Stat 415/615, Lab 6. More diagnostics in MLR

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Stat 415/615 Regression, 2023

Contents

Comments and explanations are not included here. We'll discuss them in class.

Recall the Surgical Unit example from text, p.350, p.410, and refer to Handout7_MoreDiag.pdf. We will consider the 5-parameter (1 intercept, 4 slopes) model here.

```
sudata <- read.table("../DataSets/SurgicalUnit.txt", header=T)

sureg5 <- lm(lnY~bloodclotting+ prognostic+ enzyme +alcoholeS , data=sudata)
sureg5
```

```
##
## Call:
## lm(formula = lnY ~ bloodclotting + prognostic + enzyme + alcoholeS,
##     data = sudata)
##
## Coefficients:
##   (Intercept)  bloodclotting     prognostic         enzyme      alcoholeS
##       3.85494        0.07331        0.01418        0.01543        0.35220
```

Partial regression plot (added-variable plot) and "Variance Inflation Factor" will be discussed later in car package.

1 Influential cases and stats

```
inflm.SR <- influence.measures(sureg5)
which(apply(inflm.SR$is.inf, 1, any))
```

```
## 13 17 28 38 42 52
## 13 17 28 38 42 52
```

Which observations are influential?

```
summary(inflm.SR) # show only influential cases
```

```
## Potentially influential observations of
##   lm(formula = lnY ~ bloodclotting + prognostic + enzyme + alcoholeS,      data = sudata) :
##
##    dfb.1_ dfb.bldc dfb.prgn dfb.enzy dfb.alcS dffit   cov.r   cook.d hat
## 13  0.06  -0.01    -0.06    -0.06     0.02    -0.09    1.31_*  0.00   0.16
## 17  0.44  -0.15     0.63    -1.14_*  -0.01     1.42_*  0.45_*  0.33   0.15
## 28 -0.19   0.23     0.05     0.07     0.10     0.30    1.53_*  0.02   0.29_*
## 38 -0.23   0.02     0.71    -0.42     0.20    -0.87    1.34_*  0.15   0.31_*
## 42 -0.03   0.03     0.04    -0.01    -0.05    -0.07    1.43_*  0.00   0.23
## 52 -0.07   0.07    -0.17     0.24    -0.29    -0.40    1.35_*  0.03   0.22
```

```
inflm.SR          # show all cases
```

```
## Influence measures of
##   lm(formula = lnY ~ bloodclotting + prognostic + enzyme + alcoholeS,      data = sudata) :
##
##       dfb.1_  dfb.bldc  dfb.prgn  dfb.enzy  dfb.alcS     dffit cov.r   cook.d
## 1  -0.014551  3.31e-02 -0.008406  1.61e-02 -0.029484  0.058872 1.138 7.06e-04
## 2  -0.046748  2.18e-02  0.014100  3.00e-02  0.018002 -0.072065 1.126 1.06e-03
## 3  -0.029524  7.29e-02 -0.031108  3.17e-02 -0.048356  0.100638 1.158 2.06e-03
## 4  -0.068341 -2.25e-02 -0.051396  1.66e-01  0.029252 -0.216582 1.140 9.47e-03
## 5  -0.371734  2.45e-01  0.040004  3.88e-01  0.351231  0.674411 1.063 8.87e-02
## 6  -0.056415 -1.44e-02  0.086370  8.69e-03  0.034251 -0.106206 1.173 2.30e-03
## 7   0.000472 -2.15e-04 -0.000274 -3.56e-04  0.000759  0.000937 1.285 1.79e-07
## 8   0.123127 -2.39e-01  0.073989  2.93e-03 -0.027910  0.326628 0.967 2.10e-02
## 9  -0.113098  7.27e-02  0.028782  1.65e-01 -0.119222  0.272344 0.954 1.46e-02
## 10 -0.001819 -1.86e-01  0.135445  1.01e-01 -0.030257  0.310463 1.054 1.92e-02
## 11  0.111993 -4.62e-02 -0.140614 -5.07e-02  0.060240 -0.208344 1.085 8.73e-03
## 12 -0.152925 -6.60e-02  0.108844  1.88e-01  0.060573 -0.275447 1.114 1.52e-02
## 13  0.063631 -7.48e-03 -0.058662 -5.72e-02  0.017537 -0.089033 1.307 1.62e-03
## 14  0.037515 -4.45e-03 -0.049751 -2.64e-02  0.020037 -0.074706 1.160 1.14e-03
## 15  0.002580 -6.12e-02 -0.002073  5.90e-02 -0.189193 -0.245817 1.198 1.22e-02
## 16 -0.079125  1.44e-01  0.066259 -2.43e-02 -0.087364  0.232015 1.058 1.08e-02
## 17  0.443827 -1.54e-01  0.626260 -1.14e+00 -0.010285  1.415359 0.451 3.31e-01
## 18 -0.288270  1.77e-01  0.074550  2.29e-01 -0.005880 -0.311857 1.185 1.96e-02
## 19  0.067421 -1.34e-01 -0.015416 -1.34e-02  0.087644 -0.195718 