Multiple Regression

```
#Multiple Regression

expect <- read.csv("D:/MITA 2019/Semester 2/Multivariate Analysis/lfe.csv")

head(expect)

sapply(expect, function(x) sum(is.na(x)))

expect <- expect[complete.cases(expect),]  ## to remove which has null values

sapply(expect, function(x) sum(is.na(x)))

#expect_x <- subset.data.frame(expect, Year == "2000")

View(expect)

# Performing multiple regression on life expectancy dataset

fit <- lm(
Life.expectancy~Adult.Mortality+infant.deaths+Alcohol+percentage.expenditure+Hepatitis.B+Measles+BMI+under.five.deaths+
Polio+Total.expenditure+Diphtheria+HIV.AIDS+GDP+Population, data=expect)

#show the results

summary(fit)
```

```
Call:
lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
    Alcohol + percentage.expenditure + Hepatitis.B + Measles +
    BMI + under.five.deaths + Polio + Total.expenditure + Diphtheria +
    HIV.AIDS + GDP + Population, data = expect)

Residuals:
     Min       1Q   Median       3Q      Max
-20.4084  -2.6551   0.2717   2.6345  16.9429

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)           6.388e+01  6.437e-01  99.244  < 2e-16 ***
Adult.Mortality      -2.303e-02  1.105e-03 -20.839  < 2e-16 ***
infant.deaths         1.231e-01  1.268e-02   9.707  < 2e-16 ***
Alcohol               3.428e-01  3.198e-02  10.720  < 2e-16 ***
percentage.expenditure -1.157e-04  2.161e-04  -0.535  0.59246
Hepatitis.B          -7.429e-03  5.341e-03  -1.391  0.16446
Measles              -1.023e-05  1.287e-05  -0.795  0.42667
BMI                   9.179e-02  6.315e-03  14.537  < 2e-16 ***
under.five.deaths    -9.456e-02  9.199e-03 -10.279  < 2e-16 ***
Polio                 1.862e-02  6.176e-03   3.016  0.00260 **
Total.expenditure     1.441e-01  4.874e-02   2.957  0.00316 **
Diphtheria            3.302e-02  7.087e-03   4.659 3.43e-06 ***
HIV.AIDS             -4.573e-01  2.143e-02 -21.342  < 2e-16 ***
GDP                   1.418e-04  3.367e-05   4.212 2.67e-05 ***
Population            1.967e-09  2.103e-09   0.935  0.34979
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.327 on 1634 degrees of freedom
Multiple R-squared:  0.7601,    Adjusted R-squared:  0.758
F-statistic: 369.7 on 14 and 1634 DF,  p-value: < 2.2e-16
```

#Summary has three sections. Section1: How well does the model fit the data (before Coefficients). Section2: Is the hypothesis supported? (until sifnif codes). Section3: How well does data fit the model (again).

Useful Helper Functions

coefficients(fit)

```
> coefficients(fit)
          (Intercept)        Adult.Mortality          infant.deaths
         6.388485e+01          -2.302840e-02           1.230713e-01
              Alcohol percentage.expenditure           Hepatitis.B
         3.428187e-01          -1.156811e-04          -7.428741e-03
              Measles                    BMI       under.five.deaths
        -1.023160e-05           9.179436e-02          -9.455976e-02
                Polio       Total.expenditure              Diphtheria
         1.862456e-02           1.441016e-01           3.301983e-02
             HIV.AIDS                     GDP            Population
        -4.573424e-01           1.418266e-04           1.966679e-09
```

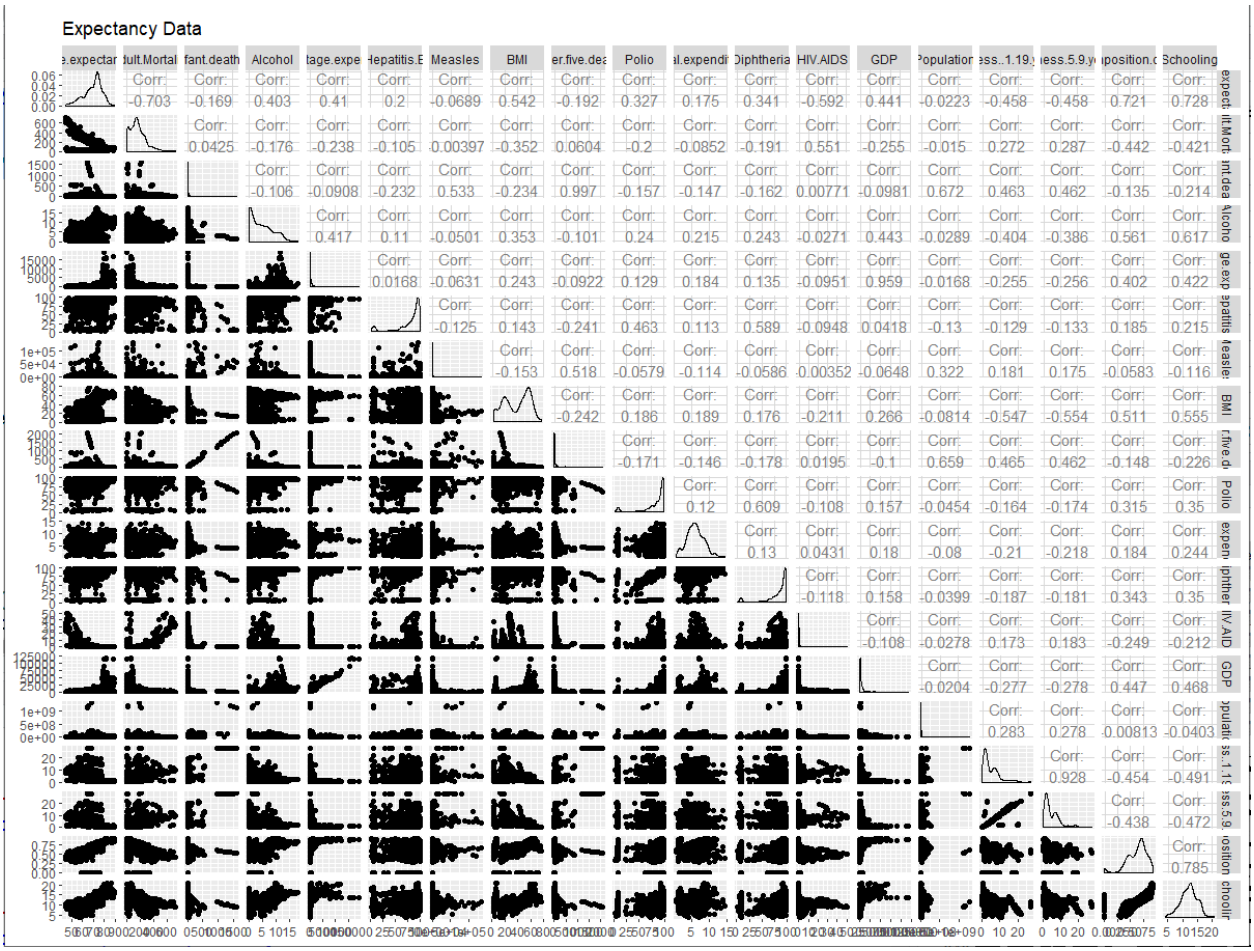
ggpairs(data=expect[,4:22], title="Expectancy Data")

