First Assignment
(Make function for Multiple Linear Regression Analysis MyReg( ))

Exploratory Data Analysis & Statistical Consulting

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R을 내가 원하는 함수를 만들어서 사용할 수 있다는 특징이 있다. 다중선형회귀분석(Multiple Linear Regression)을 수행하는 통계분석함수 lm( ) 이 이미 R에는 내장되어 있다. 하지만 내가 원하는 방식대로 회귀분석 함수를 function( )을 이용하여 다음과 같이 제작할 수 있다. 함수를 만들고 2가지의 데이터를 통해 이 함수가 제대로 작동되는지 점검하였음을 밝혀둔다.

Make function MyReg( )

```
MyReg <- function(data) {
n <- nrow(data) ; p <- ncol(data)-1
y <- as.matrix(data)[,1] ; X <- cbind(rep(1,n),as.matrix(data)[,-1])
beta <- (solve(t(X)%*%X))%*%(t(X))%*%(y)
pred <- X%*%beta
residuals <- y-pred ; sig2 <- (t(residuals)%*%residuals)/(n-p-1)
H <- (X)%*%(solve(t(X)%*%X))%*%(t(X))
stdresid <- rep(0,n)
for(i in 1:n) {
stdresid[i] <- residuals[i]/sqrt(sig2*(1-H[i,i]))
}
SST <- sum((y-mean(y))^2) ; SSE <- sum((y-pred)^2) ; SSR <- SST - SSE
MSR <- SSR/(p) ; MSE <- SSE/(n-p-1) ; F <- MSR/MSE
P.value <- 1-pf(F,p,n-p-1) ; Rsq <- SSR/SST
C <- solve(t(X)%*%X)
std.error <- rep(0,p+1)
for(i in 1:(p+1)) {
std.error[i] <- sqrt(sig2*C[i,i])
}
t.value <- rep(0,p+1)
for(i in 1:(p+1)) {
t.value[i] <- beta[i]/std.error[i]
}
Pr.t <- rep(0,(p+1))
for(i in 1:(p+1)) {
Pr.t[i] <- 2*(1-pt(abs(t.value[i]), n-p-1))
}
args <- list(Data=data, Beta=beta, Sigma2=sig2, Predict=pred,
Residuals=residuals, Standard.Residuals=stdresid,
SSR=SSR, SSE=SSE, F.Statistic=F, P.value=P.value)

aster <- function(p) {
if (p >= 0.05 & p < 0.1) "."
else if (p >= 0.01 & p < 0.05) "*"
else if (p >= 0.001 & p < 0.1) "**"
else if (p < 0.001) "***"
```

```
else " "
}

cat("₩n == ANALYSIS OF VARIANCE == ₩n₩n",
encodeString(c("Source", "    df", "    SS", "    MS", "    F", "    P-value"),
width=8, justify="right"),
"₩n",       "-----------------------------------------------------------------",
"₩n", encodeString(c("Regression", p, round(SSR,2),
round(MSR,2), round(F,2), round(P.value,2)), width=8, justify="right"),
aster(P.value), "₩n", encodeString(c("       Error", n-p-1, round(SSE,2),
round(MSE,2)), width=8, justify="right"), "₩n",
encodeString(c("       Total", n-1, round(SST,2)), width=8, justify="right"),
"₩n",       "-----------------------------------------------------------------",
"₩n", "Estimated error variance :", round(sig2,4),
"₩n","R-squares :",round(Rsq,4), "₩n₩n")

ind.name <- colnames(data)
ind.name[1] <- "(Intercept)"
test.mat <- cbind(ind.name, round(beta,4), round(std.error,4),
round(t.value,4), round(Pr.t,4))
cat("₩n₩n₩n== PARAMETER ESTIMATES ==₩n₩n",
encodeString(c(" ", "Estimate", "Std.Error", "t value", "Pr(>|t|)"),
width=11, justify="right"), "₩n")
for(i in 1:nrow(test.mat)) {
cat(encodeString(test.mat[i,], width=11, justify="right"), aster(Pr.t[i]),"₩n")
}

cat("₩n", "===Various Statistics in Multiple Regression===", "₩n₩n")
print(args)
}
```

Checking function 1

```
N <- 100
set.seed(1234)
tX1 <- rnorm(N,0,1)
tX2 <- rnorm(N,3,1)
tX3 <- rgamma(N,1,3)
tX4 <- sample(c(0,1),N,replace=T)
tX5 <- sample(1:3,N,replace=T,prob=c(1,2,3)/6)
tX6 <- rbinom(N,4,0.3)
tX <- cbind(rep(1,length(tX1)),tX1,tX2,tX3,tX4,tX5,tX6)
tbeta <- (0:6)/5
ty <- as.vector(tX%*%tbeta)+rnorm(N,0,2)
dat <- data.frame(y=ty, age=tX1, height=tX2, weight=tX3,
```

```
smoking=tX4, therapy=tX5, surgery=tX6)
