top10perc      46.76519645   47.45697849   48.00307048   48.41749265
## Top25perc     -12.20824480  -12.64839655  -12.99727434  -13.26405131
## F.Undergrad     0.04440861    0.04659999    0.04854416    0.05014443
## P.Undergrad     0.04265623    0.04314293    0.04349538    0.04374464
## Outstate       -0.07954675   -0.08099957   -0.08212718   -0.08298876
## Room.Board      0.15869563    0.15709570    0.15581189    0.15483153
## Books           0.03013345    0.02799823    0.02634917    0.02511358
## Personal        0.02660925    0.02763117    0.02842147    0.02900635
## PhD            -8.23365331   -8.33556080   -8.41443219   -8.47301799
## Terminal       -3.64701175   -3.57464094   -3.51831111   -3.47619076
## S.F.Ratio      15.44156191   15.44420669   15.44192424   15.43959147
## perc.alumni    -0.96224314   -0.71441463   -0.51828778   -0.36857065
## Expend          0.07849033    0.07837943    0.07828706    0.07822280
## Grad.Rate       8.93045478    8.87125786    8.82547563    8.79248754
##
## (Intercept)  -491.02115481 -481.25296842 -474.09675513 -468.37823221
## PrivateYes   -496.69865637 -496.15524903 -495.78686337 -495.46990089
## Accept          1.56134911    1.56657487    1.57037976    1.57342391
## Enroll         -0.78972459   -0.80827042   -0.82190613   -0.83293277
## Top10perc      48.73383014   48.98870976   49.17293410   49.32167492
## Top25perc     -13.46893193  -13.63322040  -13.75355389  -13.84963169
## F.Undergrad     0.05144140    0.05254153    0.05337216    0.05405741
## P.Undergrad     0.04392375    0.04405842    0.04415063    0.04422150
## Outstate       -0.08364474   -0.08415210   -0.08452506   -0.08481543
## Room.Board      0.15408038    0.15346445    0.15302332    0.15266006
## Books           0.02418557    0.02344931    0.02292695    0.02250281
## Personal        0.02944411    0.02979663    0.03004294    0.03024412
## PhD            -8.51723703   -8.55291705   -8.57846765   -8.59908438
```

