Chapter 9

```
library(knitr)
Surgical.Unit <- read.csv("/cloud/project/Surgical Unit.csv")

#backward elimination
model<-lm(lnY ~X1+X2+X3+X4+X5+X6+X7+X8,data =Surgical.Unit)
summary(model)
```

```
##
## Call:
## lm(formula = lnY ~ X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8, data = Surgical.Unit)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.35562 -0.13833 -0.05158  0.14949  0.46472
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.050515   0.251756  16.089  < 2e-16 ***
## X1           0.068512   0.025422   2.695  0.00986 **
## X2           0.013452   0.001947   6.909 1.39e-08 ***
## X3           0.014954   0.001809   8.264 1.43e-10 ***
## X4           0.008016   0.046708   0.172  0.86450
## X5          -0.003566   0.002752  -1.296  0.20163
## X6           0.084208   0.060750   1.386  0.17253
## X7           0.057864   0.067483   0.857  0.39574
## X8           0.388383   0.088380   4.394 6.69e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2093 on 45 degrees of freedom
## Multiple R-squared:  0.8461, Adjusted R-squared:  0.8188
## F-statistic: 30.93 on 8 and 45 DF,  p-value: 7.8e-16
```

```
model<-update(model,.~.-X4)
summary(model)
```

```
##
## Call:
## lm(formula = lnY ~ X1 + X2 + X3 + X5 + X6 + X7 + X8, data = Surgical.Unit)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.3606 -0.1312 -0.0506  0.1496  0.4682
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.036782   0.236169  17.093  < 2e-16 ***
```

```
## X1           0.071434   0.018682   3.824 0.000394 ***
## X2           0.013601   0.001722   7.896 4.21e-10 ***
## X3           0.015150   0.001389  10.906 2.41e-14 ***
## X5          -0.003709   0.002595  -1.429 0.159653
## X6           0.087042   0.057842   1.505 0.139202
## X7           0.058624   0.066624   0.880 0.383473
## X8           0.388002   0.087415   4.439 5.62e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2071 on 46 degrees of freedom
## Multiple R-squared:  0.846,  Adjusted R-squared:  0.8226
## F-statistic: 36.11 on 7 and 46 DF,  p-value: < 2.2e-16
```

```
model<-update(model,.~.-X7)
summary(model)
```

```
##
## Call:
## lm(formula = lnY ~ X1 + X2 + X3 + X5 + X6 + X8, data = Surgical.Unit)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.34608 -0.13506 -0.02851  0.13239  0.48733
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.053974   0.234794  17.266  < 2e-16 ***
## X1           0.071517   0.018637   3.837  0.00037 ***
## X2           0.013755   0.001709   8.047 2.17e-10 ***
## X3           0.015116   0.001385  10.912 1.78e-14 ***
## X5          -0.003450   0.002572  -1.342  0.18620
## X6           0.087317   0.057702   1.513  0.13691
## X8           0.350904   0.076391   4.594 3.28e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2066 on 47 degrees of freedom
## Multiple R-squared:  0.8434, Adjusted R-squared:  0.8234
## F-statistic:  42.2 on 6 and 47 DF,  p-value: < 2.2e-16
```

```
model<-update(model,.~.-X5)
summary(model)
```

```
##
## Call:
## lm(formula = lnY ~ X1 + X2 + X3 + X6 + X8, data = Surgical.Unit)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.40657 -0.13030 -0.02359  0.14138  0.54064
```

```
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 3.867095   0.190572  20.292  < 2e-16 ***
## X1          0.071241   0.018791   3.791 0.000419 ***
## X2          0.013890   0.001721   8.073 1.71e-10 ***
## X3          0.015115   0.001397  10.821 1.80e-14 ***
## X6          0.086910   0.058180   1.494 0.141768
## X8          0.362677   0.076515   4.740 1.94e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2083 on 48 degrees of freedom
## Multiple R-squared:  0.8374, Adjusted R-squared:  0.8205
## F-statistic: 49.46 on 5 and 48 DF,  p-value: < 2.2e-16
```

```
model<-update(model,.~.-X6)
summary(model)
```

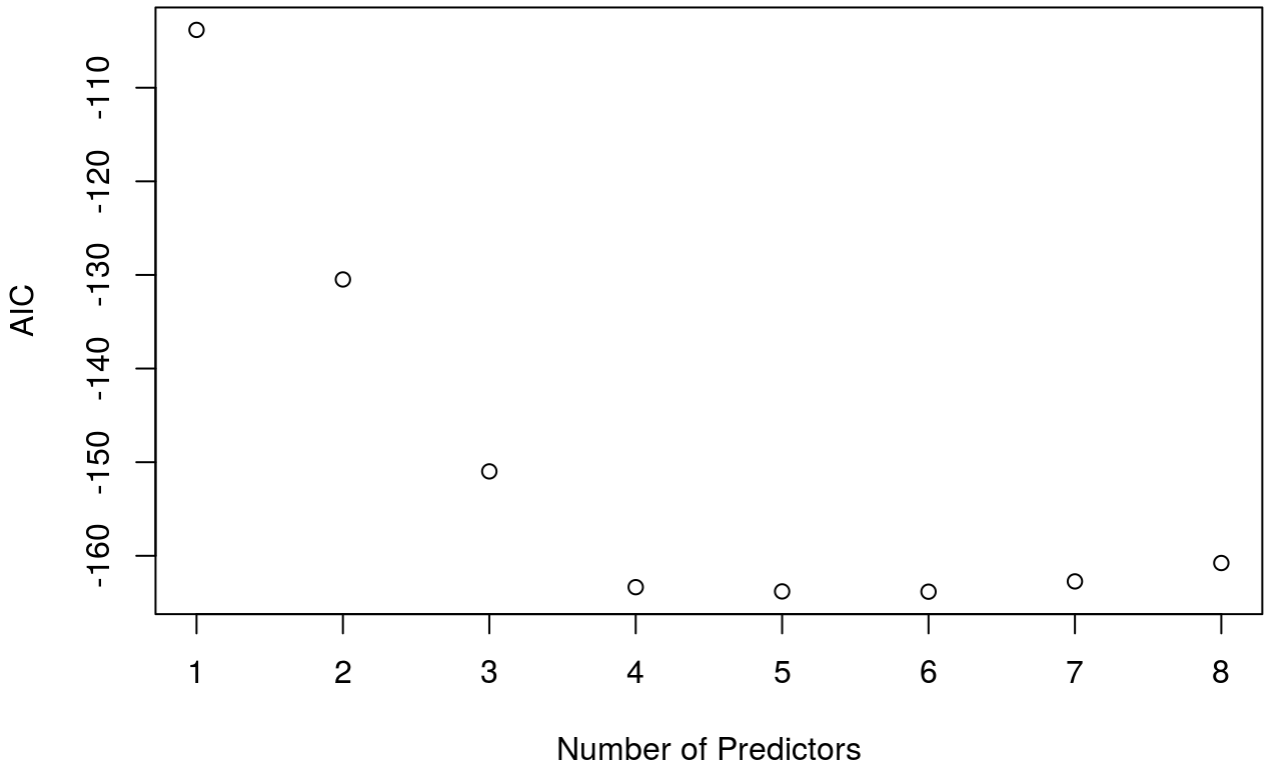
```
##
## Call:
## lm(formula = lnY ~ X1 + X2 + X3 + X8, data = Surgical.Unit)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.45307 -0.16149 -0.02779  0.12073  0.59524
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 3.852419   0.192695  19.992  < 2e-16 ***
## X1          0.073323   0.018973   3.865 0.000327 ***
## X2          0.014185   0.001731   8.196 9.58e-11 ***
## X3          0.015453   0.001396  11.072 6.15e-15 ***
## X8          0.352968   0.077191   4.573 3.29e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2109 on 49 degrees of freedom
## Multiple R-squared:  0.8299, Adjusted R-squared:  0.816
## F-statistic: 59.76 on 4 and 49 DF,  p-value: < 2.2e-16
```

```
library(leaps)
b <- regsubsets(lnY~X1+X2+X3+X4+X5+X6+X7+X8,data=Surgical.Unit)
rs <- summary(b)
rs$which
```