res1 <- MyReg(dat)
str(res1)
attributes(res1)
```

Result

```
== ANALYSIS OF VARIANCE ==

  Source        df        SS        MS         F     P-value
 ------------------------------------------------------------------
 Regression      6     195.3     32.55      8.72           0 ***
       Error    93    347.11      3.73
       Total    99    542.41
 ------------------------------------------------------------------
 Estimated error variance : 3.7323
 R-squares : 0.3601




== PARAMETER ESTIMATES ==

                Estimate   Std.Error     t value     Pr(>|t|)
(Intercept)     -0.7866       1.182     -0.6655       0.5074
        age      0.0198      0.1951      0.1012       0.9196
     height      0.5986      0.1953      3.0653       0.0028 **
     weight     -0.0803      0.6073     -0.1322       0.8951
    smoking      0.2927      0.4105       0.713       0.4776
    therapy      1.2801      0.2794      4.5809            0 ***
    surgery      1.0944      0.2018      5.4219            0 ***

 ===Various Statistics in Multiple Regression===

$Data
             y           age     height      weight smoking therapy surgery
1    7.6185092 -1.207065749 3.4145235 0.300656147       1       2       3
2   11.1395846  0.277429242 2.5252815 0.371353870       0       3       2
3    5.7838752  1.084441177 3.0659935 0.213260667       0       2       1
4    6.2143115 -2.345697703 2.4975222 0.372750095       1       2       1
5    7.7605163  0.429124689 2.1740014 0.248226012       0       2       1
6    7.7740276  0.506055892 3.1669893 0.394101281       0       3       1
7    2.0073677 -0.574739960 2.1037354 0.883828859       0       2       1
8    6.8965796 -0.546631856 3.1681854 0.531965694       1       2       1
9    7.7153296 -0.564451999 3.3549683 0.174454546       0       3       3
10   8.7708591 -0.890037829 2.9478949 0.007488234       1       1       2
11   5.1149679 -0.477192700 2.8040654 0.626116131       0       3       1
12   1.3942546 -0.998386445 2.3509302 1.179623070       1       1       1
13   8.0460598 -0.776253895 1.8902328 0.102581133       1       2       3
14   6.5964155  0.064458817 3.8492742 0.224677931       0       3       1
```

15	7.1039366	0.959494059	3.0223625	0.563909112	0	3	2
16	1.4979346	−0.110285494	3.8311406	0.167726840	0	2	0
17	3.2428745	−0.511009506	1.7557121	0.201034863	0	3	1
18	6.2127608	−0.911195417	3.1690264	0.254401211	1	3	1
19	8.1941169	−0.837171680	3.6731663	0.693440641	0	2	2
20	6.0718540	2.415835178	2.9737236	0.213521547	1	3	1
21	3.4667472	0.134088220	2.8086078	0.098975684	1	2	1
22	0.4867931	−0.490685897	2.2180934	0.176831684	1	3	1
23	4.7385541	−0.440547872	5.0581620	0.024831943	1	1	0
24	4.5970284	0.459589441	3.7505015	0.250382061	0	2	0
25	7.8639016	−0.693720247	4.8242083	0.757634302	0	3	0
26	6.9645135	−1.448204910	3.0800596	0.147808868	0	3	0
27	5.0848131	0.574755721	2.3685907	0.180896373	0	3	1
28	8.7539894	−1.023655723	1.4867119	0.278347274	0	2	3
29	8.3501663	−0.015138300	2.3639002	0.008344596	1	3	3
30	5.3399869	−0.935948601	3.2263015	0.315793550	0	3	2
31	5.1378487	1.102297546	4.0136903	0.013843684	1	3	1
32	5.0961565	−0.475593079	3.2527501	0.640095477	0	3	1
33	5.0096718	−0.709440038	1.8280517	0.275633695	1	3	0
34	4.4533125	−0.501258061	3.6687143	0.234801962	0	3	0