library(FFally)

library(GGally)

install.packages("GGally", lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")

library(GGally)



confint(fit,level=0.95)

```
> confint(fit,level=0.95)
                                  2.5 %         97.5 %
(Intercept)                6.262225e+01  6.514745e+01
Adult.Mortality           -2.519587e-02 -2.086092e-02
infant.deaths              9.820224e-02  1.479404e-01
Alcohol                    2.800921e-01  4.055453e-01
percentage.expenditure    -5.394953e-04  3.081332e-04
Hepatitis.B               -1.790497e-02  3.047487e-03
Measles                   -3.547142e-05  1.500822e-05
BMI                        7.940897e-02  1.041798e-01
under.five.deaths         -1.126036e-01 -7.651592e-02
Polio                      6.511361e-03  3.073777e-02
Total.expenditure          4.850163e-02  2.397016e-01
Diphtheria                 1.911986e-02  4.691979e-02
HIV.AIDS                  -4.993749e-01 -4.153098e-01
GDP                        7.578020e-05  2.078730e-04
Population                -2.157756e-09  6.091114e-09
```

Predicted Values

fitted(fit)

residuals(fit)

#Anova Table

anova(fit)

```
> anova(fit)
Analysis of Variance Table

Response: Life.expectancy
                       Df Sum Sq Mean Sq   F value    Pr(>F)
Adult.Mortality         1  62941   62941 3361.0963 < 2.2e-16 ***
infant.deaths           1   2477    2477  132.2949 < 2.2e-16 ***
Alcohol                 1   9379    9379  500.8226 < 2.2e-16 ***
percentage.expenditure  1   2696    2696  143.9535 < 2.2e-16 ***
Hepatitis.B             1    966     966   51.5642 1.048e-12 ***
Measles                 1      7       7    0.3616    0.5477
BMI                     1   5549    5549  296.3049 < 2.2e-16 ***
under.five.deaths       1   2949    2949  157.4961 < 2.2e-16 ***
Polio                   1    576     576   30.7652 3.391e-08 ***
Total.expenditure       1     12      12    0.6160    0.4326
Diphtheria              1    455     455   24.3228 8.976e-07 ***
HIV.AIDS                1   8577    8577  458.0369 < 2.2e-16 ***
GDP                     1    331     331   17.6890 2.742e-05 ***
Population              1     16      16    0.8747    0.3498
Residuals            1634  30599      19
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

vcov(fit)

```
> vcov(fit)
                     (Intercept) Adult.Mortality infant.deaths       Alcohol percentage.expenditure
(Intercept)         4.143724e-01   -3.065943e-04  6.765910e-04  1.962168e-03          -1.299537e-06
Adult.Mortality    -3.065943e-04    1.221147e-06  2.059695e-06  1.024604e-06           1.550849e-09
infant.deaths       6.765910e-04    2.059695e-06  1.607606e-04  6.603944e-05           4.948533e-08
Alcohol             1.962168e-03    1.024604e-06  6.603944e-05  1.022737e-03           1.376915e-07
percentage.expenditure -1.299537e-06  1.550849e-09  4.948533e-08  1.376915e-07          4.668865e-08
Hepatitis.B        -3.903751e-04   -2.093409e-07  1.155950e-06  8.300086e-06           5.991292e-08
Measles            -4.608164e-07    1.273793e-10 -4.279153e-08 -2.303163e-08           1.181022e-11
BMI                -1.374616e-03    1.441429e-06 -3.540819e-06 -4.935433e-05           4.275063e-08
under.five.deaths  -6.440332e-04   -1.487396e-06 -1.159390e-04 -4.839702e-05          -3.395494e-08
Polio              -1.172860e-03    4.255407e-07 -4.651522e-06 -1.847680e-05           5.175940e-08
Total.expenditure  -1.086382e-02    2.746093e-06  1.377724e-05 -1.488451e-04          -5.623450e-07
Diphtheria         -1.313631e-03    2.453791e-07 -1.042854e-05 -2.683524e-05          -1.314419e-08
HIV.AIDS            1.232302e-03   -1.203673e-05  2.511806e-06 -5.084679e-05          -5.292033e-08
GDP                 1.964176e-07    1.394184e-09 -8.464874e-09 -1.408911e-07          -6.900229e-09
Population          7.586424e-11   -6.363365e-14 -6.716017e-12 -1.858934e-12          -6.104738e-15
                    Hepatitis.B       Measles           BMI under.five.deaths         Polio
(Intercept)        -3.903751e-04 -4.608164e-07 -1.374616e-03     -6.440332e-04 -1.172860e-03
Adult.Mortality    -2.093409e-07  1.273793e-10  1.441429e-06     -1.487396e-06  4.255407e-07
infant.deaths       1.155950e-06 -4.279153e-08 -3.540819e-06     -1.159390e-04 -4.651522e-06
Alcohol             8.300086e-06 -2.303163e-08 -4.935433e-05     -4.839702e-05 -1.847680e-05
percentage.expenditure  5.991292e-08  1.181022e-11  4.275063e-08  -3.395494e-08  5.175940e-08
Hepatitis.B         2.852792e-05  1.703583e-09 -1.009613e-06     -4.219264e-07 -5.290071e-06
Measles             1.703583e-09  1.655894e-10  4.393305e-09      2.578469e-08 -3.376950e-10
BMI                -1.009613e-06  4.393305e-09  3.987306e-05      3.573808e-06 -5.094673e-07
under.five.deaths  -4.219264e-07  2.578469e-08  3.573808e-06      8.462880e-05  3.679569e-06
Polio              -5.290071e-06 -3.376950e-10 -5.094673e-07      3.679569e-06  3.813977e-05
Total.expenditure  -1.074054e-05  2.289181e-08 -2.727911e-05     -8.166966e-06 -3.833934e-06
Diphtheria         -1.638562e-05 -3.629134e-10  1.059630e-06      7.917045e-06 -1.821868e-05
HIV.AIDS            5.269639e-06 -3.312610e-09  8.019438e-06     -1.569916e-06 -1.598952e-06
GDP                -4.970150e-09  1.499859e-12 -9.896073e-09      6.189948e-09 -8.655941e-09
Population          2.784997e-13  2.604055e-15 -8.070775e-13      3.589362e-12 -2.005595e-13
```

cov2cor(vcov(fit))