```
## Terminal       -3.44448941    -3.41901063    -3.40094464    -3.38619805
## S.F.Ratio       15.43471108    15.42775084    15.41933783    15.41385709
## perc.alumni     -0.25298023    -0.16035411    -0.09148242    -0.03745197
## Expend           0.07817436     0.07812618     0.07809507     0.07806537
## Grad.Rate        8.76788370     8.74712195     8.73272168     8.72061765
##
## (Intercept) -463.91980972 -461.02111173 -458.34025487 -456.44652837
## PrivateYes  -495.23105966 -495.11642787 -494.93282045 -494.81566173
## Accept         1.57578864     1.57730842     1.57874959     1.57976411
## Enroll        -0.84158303    -0.84714316    -0.85245946    -0.85622367
## Top10perc     49.43730296    49.51060748    49.58148153    49.63148611
## Top25perc    -13.92421114   -13.97241791   -14.01806211   -14.05006991
## F.Undergrad    0.05460602     0.05496090     0.05530371     0.05554883
## P.Undergrad    0.04427393     0.04430365     0.04433646     0.04435735
## Outstate      -0.08503650    -0.08517874    -0.08531769    -0.08541079
## Room.Board     0.15237501     0.15220337     0.15202450     0.15190020
## Books          0.02217631     0.02196800     0.02176842     0.02162334
## Personal       0.03040016     0.03049064     0.03058891     0.03065658
## PhD           -8.61505414    -8.62524452    -8.63477946    -8.64159239
## Terminal      -3.37481733    -3.36763436    -3.36077039    -3.35585393
## S.F.Ratio     15.40887244    15.40299688    15.40200143    15.40084137
## perc.alumni    0.00448985     0.03192099     0.05740087     0.07492396
## Expend         0.07804044     0.07802653     0.07801279     0.07800149
## Grad.Rate      8.71102185     8.70498909     8.69950463     8.69529939
##
## (Intercept) -455.20105116 -453.98456323 -452.86297188 -451.84835886
## PrivateYes  -494.74972770 -494.67935924 -494.59702893 -494.51499270
## Accept         1.58042733     1.58107161     1.58167350     1.58222178
## Enroll        -0.85868268    -0.86108039    -0.86334136    -0.86542543
## Top10perc     49.66388915    49.69546400    49.72537149    49.75293930
## Top25perc    -14.07104685   -14.09143941   -14.11038988   -14.12750748
## F.Undergrad    0.05570944     0.05586697     0.05601734     0.05615822
## P.Undergrad    0.04437017     0.04438371     0.04439723     0.04440950
## Outstate      -0.08547123    -0.08553156    -0.08558732    -0.08563580
## Room.Board     0.15182225     0.15174238     0.15166282     0.15158682
## Books          0.02152805     0.02144149     0.02136005     0.02128466
## Personal       0.03069906     0.03074167     0.03078510     0.03082703
## PhD           -8.64605668    -8.65033865    -8.65432575    -8.65797767
## Terminal      -3.35268272    -3.34962934    -3.34675317    -3.34409686
## S.F.Ratio     15.39928193    15.39797135    15.39783801    15.39831030
## perc.alumni    0.08653536     0.09804528     0.10855891     0.11783496
## Expend         0.07799458     0.07798773     0.07798042     0.07797237
## Grad.Rate      8.69255472     8.69002005     8.68759740     8.68521947
##
## (Intercept) -450.93718935 -450.12509864 -449.40828988 -448.78203801
## PrivateYes  -494.44372716 -494.38698125 -494.34369837 -494.31092043
## Accept         1.58271243     1.58314568     1.58352431     1.58385256
## Enroll        -0.86731493    -0.86900691    -0.87050793    -0.87183019
## Top10perc     49.77774680    49.79963953    49.81867734    49.83505781
## Top25perc    -14.14268361   -14.15596655   -14.16748474   -14.17740294
```