35	4.9573960	−1.629093469	1.3498991	0.235832515	0	3	1
36	5.3893573	−1.167619262	2.6341478	0.285561219	1	2	1
37	7.7728607	−2.180039649	2.6838817	0.510195492	0	3	2
38	3.9803126	−1.340993192	1.0517540	0.290288645	0	3	1
39	7.9956412	−0.294293859	3.9200575	0.359636780	0	3	0
40	5.5369194	−0.465897540	2.3771284	0.006432923	1	3	0
41	3.2315194	1.449496265	2.6659634	0.770510833	1	3	0
42	6.7268347	−1.068642724	4.3951479	0.226339440	0	2	3
43	3.5572367	−0.855364634	3.6366744	0.403122869	0	1	0
44	3.9056203	−0.280623002	2.8915683	1.045380347	1	1	1
45	5.7657251	−0.994340076	3.5137628	0.115163135	1	3	0
46	6.8175870	−0.968514318	3.3992718	1.304649095	1	2	1
47	6.4152961	−1.107318193	4.6628564	0.274436277	0	2	0
48	4.8616932	−1.251985886	3.2758934	0.175208053	1	3	1
49	5.4079627	−0.523828119	3.5062726	0.239968258	1	2	1
50	4.1239824	−0.496849957	3.3475520	0.032860857	1	2	1
51	5.3127850	−1.806031257	2.6227624	0.465253488	0	3	3
52	1.2245240	−0.582075925	3.0976195	0.999719975	0	2	1
53	6.4538941	−1.108889624	4.6387446	0.048526795	0	2	2
54	7.2596023	−1.014962009	2.1244075	0.016168668	0	3	2
55	7.5936876	−0.162309524	3.1217600	0.165215369	1	3	1
56	1.5583003	0.563055819	4.3621307	0.468037451	0	1	1
57	3.0788377	1.647817473	2.7653789	1.170797202	0	2	1
58	0.4581519	−0.773353424	1.9466172	0.527473505	1	1	0
59	3.3099758	1.605909629	2.1302164	0.523417265	0	2	1
60	5.2972146	−1.157808548	2.6098730	0.240719133	1	2	1
61	7.4377150	0.656588464	2.1526499	0.093950833	1	2	2
62	5.4576686	2.548991071	2.7393606	0.136985760	1	1	3
63	−1.9376925	−0.034760390	2.5855803	0.939535162	0	1	1
64	9.2465962	−0.669633580	2.8169492	0.243493845	1	3	2
65	7.3245442	−0.007604756	3.4070561	0.554455368	0	2	2

```
66    3.3409581   1.777084448 3.6246331 0.229048919       1       2       0
67    5.8706458 -1.138607737 4.6782057 0.290679589       1       3       2
68    6.0322781   1.367827179 2.9313063 0.310287531       1       3       1
69    4.7213034   1.329564791 2.6791601 1.945855520       0       2       0
70    7.5783331   0.336472797 4.4710057 0.127057828       1       1       2
71    7.6815165   0.006892838 4.7043294 0.030359993       0       3       0
72    4.4577125 -0.455468738 3.0432440 0.048792384       1       3       1
73    7.7402535 -0.366523933 2.6673427 1.275292553       0       3       2
74    9.7061666   0.648286568 1.1777646 0.395085718       1       3       2
75    3.7923051   2.070270861 4.4112624 0.694050412       0       3       0
76    2.3613461 -0.153398412 2.1624176 0.287642700       1       1       0
77    3.1786706 -1.390700947 1.8762372 0.082086647       1       3       2
78    5.1042255 -0.723581777 6.0437659 0.760985052       1       1       0
79    5.2019065   0.258261762 3.2350213 0.231048529       1       3       1
80    2.6156518 -0.317059115 2.9667414 0.237070641       0       2       1
81    5.2341128 -0.177789958 0.2677805 0.204189201       1       1       4
82    6.4998278 -0.169994077 2.9002094 0.474560230       1       1       2
83  -0.9153396 -1.372301886 3.9760317 0.489410169       1       1       0
84    5.9297626 -0.173787170 3.4138689 0.083323763       0       3       2
85    2.6109900   0.850232257 3.9123222 0.172416743       1       2       0
86    6.4501599   0.697608712 4.9837322 0.068972247       1       3       2
