Tutorial 11: Diagnostic Techniques and Imputation of Missing Data

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Today's Agenda

1. Diagnostic techniques
2. Functional form specifications
3. Imputation of missing data
4. The most useful R packages for applied work

1. Diagnostic techniques

Diagnostic techniques are a way to assess the robustness and accuracy of our regression. Let us look at our regression from tutorial 5 to assess it in different dimensions.

```
setwd('C:/Users/Jan/OneDrive/Documents/GitHub/ps630_lab/')
library(foreign)
LDC=read.dta("LDC_IO_replication.dta")
main=lm(newtar ~ l1polity + l1signed + l1office + l1gdp_pc + l1lnpop + l1ecris2 + l1bpc1 + l1avnewtar +
summary(main)
```

```
##
## Call:
## lm(formula = newtar ~ l1polity + l1signed + l1office + l1gdp_pc +
##     l1lnpop + l1ecris2 + l1bpc1 + l1avnewtar + factor(ctylabel) -
##     1, data = LDC)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -33.852  -3.563  -0.226   3.311  34.980
##
## Coefficients:
##                                       Estimate Std. Error t value
## l1polity                            -5.715e-01  9.872e-02  -5.789
## l1signed                             6.267e-01  7.475e-01   0.838
## l1office                            -2.010e-01  6.881e-02  -2.921
## l1gdp_pc                            -1.476e-04  3.976e-04  -0.371
## l1lnpop                             -1.741e+01  3.414e+00  -5.099
## l1ecris2                            -1.391e+00  1.127e+00  -1.234
## l1bpc1                               2.283e+00  8.801e-01   2.594
## l1avnewtar                           3.739e-01  6.787e-02   5.509
## factor(ctylabel)Albania              2.723e+02  5.217e+01   5.220
## factor(ctylabel)Algeria              3.100e+02  5.877e+01   5.276
## factor(ctylabel)Argentina            3.168e+02  5.956e+01   5.318
## factor(ctylabel)Bahrain              2.207e+02  4.575e+01   4.824
```

```
## factor(ctylabel)Bangladesh              3.782e+02  6.381e+01   5.927
## factor(ctylabel)Belarus                 2.840e+02  5.589e+01   5.081
## factor(ctylabel)Benin                   2.926e+02  5.307e+01   5.513
## factor(ctylabel)Bolivia                 2.838e+02  5.401e+01   5.254
## factor(ctylabel)Botswana                2.695e+02  4.882e+01   5.520
## factor(ctylabel)Brazil                  3.543e+02  6.457e+01   5.486
## factor(ctylabel)Bulgaria                2.925e+02  5.476e+01   5.341
## factor(ctylabel)Burundi                 2.910e+02  5.370e+01   5.418
## factor(ctylabel)Cambodia                3.095e+02  5.613e+01   5.514
## factor(ctylabel)Cameroon                2.962e+02  5.602e+01   5.288
## factor(ctylabel)CentralAfricanRepublic  2.734e+02  5.157e+01   5.302
## factor(ctylabel)Chad                    2.830e+02  5.449e+01   5.193
## factor(ctylabel)Chile                   2.954e+02  5.652e+01   5.227
## factor(ctylabel)China                   3.853e+02  7.209e+01   5.345
## factor(ctylabel)Colombia                3.220e+02  5.971e+01   5.393
## factor(ctylabel)Congo                   2.695e+02  5.070e+01   5.315
## factor(ctylabel)CostaRica               2.715e+02  5.129e+01   5.293
## factor(ctylabel)Coted'Ivoire            2.958e+02  5.594e+01   5.288
## factor(ctylabel)Cyprus                  2.459e+02  4.682e+01   5.253
## factor(ctylabel)DominicanRepublic       2.892e+02  5.449e+01   5.308
## factor(ctylabel)Ecuador                 2.985e+02  5.553e+01   5.376
## factor(ctylabel)Egypt                   3.362e+02  6.136e+01   5.479
## factor(ctylabel)ElSalvador              2.791e+02  5.329e+01   5.237
## factor(ctylabel)Estonia                 2.470e+02  4.900e+01   5.040
## factor(ctylabel)Ethiopia                3.226e+02  6.157e+01   5.241
## factor(ctylabel)Fiji                    2.462e+02  4.719e+01   5.217
## factor(ctylabel)Gabon                   2.579e+02  4.807e+01   5.366
## factor(ctylabel)Gambia                  2.470e+02  4.855e+01   5.087
## factor(ctylabel)Ghana                   2.954e+02  5.701e+01   5.181
## factor(ctylabel)Guatemala               2.877e+02  5.526e+01   5.206
## factor(ctylabel)Guinea                  2.790e+02  5.417e+01   5.150
## factor(ctylabel)Guyana                  2.464e+02  4.712e+01   5.230
## factor(ctylabel)Haiti                   2.825e+02  5.413e+01   5.219
## factor(ctylabel)Honduras                2.743e+02  5.379e+01   5.100
## factor(ctylabel)Hungary                 2.923e+02  5.567e+01   5.250
## factor(ctylabel)India                   4.156e+02  7.056e+01   5.890
## factor(ctylabel)Indonesia               3.435e+02  6.556e+01   5.241
## factor(ctylabel)Israel                  2.720e+02  5.307e+01   5.126
## factor(ctylabel)Jamaica                 2.681e+02  5.042e+01   