```
> cov2cor(vcov(fit))
                    (Intercept) Adult.Mortality infant.deaths     Alcohol percentage.expenditure
(Intercept)          1.000000000    -0.431007399   0.082897431  0.09531447            -0.009343023
Adult.Mortality     -0.431007399     1.000000000   0.147004009  0.02899279             0.006495011
infant.deaths        0.082897431     0.147004009   1.000000000  0.16286649             0.018062633
Alcohol              0.095314470     0.028992787   0.162866487  1.00000000             0.019925977
percentage.expenditure -0.009343023  0.006495011   0.018062633  0.01992598             1.000000000
Hepatitis.B         -0.113540728    -0.035467860   0.017069236  0.04859210             0.051913438
Measles             -0.055630917     0.008957744  -0.262271906 -0.05596627             0.004247524
BMI                 -0.338178676     0.206571058  -0.044225645 -0.24440135             0.031332644
under.five.deaths   -0.108756137    -0.146313203  -0.993986867 -0.16450446            -0.017081979
Polio               -0.295026979     0.062354542  -0.059404072 -0.09355258             0.038787741
Total.expenditure   -0.346257362     0.050985100   0.022293819 -0.09549151            -0.053396054
Diphtheria          -0.287961476     0.031333564  -0.116061946 -0.11840767            -0.008583896
HIV.AIDS             0.089331743    -0.508286743   0.009244437 -0.07419349            -0.011428809
GDP                  0.009061616     0.037467677  -0.019826742 -0.13083454            -0.948371425
Population           0.056046324    -0.027384718  -0.251899568 -0.02764315            -0.013435900
                    Hepatitis.B      Measles         BMI under.five.deaths        Polio
(Intercept)         -0.113540728 -0.055630917 -0.33817868      -0.108756137 -0.295026979
Adult.Mortality     -0.035467860  0.008957744  0.20657106      -0.146313203  0.062354542
infant.deaths        0.017069236 -0.262271906 -0.04422564      -0.993986867 -0.059404072
Alcohol              0.048592099 -0.055966272 -0.24440135      -0.164504455 -0.093552583
percentage.expenditure  0.051913438  0.004247524  0.03133264      -0.017081979  0.038787741
Hepatitis.B          1.000000000  0.024786310 -0.02993506      -0.008587023 -0.160375273
Measles              0.024786310  1.000000000  0.05406737       0.217814351 -0.004249318
BMI                 -0.029935064  0.054067375  1.00000000       0.061522269 -0.013064341
under.five.deaths   -0.008587023  0.217814351  0.06152227       1.000000000  0.064766255
Polio               -0.160375273 -0.004249318 -0.01306434       0.064766255  1.000000000
Total.expenditure   -0.041257534  0.036498573 -0.08863443      -0.018214350 -0.012737013
Diphtheria          -0.432896493 -0.003979633  0.02367940       0.121439609 -0.416278633
HIV.AIDS             0.046039434 -0.012012629  0.05926363      -0.007963452 -0.012081767
GDP                 -0.027634722  0.003461424 -0.04654186       0.019982440 -0.041624197
Population           0.024796767  0.096236352 -0.06078283       0.185551125 -0.015443990