87    8.4683504   0.549997351 4.1691085 0.569063747       0       3       2
88    4.8777452 -0.402731975 2.4912630 0.430463151       0       3       0
89    7.8100242 -0.191593770 3.7041802 0.301186011       1       2       3
90    5.2398306 -1.194527880 2.8015837 0.138446892       0       2       1
91    5.2926870 -0.053158819 2.4619292 0.537928137       1       2       2
92    2.6914147   0.255196001 0.1442413 0.048790497       0       3       3
93    7.0006510   1.705964007 2.2103531 0.777457371       0       3       0
94    5.5954422   1.001513252 3.4878146 0.102332856       0       2       2
95    7.2981776 -0.495583443 5.1680325 0.767098073       0       2       3
96    4.8584337   0.355550297 3.5006946 0.120016478       1       1       1
97    7.0215120 -1.134608044 3.6202102 0.780808501       1       3       0
98    8.6139680   0.878203627 2.0340968 0.287524310       0       3       3
99    7.4413886   0.972916753 3.1626547 0.545354279       1       3       0
100   3.9999188   2.121117105 0.9217625 0.191202086       0       3       0

$Beta
                [,1]
          -0.78660499
age         0.01975009
height      0.59862082
weight    -0.08026628
smoking     0.29271521
therapy     1.28005300
surgery     1.09439426

$Sigma2
           [,1]
[1,] 3.732336

$Predict
```

```
          [,1]
 [1,] 7.345432
 [2,] 6.729701
 [3,] 4.707563
 [4,] 4.579432
 [5,] 4.157849
 [6,] 6.022136
 [7,] 4.044942
 [8,] 5.003657
 [9,] 8.319940
[10,] 4.721444
[11,] 5.766840
[12,] 3.173471
[13,] 6.457367
[14,] 6.435443
[15,] 7.025279
[16,] 4.051261
[17,] 5.172725
[18,] 6.299293
[19,] 6.088929
[20,] 6.251371
[21,] 4.836605
[22,] 5.744576
[23,] 3.803390
[24,] 4.007609
[25,] 5.866912
[26,] 4.856876
[27,] 5.562668
[28,] 5.904101
[29,] 8.043563
[30,] 7.129841
[31,] 6.864001
[32,] 6.034341
[33,] 4.404443
[34,] 5.220976
[35,] 4.904922
[36,] 4.691485
[37,] 6.764963
[38,] 4.727765
[39,] 5.365503
[40,] 4.759550
[41,] 4.908952
[42,] 7.648438
[43,] 2.621186
[44,] 3.522059
[45,] 5.420799
[46,] 5.071638
[47,] 4.520886
[48,] 6.362891
[49,] 5.229931
[50,] 5.152074
```

```
 [51,] 7.833764
 [52,] 4.630455
 [53,] 6.713343
 [54,] 6.492714
 [55,] 6.292947
 [56,] 4.172657
 [57,] 4.461878
 [58,] 1.893837
 [59,] 4.132791
 [60,] 4.680746
 [61,] 5.549052
 [62,] 5.748532
 [63,] 3.059525
 [64,] 7.188573
 [65,] 5.957170
 [66,] 4.252710
 [67,] 8.289710
 [68,] 6.197514
 [69,] 3.247374
 [70,] 5.647836
 [71,] 5.867363
 [72,] 6.249501
 [73,] 6.729468
 [74,] 6.221184
 [75,] 5.679407
 [76,] 2.054514
 [77,] 6.624157
 [78,] 4.328715
 [79,] 6.363770
 [80,] 4.618558
 [81,] 5.304138
 [82,] 4.669629
 [83,] 3.099912
 [84,] 7.275835
 [85,] 4.411167
 [86,] 8.526665
 [87,] 7.703244
 [88,] 4.502370
 [89,] 7.538839
 [90,] 4.510277
 [91,] 5.684539
 [92,] 6.424207
 [93,] 4.348007
 [94,] 6.061734
 [95,] 8.079016
 [96,] 3.973535
 [97,] 5.428321
 [98,] 7.548656
 [99,] 5.214942
[100,] 3.631885
```

```
$Residuals
              [,1]
 [1,]  0.27307748
 [2,]  4.40988390
 [3,]  1.07631221
 [4,]  1.63487922
 [5,]  3.60266744
 [6,]  1.75189198
 [7,] -2.03757453
 [8,]  1.89292234
 [9,] -0.60461022
[10,]  4.04941549
[11,] -0.65187166
[12,] -1.77921650
[13,]  1.58869294
[14,]  0.16097255
[15,]  0.07865770
[16,] -2.55332600
[17,] -1.92985078
