Ch 9 - Surgical Unit Example

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The dataset

Variable	Description
X1	blood clotting score
X2	prognostic index
X3	enzyme function score
X4	liver function test score
X5	age in years
X6	gender, 0 for male and 1 for female
X7, X8	alcohol use. see table below
Y	Survival time

Alcohol Use	X7	X8
None	0	0
Moderate	1	0
Severe	0	1

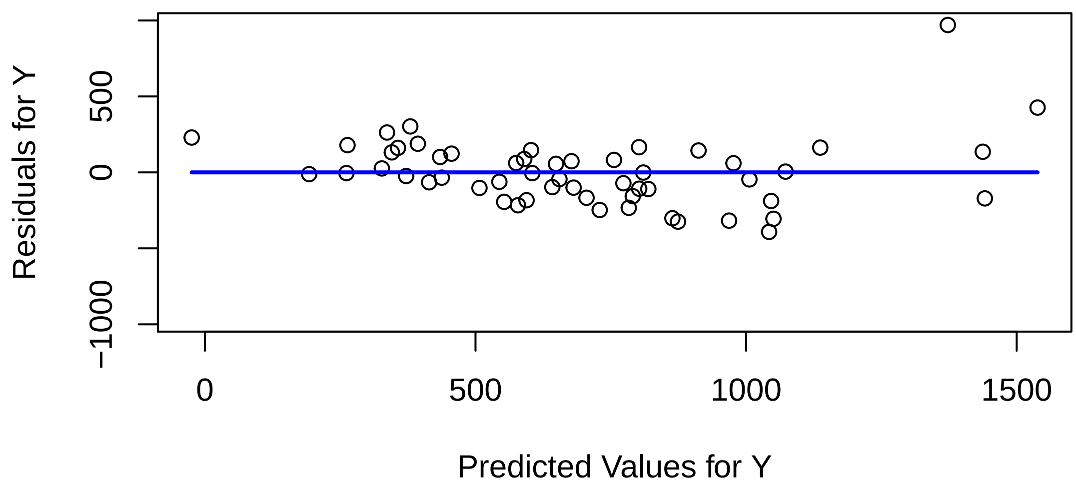
```
df <- read.table(file="CH09TA01.txt", sep="\t", header=F)
names(df) = c("X1","X2","X3","X4","X5","X6","X7","X8","Y", "lnY")
str(df)
```

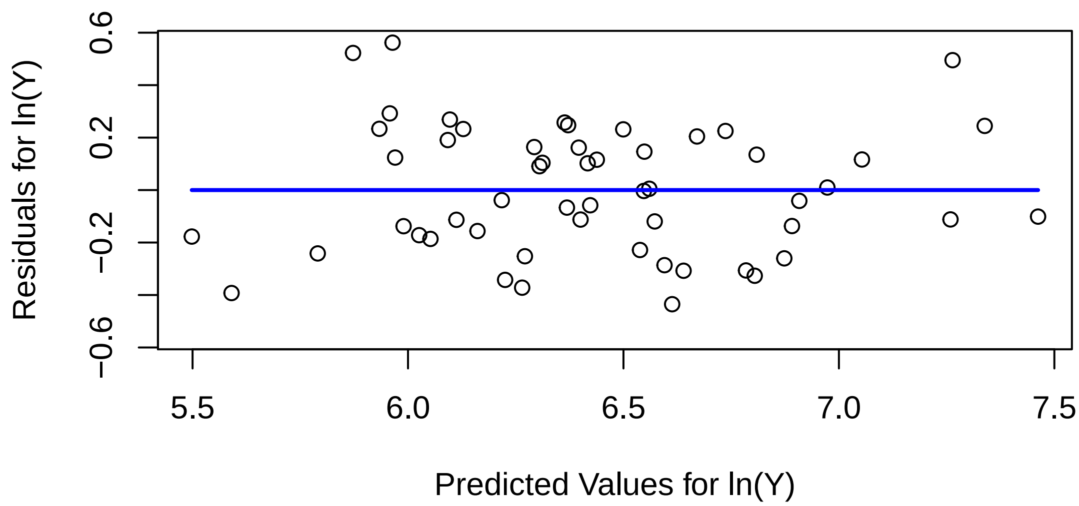
```
## 'data.frame':    54 obs. of  10 variables:
##  $ X1 : num  6.7 5.1 7.4 6.5 7.8 5.8 5.7 3.7 6 3.7 ...
##  $ X2 : int  62 59 57 73 65 38 46 68 67 76 ...
##  $ X3 : int  81 66 83 41 115 72 63 81 93 94 ...
##  $ X4 : num  2.59 1.7 2.16 2.01 4.3 1.42 1.91 2.57 2.5 2.4 ...
##  $ X5 : int  50 39 55 48 45 65 49 69 58 48 ...
##  $ X6 : int  0 0 0 0 0 1 1 1 0 0 ...
##  $ X7 : int  1 0 0 0 0 1 0 1 1 1 ...
##  $ X8 : int  0 0 0 0 1 0 1 0 0 0 ...
##  $ Y  : int  695 403 710 349 2343 348 518 749 1056 968 ...
##  $ lnY: num  6.54 6 6.57 5.85 7.76 ...
```