1.068 7.69e-03
## 20 -0.008666  1.51e-02  0.003627 -3.25e-03 -0.057906 -0.066133 1.237 8.92e-04
## 21 -0.126022  3.44e-02  0.122602  7.41e-03  0.082653 -0.237415 0.967 1.11e-02
## 22 -0.200067  3.04e-01 -0.224252  2.36e-01 -0.036428 -0.446391 1.106 3.96e-02
## 23  0.326860  4.94e-02 -0.472729 -1.51e-01  0.424961  0.726342 1.084 1.03e-01
## 24  0.045399 -2.88e-02 -0.025546 -7.70e-02  0.082081 -0.186645 1.009 6.94e-03
## 25  0.102154 -1.03e-01  0.052441 -1.86e-01  0.116434 -0.261299 1.049 1.36e-02
## 26  0.068186  2.73e-02 -0.044005 -2.78e-02 -0.113169  0.265692 0.849 1.36e-02
## 27 -0.000171  4.57e-05  0.000302 -1.94e-04  0.000236 -0.000613 1.151 7.67e-08
## 28 -0.194739  2.34e-01  0.046002  7.12e-02  0.096728  0.304000 1.528 1.88e-02
## 29  0.265068 -7.96e-02 -0.116628 -2.11e-01 -0.062094  0.338663 0.930 2.24e-02
## 30  0.023894 -9.45e-03  0.063426 -7.09e-02 -0.024714  0.136394 1.113 3.77e-03
## 31  0.091117 -1.05e-01  0.011640 -5.12e-02  0.002164  0.130159 1.182 3.45e-03
## 32 -0.293124 -4.07e-01  0.322952  5.25e-01  0.166328 -0.824500 1.113 1.32e-01
## 33 -0.072062  4.32e-02  0.027108  2.32e-02  0.039269 -0.132566 1.070 3.54e-03
## 34  0.044338  5.03e-02 -0.081492 -4.62e-02 -0.229011 -0.272314 1.187 1.50e-02
## 35  0.010966 -2.66e-03 -0.005861 -5.39e-03 -0.007148  0.020907 1.138 8.92e-05
## 36  0.000729 -2.48e-03  0.022843 -3.26e-02  0.019825 -0.052091 1.169 5.53e-04
## 37  0.050949 -1.38e-01  0.057804  8.67e-03  0.002829  0.167082 1.210 5.67e-03
## 38 -0.226290  2.42e-02  0.705250 -4.20e-01  0.197828 -0.871528 1.339 1.50e-01
```

```
## 39  0.083604 -7.38e-02 -0.016466 -1.33e-02 -0.048216  0.176085 1.022 6.19e-03
## 40  0.036022  6.48e-03 -0.101023  8.10e-02 -0.084202  0.205288 1.033 8.42e-03
## 41  0.147684 -3.32e-02 -0.138527 -3.75e-02 -0.072271  0.231924 1.007 1.07e-02
## 42 -0.034025  3.33e-02  0.036807 -1.00e-02 -0.045897 -0.074043 1.430 1.12e-03
## 43 -0.113396  1.11e-01  0.058653  5.15e-02 -0.050596  0.147835 1.272 4.45e-03
## 44 -0.000738 -1.02e-02  0.008526 -2.54e-03  0.010446 -0.021512 1.147 9.45e-05
## 45 -0.034983  4.63e-01 -0.312922 -1.85e-01  0.042433 -0.700062 0.709 8.99e-02
## 46  0.049867  1.28e-01 -0.236938  7.98e-02 -0.128861  0.317099 1.057 2.00e-02
## 47 -0.005926 -5.19e-03  0.006048  1.29e-02 -0.004275  0.019238 1.194 7.56e-05
## 48  0.092432  1.51e-01 -0.219691 -9.09e-02 -0.305256 -0.414332 1.256 3.45e-02
## 49  0.000463 -6.39e-04  0.000408 -1.98e-05 -0.000652  0.002145 1.138 9.40e-07
## 50 -0.034055 -6.22e-02  0.073966  6.75e-02 -0.015710  0.138878 1.202 3.92e-03
## 51 -0.030483 -2.70e-02 -0.065458  1.21e-01  0.027973 -0.179103 1.147 6.49e-03
## 52 -0.071253  7.16e-02 -0.173140  2.38e-01 -0.287311 -0.396318 1.346 3.17e-02
## 53  0.027791 -6.83e-02  0.038493 -5.79e-02  0.074361 -0.148610 1.079 4.45e-03
## 54  0.234893 -3.40e-01 -0.105984 -3.19e-02  0.150150 -0.417070 1.075 3.45e-02
##       hat inf
## 1  0.0352
## 2  0.0315
## 3  0.0588
## 4  0.0803
## 5  0.1693
## 6  0.0695
## 7  0.1370
## 8  0.0538
## 9  0.0385
## 10 0.0727
## 11 0.0546
## 12 0.0853
## 13 0.1555   *
## 14 0.0537
## 15 0.1174
## 16 0.0522
## 17 0.1499   *
## 18 0.1271
## 19 0.0452
## 20 0.1073
## 21 0.0328
## 22 0.1282
## 23 0.1885
## 24 0.0284
## 25 0.0577
## 26 0.0239
## 27 0.0365
## 28 0.2914   *
## 29 0.0491
## 30 0.0445
## 31 0.0809
## 32 0.2202
## 33 0.0277
## 34 0.1182
## 35 0.0270
## 36 0.0560
## 37 0.1059
```

```
## 38 0.3059   *
## 39 0.0283
## 40 0.0382
## 41 0.0391
## 42 0.2262   *
## 43 0.1407
## 44 0.0347
## 45 0.0831
## 46 0.0756
## 47 0.0722
## 48 0.1840
## 49 0.0257
## 50 0.0954
## 51 0.0732
## 52 0.2221   *
## 53 0.0352
## 54 0.1089
```

You can use other functions to get one measure at a time.