[18,] -0.08653188
[19,]  2.10518761
[20,] -0.17951677
[21,] -1.36985822
[22,] -5.25778252
[23,]  0.93516377
[24,]  0.58941938
[25,]  1.99698954
[26,]  2.10763788
[27,] -0.47785447
[28,]  2.84988813
[29,]  0.30660316
[30,] -1.78985430
[31,] -1.72615274
[32,] -0.93818463
[33,]  0.60522834
[34,] -0.76766374
[35,]  0.05247420
[36,]  0.69787267
[37,]  1.00789823
[38,] -0.74745238
[39,]  2.63013818
[40,]  0.77736946
[41,] -1.67743265
[42,] -0.92160296
[43,]  0.93605032
[44,]  0.38356091
[45,]  0.34492631
[46,]  1.74594924
[47,]  1.89440971
[48,] -1.50119816
[49,]  0.17803138
```

```
 [50,] -1.02809195
 [51,] -2.52097847
 [52,] -3.40593097
 [53,] -0.25944882
 [54,]  0.76688853
 [55,]  1.30074046
 [56,] -2.61435704
 [57,] -1.38304001
 [58,] -1.43568476
 [59,] -0.82281543
 [60,]  0.61646826
 [61,]  1.88866260
 [62,] -0.29086317
 [63,] -4.99721750
 [64,]  2.05802371
 [65,]  1.36737425
 [66,] -0.91175167
 [67,] -2.41906393
 [68,] -0.16523549
 [69,]  1.47392896
 [70,]  1.93049729
 [71,]  1.81415371
 [72,] -1.79178830
 [73,]  1.01078597
 [74,]  3.48498284
 [75,] -1.88710167
 [76,]  0.30683238
 [77,] -3.44548652
 [78,]  0.77551044
 [79,] -1.16186342
 [80,] -2.00290589
 [81,] -0.07002558
 [82,]  1.83019893
 [83,] -4.01525198
 [84,] -1.34607257
 [85,] -1.80017661
 [86,] -2.07650540
 [87,]  0.76510680
 [88,]  0.37537499
 [89,]  0.27118489
 [90,]  0.72955358
 [91,] -0.39185245
 [92,] -3.73279184
 [93,]  2.65264428
 [94,] -0.46629188
 [95,] -0.78083813
 [96,]  0.88489860
 [97,]  1.59319079
 [98,]  1.06531237
 [99,]  2.22644678
[100,]  0.36803345
```

```
$Standard.Residuals
  [1]  0.14621932  2.32114970  0.57153929  0.87974071  1.90940601  0.92011018
  [7] -1.08413684  0.99306711 -0.32351339  2.17266615 -0.34288737 -0.98076112
 [13]  0.84919099  0.08485406  0.04173664 -1.36122109 -1.02336295 -0.04573283
 [19]  1.11549389 -0.09804247 -0.71981894 -2.77953994  0.51186661  0.31366989
 [25]  1.07755297  1.13136116 -0.25226494  1.53626742  0.16453837 -0.94461232
 [31] -0.92611157 -0.49376898  0.32502459 -0.40735099  0.02834328  0.36761431
 [37]  0.54242613 -0.40399631  1.39370414  0.41608024 -0.91057152 -0.49983195
 [43]  0.50878722  0.20754560  0.18421732  0.96496966  1.01878534 -0.79633830
 [49]  0.09331282 -0.54082447 -1.36291393 -1.81089345 -0.13990659  0.40781113
 [55]  0.68549359 -1.41232270 -0.75325283 -0.78080575 -0.44049989  0.32484902
 [61]  1.00074739 -0.16549547 -2.69924865  1.08900085  0.72007226 -0.49087686
 [67] -1.31213965 -0.08811307  0.87626859  1.04331695  0.97856093 -0.94605065
 [73]  0.55642828  1.87485168 -1.03107986  0.16624905 -1.84199828  0.43186179
 [79] -0.61288542 -1.05455478 -0.04005917  0.97389414 -2.16611993 -0.71160574
 [85] -0.95776832 -1.13700689  0.40890568  0.19899248  0.14514993  0.38777677
 [91] -0.20652954 -2.06344447  1.43414533 -0.24914333 -0.43376220  0.47286605
 [97]  0.86279698  0.57223897  1.19066657  0.20592839

$SSR
[1] 195.2996

$SSE
[1] 347.1072

$F.Statistic
[1] 8.721064

$P.value
[1] 1.556127e-07

> str(res1)
List of 10
 $ Data                :'data.frame':        100 obs. of  7 variables:
  ..$ y       : num [1:100] 7.62 11.14 5.78 6.21 7.76 ...
  ..$ age     : num [1:100] -1.207 0.277 1.084 -2.346 0.429 ...
  ..$ height : num [1:100] 3.41 2.53 3.07 2.5 2.17 ...