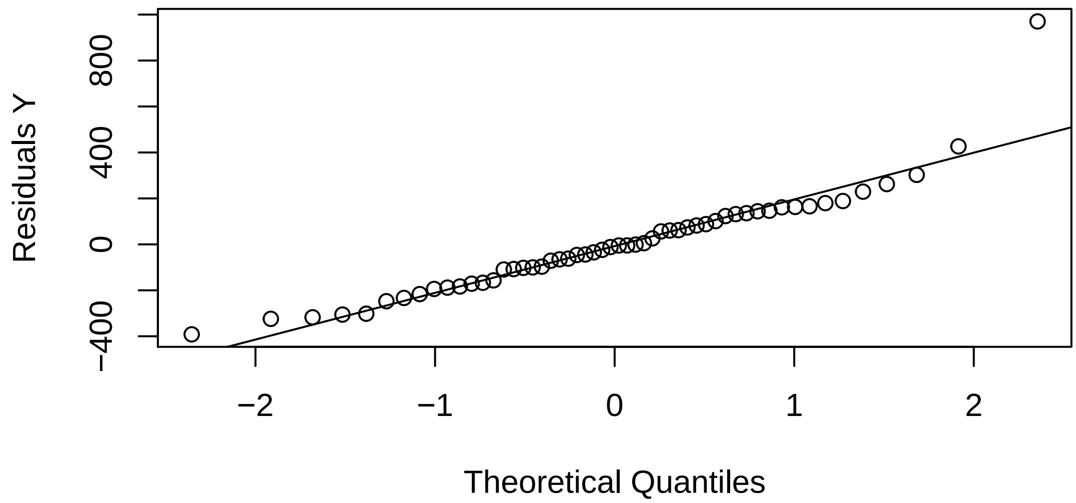
Subsetting the Data into First 54 Cases and First 4 Variables

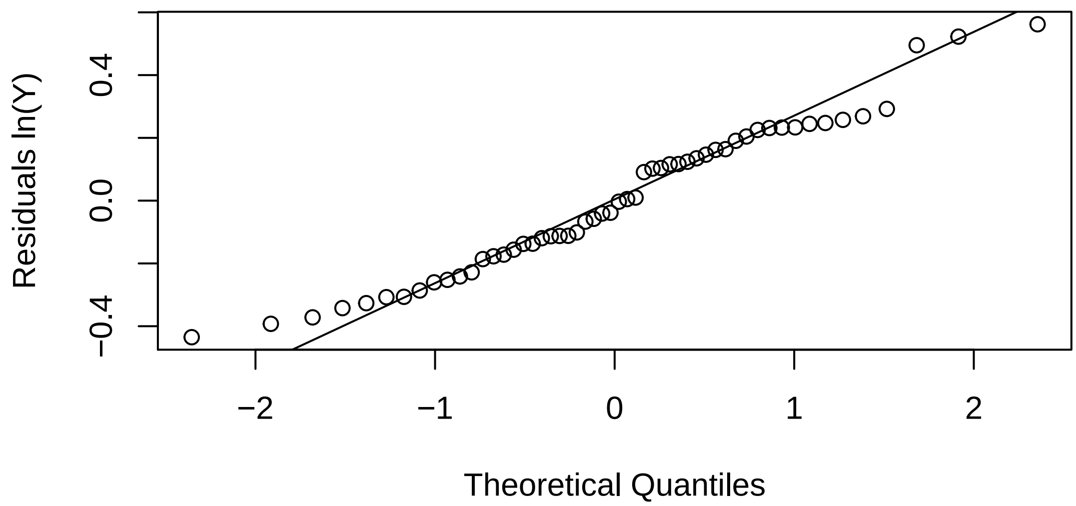
```
df54 <- df[1:54,c("X1","X2","X3","X4","Y","lnY")]
resultY <- lm(Y ~ X1 + X2 + X3 + X4, data=df)
resultlnY <- lm(lnY ~ X1 + X2 + X3 + X4, data=df)
```