- Studentized deleted residual (studentized residual in some reference.

```
rstudent(sureg5)
```

```
##           1           2           3           4           5           6
##  0.30825788 -0.39986096  0.40278356 -0.73289176  1.49408026 -0.38871507
##           7           8           9          10          11          12
##  0.00235316  1.36973328  1.36044928  1.10878738 -0.86699358 -0.90208485
##          13          14          15          16          17          18
## -0.20746551 -0.31369201 -0.67414896  0.98859746  3.37029932 -0.81726410
##          19          20          21          22          23          24
## -0.89946266 -0.19078912 -1.28822510 -1.16395842  1.50696453 -1.09207949
##          25          26          27          28          29          30
## -1.05549078  1.69722468 -0.00315068  0.47408813  1.49048257  0.63196082
##          31          32          33          34          35          36
##  0.43882159 -1.55138464 -0.78601409 -0.74386072  0.12543201 -0.21378526
##          37          38          39          40          41          42
##  0.48541057 -1.31277013  1.03263935  1.03068966  1.15040297 -0.13693613
##          43          44          45          46          47          48
##  0.36534015 -0.11343555 -2.32467276  1.10869891  0.06897802 -0.87248323
##          49          50          51          52          53          54
##  0.01321043  0.42772808 -0.63744341 -0.74175642 -0.77840592 -1.19295712
```

- DFfits

```
dffits(sureg5)
```

```
##           1           2           3           4           5
##  0.05887151 -0.07206498  0.10063819 -0.21658224  0.67441078
##           6           7           8           9          10
## -0.10620568  0.00093748  0.32662831  0.27234350  0.31046313
##          11          12          13          14          15
## -0.20834355 -0.27544678 -0.08903297 -0.07470615 -0.24581696
##          16          17          18          19          20
##  0.23201546  1.41535915 -0.31185699 -0.19571785 -0.06613334
##          21          22          23          24          25
## -0.23741489 -0.44639088  0.72634218 -0.18664469 -0.26129916
```

```
##            26            27            28            29            30
##  0.2656915073 -0.0006130687  0.3039995835  0.3386625852  0.1363939003
##            31            32            33            34            35
##  0.1301585410 -0.8244999558 -0.1325656202 -0.2723137134  0.0209068319
##            36            37            38            39            40
## -0.0520906871  0.1670816678 -0.8715284628  0.1760854091  0.2052875832
##            41            42            43            44            45
##  0.2319235625 -0.0740429525  0.1478347032 -0.0215121808 -0.7000622705
##            46            47            48            49            50
##  0.3170991603  0.0192379554 -0.4143324407  0.0021454145  0.1388779888
##            51            52            53            54
## -0.1791025024 -0.3963181959 -0.1486097692 -0.4170704658
```