  ..$ weight : num [1:100] 0.301 0.371 0.213 0.373 0.248 ...
  ..$ smoking: num [1:100] 1 0 0 1 0 0 0 1 0 1 ...
  ..$ therapy: int [1:100] 2 3 2 2 2 3 2 2 3 1 ...
  ..$ surgery: int [1:100] 3 2 1 1 1 1 1 1 3 2 ...
 $ Beta                : num [1:7, 1] -0.7866 0.0198 0.5986 -0.0803 0.2927 ...
  ..- attr(*, "dimnames")=List of 2
  .. ..$ : chr [1:7] "" "age" "height" "weight" ...
  .. ..$ : NULL
 $ Sigma2              : num [1, 1] 3.73
 $ Predict             : num [1:100, 1] 7.35 6.73 4.71 4.58 4.16 ...
 $ Residuals           : num [1:100, 1] 0.273 4.41 1.076 1.635 3.603 ...
 $ Standard.Residuals: num [1:100] 0.146 2.321 0.572 0.88 1.909 ...
 $ SSR                 : num 195
```

```
 $ SSE                 : num 347
 $ F.Statistic         : num 8.72
 $ P.value             : num 1.56e-07
> attributes(res1)
$names
 [1] "Data"                "Beta"                "Sigma2"
 [4] "Predict"             "Residuals"           "Standard.Residuals"
 [7] "SSR"                 "SSE"                 "F.Statistic"
[10] "P.value"
```

Checking function 2

```
crime <- read.csv("D:/수업자료/대학/(4)Senior/4-2/
탐색적자료분석및상담(1전공)/Assignment/crime.csv",sep=",",header=T)
crime1 <- crime[,-1]
res2 <- MyReg(crime1)
str(res2)
attributes(res2)
```

Result

```
== ANALYSIS OF VARIANCE ==

   Source        df        SS        MS         F     P-value
 ------------------------------------------------------------------
 Regression       7   2405.09    343.58      1.47       0.2
      Error      42   9799.79    233.33
      Total      49  12204.88
 ------------------------------------------------------------------
 Estimated error variance : 233.3282
 R-squares : 0.1971



== PARAMETER ESTIMATES ==

                Estimate    Std.Error      t value     Pr(>|t|)
(Intercept)     58.1798      10.0669       5.7793            0 ***
      MURDER    -1.6568       0.9025      -1.8358       0.0735 .
        RAPE     0.0764       0.3902       0.1959       0.8457
    ROBBERY      0.0328       0.0388       0.8454       0.4027
    ASSAULT      0.0064       0.0365       0.1739       0.8628
   BURGLARY       0.002       0.0111       0.1823       0.8562
    LARCENY    -0.0069       0.0058      -1.2057       0.2347
       AUTO    -0.0212       0.0157      -1.3457       0.1856

 ===Various Statistics in Multiple Regression===
```

$Data

	STATE	MURDER	RAPE	ROBBERY	ASSAULT	BURGLARY	LARCENY	AUTO
1	38	0.9	9.0	13.3	43.8	446.1	1843.0	144.7
2	55	2.8	12.9	52.2	63.7	846.9	2614.2	220.7
3	15	7.2	25.5	128.0	64.1	1911.5	3920.4	489.4
4	33	3.2	10.7	23.2	76.0	1041.7	2343.9	293.4
5	27	2.7	19.5	85.9	85.8	1134.7	2559.3	343.1
6	19	2.3	10.6	41.2	89.8	812.5	2685.1	219.9
7	54	6.0	13.2	42.2	90.9	597.4	1341.7	163.3
8	50	1.4	15.9	30.8	101.2	1348.2	2201.0	265.2
9	31	3.9	18.1	64.7	112.7	760.0	2316.1	249.1
10	21	10.1	19.1	81.1	123.3	872.2	1662.1	245.4
11	42	5.6	19.0	130.3	128.0	877.5	1624.1	333.2
12	9	4.2	16.8	129.5	131.8	1346.0	2620.7	593.2
13	49	3.5	20.3	68.8	147.3	1171.6	3004.6	334.5