```
## F.Undergrad      0.05628848     0.05640780     0.05651630     0.05661440
## P.Undergrad      0.04441994     0.04442850     0.04443533     0.04444067
## Outstate        -0.08567637    -0.08570968    -0.08573690    -0.08575920
## Room.Board       0.15151662     0.15145333     0.15139718     0.15134787
## Books            0.02121738     0.02115933     0.02111048     0.02107003
## Personal         0.03086568     0.03090023     0.03093052     0.03095675
## PhD             -8.66127163    -8.66418687    -8.66671380    -8.66886205
## Terminal        -3.34170848    -3.33962422    -3.33785463    -3.33638505
## S.F.Ratio       15.39869727    15.39869024    15.39829058    15.39762940
## perc.alumni      0.12596523     0.13310284     0.13936925     0.14485142
## Expend           0.07796379     0.07795514     0.07794689     0.07793936
## Grad.Rate        8.68290574     8.68071987     8.67872326     8.67695243
##
## (Intercept)  -448.23991308  -447.77403369  -447.37579398  -447.03658576
## PrivateYes   -494.28566020  -494.26563405  -494.24931729  -494.23574722
## Accept          1.58413542     1.58437807     1.58458556     1.58476260
## Enroll         -0.87298890    -0.87400038    -0.87488088    -0.87564584
## Top10perc      49.84904766    49.86093457    49.87099879    49.87949892
## Top25perc     -14.18589778   -14.19314405   -14.19930682   -14.20453726
## F.Undergrad     0.05670268     0.05678179     0.05685247     0.05691543
## P.Undergrad     0.04444476     0.04444782     0.04445003     0.04445156
## Outstate       -0.08577755    -0.08579271    -0.08580527    -0.08581569
## Room.Board      0.15130484     0.15126744     0.15123502     0.15120696
## Books           0.02103687     0.02100986     0.02098793     0.02097018
## Personal        0.03097926     0.03099848     0.03101481     0.03102865
## PhD            -8.67065946    -8.67214544    -8.67336362    -8.67435648
## Terminal       -3.33518427    -3.33421412    -3.33343638    -3.33281648
## S.F.Ratio      15.39684653    15.39604270    15.39527541    15.39457095
## perc.alumni     0.14962049     0.15374478     0.15729384     0.16033700
## Expend          0.07793270     0.07792694     0.07792202     0.07791786
## Grad.Rate       8.67541692     8.67410665     8.67300081     8.67207451
##
## (Intercept)  -446.74830401  -446.50361548  -446.29605124  -446.11999448
## PrivateYes   -494.22430860  -494.21458243  -494.20626019  -494.19910151
## Accept          1.58491344     1.58504187     1.58515120     1.58524428
## Enroll         -0.87630955    -0.87688492    -0.87738348    -0.87781541
## Top10perc      49.88666627    49.89270385    49.89778753    49.90206822
## Top25perc     -14.20897065   -14.21272600   -14.21590665   -14.21860143
## F.Undergrad     0.05697139     0.05702103     0.05706499     0.05710387
## P.Undergrad     0.04445255     0.04445312     0.04445338     0.04445340
## Outstate       -0.08582434    -0.08583154    -0.08583752    -0.08584251
## Room.Board      0.15118272     0.15116179     0.15114373     0.15112815
## Books           0.02095584     0.02094428     0.02093498     0.02092752
## Personal        0.03104034     0.03105021     0.03105852     0.03106553
## PhD            -8.67516240    -8.67581455    -8.67634098    -8.67676502
## Terminal       -3.33232477    -3.33193652    -3.33163139    -3.33139275
## S.F.Ratio      15.39393765    15.39337506    15.39287905    15.39244418
## perc.alumni     0.16294053     0.16516527     0.16706547     0.16868856
## Expend          0.07791437     0.07791146     0.07790904     0.07790702
## Grad.Rate       8.67130271     8.67066221     8.67013233     8.66969506
```

```
cv.out = cv.glmnet(x,y,alpha =0)
plot(cv.out)
```
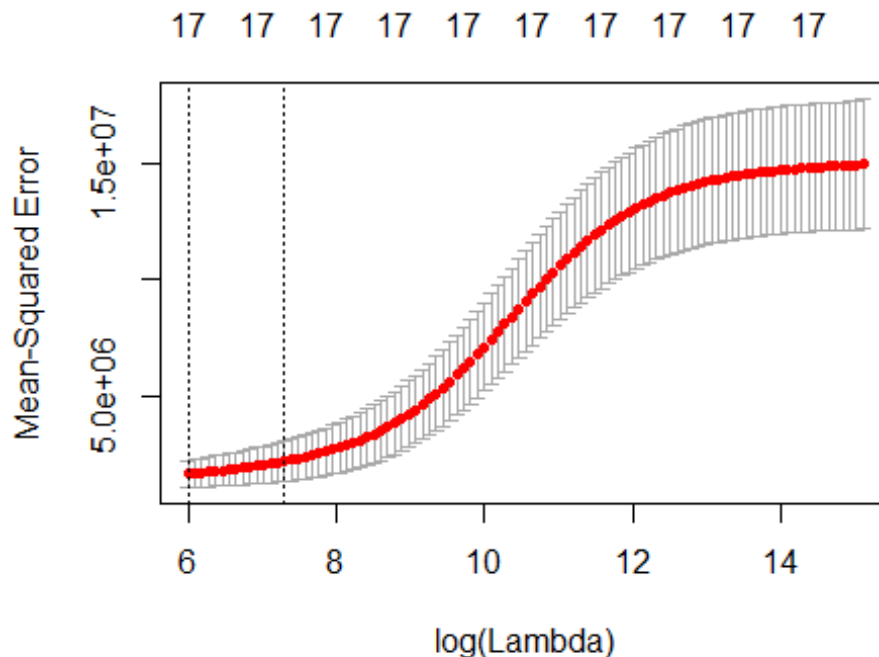