- DFbetas

```
dfbetas(sureg5)  # use `dfbetas()` to get the standardized DfBeta.
```

```
##      (Intercept) bloodclotting    prognostic        enzyme     alcoholeS
## 1  -0.0145514278  3.313360e-02 -0.0084059862  1.612463e-02 -0.0294840301
## 2  -0.0467478140  2.179796e-02  0.0141000914  3.000559e-02  0.0180021759
## 3  -0.0295243310  7.287691e-02 -0.0311079205  3.168351e-02 -0.0483556512
## 4  -0.0683408708 -2.253862e-02 -0.0513962245  1.660035e-01  0.0292521613
## 5  -0.3717340200  2.446293e-01  0.0400040381  3.883311e-01  0.3512305078
## 6  -0.0564149242 -1.440517e-02  0.0863699959  8.692709e-03  0.0342508327
## 7   0.0004717180 -2.147314e-04 -0.0002740558 -3.559066e-04  0.0007591357
## 8   0.1231270726 -2.391556e-01  0.0739892340  2.934099e-03 -0.0279097372
## 9  -0.1130980180  7.274352e-02  0.0287822065  1.652483e-01 -0.1192223704
## 10 -0.0018187614 -1.860104e-01  0.1354449163  1.009669e-01 -0.0302565580
## 11  0.1119927889 -4.624631e-02 -0.1406142410 -5.072911e-02  0.0602396549
## 12 -0.1529245676 -6.603704e-02  0.1088441245  1.881885e-01  0.0605733895
## 13  0.0636312839 -7.477587e-03 -0.0586618416 -5.717404e-02  0.0175370447
## 14  0.0375148480 -4.448367e-03 -0.0497514128 -2.640231e-02  0.0200366447
## 15  0.0025800769 -6.124137e-02 -0.0020732429  5.902383e-02 -0.1891934497
## 16 -0.0791246654  1.441698e-01  0.0662594144 -2.425397e-02 -0.0873641009
## 17  0.4438266971 -1.538290e-01  0.6262598500 -1.140756e+00 -0.0102847698
## 18 -0.2882702565  1.769741e-01  0.0745498884  2.289451e-01 -0.0058796252
## 19  0.0674207425 -1.340910e-01 -0.0154162348 -1.336529e-02  0.0876444394
## 20 -0.0086659942  1.514759e-02  0.0036272033 -3.252019e-03 -0.0579056433
## 21 -0.1260215538  3.437409e-02  0.1226017785  7.405541e-03  0.0826531575
## 22 -0.2000670818  3.043905e-01 -0.2242517634  2.355415e-01 -0.0364276755
## 23  0.3268597890  4.935376e-02 -0.4727290100 -1.505652e-01  0.4249609134
## 24  0.0453993068 -2.883877e-02 -0.0255455915 -7.701043e-02  0.0820811452
## 25  0.1021537161 -1.034573e-01  0.0524410123 -1.856804e-01  0.1164338444
## 26  0.0681856035  2.733020e-02 -0.0440054768 -2.783630e-02 -0.1131687143
## 27 -0.0001714759  4.568858e-05  0.0003018249 -1.942892e-04  0.0002357833
## 28 -0.1947394291  2.337612e-01  0.0460015300  7.115204e-02  0.0967276740
## 29  0.2650677037 -7.961085e-02 -0.1166284261 -2.111283e-01 -0.0620939037
## 30  0.0238938182 -9.453590e-03  0.0634263889 -7.090728e-02 -0.0247137103
## 31  0.0911173671 -1.054483e-01  0.0116401776 -5.115230e-02  0.0021644485
## 32 -0.2931239222 -4.066101e-01  0.3229524174  5.251568e-01  0.1663280509
## 33 -0.0720624378  4.323718e-02  0.0271077499  2.323893e-02  0.0392688033
## 34  0.0443376225  5.033060e-02 -0.0814920684 -4.615380e-02 -0.2290113515
## 35  0.0109655931 -2.662666e-03 -0.0058614902 -5.394900e-03 -0.0071484085
## 36  0.0007292257 -2.483687e-03  0.0228430216 -3.262236e-02  0.0198252260
## 37  0.0509485088 -1.377331e-01  0.0578042183  8.672576e-03  0.0028289083
```

```
## 38 -0.2262899901  2.417025e-02  0.7052497969 -4.201501e-01  0.1978279528
## 39  0.0836039651 -7.381492e-02 -0.0164660682 -1.327450e-02 -0.0482159300
## 40  0.0360219289  6.476279e-03 -0.1010227982  8.095571e-02 -0.0842024074
## 41  0.1476843228 -3.321132e-02 -0.1385269379 -3.751127e-02 -0.0722706350
## 42 -0.0340246038  3.331862e-02  0.0368071583 -1.003387e-02 -0.0458972840
## 43 -0.1133962026  1.107385e-01  0.0586526098  5.150482e-02 -0.0505957217
## 44 -0.0007375038 -1.019130e-02  0.0085262101 -2.536379e-03  0.0104456838
## 45 -0.0349827637  4.628719e-01 -0.3129216774 -1.847996e-01  0.0424326344
## 46  0.0498669463  1.283580e-01 -0.2369375726  7.975975e-02 -0.1288611903
## 47 -0.0059261264 -5.185553e-03  0.0060483072  1.291358e-02 -0.0042754472
## 48  0.0924321466  1.513655e-01 -0.2196908786 -9.091468e-02 -0.3052558392
## 49  0.0004629873 -6.391938e-04  0.0004078216 -1.984356e-05 -0.0006516731
## 50 -0.0340545913 -6.216508e-02  0.0739657256  6.754285e-02 -0.0157103423
## 51 -0.0304827958 -2.703745e-02 -0.0654575497  1.209781e-01  0.0279729501
## 52 -0.0712531237  7.155340e-02 -0.1731398769  2.383570e-01 -0.2873112508
## 53  0.0277907395 -6.825723e-02  0.0384927954 -5.794496e-02  0.0743613214
## 54  0.2348929445 -3.400596e-01 -0.1059840998 -3.187757e-02  0.1501503745
```

- Cook's distance

```
cooks.distance(sureg5)
```

```
##            1            2            3            4            5            6
## 7.062138e-04 1.056791e-03 2.060844e-03 9.471039e-03 8.873444e-02 2.295701e-03
##            7            8            9           10           11           12
## 1.794362e-07 2.096238e-02 1.458102e-02 1.918764e-02 8.725627e-03 1.523208e-02
##           13           14           15           16           17           18
## 1.616953e-03 1.137125e-03 1.222126e-02 1.077122e-02 3.307299e-01 1.958368e-02
##           19           20           21           22           23           24
## 7.691069e-03 8.922704e-04 1.112345e-02 3.956647e-02 1.028470e-01 6.939965e-03
##           25           26           27           28           29           30
## 1.362374e-02 1.359657e-02 7.673669e-08 1.878028e-02 2.238054e-02 3.766832e-03
##           31           32           33           34           35           36
## 3.445017e-03 1.321656e-01 3.542358e-03 1.496739e-02 8.921111e-05 5.534669e-04
##           37           38           39           40           41           42
## 5.671733e-03 1.497024e-01 6.192829e-03 8.417892e-03 1.068717e-02 1.118878e-03
##           43           44           45           46           47           48
## 4.449710e-03 9.445769e-05 8.993418e-02 2.001674e-02 7.555438e-05 3.450240e-02
##           49           50           51           52           53           54
## 9.397356e-07 3.922830e-03 6.494223e-03 3.170466e-02 4.452784e-03 3.449170e-02
```