14	18	7.4	26.5	123.2	153.5	1086.2	2498.7	377.4
15	46	2.0	13.5	17.9	155.7	570.5	1704.4	147.5
16	30	5.4	16.7	39.2	156.8	804.9	2773.2	309.2
17	51	9.0	23.3	92.1	165.7	986.2	2521.2	226.7
18	23	2.4	13.5	38.7	170.0	1253.1	2350.7	246.9
19	16	5.5	19.4	39.6	172.5	1050.8	2599.6	237.6
20	56	5.4	21.9	39.7	173.9	811.6	2772.2	282.0
21	20	6.6	22.0	100.7	180.5	1270.4	2739.3	244.3
22	39	7.8	27.3	190.5	181.1	1216.0	2696.8	400.4
23	34	5.6	21.0	180.4	185.1	1435.8	2774.5	511.5
24	28	14.3	19.6	65.7	189.1	915.6	1239.9	144.4
25	10	6.0	24.9	157.0	194.2	1682.6	3678.4	467.0
26	44	3.6	10.5	86.5	201.0	1489.5	2844.1	791.4
27	5	8.8	27.6	83.2	203.4	972.6	1862.1	183.4
28	47	10.1	29.7	145.8	203.9	1259.7	1776.5	314.0
29	40	8.6	29.2	73.8	205.0	1288.2	2228.1	326.8
30	48	13.3	33.8	152.4	208.2	1603.1	2988.7	397.6
31	17	9.9	21.8	211.3	209.0	1085.0	2828.5	528.6
32	53	4.3	39.6	106.2	224.8	1605.6	3386.9	360.3
33	25	3.1	20.8	169.1	231.6	1532.2	2311.3	1140.1
34	29	9.6	28.3	189.0	233.5	1318.3	2424.2	378.4
35	13	11.7	31.1	140.5	256.5	1351.1	2170.2	297.9
36	26	9.3	38.9	261.9	274.6	1522.7	3159.0	545.5
37	1	14.2	25.2	96.8	278.3	1135.5	1881.9	280.7
38	2	10.8	51.6	96.8	284.0	1331.7	3369.8	753.3
39	41	4.9	39.9	124.1	286.9	1636.4	3506.1	388.9
40	8	6.3	42.0	170.7	292.9	1935.2	3903.2	477.1
41	4	9.5	34.2	138.2	312.3	2346.1	4467.4	439.5
42	37	10.6	17.0	61.3	318.3	1154.1	2037.8	192.1
43	36	10.7	29.4	472.6	319.1	1728.0	2782.0	745.8
44	22	15.5	30.9	142.9	335.5	1165.5	2469.9	337.7
45	35	8.8	39.1	109.6	343.4	1418.7	3008.6	259.5
46	32	15.8	49.1	323.1	355.0	2453.1	4212.6	559.2
47	6	11.5	49.4	287.0	358.0	2139.4	3499.8	663.5
48	24	8.0	34.8	292.1	358.9	1400.0	3177.7	428.5
49	12	10.2	39.6	187.9	449.1	1859.9	3840.5	351.4

```
50     45    11.9 33.0    105.9    485.3    1613.6   2342.4   245.1

$Beta
                    [,1]
           58.179791780
MURDER     -1.656824516
RAPE        0.076432200
ROBBERY     0.032812798
ASSAULT     0.006353436
BURGLARY    0.002030337
LARCENY    -0.006939401
AUTO       -0.021173230

$Sigma2
          [,1]
[1,] 233.3282

$Predict
           [,1]
 [1,] 43.14388
 [2,] 35.54978
 [3,] 19.12055
 [4,] 34.57741
 [5,] 35.83982
 [6,] 35.46237
 [7,] 39.65472
 [8,] 40.57765
 [9,] 36.13708
[10,] 31.39119
[11,] 38.89895
[12,] 29.57862
[13,] 31.57203
[14,] 29.83763
[15,] 43.68230
[16,] 28.63495
[17,] 28.83079
[18,] 38.58928
[19,] 32.00845
[20,] 29.75390
[21,] 31.77492
[22,] 30.02156
[23,] 30.43378
[24,] 29.53991
[25,] 24.52991
[26,] 23.66445
[27,] 34.90126
[28,] 33.37685
[29,] 30.12135
[30,] 19.14746
[31,] 23.08731
[32,] 31.12327
```

```
[33,] 24.58577
[34,] 29.96460
[35,] 28.78764
[36,] 25.70289
[37,] 24.82628
[38,] 12.58026
[39,] 29.76381
[40,] 25.15551
[41,] 16.02951
[42,] 30.08525
[43,] 28.64560
[44,] 19.75782
[45,] 28.87439
[46,] 12.51970
[47,] 20.60261
[48,] 31.16831
[49,] 23.01093
[50,] 29.37578

$Residuals
               [,1]
 [1,]  -5.1438808
 [2,]  19.4502215
 [3,]  -4.1205523
 [4,]  -1.5774101
 [5,]  -8.8398167
 [6,] -16.4623721
 [7,]  14.3452824