```
bestlam =cv.out$lambda.min
bestlam
```

```
## [1] 400.4766
```

```
predict(ridge.mod,s=bestlam,type="coefficients")[1:18,]
```

```
##    (Intercept)      PrivateYes          Accept          Enroll      Top10perc
## -1.512577e+03 -5.297867e+02  9.789533e-01  4.663570e-01  2.500038e+01
##        Top25perc     F.Undergrad     P.Undergrad        Outstate      Room.Board
##   1.048650e+00  7.633057e-02  2.446417e-02 -2.134950e-02  1.997989e-01
##        Books         Personal             PhD        Terminal        S.F.Ratio
##   1.351305e-01 -8.933673e-03 -3.779999e+00 -4.713986e+00  1.278148e+01
##    perc.alumni          Expend        Grad.Rate
## -8.809281e+00  7.520720e-02  1.134540e+01
```

```
# (e) Now split the data set into a training set and a test set.
# i. Fit the best models obtained in the best subset selection (according to
Cp, BIC or adjusted R2) to the training set, and report the test error
obtained.

set.seed(1)
train= sample(c(TRUE,FALSE), nrow(College), rep=TRUE)
test=(!train)
```

```r
regfit.best = regsubsets(Apps~., data=College[train,], nvmax=18)
regfit.summary = summary(regfit.best)

par(mfrow =c(2,2))

#1
plot(regfit.summary$cp ,xlab =" Number of Variables ",ylab="Cp", type="l")
points(which.min (regfit.summary$cp), regfit.summary$cp [which.min
(regfit.summary$cp)], col ="red",cex =2, pch =20)

#2
plot(regfit.summary$bic ,xlab=" Number of Variables ",ylab=" BIC", type="l")
points (which.min (regfit.summary$bic ), regfit.summary$bic [which.min
(regfit.summary$bic )], col =" red",cex =2, pch =20)

#3
plot(regfit.summary$adjr2 ,xlab =" Number of Variables ", ylab=" Adjusted
RSq",type="l")
points (which.max(regfit.summary$adjr2),
regfit.summary$adjr2[which.max(regfit.summary$adjr2)], col ="red",cex =2, pch
=20)

#building an "X" matrix from test data
test.mat = model.matrix(Apps~.,data=College[test,])

coefi=coef(regfit.best,id=which.min (regfit.summary$bic))
pred=test.mat[,names(coefi)]%*%coefi
mean((College$Apps[test]-pred)^2)

## [1] 1635683
```
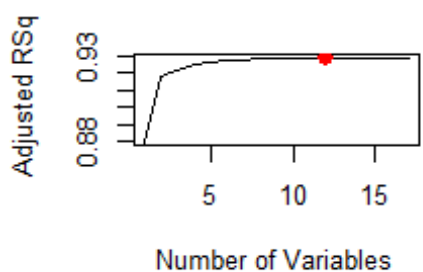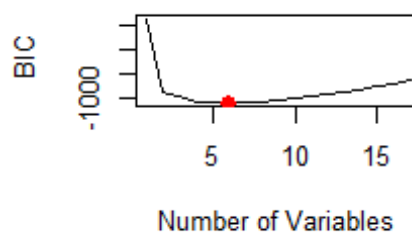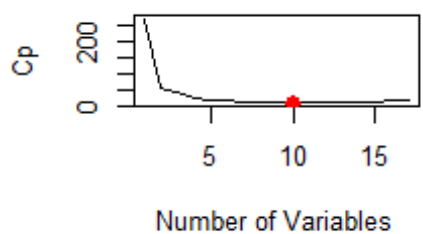
```
# ii. Fit a lasso model to the training set, with lambda chosen by cross
validation. Report the test error obtained.

library(glmnet)
set.seed (1)
lasso.mod =glmnet (x[train ,],y[train],alpha =1, lambda =grid)
cv.out =cv.glmnet (x[train ,],y[train],alpha =1)
bestlam = cv.out$lambda.min
lasso.pred = predict (lasso.mod ,s=bestlam ,newx=x[test ,])
mean(( lasso.pred - y[test])^2)