Residual Plots of Y and lnY









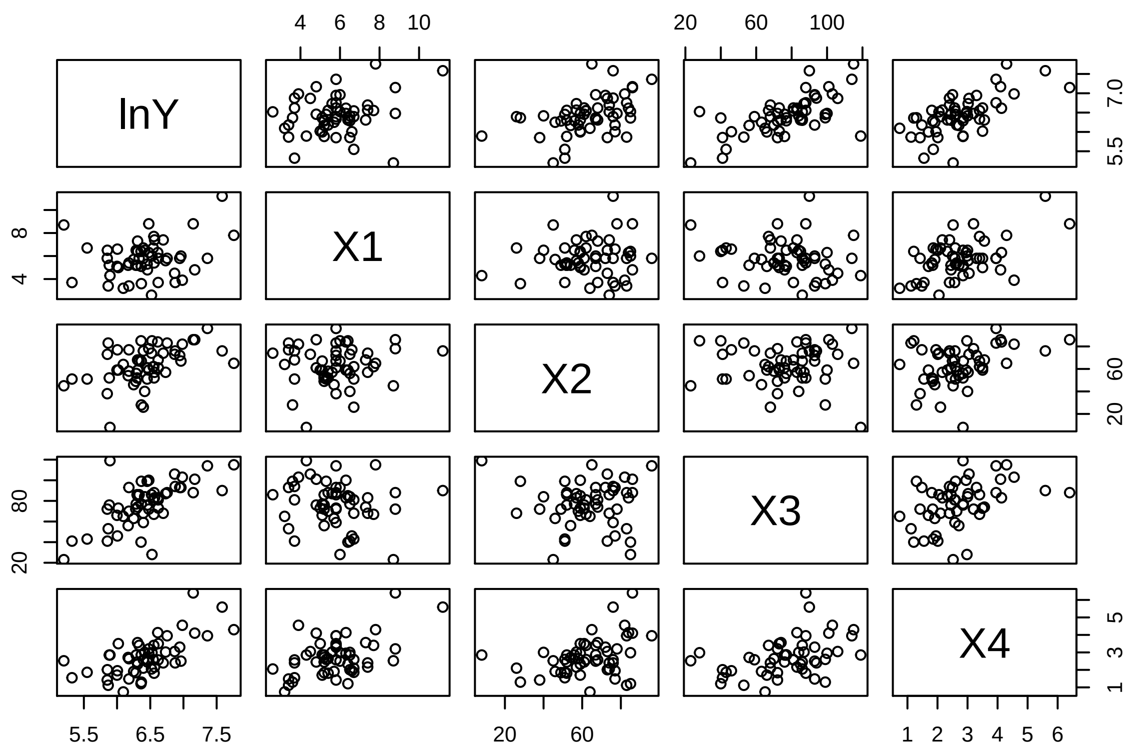
Correlations and Scatter Plot Matrix

```
with(df54, cor(df54[,c("lnY","X1","X2","X3","X4")]))
```

```
##           lnY         X1         X2         X3        X4
## lnY 1.0000000  0.24618787  0.46994325  0.65388548 0.6492627
```

```
## X1  0.2461879  1.00000000  0.09011973 -0.14963411 0.5024157
## X2  0.4699432  0.09011973  1.00000000 -0.02360544 0.3690256
## X3  0.6538855 -0.14963411 -0.02360544  1.00000000 0.4164245
## X4  0.6492627  0.50241567  0.36902563  0.41642451 1.0000000
```

```r
with(df54, pairs(df54[,c("lnY","X1","X2","X3","X4")]))
```