                    Total.expenditure   Diphtheria     HIV.AIDS           GDP    Population
(Intercept)           -0.3462573623 -0.287961476  0.089331743  0.009061616  0.0560463238
Adult.Mortality        0.0509851000  0.031333564 -0.508286743  0.037467677 -0.0273847183
infant.deaths          0.0222938186 -0.116061946  0.009244437 -0.019826742 -0.2518995676
Alcohol               -0.0954915114 -0.118407666 -0.074193489 -0.130834538 -0.0276431485
percentage.expenditure -0.0533960544 -0.008583896 -0.011428809 -0.948371425 -0.0134358999
Hepatitis.B           -0.0412575338 -0.432896493  0.046039434 -0.027634722  0.0247967671
Measles                0.0364985734 -0.003979633 -0.012012629  0.003461424  0.0962363521
BMI                   -0.0886344324  0.023679398  0.059263633 -0.046541862 -0.0607828276
under.five.deaths     -0.0182143497  0.121439609 -0.007963452  0.019982440  0.1855511248
Polio                 -0.0127370127 -0.416278633 -0.012081767 -0.041624197 -0.0154439903
Total.expenditure      1.0000000000 -0.021737106 -0.101089060  0.025875459 -0.0008515652
Diphtheria            -0.0217371058  1.000000000  0.010204335 -0.003156184 -0.0324808352
HIV.AIDS              -0.1010890605  0.010204335  1.000000000  0.011335727  0.0109577761
GDP                    0.0258754590 -0.003156184  0.011335727  1.000000000  0.0065860967
Population            -0.0008515652 -0.032480835  0.010957776  0.006586097  1.0000000000
>
```

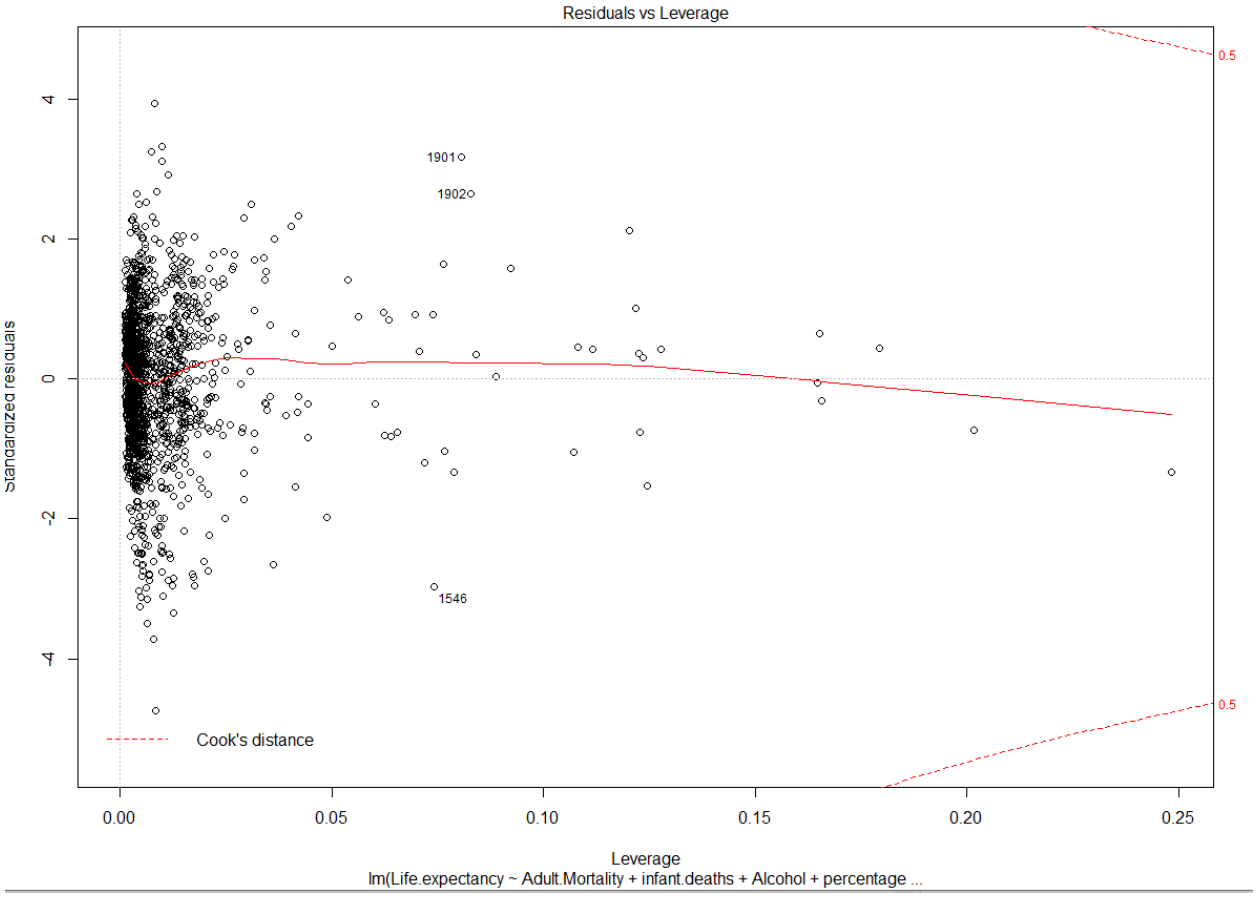
temp <- influence.measures(fit)

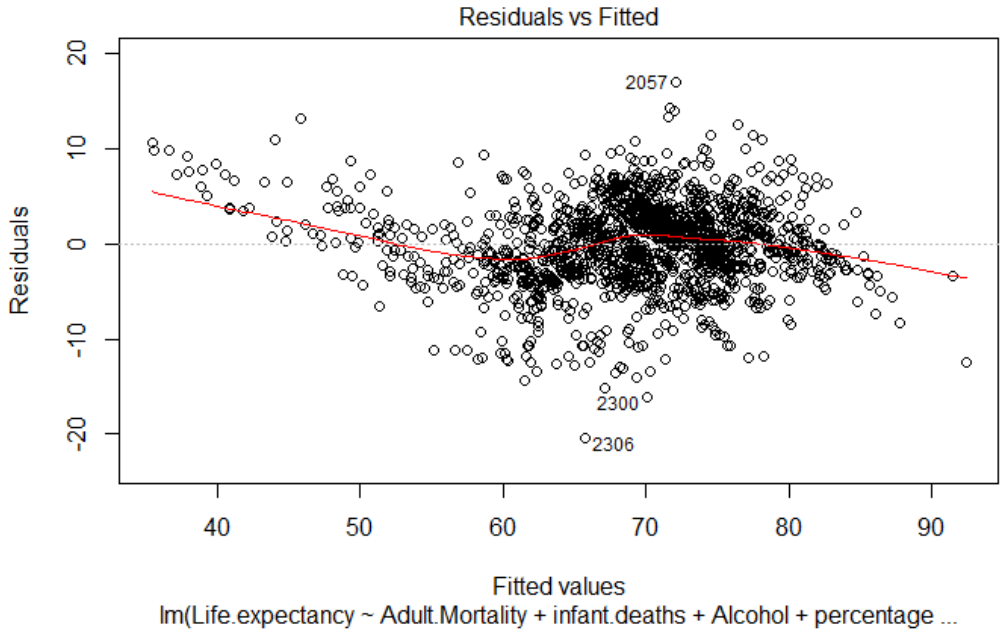
temp

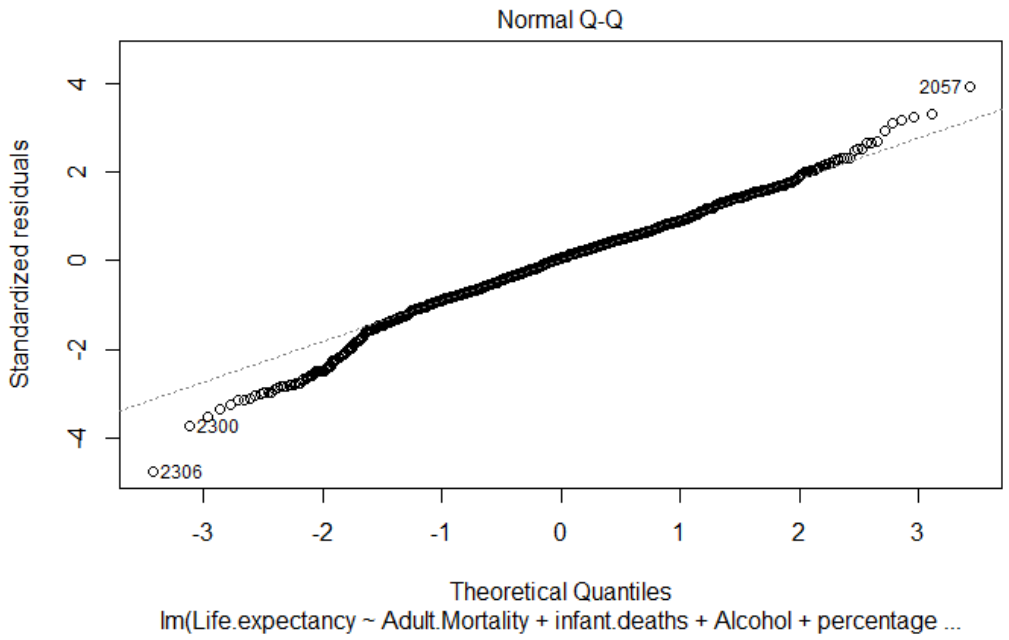
View(temp)

#diagnostic plots

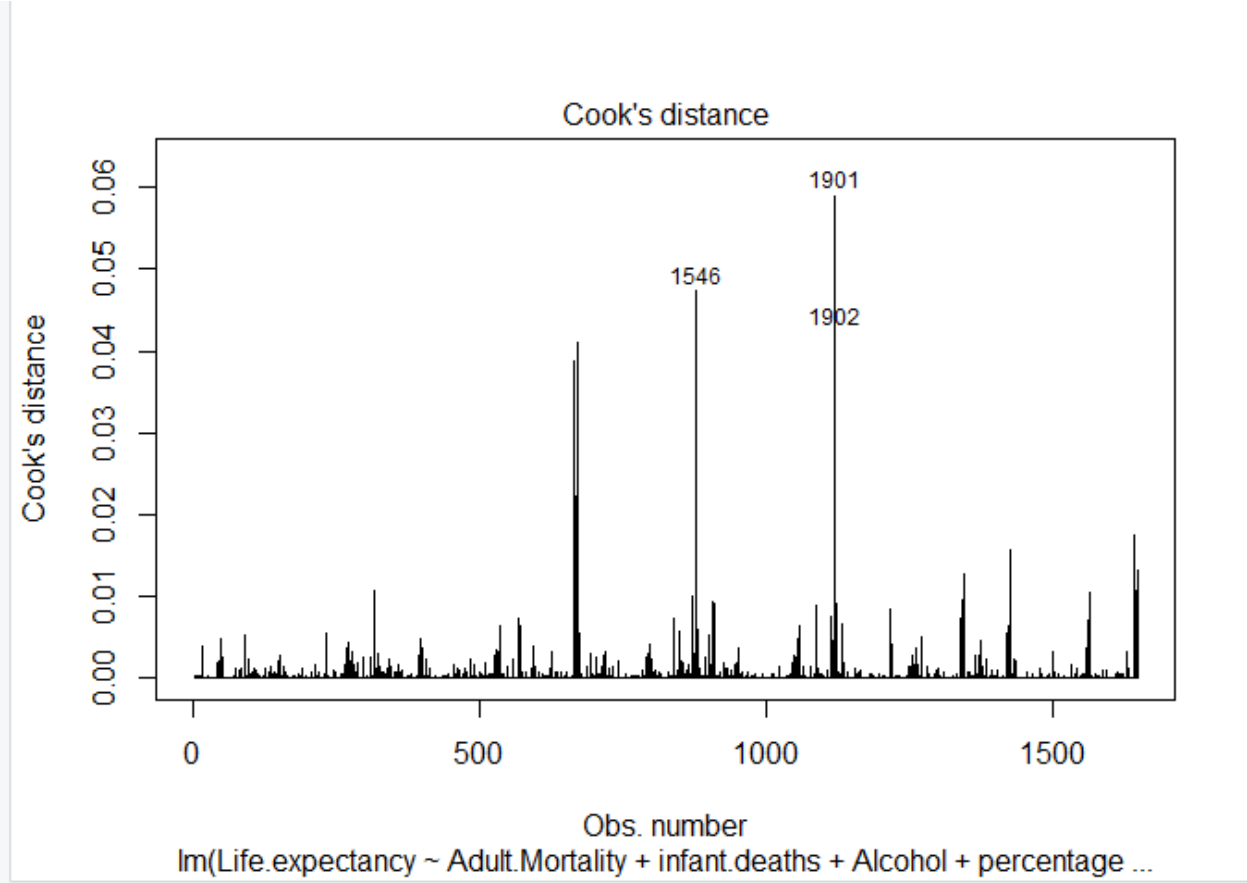
plot(fit)


Residuals vs Leverage
Standardized residuals
Leverage
lm(Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol + percentage ...
Cook's distance
0.5
1901
1902
1546
4
2
0
-2
-4
0.00
0.05
0.10
0.15
0.20
0.25

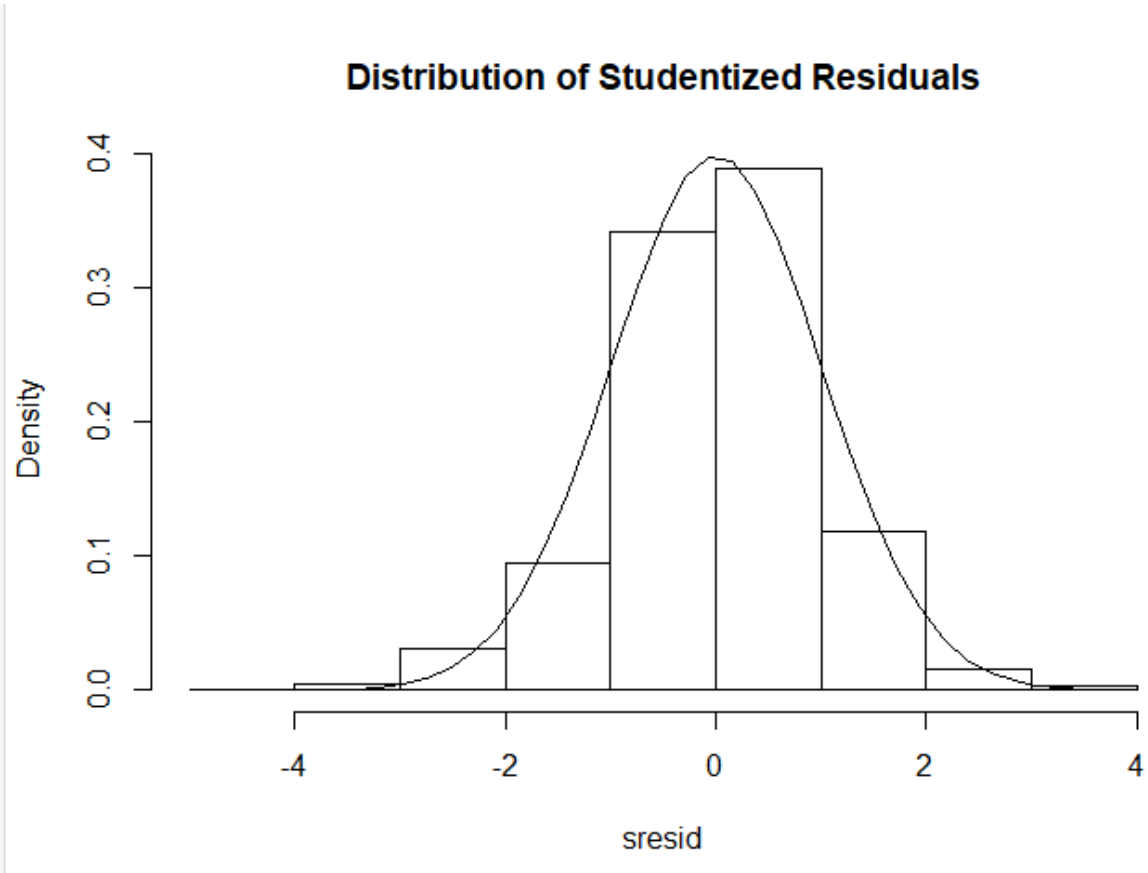

Residuals vs Fitted
Residuals
Fitted values
lm(Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol + percentage ...
2057
2300
2306
20
10
0
-10
-20
40
50
60
70
80
90