## [1] 1612366

# iii. Fit a ridge regression model to the training set, with λ chosen by
cross validation. Report the test error obtained.

ridge.mod = glmnet(x[train,], y[train],alpha =0, lambda =grid)
ridge.pred = predict(ridge.mod ,s=4 , newx = x[test ,])
mean(( ridge.pred -y[test])^2)

## [1] 1547703

# iv. Compare the test errors obtained in the above analysis (i-iii) and
determine the optimal model.

# The following are the test errors for the above three models :
# best subset selection - 1635683
```

```
# lasso model - 1612366
# ridge model - 1547703
# Ridge regression model is the optimal model.

# In the lab, a classification tree was applied to the Carseats data set
after converting Sales into a binary response variable. This question will
seek to predict Sales using regression trees and related approaches, treating
the response as a quantitative variable (that is, without the conversion).
# (a) Split the data set into a training set and a test set.

library(ISLR)
set.seed(1)
train <- sample(1:nrow(Carseats), nrow(Carseats) / 2)
Carseats_train <- Carseats[train, ]
Carseats_test <- Carseats[-train, ]

# (b) Fit a regression tree to the training set. Plot the tree, and interpret
the results. Then compute the test MSE.

library(tree)
tree_carseats <- tree(Sales ~ ., data = Carseats_train)
summary(tree_carseats)

##
## Regression tree:
## tree(formula = Sales ~ ., data = Carseats_train)
## Variables actually used in tree construction:
## [1] "ShelveLoc"   "Price"         "Age"           "Advertising" "Income"
## [6] "CompPrice"
## Number of terminal nodes:  18
## Residual mean deviance:  2.36 = 429.5 / 182
## Distribution of residuals:
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -4.2570 -1.0360  0.1024  0.0000  0.9301  3.9130

plot(tree_carseats)
text(tree_carseats, pretty = 0)
```
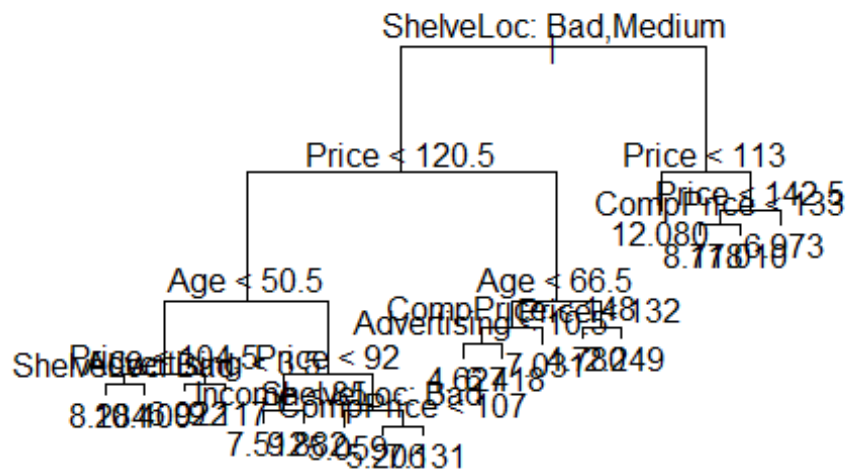
```r
yhat <- predict(tree_carseats, Carseats_test)
mean((yhat - Carseats_test$Sales)^2)