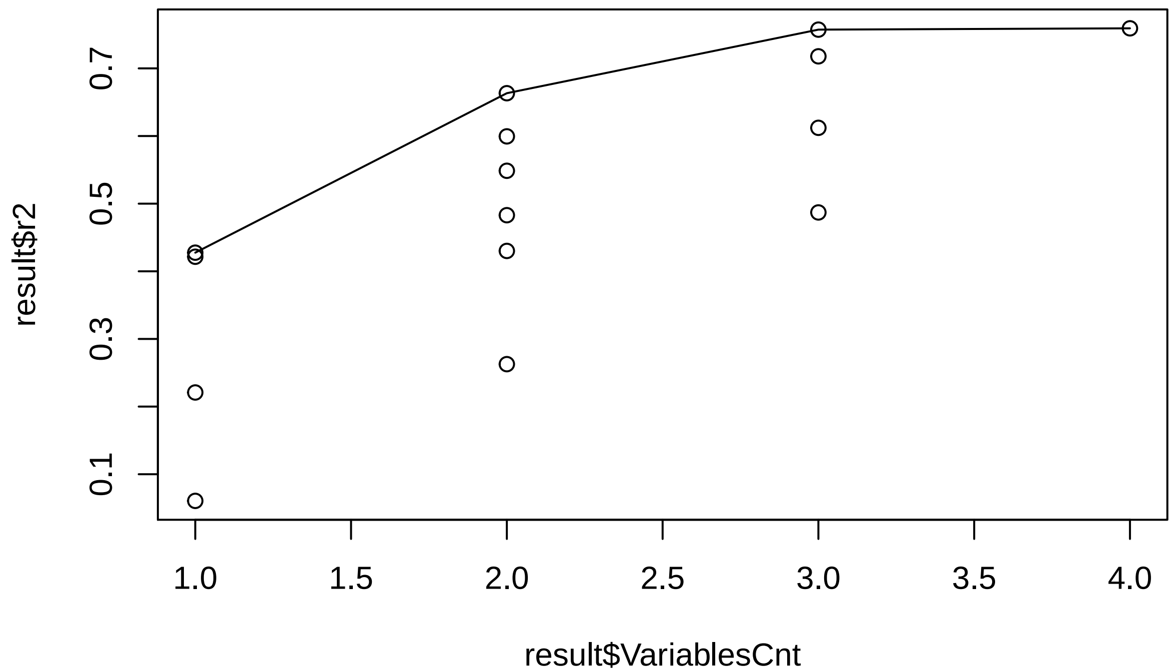
Using R_p^2 and SSE_p

```r
library(leaps)

evaluateRegressionModel <- function(x, y, method, names){
  result <- leaps(x=x, y=y,method=method,names=names)
  labels <- result$label[2:length(result$label)]

  Variables <- vector()
  VariablesCnt <- vector()
  metric <- vector()

  for(rowIdx in 1:dim(result$which)[1]){
    selected <- result$which[rowIdx,]
    VariablesCnt <- c(VariablesCnt, sum(result$which[rowIdx,]))
    vars <- paste(labels[selected], collapse=" ")
```

```r
    Variables <- c(Variables, vars)

    thisMetric <- switch(method,
                     r2=result$r2[rowIdx],
                     Cp=result$Cp[rowIdx],
                     adjr2=result$adjr2[rowIdx])

    metric <- c(metric, thisMetric)
  }

  out <- data.frame(Variables, VariablesCnt, metric)
  names(out)[3] = method
  print(out)
  return(out)
}

result <- evaluateRegressionModel(x=as.matrix(df54[,1:4]),
                                  y=df54$lnY,
                                  method="r2",
                                  names=names(df54)[1:4])
```

```
##      Variables VariablesCnt         r2
## 1           X3            1 0.42756622
## 2           X4            1 0.42154199
## 3           X2            1 0.22084666
## 4           X1            1 0.06060847
## 5        X2 X3            2 0.66328986
## 6        X3 X4            2 0.59948374
## 7        X1 X3            2 0.54863462
## 8        X2 X4            2 0.48296742
## 9        X1 X4            2 0.43010550
## 10       X1 X2            2 0.26273627
## 11    X1 X2 X3            3 0.75729185
## 12    X2 X3 X4            3 0.71781636
## 13    X1 X3 X4            3 0.61212320
## 14    X1 X2 X4            3 0.48701249
## 15 X1 X2 X3 X4            4 0.75921083
```

```r
library(dplyr)
df_tbl <- tbl_df(result) %>%
            group_by(VariablesCnt) %>%
            summarize(MaxR2 = max(r2))

plot(x=result$VariablesCnt, y=result$r2)
lines(df_tbl$VariablesCnt, df_tbl$MaxR2)
```