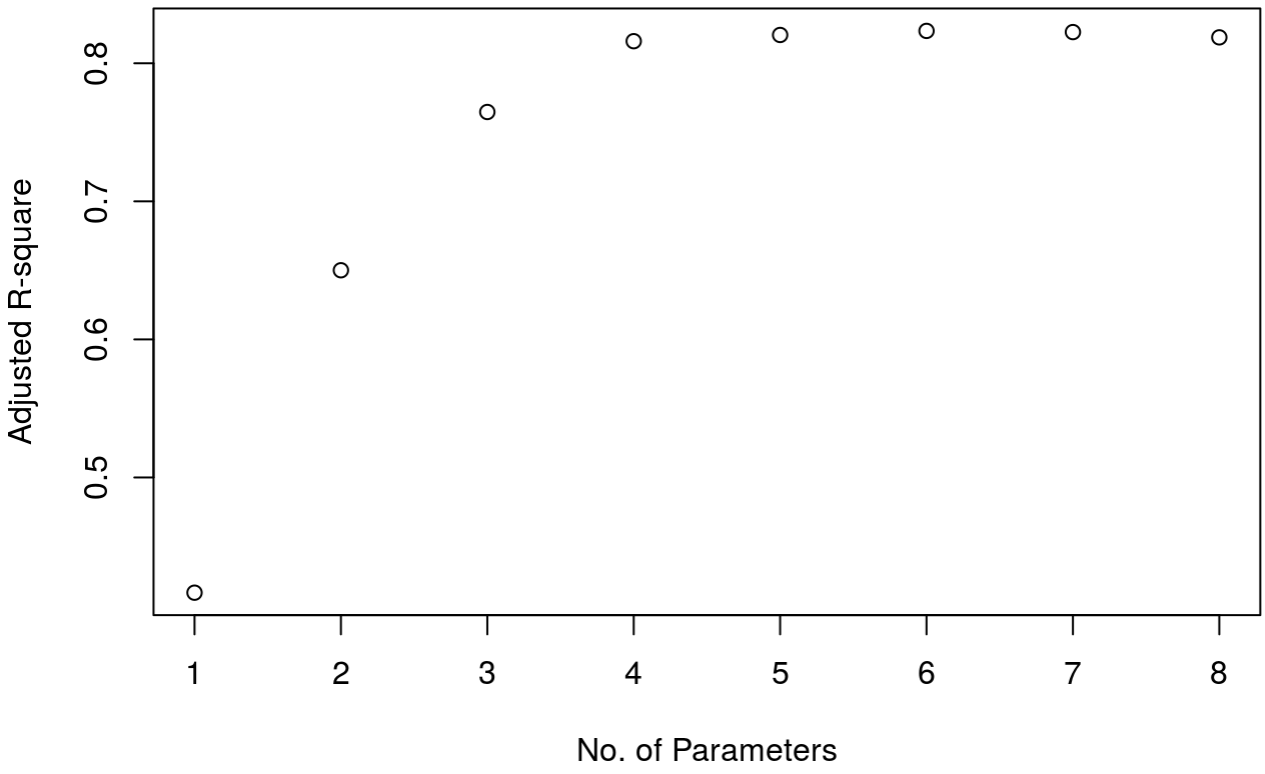
```
##   (Intercept)    X1    X2   X3    X4    X5    X6    X7    X8
## 1        TRUE FALSE FALSE TRUE FALSE FALSE FALSE FALSE FALSE
## 2        TRUE FALSE  TRUE TRUE FALSE FALSE FALSE FALSE FALSE
## 3        TRUE FALSE  TRUE TRUE FALSE FALSE FALSE FALSE  TRUE
## 4        TRUE  TRUE  TRUE TRUE FALSE FALSE FALSE FALSE  TRUE
```

```
## 5         TRUE   TRUE   TRUE TRUE FALSE FALSE   TRUE FALSE   TRUE
## 6         TRUE   TRUE   TRUE TRUE FALSE  TRUE   TRUE FALSE   TRUE
## 7         TRUE   TRUE   TRUE TRUE FALSE  TRUE   TRUE  TRUE   TRUE
## 8         TRUE   TRUE   TRUE TRUE  TRUE  TRUE   TRUE  TRUE   TRUE
```

```
AIC <- 54*log(rs$rss/54) + (2:9)*2
plot(AIC ~ I(1:8), ylab="AIC", xlab="Number of Predictors")
```




```
plot(1:8,rs$adjr2,xlab="No. of Parameters",ylab="Adjusted R-square")
```




```
which.max(rs$adjr2)
```

```
## [1] 6
```

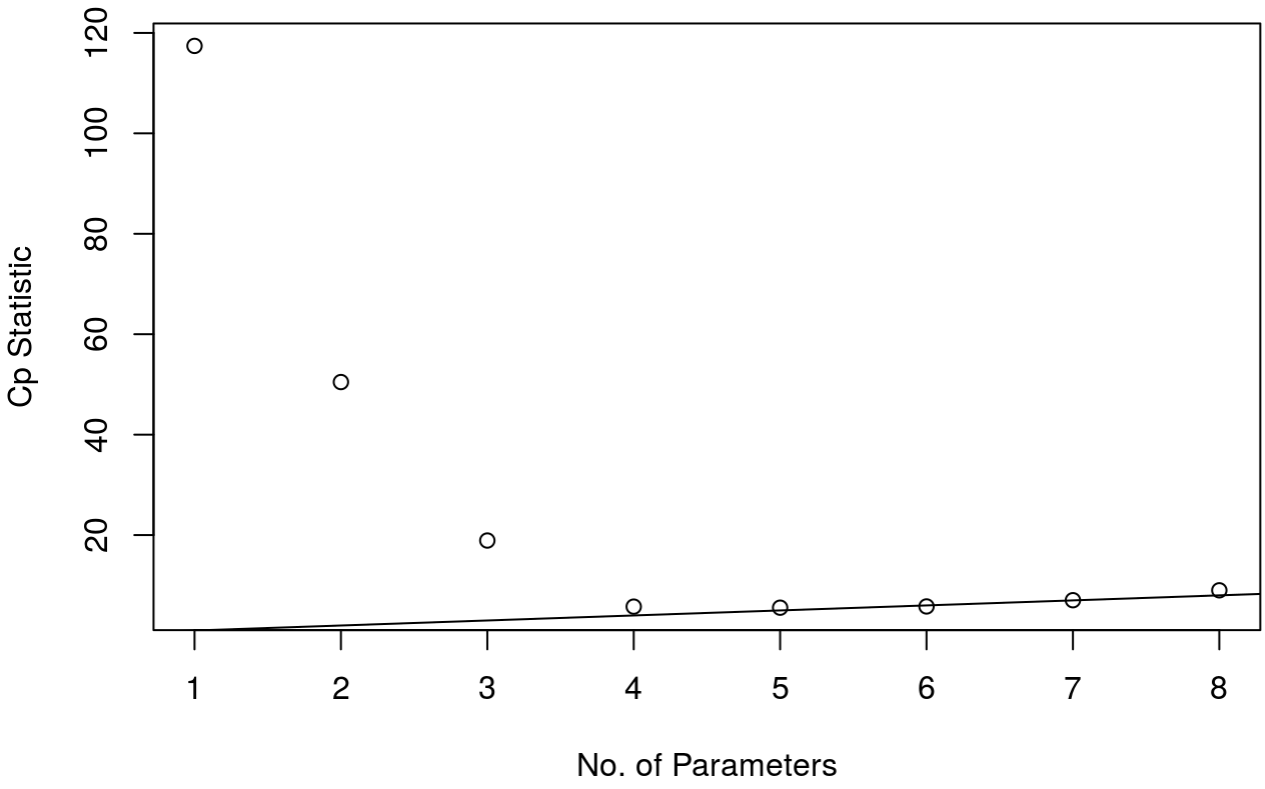
```
plot(1:8,rs$cp,xlab="No. of Parameters",ylab="Cp Statistic")
abline(0,1)


#install.packages("olsrr")
library(olsrr)
```

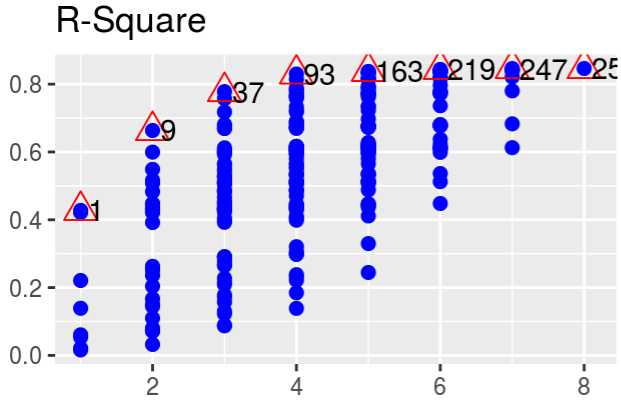
```
##
## Attaching package: 'olsrr'
```