- Leverage

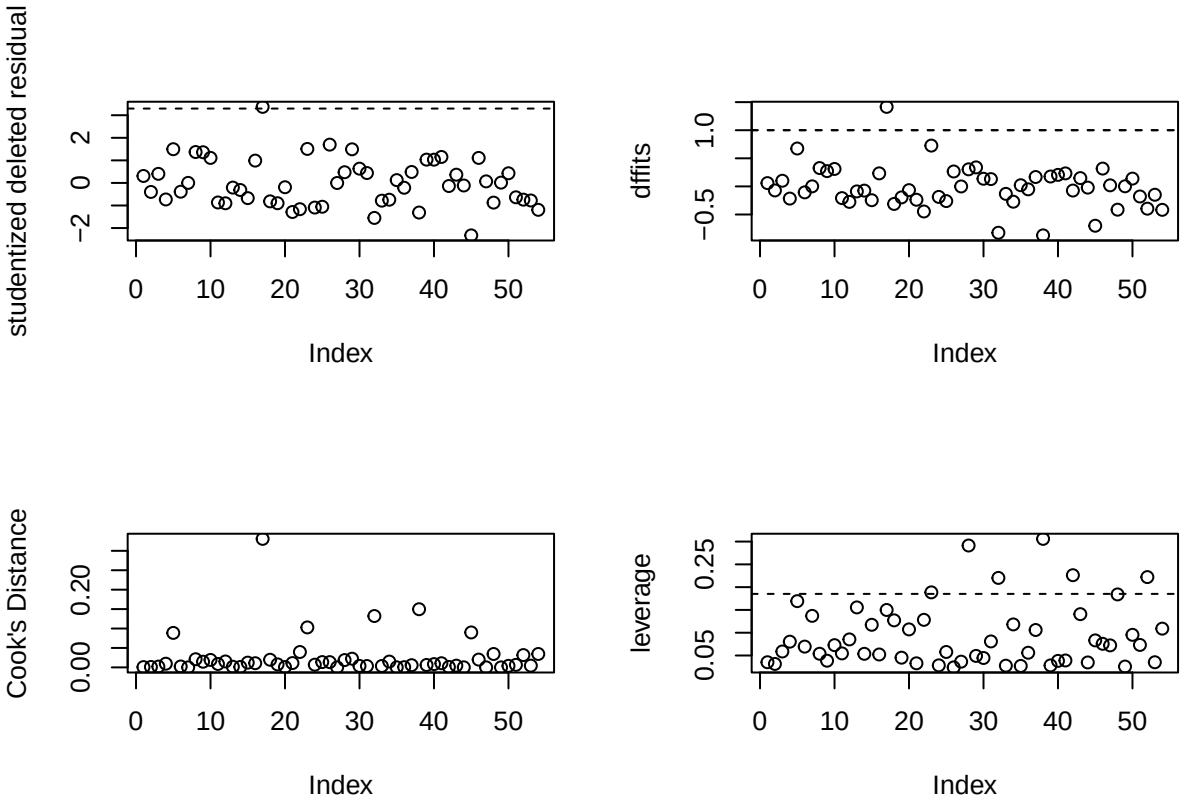
```
hatvalues(sureg5)
```

```
##          1          2          3          4          5          6          7
## 0.03519035 0.03145926 0.05876010 0.08031643 0.16926387 0.06946491 0.13697626
##          8          9         10         11         12         13         14
## 0.05380426 0.03853052 0.07270145 0.05459422 0.08528388 0.15552396 0.05367197
##         15         16         17         18         19         20         21
## 0.11735414 0.05220468 0.14991900 0.12710129 0.04520681 0.10726460 0.03284933
##         22         23         24         25         26         27         28
## 0.12822176 0.18851889 0.02838043 0.05774766 0.02392005 0.03648132 0.29137119
##         29         30         31         32         33         34         35
## 0.04909290 0.04450786 0.08086296 0.22024279 0.02765796 0.11817802 0.02703079
##         36         37         38         39         40         41         42
```