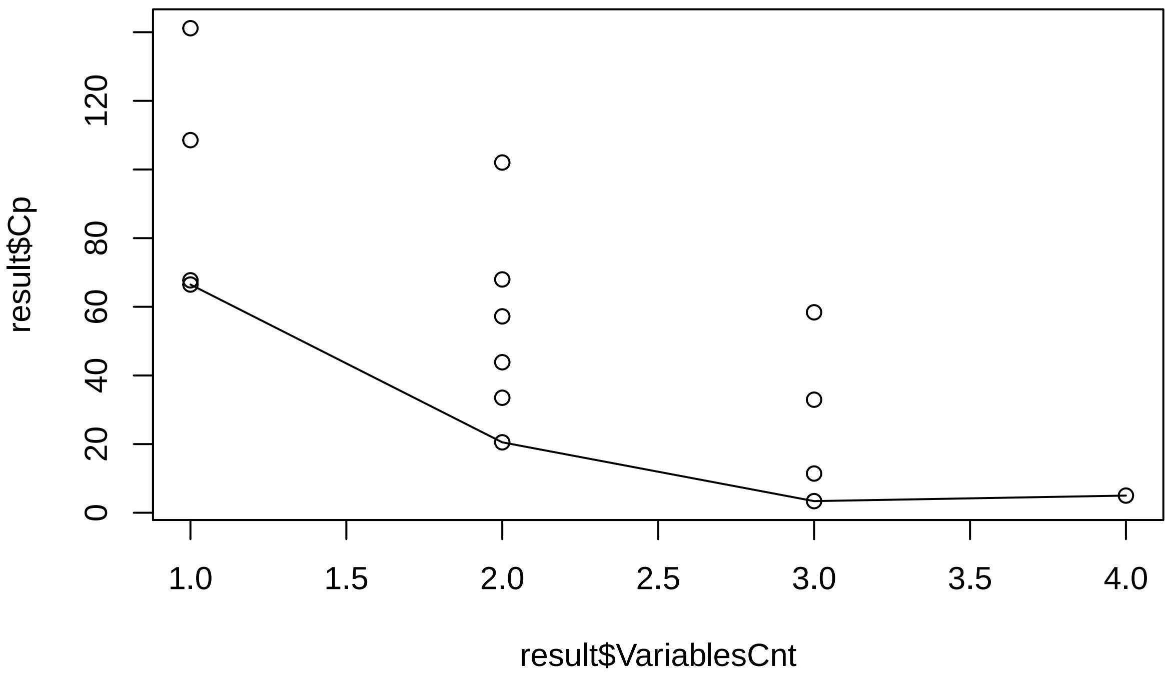


Mallows C_p Criterion

```
result <- evaluateRegressionModel(x=as.matrix(df54[,1:4]),
      y=df54$lnY,
      method="Cp",
      names=names(df54)[1:4])
```

```
##       Variables VariablesCnt         Cp
## 1            X3            1  66.488856
## 2            X4            1  67.714773
## 3            X2            1 108.555776
## 4            X1            1 141.163851
## 5         X2 X3            2  20.519679
## 6         X3 X4            2  33.504067
## 7         X1 X3            2  43.851738
## 8         X2 X4            2  57.214850
## 9         X1 X4            2  67.972119
## 10        X1 X2            2 102.031343
## 11     X1 X2 X3            3   3.390508
## 12     X2 X3 X4            3  11.423673
## 13     X1 X3 X4            3  32.931969
## 14     X1 X2 X4            3  58.391689
## 15 X1 X2 X3 X4            4   5.000000
```

```r
df_tbl <- tbl_df(result) %>%
            group_by(VariablesCnt) %>%
            summarize(MinCp = min(Cp))

plot(x=result$VariablesCnt, y=result$Cp)
lines(df_tbl$VariablesCnt, df_tbl$MinCp)
```