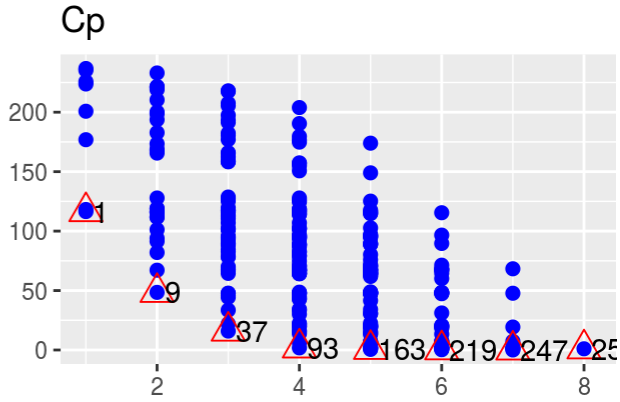
```
## The following object is masked from 'package:datasets':
##
##     rivers
```

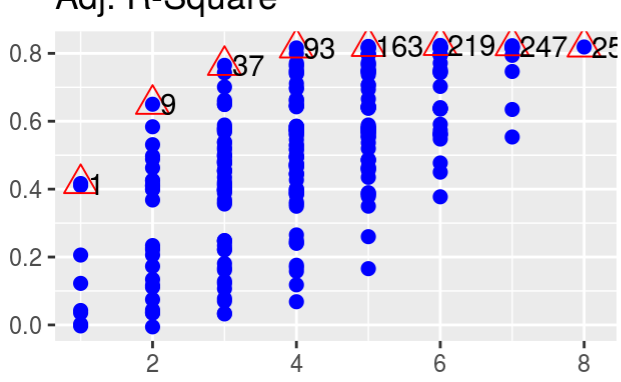
```
model<-lm(lnY ~X1+X2+X3+X4+X5+X6+X7+X8,data =Surgical.Unit)
f1 <- ols_step_all_possible(model)
plot(f1)
```

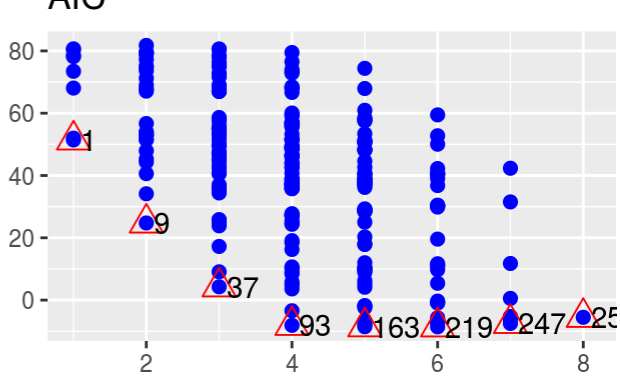

Cp Statistic
20
40
60
80
100
120
1
2
3
4
5
6
7
8
No. of Parameters

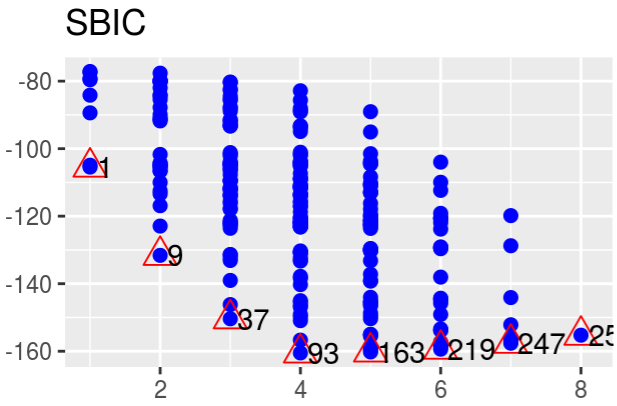
page 1 of 2

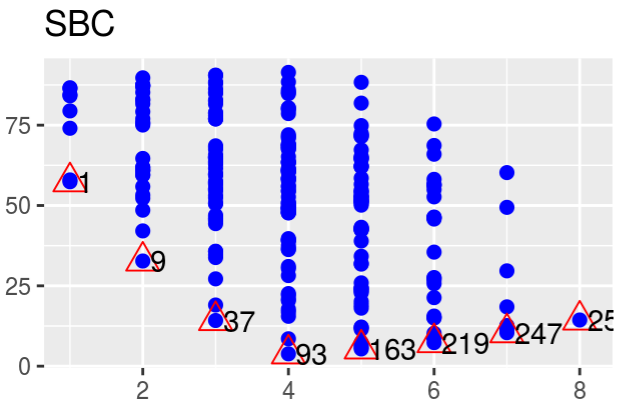

R-Square
0.0
0.2
0.4
0.6
0.8
2
4
6
8
1
9
37
93
163
219
247


Cp
0
50
100
150
200
2
4
6
8
1
9
37
93
163
219
247


Adj. R-Square
0.0
0.2
0.4
0.6
0.8
2
4
6
8
1
9
37
93
163
219
247

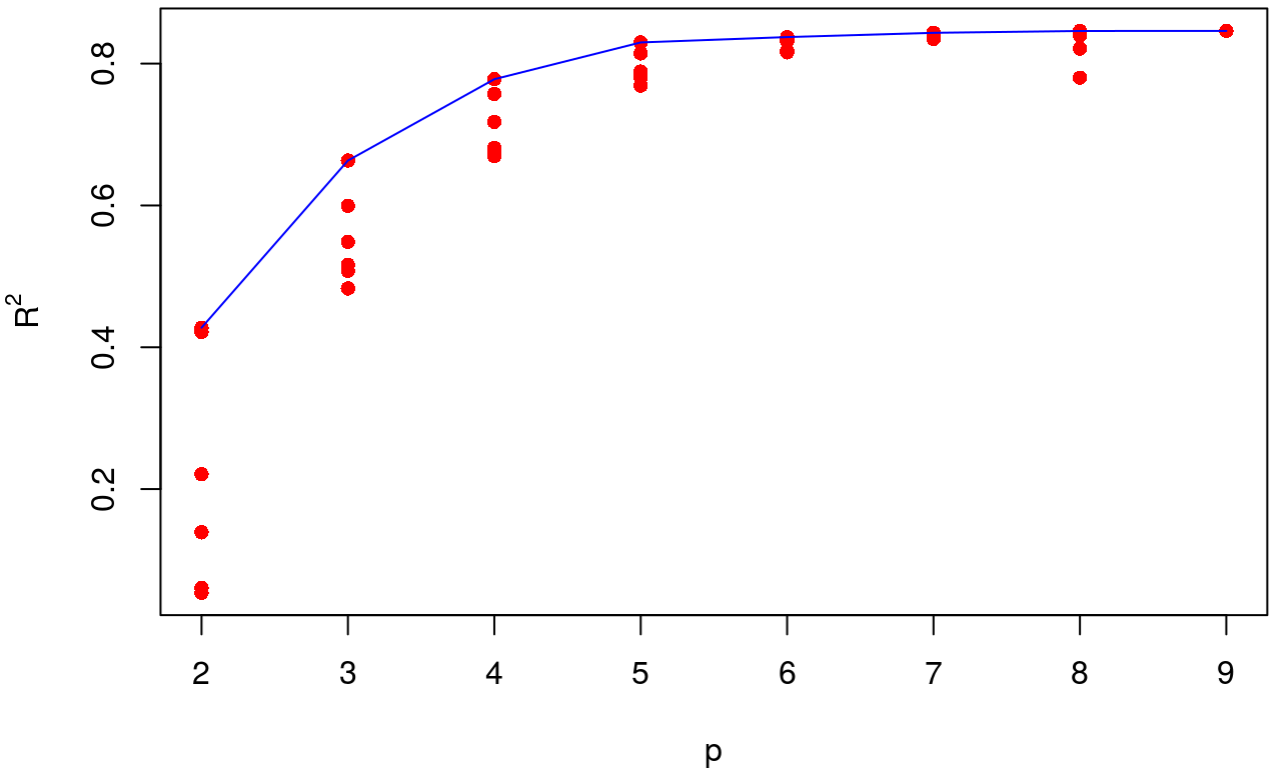

AIC
0
20
40
60
80
2
4
6
8
1
9
37
93
163
219
247






```
#install.packages("leaps")
library(leaps)
ex<- Surgical.Unit
ex.r2<-leaps( x=cbind(ex$X1,ex$X2,ex$X3,ex$X4,ex$X5,ex$X6,ex$X7,ex$X8),y=ex$lnY, method='r2',
nbest=6)
p<-seq( min(ex.r2$size),max(ex.r2$size) )
ind<-as.data.frame(ex.r2[c(3:4)])
ind<-ind[with(ind, order(size,r2)), ]
plot(ind[,c(1:2)] ,ylab=expression(R^2), xlab='p' ,col="red",pch=16)
Rp2 = by( data=ex.r2[4],INDICES=factor(ex.r2$size), FUN=max)
lines( Rp2 ~ p,col="blue" )
```