```
# Cook's D plot

# identify D values > 4/(n-k-1)

cutoff <- 4/((nrow(expect)-length(fit$coefficients)-2))

plot(fit, which=4, cook.levels=cutoff)
```




```
# distribution of studentized residuals

library(MASS)

sresid <- studres(fit)


hist(sresid, freq=FALSE,

    main="Distribution of Studentized Residuals")

xfit<-seq(min(sresid),max(sresid),length=40)

yfit<-dnorm(xfit)

lines(xfit, yfit)

#Non-constant Error Variance

# Evaluate homoscedasticity
```




```
# Global test of model assumptions

library(gvlma)

install.packages("gvlma", lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")

library(gvlma)

gvmodel <- gvlma(fit)

summary(gvmodel)

fit
```

```
Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)               6.388e+01  6.437e-01  99.244  < 2e-16 ***
Adult.Mortality          -2.303e-02  1.105e-03 -20.839  < 2e-16 ***
infant.deaths             1.231e-01  1.268e-02   9.707  < 2e-16 ***
Alcohol                   3.428e-01  3.198e-02  10.720  < 2e-16 ***
percentage.expenditure -1.157e-04  2.161e-04  -0.535  0.59246
Hepatitis.B              -7.429e-03  5.341e-03  -1.391  0.16446
Measles                  -1.023e-05  1.287e-05  -0.795  0.42667
BMI                       9.179e-02  6.315e-03  14.537  < 2e-16 ***
under.five.deaths        -9.456e-02  9.199e-03 -10.279  < 2e-16 ***
Polio                     1.862e-02  6.176e-03   3.016  0.00260 **
Total.expenditure         1.441e-01  4.874e-02   2.957  0.00316 **
Diphtheria                3.302e-02  7.087e-03   4.659 3.43e-06 ***
HIV.AIDS                 -4.573e-01  2.143e-02 -21.342  < 2e-16 ***
GDP                       1.418e-04  3.367e-05   4.212 2.67e-05 ***
Population                1.967e-09  2.103e-09   0.935  0.34979
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.327 on 1634 degrees of freedom
Multiple R-squared:  0.7601,    Adjusted R-squared:  0.758
F-statistic: 369.7 on 14 and 1634 DF,  p-value: < 2.2e-16


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05

Call:
 gvlma(x = fit)