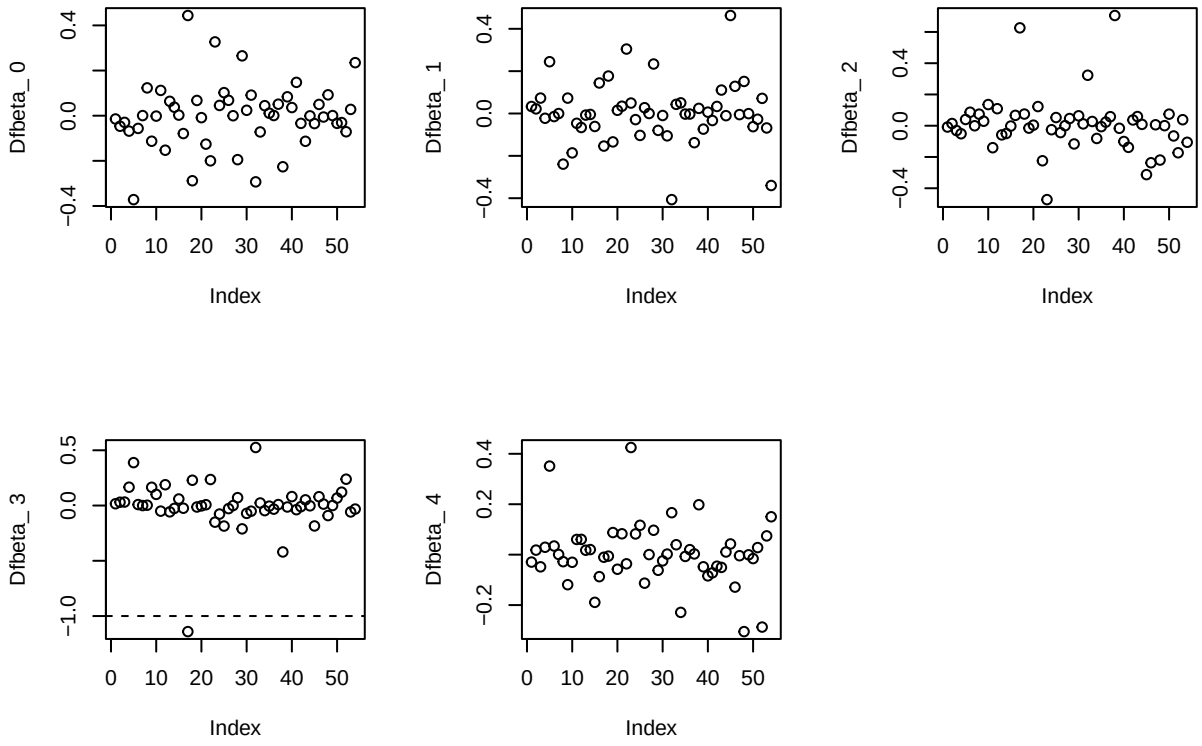
```
## 0.05604245 0.10592819 0.30591386 0.02825540 0.03815696 0.03905601 0.22622720
##         43         44         45         46         47         48         49
## 0.14070242 0.03471569 0.08314749 0.07561627 0.07217125 0.18401937 0.02569701
##         50         51         52         53         54
## 0.09536812 0.07316798 0.22207637 0.03516694 0.10891514
```

- **See handout 7 for the threshold to identify outliers or influential cases.**
- Use index (sequence) plot to show the values in a graph. Threshold values are added to the plots. (See section 2.4 for more graphing options.)

```r
n <- 54  # sample size
p <- 5  # 5 parameters (1 intercept, 4 slopes)

par(mfrow=c(2,2))
plot(rstudent(sureg5), ylab="studentized deleted residual")
abline(qt(1-0.1/(2*n), df=n - p - 1), 0, lty=2)
abline(qt(0.1/(2*n), df=n - p - 1), 0, lty=2)

plot(dffits(sureg5), ylab = "dffits")
abline(1, 0, lty=2)
abline(1, 0, lty=2)

plot(cooks.distance(sureg5), ylab="Cook's Distance")
abline(qf(0.5, df1=5, df2=n-p), 0, lty=2)

plot(hatvalues(sureg5), ylab="leverage")
abline(2*p/n, 0, lty=2)
```



```
par(mfrow=c(2,3))
for (i in 1:5) {
  plot(dfbetas(sureg5)[, i], ylab=paste("Dfbeta_", i-1))
  abline(1, 0, lty=2)
  abline(-1, 0, lty=2)
}
```



2 Compute leverage for a new set of x-values:

i. Save the "design matrix" when you run the regression.

```
sureg5<-lm(lnY~bloodclotting+ prognostic+ enzyme +alcoholeS , data=sudata, x=T)
designX<-sureg5$x
```

ii. Input the new set of x-values. Be sure in include 1 (for the intercept)

```
newX<-c(1, 7, 60, 80, 0)
```

iii. Matrix computation using R

```
lev<-t(newX)%*%solve(t(designX)%*%designX)%*%newX
lev
```

```
##             [,1]
## [1,] 0.04216363
```

2.1 Durbin-Waston test

- Run the following line if package `lmtest` has not been installed

```
install.packages("lmtest")
```

- Load package `lmtest`.

```
library(lmtest)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

- Note that computation in `dwtest()` is slightly different from what introduced in the textbook (p.487). Both are valid.

```
dwtest(sureg5)
```

```
##
##  Durbin-Watson test
##
## data:  sureg5
## DW = 1.8634, p-value = 0.3226
## alternative hypothesis: true autocorrelation is greater than 0
```

- The default alternative hypothesis is "greater". You can change it "two.sided" or "less".

```
dwtest(sureg5, alternative = "two.sided")
```

```
##
##  Durbin-Watson test
##
## data:  sureg5
## DW = 1.8634, p-value = 0.6453
## alternative hypothesis: true autocorrelation is not 0
```

3 Package car (Companion to Applied Regression)

Package `car` includes lots of function for regression. More details at: [http://cran.r-project.org/web/packages/car/car.pdf]

Run the following line if package `car` is not installed

```
install.packages("car")
```

```
library(car)
```

```
## Loading required package: carData
```

```
sureg4<-lm(lnY~bloodclotting+ prognostic+ enzyme+ age +alcoholeS , data=sudata)
sureg4
```