OLSRR

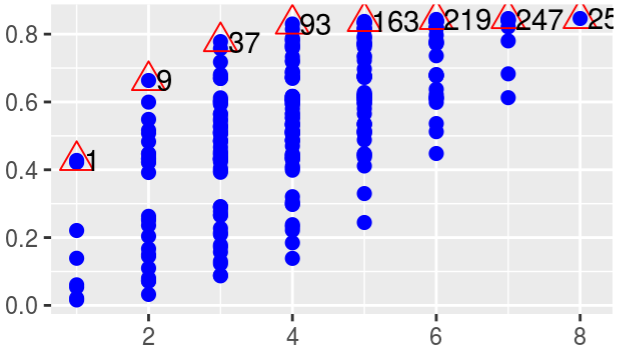


Package

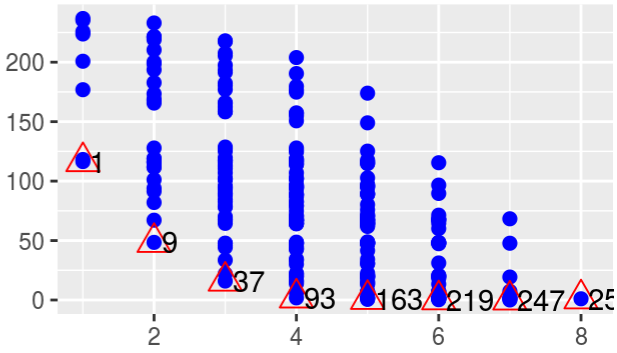
```
library(olsrr)
library(datasets)
k <- ols_step_all_possible(model)
plot(k)
```

page 1 of 2

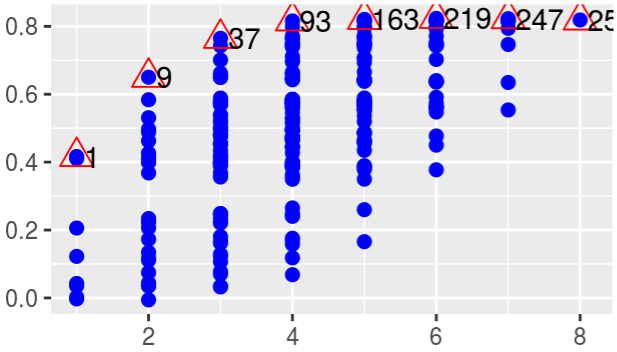
R-Square



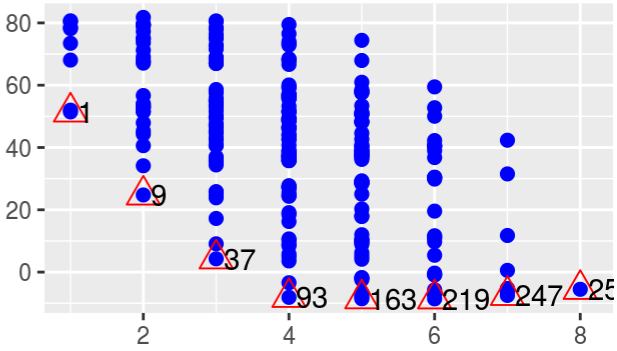
Cp



Adj. R-Square

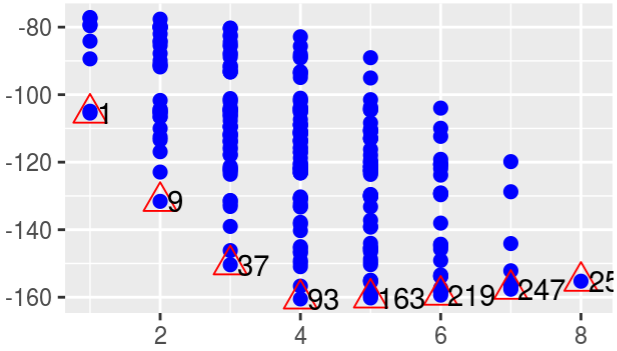


AIC

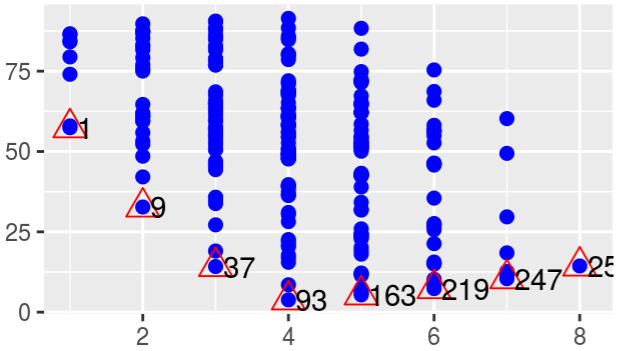


page 2 of 2

SBIC

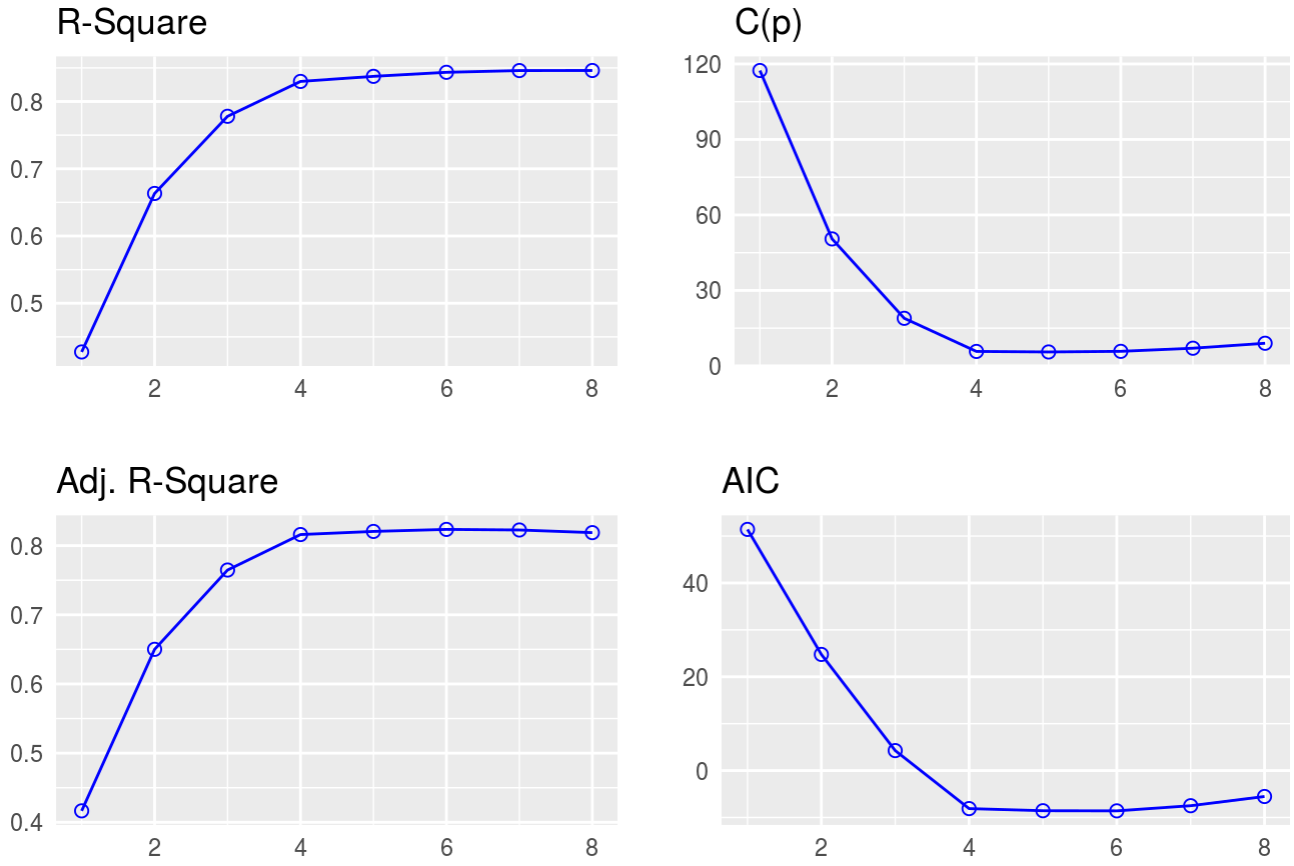


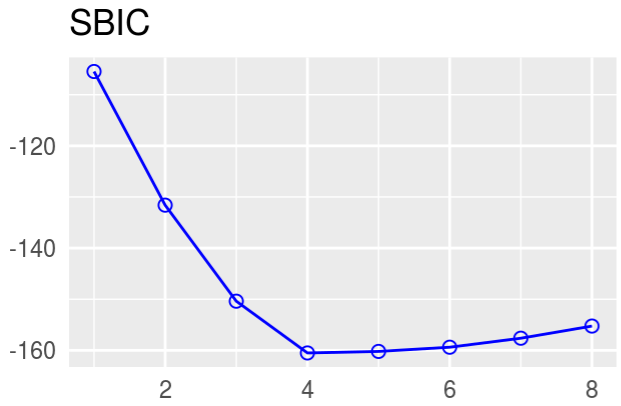
SBC

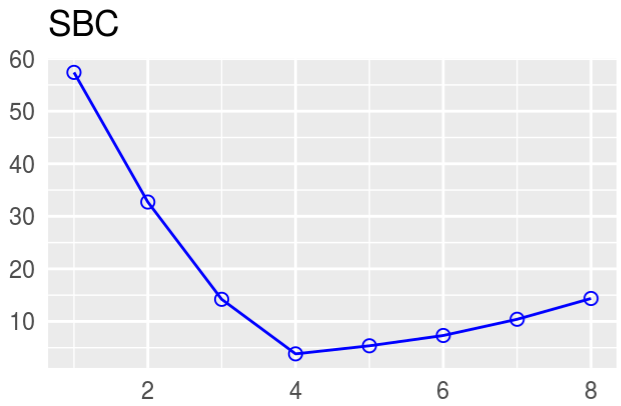


```
#Best Subset Regression
k1<-ols_step_best_subset(model, details = FALSE)
plot(k1)
```

page 1 of 2








```
# stepwise forward regression
k2<-ols_step_forward_p(model,details = FALSE)
```