                     Value   p-value                   Decision
Global Stat        190.7227 0.000e+00 Assumptions NOT satisfied!
Skewness            32.9997 9.217e-09 Assumptions NOT satisfied!
Kurtosis            77.2465 0.000e+00 Assumptions NOT satisfied!
Link Function       80.0423 0.000e+00 Assumptions NOT satisfied!
Heteroscedasticity   0.4342 5.099e-01    Assumptions acceptable.
```

fit

```
> fit

Call:
lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
    Alcohol + percentage.expenditure + Hepatitis.B + Measles +
    BMI + under.five.deaths + Polio + Total.expenditure + Diphtheria +
    HIV.AIDS + GDP + Population, data = expect)

Coefficients:
          (Intercept)         Adult.Mortality           infant.deaths
            6.388e+01             -2.303e-02              1.231e-01
              Alcohol  percentage.expenditure          Hepatitis.B
            3.428e-01             -1.157e-04             -7.429e-03
             Measles                     BMI       under.five.deaths
           -1.023e-05              9.179e-02             -9.456e-02
               Polio       Total.expenditure             Diphtheria
            1.862e-02              1.441e-01              3.302e-02
             HIV.AIDS                    GDP              Population
           -4.573e-01              1.418e-04              1.967e-09
```

Summary(fit)

```
> summary(fit)

Call:
lm(formula = Life.expectancy ~ Adult.Mortality + infant.deaths +
    Alcohol + percentage.expenditure + Hepatitis.B + Measles +
    BMI + under.five.deaths + Polio + Total.expenditure + Diphtheria +
    HIV.AIDS + GDP + Population, data = expect)

Residuals:
     Min       1Q   Median       3Q      Max
-20.4084  -2.6551   0.2717   2.6345  16.9429

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)             6.388e+01  6.437e-01  99.244  < 2e-16 ***
Adult.Mortality        -2.303e-02  1.105e-03 -20.839  < 2e-16 ***
infant.deaths           1.231e-01  1.268e-02   9.707  < 2e-16 ***
Alcohol                 3.428e-01  3.198e-02  10.720  < 2e-16 ***
percentage.expenditure -1.157e-04  2.161e-04  -0.535  0.59246
Hepatitis.B            -7.429e-03  5.341e-03  -1.391  0.16446
Measles                -1.023e-05  1.287e-05  -0.795  0.42667
BMI                     9.179e-02  6.315e-03  14.537  < 2e-16 ***
under.five.deaths      -9.456e-02  9.199e-03 -10.279  < 2e-16 ***
Polio                   1.862e-02  6.176e-03   3.016  0.00260 **
Total.expenditure       1.441e-01  4.874e-02   2.957  0.00316 **
Diphtheria              3.302e-02  7.087e-03   4.659 3.43e-06 ***
HIV.AIDS               -4.573e-01  2.143e-02 -21.342  < 2e-16 ***
GDP                     1.418e-04  3.367e-05   4.212 2.67e-05 ***
Population              1.967e-09  2.103e-09   0.935  0.34979
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.327 on 1634 degrees of freedom
Multiple R-squared:  0.7601,    Adjusted R-squared:  0.758
F-statistic: 369.7 on 14 and 1634 DF,  p-value: < 2.2e-16
```

```
fit1 <- fit

fit2 <- lm(Life.expectancy~GDP+Population+Alcohol, data=expect)

# compare models

anova(fit1, fit2)

step <- stepAIC(fit, direction="both")
```

```
Life.expectancy ~ Adult.Mortality + infant.deaths + Alcohol +
    Hepatitis.B + BMI + under.five.deaths + Polio + Total.expenditure +
    Diphtheria + HIV.AIDS + GDP + Population