```
##
## Call:
## lm(formula = lnY ~ bloodclotting + prognostic + enzyme + age +
```

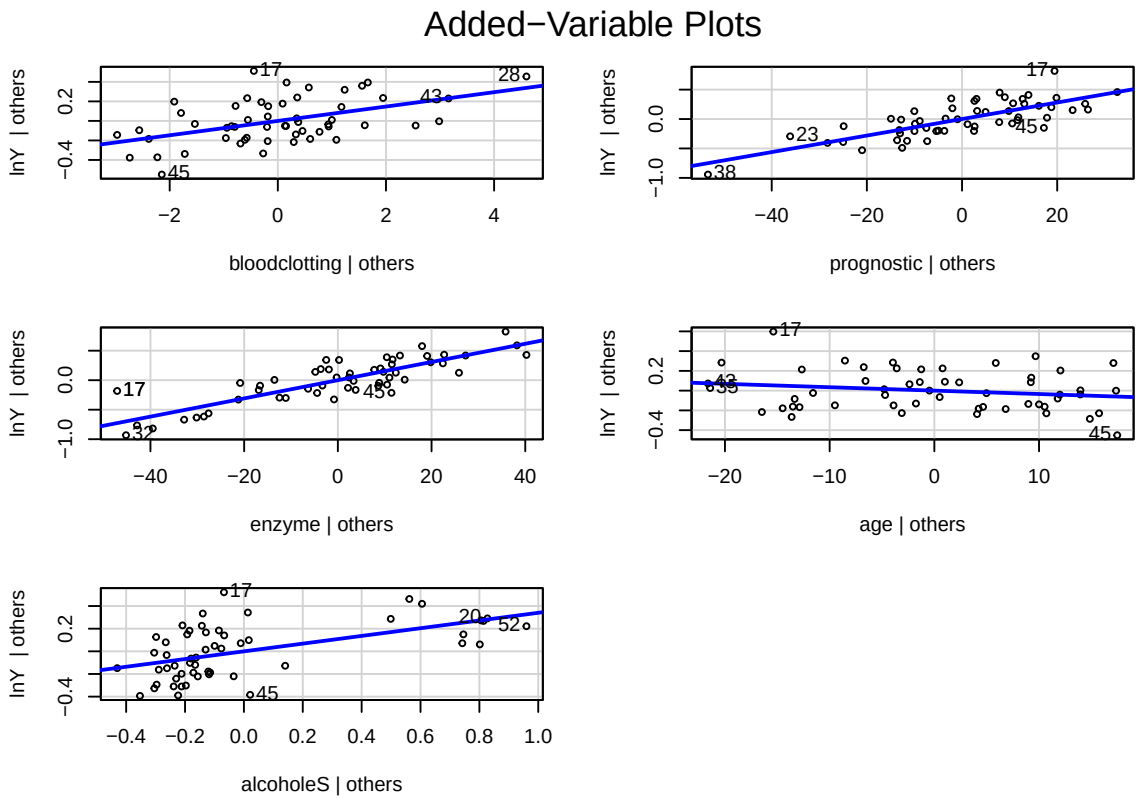
```
##     alcoholeS, data = sudata)
##
## Coefficients:
##   (Intercept)  bloodclotting     prognostic         enzyme            age
##       4.04120        0.07360        0.01405        0.01543       -0.00344
##     alcoholeS
##       0.34042
```

```
sureg5<-lm(lnY~bloodclotting+ prognostic+ enzyme +alcoholeS , data=sudata)
sureg5
```

```
##
## Call:
## lm(formula = lnY ~ bloodclotting + prognostic + enzyme + alcoholeS,
##     data = sudata)
##
## Coefficients:
##   (Intercept)  bloodclotting     prognostic         enzyme      alcoholeS
##       3.85494        0.07331        0.01418        0.01543        0.35220
```

a. **Added-variable plot (partial regression plot)**

```
avPlots(sureg4)
```



b. **Variance Inflation Factor (VIF)**

```
vif(sureg4)
```

```
## bloodclotting    prognostic       enzyme           age     alcoholeS
##      1.102735      1.023440     1.048711      1.016443      1.106683
```

```
vif(sureg5)
```

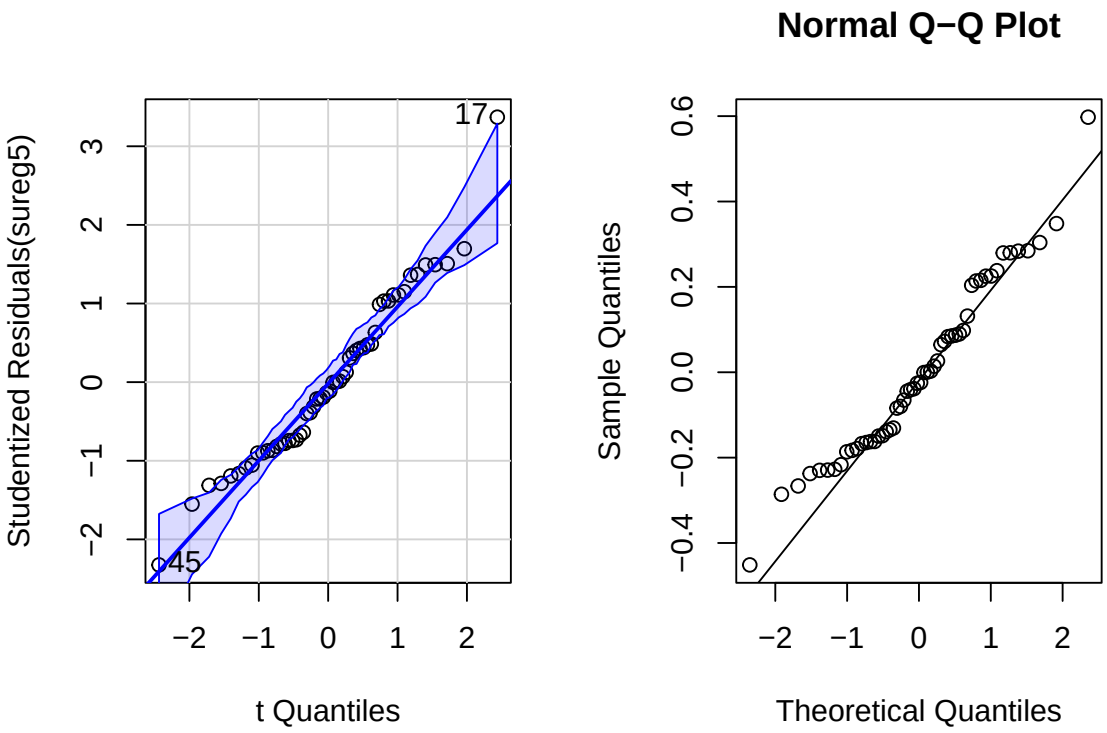
```
## bloodclotting    prognostic       enzyme     alcoholeS
##      1.102590      1.019925     1.048708      1.091860
```

c. **Another version of qq plot**