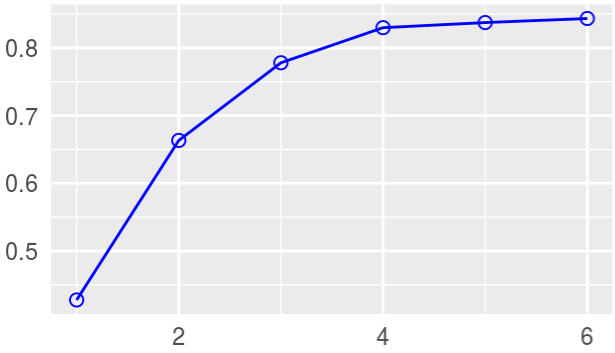
```
## Forward Selection Method
## ---------------------------
##
## Candidate Terms:
##
## 1. X1
## 2. X2
## 3. X3
## 4. X4
## 5. X5
## 6. X6
## 7. X7
## 8. X8
##
## We are selecting variables based on p value...
##
## Variables Entered:
##
## - X3
## - X2
## - X8
## - X1
```

```
## - X6
## - X5
##
## No more variables to be added.
##
## Final Model Output
## ------------------
##
##                         Model Summary
## ----------------------------------------------------------------
## R                       0.918       RMSE                 0.207
## R-Squared               0.843       Coef. Var            3.212
## Adj. R-Squared          0.823       MSE                  0.043
## Pred R-Squared          0.784       MAE                  0.162
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## --------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## --------------------------------------------------------------------
## Regression     10.803         6          1.800      42.2    0.0000
## Residual        2.005        47          0.043
## Total          12.808        53
## --------------------------------------------------------------------
##
##                                  Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model      Beta    Std. Error    Std. Beta      t        Sig      lower    upper
## ----------------------------------------------------------------------------------------
## (Intercept)     4.054         0.235                17.266    0.000     3.582    4.526
##          X3     0.015         0.001        0.654   10.912    0.000     0.012    0.018
##          X2     0.014         0.002        0.473    8.047    0.000     0.010    0.017
##          X8     0.351         0.076        0.280    4.594    0.000     0.197    0.505
##          X1     0.072         0.019        0.233    3.837    0.000     0.034    0.109
##          X6     0.087         0.058        0.089    1.513    0.137    -0.029    0.203
##          X5    -0.003         0.003       -0.078   -1.342    0.186    -0.009    0.002
## ----------------------------------------------------------------------------------------
```

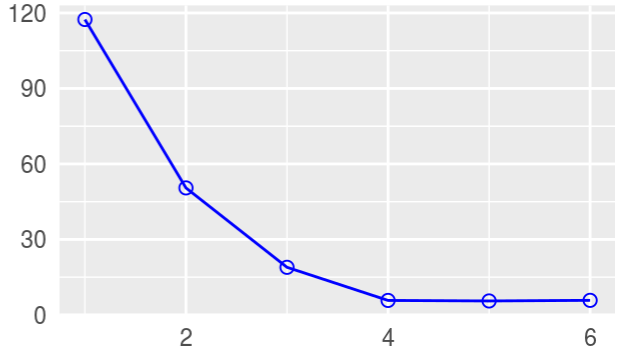
```
plot(k2)
```

page 1 of 2

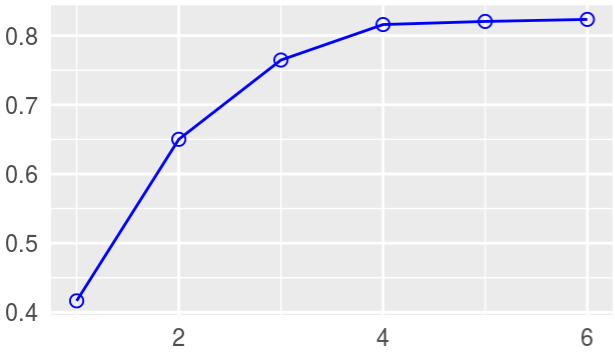
R-Square



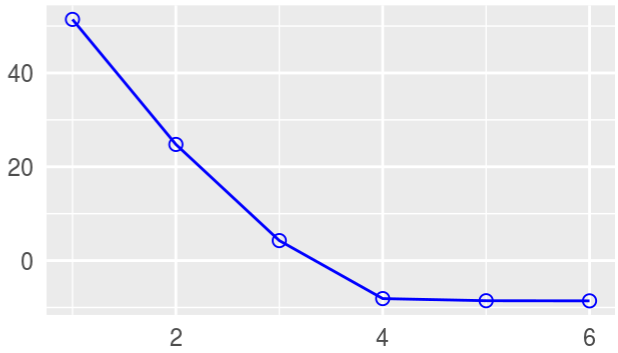
C(p)