                        Df Sum of Sq   RSS    AIC
- Population             1      19.1 30635 4842.3
- Hepatitis.B            1      33.9 30650 4843.1
<none>                               30616 4843.3
+ Measles                1      11.8 30604 4844.7
+ percentage.expenditure 1       5.3 30610 4845.0
- Total.expenditure      1     164.4 30780 4850.1
- Polio                  1     172.5 30788 4850.6
- Diphtheria             1     405.2 31021 4863.0
- infant.deaths          1    1818.8 32435 4936.5
- under.five.deaths      1    2012.2 32628 4946.3
- Alcohol                1    2145.9 32762 4953.0
- GDP                    1    2563.9 33180 4973.9
- BMI                    1    4005.4 34621 5044.0
- Adult.Mortality        1    8125.0 38741 5229.4
- HIV.AIDS               1    8543.9 39160 5247.2
```

step$anova # display results

install.packages("leaps", lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")

library(leaps)

leaps<-regsubsets(Life.expectancy~GDP+Population+Alcohol, data=expect,nbest=10)

view results

summary(leaps)

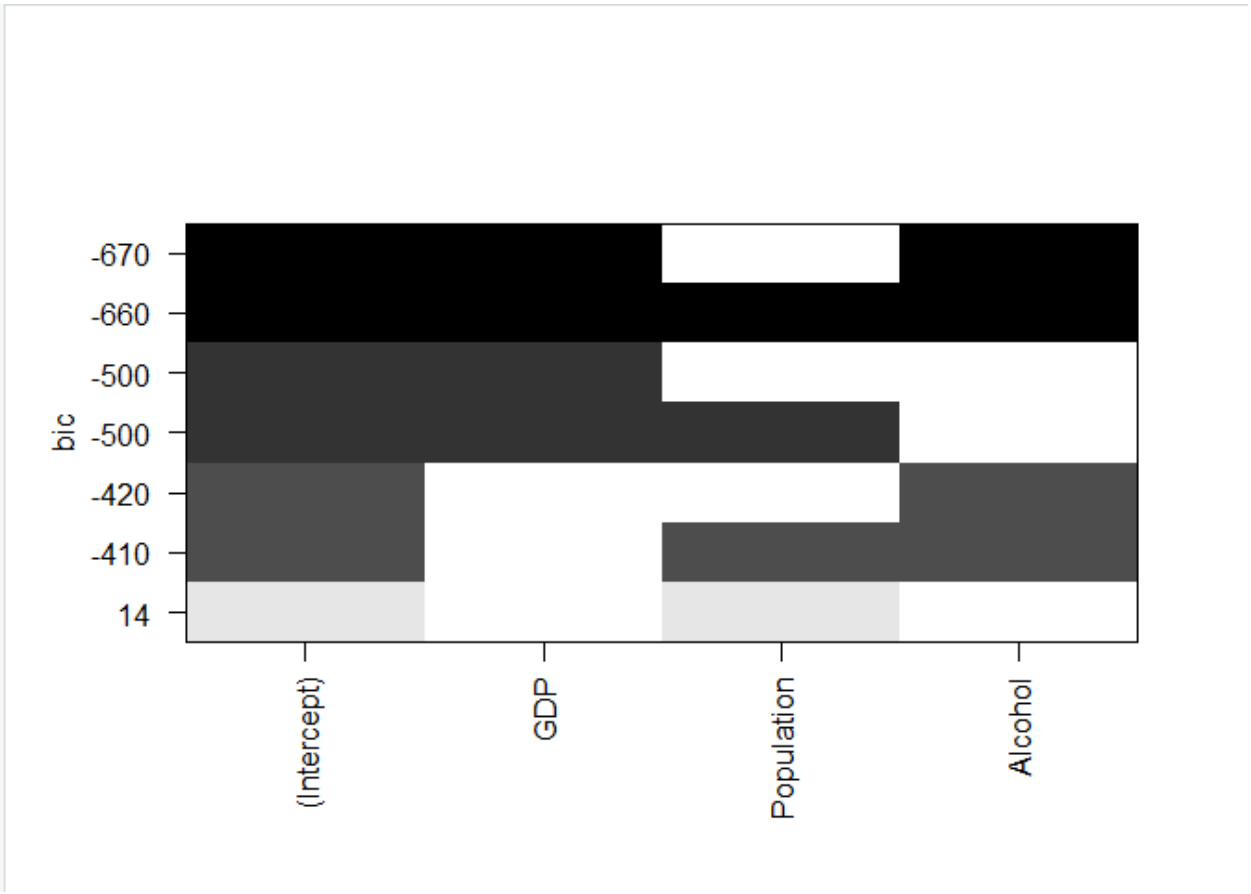
```
Subset selection object
Call: regsubsets.formula(Life.expectancy ~ GDP + Population + Alcohol,
    data = expect, nbest = 10)
3 Variables  (and intercept)
           Forced in Forced out
GDP            FALSE      FALSE
Population     FALSE      FALSE
Alcohol        FALSE      FALSE
10 subsets of each size up to 3
Selection Algorithm: exhaustive
         GDP Population Alcohol
1  ( 1 ) "*" " "        " "
1  ( 2 ) " " " "        "*"
1  ( 3 ) " " "*"        " "
2  ( 1 ) "*" " "        "*"
2  ( 2 ) "*" "*"        " "
2  ( 3 ) " " "*"        "*"
3  ( 1 ) "*" "*"        "*"
```

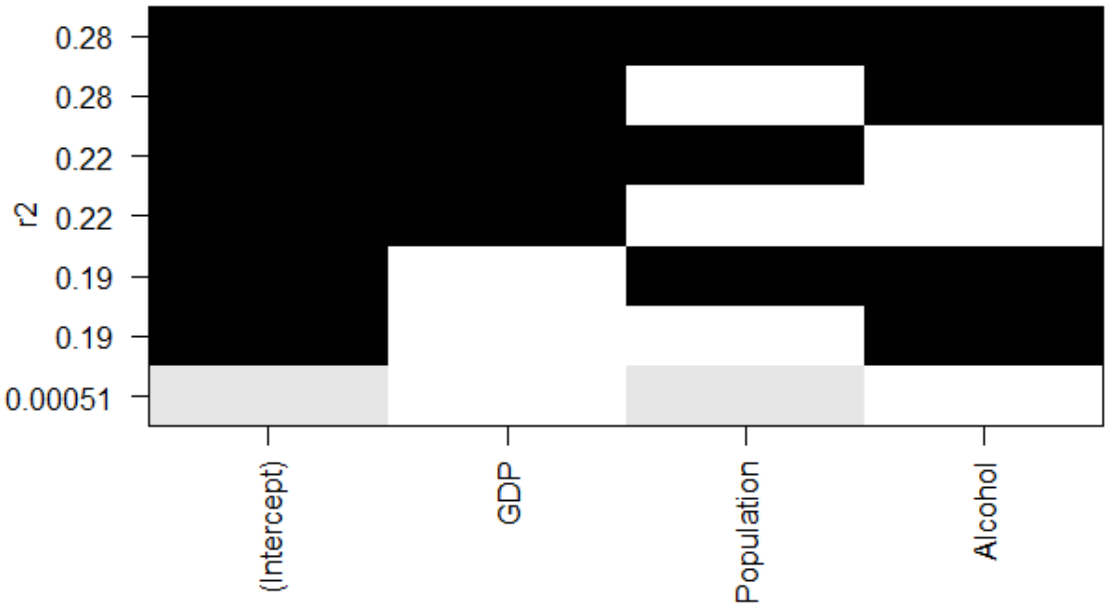
plot a table of models showing variables in each model.

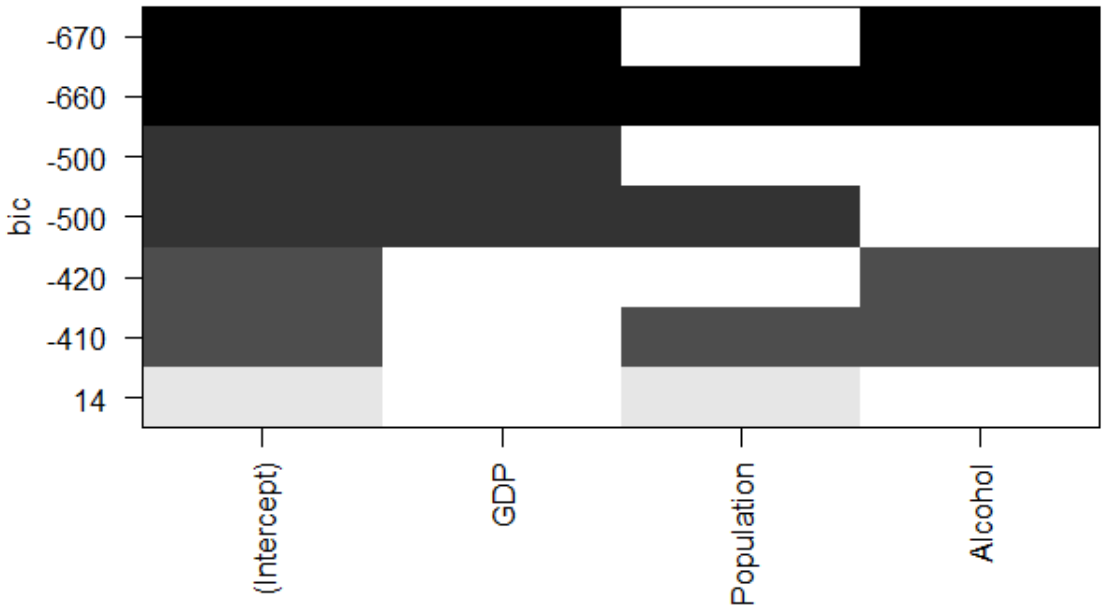
models are ordered by the selection statistic.

plot(leaps)

```
plot(leaps,scale="r2")

subsets(leaps, statistic="rsq")

# All Subsets Regression

plot(leaps,scale="bic")
```




r2
0.28
0.28
0.22
0.22
0.19
0.19
0.00051
(Intercept)
GDP
Population
Alcohol



summary(leaps)

?regsubsets

summary(leaps)

View(leaps)

leaps

coef(leaps,1:5)

```
[[1]]
 (Intercept)          GDP
6.639111e+01 3.350929e-04

[[2]]
(Intercept)     Alcohol
  63.669752    1.052405

[[3]]
  (Intercept)    Population
 6.867508e+01 -3.553365e-09

[[4]]
 (Intercept)          GDP      Alcohol
63.814364873  0.000244927  0.674598264

[[5]]
  (Intercept)           GDP    Population
 6.640916e+01  3.349098e-04 -1.297442e-09
```

```
# Calculate Relative Importance for Each Predictor

install.packages("relaimpo", lib="/Library/Frameworks/R.framework/Versions/3.5/Resources/library")

library(relaimpo)

calc.relimp(fit,type=c("lmg","last","first","pratt"),

        rela=TRUE)
```

```
Response variable: Life.expectancy
Total response variance: 77.38429
Analysis based on 1649 observations

14 Regressors:
Adult.Mortality infant.deaths Alcohol percentage.expenditure Hepatitis.B Measles BMI under.five.deaths
io Total.expenditure Diphtheria HIV.AIDS GDP Population
Proportion of variance explained by model: 76.01%
Metrics are normalized to sum to 100% (rela=TRUE).