Stepwise Regression - Forward

For forward stepwise regression it is important to identify an α cut off for determining which predictors to let into the model. For example, if your cut of is 0.05 then you would only include variables with pvalues below the variable.

```r
library(MASS)

full <- lm(lnY ~ X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8,
           data=df)
Null <- lm(lnY ~ 1, data=df)
addterm(Null, scope=full, test="F")
```

```
## Single term additions
##
## Model:
```

```
## lnY ~ 1
##        Df Sum of Sq     RSS      AIC F Value     Pr(F)
## <none>               12.8077  -75.703
## X1      1    0.7763 12.0315  -77.079   3.355 0.0727328 .
## X2      1    2.8285  9.9792  -87.178  14.739 0.0003366 ***
## X3      1    5.4762  7.3316 -103.827  38.840 8.261e-08 ***
## X4      1    5.3990  7.4087 -103.262  37.894 1.092e-07 ***
## X5      1    0.2691 12.5386  -74.849   1.116 0.2956212
## X6      1    0.6897 12.1180  -76.692   2.960 0.0913204 .
## X7      1    0.2052 12.6025  -74.575   0.847 0.3616983
## X8      1    1.7798 11.0279  -81.782   8.392 0.0055015 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

For this iteration we would include the predictor with the lowest p value which is X3. A new base model is built by including the X3 value then the procedure is ran again.

```
newModel <- lm(lnY ~ X3, data=df)
addterm(newModel, scope=full, test="F")
```

```
## Single term additions
##
## Model:
## lnY ~ X3
##        Df Sum of Sq    RSS     AIC F Value     Pr(F)
## <none>              7.3316 -103.83
## X1      1   1.55061 5.7810 -114.66  13.680 0.0005312 ***
## X2      1   3.01908 4.3125 -130.48  35.704 2.242e-07 ***
## X4      1   2.20187 5.1297 -121.11  21.891 2.161e-05 ***
## X5      1   0.23877 7.0928 -103.61   1.717 0.1959722
## X6      1   0.25854 7.0730 -103.77   1.864 0.1781349
## X7      1   0.06498 7.2666 -102.31   0.456 0.5025196
## X8      1   1.13756 6.1940 -110.93   9.366 0.0035199 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Now I'll add in X2

```
newModel <- lm(lnY ~ X3 + X2, data=df)
addterm(newModel, scope=full, test="F")
```

```
## Single term additions
##
## Model:
## lnY ~ X3 + X2
##        Df Sum of Sq    RSS     AIC F Value     Pr(F)
## <none>              4.3125 -130.48
## X1      1   1.20395 3.1085 -146.16 19.3652 5.670e-05 ***
## X4      1   0.69836 3.6141 -138.02  9.6615  0.003102 **
## X5      1   0.16461 4.1479 -130.59  1.9843  0.165127
## X6      1   0.08245 4.2300 -129.53  0.9745  0.328307
## X7      1   0.22632 4.0862 -131.39  2.7693  0.102341
```

```
## X8       1   1.46961 2.8429 -150.99 25.8471 5.558e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This time X1 is added

```r
newModel <- lm(lnY ~ X3 + X2 + X1, data=df)
addterm(newModel, scope=full, test="F")
```

```
## Single term additions
##
## Model:
## lnY ~ X3 + X2 + X1
##        Df Sum of Sq    RSS     AIC F Value     Pr(F)
## <none>              3.1085 -146.16
## X4      1   0.02458 3.0840 -144.59  0.3905    0.5349
## X5      1   0.14838 2.9602 -146.80  2.4561    0.1235
## X6      1   0.05202 3.0565 -145.07  0.8339    0.3656
## X7      1   0.11790 2.9906 -146.25  1.9316    0.1709
## X8      1   0.92974 2.1788 -163.35 20.9094 3.291e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

This time through the only variable making the cut off is X8. Adding this gives us our full model.

```r
newModel <- lm(lnY ~ X3 + X2 + X1 + X8, data=df)
addterm(newModel, scope=full, test="F")
```

```
## Single term additions
##
## Model:
## lnY ~ X3 + X2 + X1 + X8
##        Df Sum of Sq    RSS     AIC F Value  Pr(F)
## <none>              2.1788 -163.35
## X4      1  0.041701 2.1371 -162.40 0.93662 0.3380
## X5      1  0.075876 2.1029 -163.26 1.73190 0.1944
## X6      1  0.096791 2.0820 -163.81 2.23149 0.1418
## X7      1  0.022944 2.1559 -161.92 0.51085 0.4782
```