Adj. R-Square

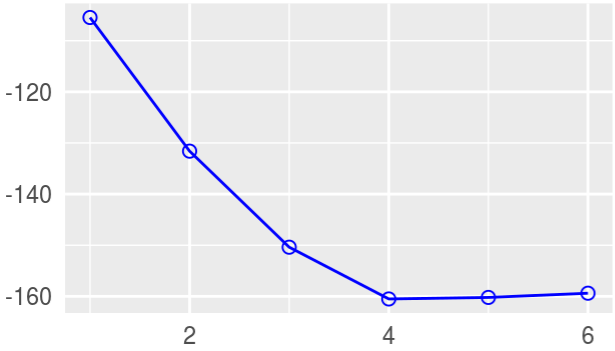


AIC

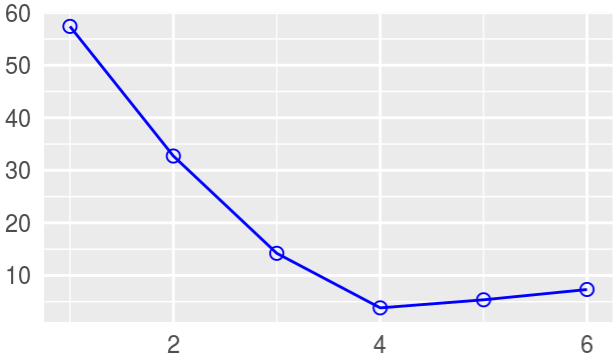


page 2 of 2

SBIC



SBC



```
# stepwise backward regression
k4<-ols_step_backward_p(model,prem=0.05,details = FALSE)
```

```
## Backward Elimination Method
## ---------------------------
##
## Candidate Terms:
##
## 1 . X1
## 2 . X2
## 3 . X3
## 4 . X4
## 5 . X5
## 6 . X6
## 7 . X7
## 8 . X8
##
## We are eliminating variables based on p value...
##
## Variables Removed:
##
## - X4
## - X7
## - X5
## - X6
##
## No more variables satisfy the condition of p value = 0.05
##
##
## Final Model Output
## ------------------
##
##                         Model Summary
## ------------------------------------------------------------
## R                       0.911       RMSE                0.211
## R-Squared               0.830       Coef. Var           3.279
## Adj. R-Squared          0.816       MSE                 0.044
## Pred R-Squared          0.786       MAE                 0.164
## ------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## --------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## --------------------------------------------------------------------
## Regression     10.629         4          2.657     59.76    0.0000
## Residual        2.179        49          0.044
## Total          12.808        53
## --------------------------------------------------------------------
##
```

```
##                                 Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ----------------------------------------------------------------------------------------
## (Intercept)    3.852         0.193                19.992    0.000    3.465    4.240
##          X1    0.073         0.019        0.239    3.865    0.000    0.035    0.111
##          X2    0.014         0.002        0.488    8.196    0.000    0.011    0.018
##          X3    0.015         0.001        0.668   11.072    0.000    0.013    0.018
##          X8    0.353         0.077        0.282    4.573    0.000    0.198    0.508
## ----------------------------------------------------------------------------------------
```

```
#plot(k4)
# stepwise regression
ols_step_both_p(model,pent=0.1,prem=0.05,details=TRUE)
```

```
## Stepwise Selection Method
## --------------------------
##
## Candidate Terms:
##
## 1. X1
## 2. X2
## 3. X3
## 4. X4
## 5. X5
## 6. X6
## 7. X7
## 8. X8
##
## We are selecting variables based on p value...
##
##
## Stepwise Selection: Step 1
##
## - X3 added
##
##                        Model Summary
## ------------------------------------------------------------
## R                       0.654       RMSE                0.375
## R-Squared               0.428       Coef. Var           5.839
## Adj. R-Squared          0.417       MSE                 0.141
## Pred R-Squared          0.350       MAE                 0.277
## ------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## -----------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## -----------------------------------------------------------------
```

```
## Regression      5.476         1          5.476     38.84    0.0000
## Residual        7.332        52          0.141
## Total          12.808        53
## ----------------------------------------------------------------
##
##                                Parameter Estimates
## ------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ------------------------------------------------------------------------------------
## (Intercept)    5.264         0.194                27.138    0.000    4.875    5.654
##          X3    0.015         0.002        0.654    6.232    0.000    0.010    0.020
## ------------------------------------------------------------------------------------
##
##
##
## Stepwise Selection: Step 2
##
## - X2 added
##
##                         Model Summary
## ---------------------------------------------------------------
## R                       0.814       RMSE                0.291
## R-Squared               0.663       Coef. Var           4.522
## Adj. R-Squared          0.650       MSE                 0.085
## Pred R-Squared          0.605       MAE                 0.223
## ---------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## ----------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ----------------------------------------------------------------
## Regression      8.495         2          4.248    50.233    0.0000
## Residual        4.312        51          0.085
## Total          12.808        53
## ----------------------------------------------------------------
##
##                                Parameter Estimates
## ------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ------------------------------------------------------------------------------------
## (Intercept)    4.351         0.214                20.296    0.000    3.920    4.781
##          X3    0.015         0.002        0.665    8.186    0.000    0.012    0.019
##          X2    0.014         0.002        0.486    5.975    0.000    0.009    0.019
## ------------------------------------------------------------------------------------
##
##
##
##                         Model Summary
## ---------------------------------------------------------------
## R                       0.814       RMSE                0.291
```

```
## R-Squared               0.663       Coef. Var          4.522
## Adj. R-Squared          0.650       MSE                0.085
## Pred R-Squared          0.605       MAE                0.223
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## ------------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ------------------------------------------------------------------------
## Regression      8.495         2          4.248    50.233    0.0000
## Residual        4.312        51          0.085
## Total          12.808        53
## ------------------------------------------------------------------------
##
##                                  Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ----------------------------------------------------------------------------------------
## (Intercept)    4.351         0.214                20.296    0.000    3.920    4.781
##          X3    0.015         0.002        0.665    8.186    0.000    0.012    0.019
##          X2    0.014         0.002        0.486    5.975    0.000    0.009    0.019
## ----------------------------------------------------------------------------------------
##
##
##
## Stepwise Selection: Step 3
##
## - X8 added
##
##                         Model Summary
## ----------------------------------------------------------------
## R                       0.882       RMSE               0.238
## R-Squared               0.778       Coef. Var          3.708
## Adj. R-Squared          0.765       MSE                0.057
## Pred R-Squared          0.729       MAE                0.183
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## ------------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ------------------------------------------------------------------------
## Regression      9.965         3          3.322     58.42    0.0000
## Residual        2.843        50          0.057
## Total          12.808        53
## ------------------------------------------------------------------------
##
```

```
##                                 Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ----------------------------------------------------------------------------------------
## (Intercept)    4.291         0.176                24.356    0.000    3.937    4.645
##          X3    0.014         0.002        0.626    9.326    0.000    0.011    0.018
##          X2    0.015         0.002        0.513    7.677    0.000    0.011    0.019
##          X8    0.429         0.084        0.342    5.084    0.000    0.260    0.599
## ----------------------------------------------------------------------------------------
##
##
##
##                          Model Summary
## ----------------------------------------------------------------
## R                        0.882       RMSE                0.238
## R-Squared                0.778       Coef. Var           3.708
## Adj. R-Squared           0.765       MSE                 0.057
## Pred R-Squared           0.729       MAE                 0.183
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                 ANOVA
## ---------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ---------------------------------------------------------------------
## Regression      9.965         3          3.322     58.42    0.0000
## Residual        2.843        50          0.057
## Total          12.808        53
## ---------------------------------------------------------------------
##
##                                 Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ----------------------------------------------------------------------------------------
## (Intercept)    4.291         0.176                24.356    0.000    3.937    4.645
##          X3    0.014         0.002        0.626    9.326    0.000    0.011    0.018
##          X2    0.015         0.002        0.513    7.677    0.000    0.011    0.019
##          X8    0.429         0.084        0.342    5.084    0.000    0.260    0.599
## ----------------------------------------------------------------------------------------
##
##
##
## Stepwise Selection: Step 4
##
## - X1 added
##
##                          Model Summary
## ----------------------------------------------------------------
## R                        0.911       RMSE                0.211
## R-Squared                0.830       Coef. Var           3.279
## Adj. R-Squared           0.816       MSE                 0.044
```

```
## Pred R-Squared          0.786       MAE                 0.164
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## ---------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ---------------------------------------------------------------------
## Regression     10.629         4          2.657     59.76    0.0000
## Residual        2.179        49          0.044
## Total          12.808        53
## ---------------------------------------------------------------------
##
##                                  Parameter Estimates
## ------------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ------------------------------------------------------------------------------------------
## (Intercept)    3.852         0.193                19.992    0.000    3.465    4.240
##          X3    0.015         0.001        0.668   11.072    0.000    0.013    0.018
##          X2    0.014         0.002        0.488    8.196    0.000    0.011    0.018
##          X8    0.353         0.077        0.282    4.573    0.000    0.198    0.508
##          X1    0.073         0.019        0.239    3.865    0.000    0.035    0.111
## ------------------------------------------------------------------------------------------
##
##
##
##                          Model Summary
## ----------------------------------------------------------------
## R                        0.911       RMSE                0.211
## R-Squared                0.830       Coef. Var           3.279
## Adj. R-Squared           0.816       MSE                 0.044
## Pred R-Squared           0.786       MAE                 0.164
## ----------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## ---------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## ---------------------------------------------------------------------
## Regression     10.629         4          2.657     59.76    0.0000
## Residual        2.179        49          0.044
## Total          12.808        53
## ---------------------------------------------------------------------
##
##                                  Parameter Estimates
## ------------------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ------------------------------------------------------------------------------------------
```

```
## (Intercept)    3.852         0.193                19.992    0.000    3.465    4.240
##          X3    0.015         0.001        0.668   11.072    0.000    0.013    0.018
##          X2    0.014         0.002        0.488    8.196    0.000    0.011    0.018
##          X8    0.353         0.077        0.282    4.573    0.000    0.198    0.508
##          X1    0.073         0.019        0.239    3.865    0.000    0.035    0.111
## ----------------------------------------------------------------------------------
##
##
##
## No more variables to be added/removed.
##
##
## Final Model Output
## ------------------
##
##                         Model Summary
## ------------------------------------------------------------
## R                       0.911       RMSE               0.211
## R-Squared               0.830       Coef. Var          3.279
## Adj. R-Squared          0.816       MSE                0.044
## Pred R-Squared          0.786       MAE                0.164
## ------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                               ANOVA
## --------------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## --------------------------------------------------------------------
## Regression     10.629         4          2.657     59.76    0.0000
## Residual        2.179        49          0.044
## Total          12.808        53
## --------------------------------------------------------------------
##
##                                Parameter Estimates
## ----------------------------------------------------------------------------------
##       model     Beta    Std. Error    Std. Beta      t        Sig     lower    upper
## ----------------------------------------------------------------------------------
## (Intercept)    3.852         0.193                19.992    0.000    3.465    4.240
##          X3    0.015         0.001        0.668   11.072    0.000    0.013    0.018
##          X2    0.014         0.002        0.488    8.196    0.000    0.011    0.018
##          X8    0.353         0.077        0.282    4.573    0.000    0.198    0.508
##          X1    0.073         0.019        0.239    3.865    0.000    0.035    0.111
## ----------------------------------------------------------------------------------
```

```
##
##                             Stepwise Selection Summary
## ----------------------------------------------------------------------------------
##                      Added/                   Adj.
## Step    Variable    Removed     R-Square    R-Square      C(p)        AIC        RMSE
## ----------------------------------------------------------------------------------
```