Relative importance metrics:

                              lmg         last        first         pratt
Adult.Mortality        0.288903653 0.2940499218 0.2433911788  0.3032032727
infant.deaths          0.024127002 0.0637963509 0.0140973120 -0.3760903219
Alcohol                0.067023287 0.0778084810 0.0799809281  0.0831966795
percentage.expenditure 0.056236488 0.0001940774 0.0827501750 -0.0124680867
Hepatitis.B            0.009735655 0.0013098514 0.0197134446 -0.0056878241
Measles                0.001354350 0.0004280712 0.0023398356  0.0010631076
BMI                    0.141943508 0.1430916161 0.1448934922  0.1470048294
under.five.deaths      0.028531544 0.0715412008 0.0182299504  0.4429405600
Polio                  0.032837420 0.0061582281 0.0528275926  0.0204679453
Total.expenditure      0.009423691 0.0059186615 0.0150541825  0.0086584444
Diphtheria             0.038585818 0.0147002206 0.0574560446  0.0363754556
HIV.AIDS               0.230005310 0.3083989363 0.1729711600  0.2443690171
GDP                    0.068910486 0.0120120859 0.0960493530  0.1074291986
Population             0.002381787 0.0005922968 0.0002453507 -0.0004622775


Average coefficients for different model sizes:

                                1Xs           2Xs           3Xs           4Xs           5Xs
Adult.Mortality        -4.931736e-02 -4.617775e-02 -4.342330e-02 -4.094878e-02 -3.868662e-02
infant.deaths          -1.230740e-02  1.086976e-02  2.870761e-02  4.303442e-02  5.492762e-02
Alcohol                 8.792455e-01  7.534034e-01  6.550035e-01  5.779531e-01  5.177256e-01
percentage.expenditure  2.048314e-03  1.607786e-03  1.266960e-03  9.976835e-04  7.808908e-04
Hepatitis.B             6.869051e-02  5.020952e-02  3.671099e-02  2.661664e-02  1.889486e-02
Measles                -6.007819e-05 -3.029413e-05 -1.310883e-05 -3.079806e-06  2.629965e-06
BMI                     2.413784e-01  2.175559e-01  1.973803e-01  1.801321e-01  1.652629e-01
under.five.deaths      -1.038273e-02 -2.417347e-02 -3.492251e-02 -4.368265e-02 -5.105386e-02
Polio                   1.282442e-01  1.068944e-01  8.999077e-02  7.635679e-02  6.520482e-02
Total.expenditure       6.684230e-01  5.164593e-01  4.102915e-01  3.347731e-01  2.804048e-01
Diphtheria              1.391449e-01  1.186441e-01  1.024038e-01  8.929591e-02  7.856435e-02
HIV.AIDS               -8.636429e-01 -8.025153e-01 -7.524211e-01 -7.099144e-01 -6.728946e-01
GDP                     3.382946e-04  3.127925e-04  2.896111e-04  2.685249e-04  2.493742e-04
Population             -2.784730e-09  2.309658e-09  4.886594e-09  6.120672e-09  6.605050e-09
                                6Xs           7Xs           8Xs           9Xs          10Xs
Adult.Mortality        -3.659046e-02 -3.462673e-02 -3.277016e-02 -3.100123e-02 -2.930456e-02
infant.deaths           6.506700e-02  7.391972e-02  8.183573e-02  8.909705e-02  9.594331e-02
Alcohol                 4.708248e-01  4.345090e-01  4.066180e-01  3.854504e-01  3.696701e-01
percentage.expenditure  6.034480e-04  4.561456e-04  3.323909e-04  2.273631e-04  1.374724e-04
Hepatitis.B             1.287286e-02  8.104928e-03  4.287444e-03  1.206668e-03 -1.292708e-03
Measles                 5.591902e-06  6.718601e-06  6.555415e-06  5.431273e-06  3.541602e-06
BMI                     1.523519e-01  1.410730e-01  1.311707e-01  1.224432e-01  1.147299e-01
under.five.deaths      -5.740822e-02 -6.300288e-02 -6.803563e-02 -7.267179e-02 -7.705705e-02
Polio                   5.598056e-02  4.828006e-02  4.180122e-02  3.631338e-02  3.163746e-02
Total.expenditure       2.409636e-01  2.122340e-01  1.912820e-01  1.760211e-01  1.649412e-01
Diphtheria              6.967723e-02  6.224651e-02  5.598065e-02  5.065519e-02  4.609358e-02
HIV.AIDS               -6.399927e-01 -6.102890e-01 -5.831556e-01 -5.581597e-01 -5.350009e-01
GDP                     2.320188e-04  2.163241e-04  2.021578e-04  1.893888e-04  1.778867e-04
Population              6.655384e-09  6.445279e-09  6.071095e-09  5.585232e-09  5.014177e-09
```

	lIXs	lZXs	lSXs	lAXs
Adult.Mortality	-2.766789e-02	-2.608138e-02	-2.453704e-02	-2.302840e-02
infant.deaths	1.025851e-01	1.092107e-01	1.159892e-01	1.230713e-01
Alcohol	3.582336e-01	3.503327e-01	3.453493e-01	3.428187e-01
percentage.expenditure	6.001532e-05	-7.046383e-06	-6.523689e-05	-1.156811e-04
Hepatitis.B	-3.326666e-03	-4.983771e-03	-6.332926e-03	-7.428741e-03
Measles	9.960131e-07	-2.152977e-06	-5.891527e-06	-1.023160e-05
BMI	1.079027e-01	1.018583e-01	9.651239e-02	9.179436e-02
under.five.deaths	-8.132334e-02	-8.559119e-02	-8.997038e-02	-9.455976e-02
Polio	2.763248e-02	2.418611e-02	2.120794e-02	1.862456e-02
Total.expenditure	1.569344e-01	1.511784e-01	1.470566e-01	1.441016e-01
Diphtheria	4.215443e-02	3.872280e-02	3.570411e-02	3.301983e-02
HIV.AIDS	-5.134696e-01	-4.934176e-01	-4.747365e-01	-4.573424e-01
GDP	1.675187e-04	1.581482e-04	1.496330e-04	1.418266e-04
Population	4.368652e-09	3.649572e-09	2.851784e-09	1.966679e-09

```
# Bootstrap Measures of Relative Importance (1000 samples)

boot <- boot.relimp(fit, b = 1000, type = c("lmg",

                                "last", "first", "pratt"), rank = TRUE,

              diff = TRUE, rela = TRUE)


booteval.relimp(boot) # print result

plot(booteval.relimp(boot,sort=TRUE)) # plot result

#https://rpubs.com/davoodastaraky/mtRegression

summary(fit)

predict.lm(fit, data.frame(wt =3.2 ,drat=3.9,hp=130,disp=150) )
```