```
par(mfrow=c(1,2))
qqPlot(sureg5)  # this is the "car" version
```

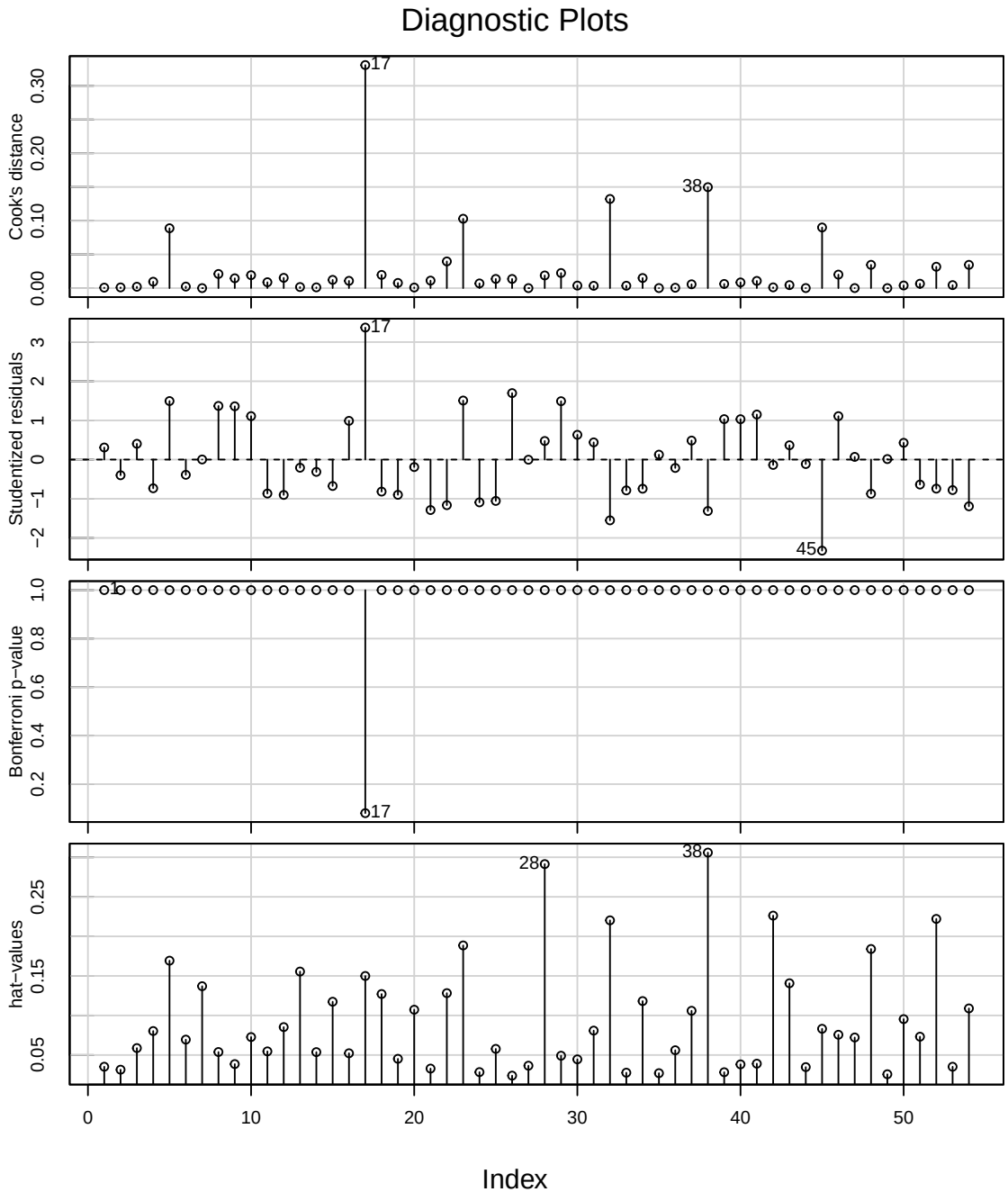
```
## [1] 17 45
```

```
qqnorm(sureg5$residual)  # this is what we did before.
qqline(sureg5$residual)
```



d. **Index plots for Cook's D, leverage, studentized residual and their p-values**

```
influenceIndexPlot(sureg5)
```



—— This is the end of Lab 6. ——