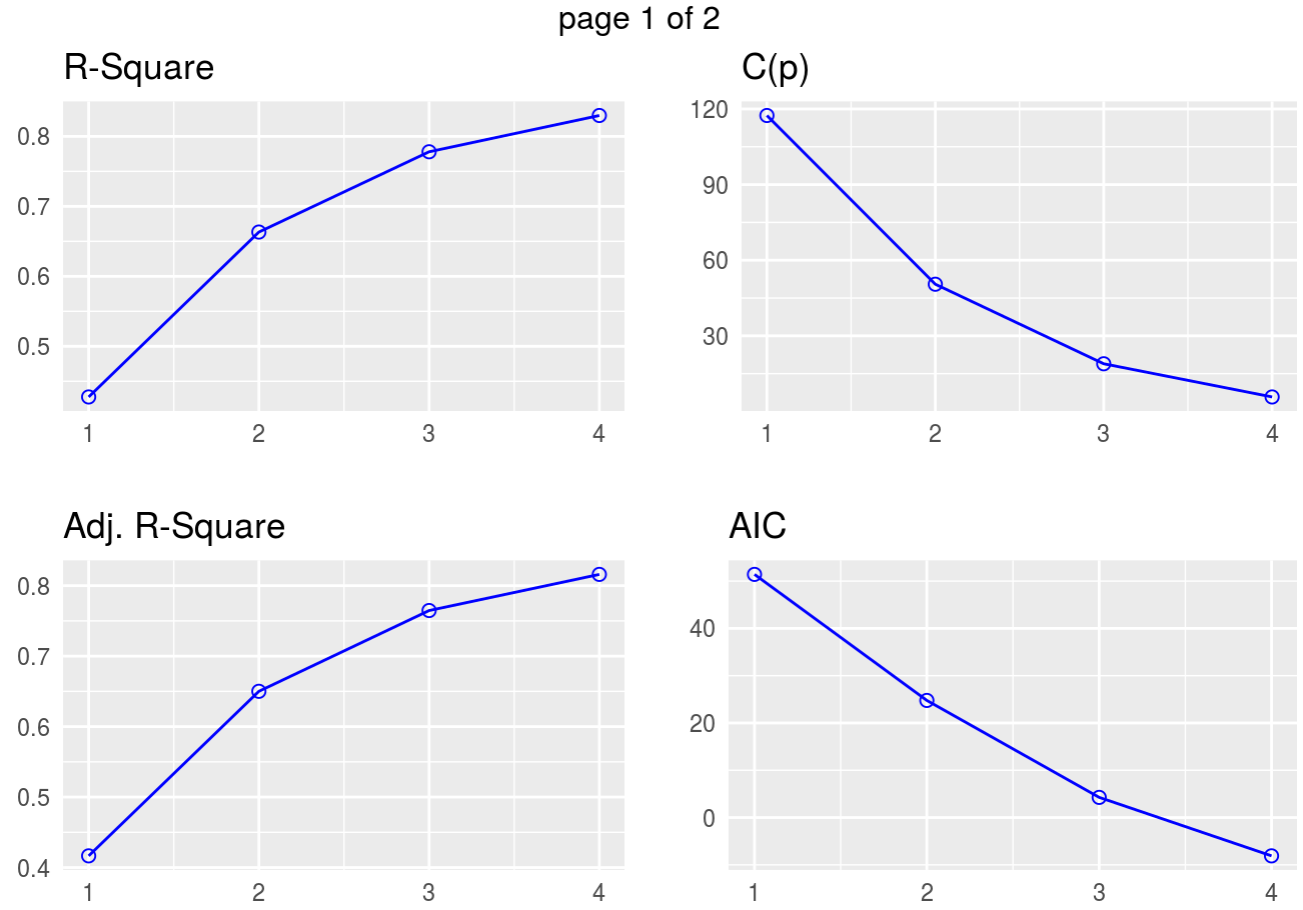
```
##    1       X3       addition       0.428       0.417    117.4090    51.4185    0.3755
##    2       X2       addition       0.663       0.650     50.4720    24.7621    0.2908
##    3       X8       addition       0.778       0.765     18.9140     4.2604    0.2384
##    4       X1       addition       0.830       0.816      5.7510    -8.1060    0.2109
## ---------------------------------------------------------------------------------------
```

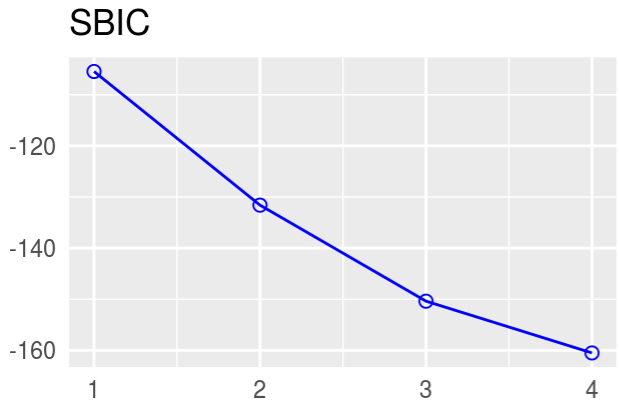
```
k5<-ols_step_both_p(model)
```

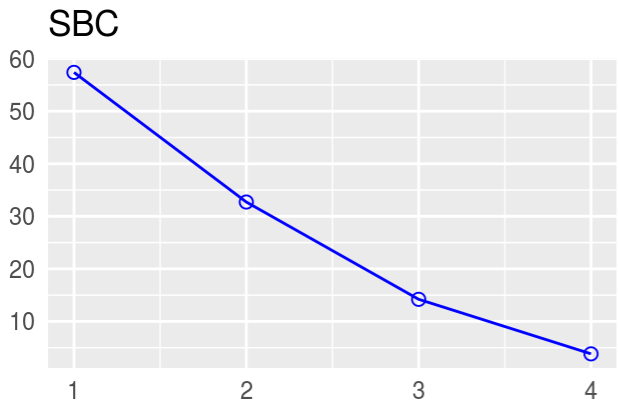
```
## Stepwise Selection Method
## -------------------------
##
## Candidate Terms:
##
## 1. X1
## 2. X2
## 3. X3
## 4. X4
## 5. X5
## 6. X6
## 7. X7
## 8. X8
##
## We are selecting variables based on p value...
##
## Variables Entered/Removed:
##
## - X3 added
## - X2 added
## - X8 added
## - X1 added
##
## No more variables to be added/removed.
##
##
## Final Model Output
## ------------------
##
##                         Model Summary
## ------------------------------------------------------------
## R                       0.911       RMSE               0.211
## R-Squared               0.830       Coef. Var          3.279
## Adj. R-Squared          0.816       MSE                0.044
## Pred R-Squared          0.786       MAE                0.164
## ------------------------------------------------------------
##  RMSE: Root Mean Square Error
##  MSE: Mean Square Error
##  MAE: Mean Absolute Error
##
##                                ANOVA
## -----------------------------------------------------------------
##                Sum of
##               Squares        DF    Mean Square      F         Sig.
## -----------------------------------------------------------------
```

```
## Regression     10.629          4          2.657     59.76    0.0000
## Residual        2.179         49          0.044
## Total          12.808         53
## ----------------------------------------------------------------------
##
##                                Parameter Estimates
## ----------------------------------------------------------------------------------------
##       model      Beta    Std. Error    Std. Beta       t        Sig      lower     upper
## ----------------------------------------------------------------------------------------
## (Intercept)     3.852         0.193                 19.992     0.000     3.465     4.240
##          X3     0.015         0.001         0.668   11.072     0.000     0.013     0.018
##          X2     0.014         0.002         0.488    8.196     0.000     0.011     0.018
##          X8     0.353         0.077         0.282    4.573     0.000     0.198     0.508
##          X1     0.073         0.019         0.239    3.865     0.000     0.035     0.111
## ----------------------------------------------------------------------------------------
```

```
plot(k5)
```