## [1] 4.148897
```
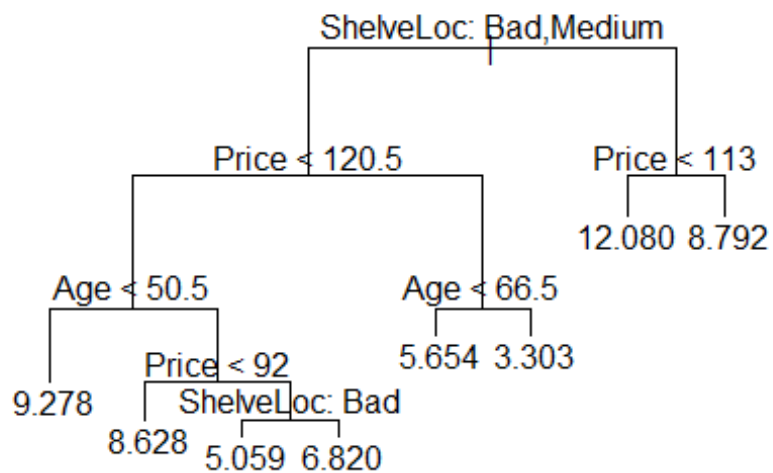
(c) Prune the tree obtained in (b). Use cross validation to determine the optimal level of tree complexity. Plot the pruned tree and interpret the results. Compute the test MSE of the pruned tree. Does pruning improve the test error?

```r
cv_carseats <- cv.tree(tree_carseats)
plot(cv_carseats$size, cv_carseats$dev, type = "b")
tree_min <- which.min(cv_carseats$dev)
points(tree_min, cv_carseats$dev[tree_min], col = "red", cex = 2, pch = 20)
```
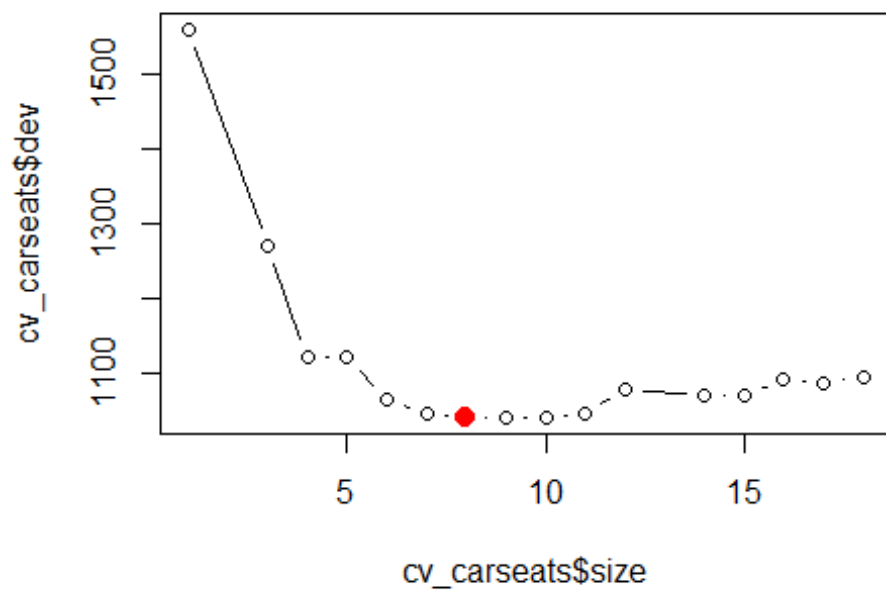
```
prune_carseats <- prune.tree(tree_carseats, best = 8)
plot(prune_carseats)
text(prune_carseats, pretty = 0)
```

```r
library(randomForest)
```

```
## randomForest 4.6-14
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```r
bag.carseats <- randomForest(Sales ~ ., data = Carseats_train, mtry = 10,
ntree = 500)
yhat.bag <- predict(bag.carseats, newdata = Carseats_test)
mean((yhat.bag - Carseats_test$Sales)^2)
```

```
## [1] 2.553118
```

```r
importance(bag.carseats)
```

```
##              IncNodePurity
## CompPrice       130.725006
## Income           77.495031
## Advertising     124.129450
## Population       62.078103
## Price           505.500563
## ShelveLoc       325.698430
## Age             192.250330
## Education        40.007558
## Urban             8.741943
## US               14.682941
```

```r
# We may conclude that "Price" and "ShelveLoc" are the two most important
variables.
```

```r
# (e) Use random forests to analyze the data. What test MSE do you obtain?
Determine which variables are most important.
```