 [8,]   9.4223505
 [9,]  -5.1370768
[10,] -10.3911866
[11,]   3.1010470
[12,] -20.5786153
[13,]  17.4279659
[14,] -11.8376264
[15,]   2.3177029
[16,]   1.3650541
[17,]  22.1692065
[18,] -15.5892818
[19,] -16.0084477
[20,]  26.2461020
[21,] -11.7749210
[22,]   8.9784434
[23,]   3.5662170
[24,]  -1.5399068
[25,] -14.5299068
[26,]  20.3355484
[27,] -29.9012552
[28,]  13.6231524
[29,]   9.8786508
[30,]  28.8525410
```

```
[31,]  -6.0873137
[32,]  21.8767301
[33,]   0.4142290
[34,]  -0.9646009
[35,] -15.7876359
[36,]   0.2971090
[37,] -23.8262785
[38,] -10.5802551
[39,]  11.2361943
[40,] -17.1555057
[41,] -12.0295057
[42,]   6.9147544
[43,]   7.3544001
[44,]   2.2421752
[45,]   6.1256085
[46,]  19.4803009
[47,] -14.6026130
[48,]  -7.1683107
[49,] -11.0109307
[50,]  15.6242192

$Standard.Residuals
 [1] -0.36121647  1.33939163 -0.32444263 -0.10775065 -0.60168076 -1.14712006
 [7]  0.98970216  0.69457958 -0.34873481 -0.71896082  0.21461404 -1.41042592
[13]  1.17530965 -0.79460820  0.16332833  0.09628086  1.50152330 -1.09362497
[19] -1.07409594  1.83237798 -0.78733160  0.60605599  0.24074008 -0.11419928
[25] -0.99896653  1.61278352 -2.04641305  0.96093626  0.67352815  2.02738267
[31] -0.44035735  1.56942649  0.04068382 -0.06466979 -1.07521232  0.02053804
[37] -1.68470507 -1.03165343  0.79409809 -1.20067617 -0.92558091  0.50411206
[43]  0.67109925  0.16273439  0.42701794  1.46902313 -1.04447941 -0.53624931
[49] -0.81275898  1.25500996

$SSR
[1] 2405.095

$SSE
[1] 9799.785

$F.Statistic
[1] 1.472539

$P.value
[1] 0.2033474

> str(res2)
List of 10
 $ Data                :'data.frame':        50 obs. of  8 variables:
  ..$ STATE   : int [1:50] 38 55 15 33 27 19 54 50 31 21 ...
  ..$ MURDER  : num [1:50] 0.9 2.8 7.2 3.2 2.7 2.3 6 1.4 3.9 10.1 ...
  ..$ RAPE    : num [1:50] 9 12.9 25.5 10.7 19.5 10.6 13.2 15.9 18.1 19.1 ...
  ..$ ROBBERY : num [1:50] 13.3 52.2 128 23.2 85.9 41.2 42.2 30.8 64.7 81.1 ...
```

```
  ..$ ASSAULT : num [1:50] 43.8 63.7 64.1 76 85.8 ...
  ..$ BURGLARY: num [1:50] 446 847 1912 1042 1135 ...
  ..$ LARCENY : num [1:50] 1843 2614 3920 2344 2559 ...
  ..$ AUTO    : num [1:50] 145 221 489 293 343 ...
 $ Beta                : num [1:8, 1] 58.17979 -1.65682 0.07643 0.03281 0.00635 ...
  ..- attr(*, "dimnames")=List of 2
  .. ..$ : chr [1:8] "" "MURDER" "RAPE" "ROBBERY" ...
  .. ..$ : NULL
 $ Sigma2              : num [1, 1] 233
 $ Predict             : num [1:50, 1] 43.1 35.5 19.1 34.6 35.8 ...
 $ Residuals           : num [1:50, 1] -5.14 19.45 -4.12 -1.58 -8.84 ...
 $ Standard.Residuals: num [1:50] -0.361 1.339 -0.324 -0.108 -0.602 ...
 $ SSR                 : num 2405
 $ SSE                 : num 9800
 $ F.Statistic         : num 1.47
 $ P.value             : num 0.203
> attributes(res2)
$names
 [1] "Data"                "Beta"                "Sigma2"
 [4] "Predict"             "Residuals"           "Standard.Residuals"
 [7] "SSR"                 "SSE"                 "F.Statistic"
[10] "P.value"
```