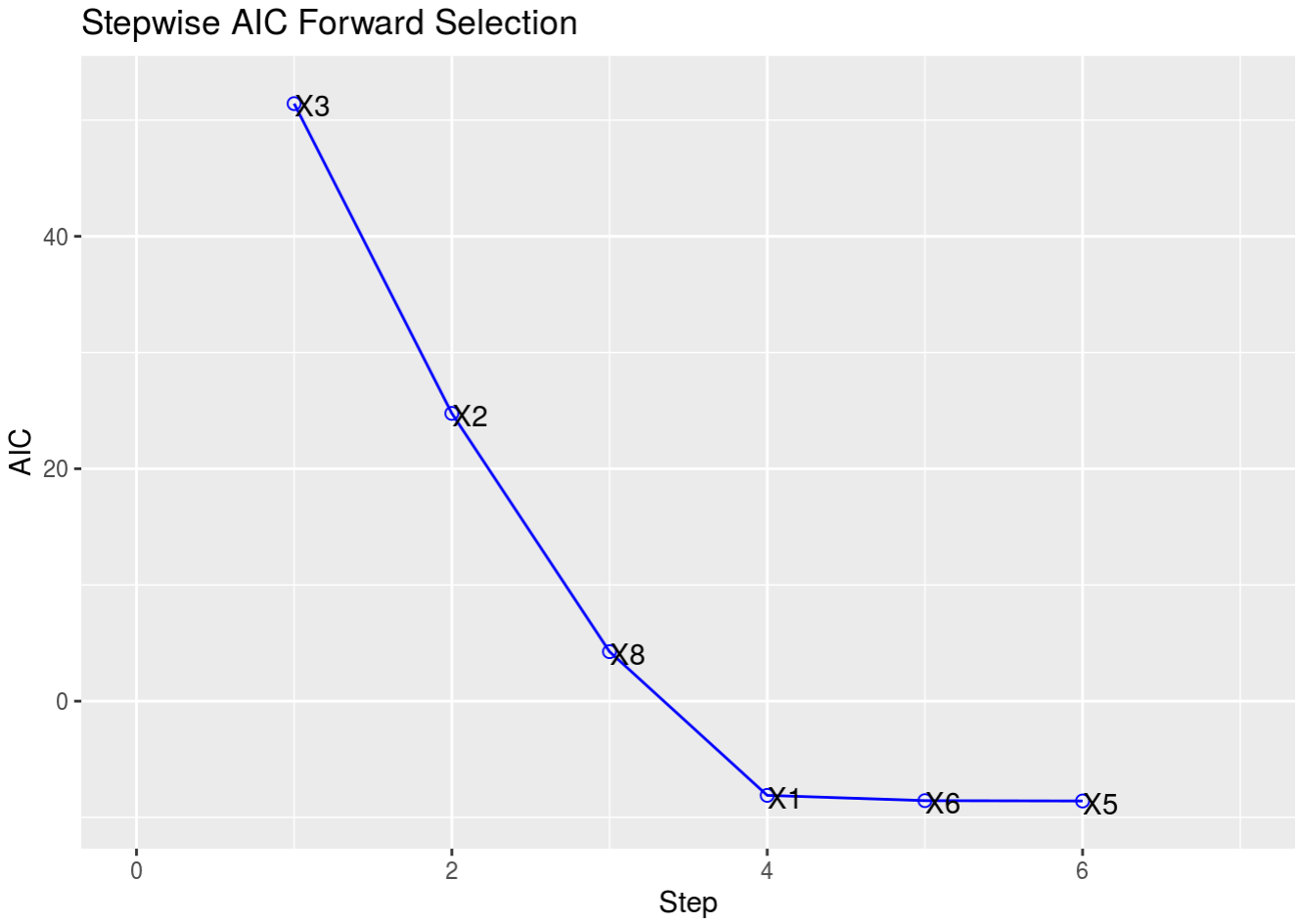



```
# stepwise aic forward regression
k6<-ols_step_forward_aic(model,details = FALSE)
```

```
## Forward Selection Method
## -------------------------
##
## Candidate Terms:
##
## 1 . X1
## 2 . X2
## 3 . X3
## 4 . X4
## 5 . X5
## 6 . X6
## 7 . X7
## 8 . X8
##
##
## Variables Entered:
##
## - X3
## - X2
## - X8
## - X1
## - X6
```

```
## - X5
##
## No more variables to be added.
```

```
plot(k6)
```



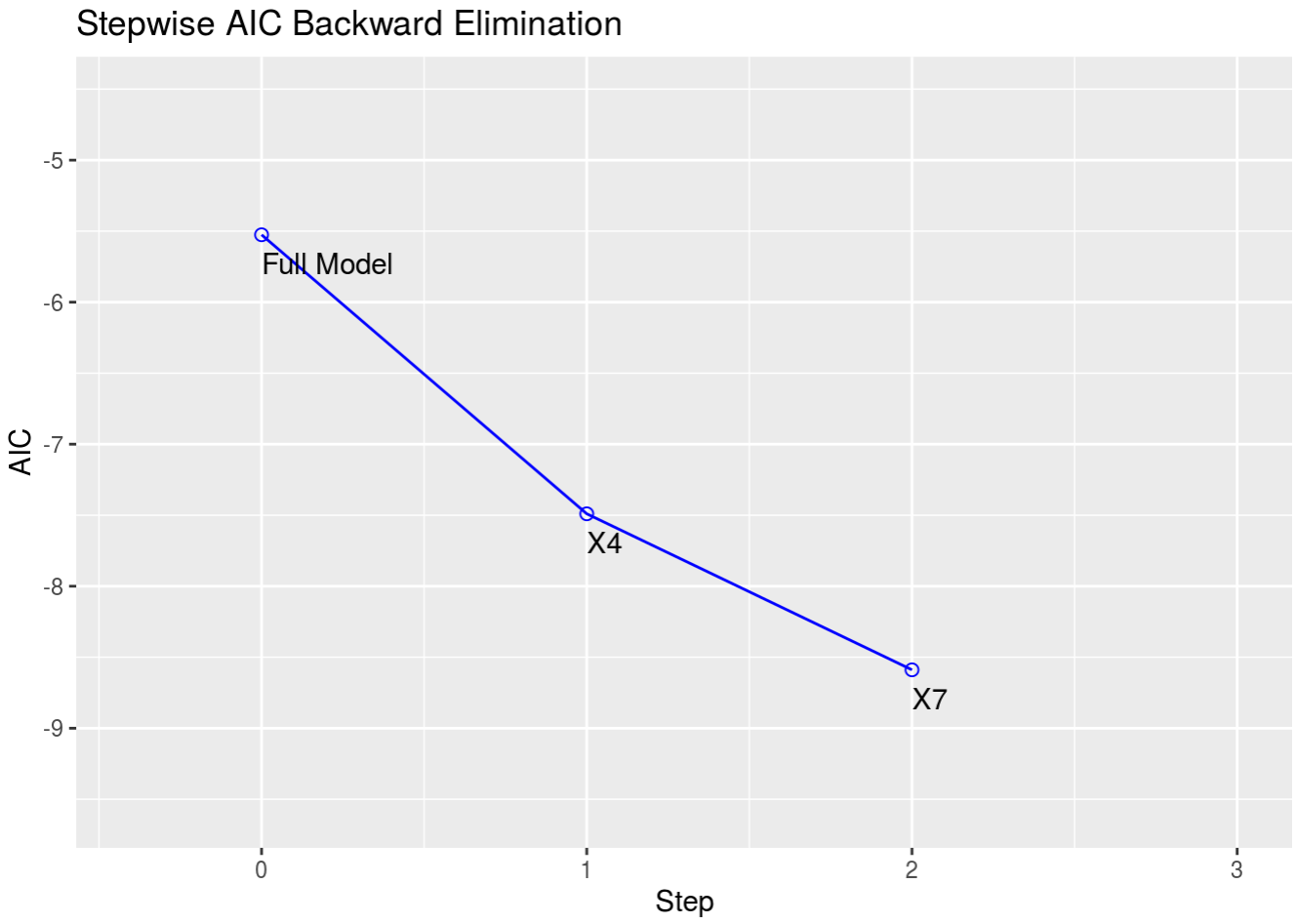

```
# stepwise aic backward regression
k7 <- ols_step_backward_aic(model,details = FALSE)
```

```
## Backward Elimination Method
## ---------------------------
##
## Candidate Terms:
##
## 1 . X1
## 2 . X2
## 3 . X3
## 4 . X4
## 5 . X5
## 6 . X6
## 7 . X7
## 8 . X8
##
##
## Variables Removed:
```

```
##
## - X4
## - X7
##
## No more variables to be removed.
```

```
plot(k7)
```

```
## Warning: `prepend()` is deprecated as of rlang 0.4.0.
##
## Vector tools are now out of scope for rlang to make it a more
## focused package.
## This warning is displayed once per session.
```




```
# stepwise aic regression
k8<-ols_step_both_aic(model,details = FALSE)
```

```
## Stepwise Selection Method
## -------------------------
##
## Candidate Terms:
##
## 1 . X1
## 2 . X2
```

```
## 3 . X3
## 4 . X4
## 5 . X5
## 6 . X6
## 7 . X7
## 8 . X8
##
##
## Variables Entered/Removed:
##
## - X3 added
## - X2 added
## - X8 added
## - X1 added
## - X6 added
## - X5 added
##
## No more variables to be added or removed.
```

```
plot(k8)
```