```r
rf.carseats <- randomForest(Sales ~ ., data = Carseats_train, mtry = 3, ntree
= 500, importance = TRUE)
yhat.rf <- predict(rf.carseats, newdata = Carseats_test)
mean((yhat.rf - Carseats_test$Sales)^2)
```

```
## [1] 3.286144
```

```r
importance(rf.carseats)
```

```
##                %IncMSE IncNodePurity
## CompPrice     8.3370363     129.69721
## Income        4.0540506     127.70485
## Advertising  11.9343057     139.03662
## Population    0.6266783      97.93305
## Price        38.4595875     388.45041
## ShelveLoc    29.8867032     234.02006
```

```
## Age          18.1019639     197.17165
## Education     2.3638614       63.07024
## Urban        -0.5623597       15.93606
## US            6.2576901       32.71135
```

We may conclude that, in this case also, "Price" and "ShelveLoc" are the two most important variables.

```r
library (MASS)
library (randomForest)
set.seed (100)
train = sample (1: nrow(Boston), nrow(Boston )/2)
x_train = Boston[train, -14]
x_test = Boston[-train, -14]
y_train = Boston[train, 14]
y_test = Boston[-train, 14]
test_error1 = rep(0,13)

for (i in 1:13){
bag.boston = randomForest(x_train, y_train, mtry= i, ntree =100, importance
=TRUE)
yhat.bag = predict(bag.boston, newdata = Boston[-train,])
test_error1[i] = mean(( yhat.bag - y_test)^2)
}

test_error1
```

```
##  [1] 18.611813 10.282254  9.624311  8.896569  8.990730  9.052735  9.084105
##  [8]  9.429814 10.228730  9.661823  9.908464 10.251536  9.673689
```

```r
mtry = 1:13
plot(mtry, test_error1, xlab =" mtry ", ylab=" error rate",type="l")
```
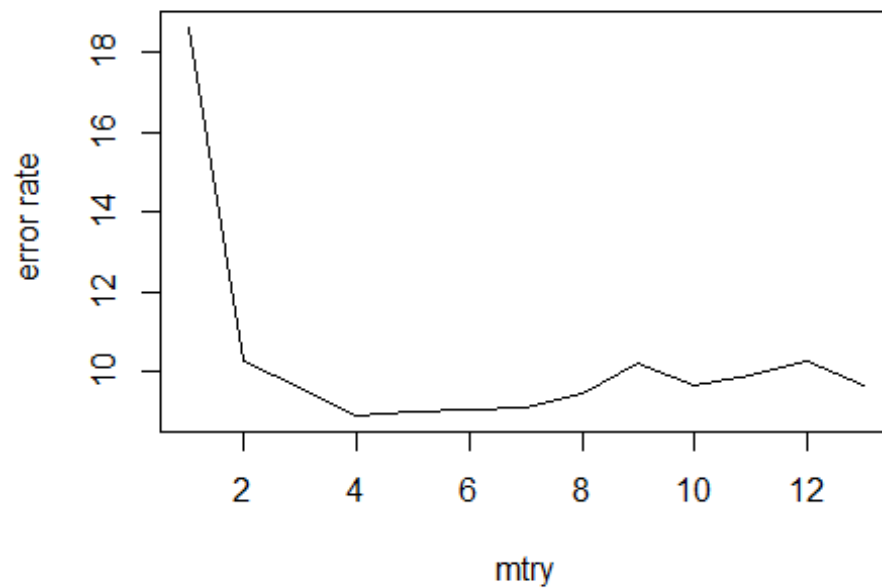
```r
test_error2 = rep(0,196)
for (i in 5:200){
bag.boston = randomForest(medv~., data=Boston[train,] , mtry= 6, ntree = i ,
importance =TRUE)
yhat.bag = predict (bag.boston, newdata = Boston[-train,])
test_error2[i-4] = mean(( yhat.bag - y_test)^2)
}

ntree = 5:200
plot(ntree, test_error2, xlab = " ntree ", ylab=" error rate",type="l")
```