5.317
## factor(ctylabel)Jordan                  2.659e+02  5.131e+01   5.183
## factor(ctylabel)Kenya                   3.163e+02  5.851e+01   5.406
## factor(ctylabel)Korea                   3.137e+02  6.062e+01   5.175
## factor(ctylabel)Kuwait                  2.404e+02  5.046e+01   4.764
## factor(ctylabel)Latvia                  2.599e+02  5.061e+01   5.136
## factor(ctylabel)Lesotho                 2.662e+02  5.019e+01   5.303
## factor(ctylabel)Lithuania               2.664e+02  5.184e+01   5.140
## factor(ctylabel)Madagascar              2.844e+02  5.619e+01   5.062
## factor(ctylabel)Malawi                  2.878e+02  5.486e+01   5.246
## factor(ctylabel)Malaysia                2.996e+02  5.754e+01   5.207
## factor(ctylabel)Mali                    2.954e+02  5.526e+01   5.345
## factor(ctylabel)Mauritania              2.604e+02  5.030e+01   5.178
## factor(ctylabel)Mauritius               2.712e+02  4.769e+01   5.687
## factor(ctylabel)Mexico                  3.238e+02  6.281e+01   5.155
## factor(ctylabel)Mongolia                2.609e+02  5.055e+01   5.161
```

```
## factor(ctylabel)Morocco                3.136e+02  5.859e+01   5.353
## factor(ctylabel)Mozambique             2.989e+02  5.694e+01   5.249
## factor(ctylabel)Namibia                2.701e+02  4.934e+01   5.474
## factor(ctylabel)Nepal                  3.022e+02  5.782e+01   5.226
## factor(ctylabel)Nicaragua              2.718e+02  5.242e+01   5.185
## factor(ctylabel)Niger                  2.941e+02  5.535e+01   5.312
## factor(ctylabel)Nigeria                3.406e+02  6.343e+01   5.369
## factor(ctylabel)Oman                   2.494e+02  5.040e+01   4.947
## factor(ctylabel)Pakistan               3.761e+02  6.357e+01   5.916
## factor(ctylabel)Panama                 2.662e+02  5.079e+01   5.241
## factor(ctylabel)PapuaNewGuinea         2.805e+02  5.230e+01   5.364
## factor(ctylabel)Paraguay               2.721e+02  5.252e+01   5.180
## factor(ctylabel)Peru                   3.166e+02  5.799e+01   5.459
## factor(ctylabel)Philippines            3.300e+02  6.153e+01   5.363
## factor(ctylabel)Poland                 3.130e+02  5.990e+01   5.226
## factor(ctylabel)Romania                3.029e+02  5.837e+01   5.190
## factor(ctylabel)Russia                 3.353e+02  6.454e+01   5.195
## factor(ctylabel)Rwanda                 2.995e+02  5.465e+01   5.479
## factor(ctylabel)SaudiArabia            2.835e+02  5.720e+01   4.956
## factor(ctylabel)Senegal                2.781e+02  5.453e+01   5.101
## factor(ctylabel)SierraLeone            2.797e+02  5.267e+01   5.311
## factor(ctylabel)Singapore              2.564e+02  5.233e+01   4.899
## factor(ctylabel)Slovenia               2.625e+02  5.033e+01   5.216
## factor(ctylabel)SouthAfrica            3.096e+02  5.979e+01   5.178
## factor(ctylabel)SriLanka               3.101e+02  5.727e+01   5.414
## factor(ctylabel)Swaziland              2.435e+02  4.813e+01   5.059
## factor(ctylabel)Syria                  2.810e+02  5.608e+01   5.011
## factor(ctylabel)Tanzania               3.144e+02  5.915e+01   5.315
## factor(ctylabel)Thailand               3.391e+02  6.133e+01   5.530
## factor(ctylabel)Togo                   2.718e+02  5.261e+01   5.166
## factor(ctylabel)Trinidad&Tobago        2.563e+02  4.824e+01   5.312
## factor(ctylabel)Tunisia                2.923e+02  5.483e+01   5.331
## factor(ctylabel)Turkey                 3.272e+02  6.121e+01   5.345
## factor(ctylabel)Uganda                 2.971e+02  5.771e+01   5.147
## factor(ctylabel)Ukraine                3.154e+02  6.088e+01   5.180
## factor(ctylabel)Uruguay                2.802e+02  5.151e+01   5.440
## factor(ctylabel)Venezuela              3.106e+02  5.768e+01   5.384
## factor(ctylabel)Zambia                 2.912e+02  5.488e+01   5.305
## factor(ctylabel)Zimbabwe               2.859e+02  5.563e+01   5.139
##                                       Pr(>|t|)
## l1polity                              1.15e-08 ***
## l1signed                               0.40213
## l1office                               0.00362 **
## l1gdp_pc                               0.71061
## l1lnpop                               4.61e-07 ***
## l1ecris2                               0.21754
## l1bpc1                                 0.00971 **
## l1avnewtar                            5.38e-08 ***
## factor(ctylabel)Albania               2.48e-07 ***
## factor(ctylabel)Algeria               1.86e-07 ***
## factor(ctylabel)Argentina             1.49e-07 ***
## factor(ctylabel)Bahrain               1.80e-06 ***
## factor(ctylabel)Bangladesh            5.25e-09 ***
## factor(ctylabel)Belarus               5.05e-07 ***
```

```
## factor(ctylabel)Benin                  5.27e-08 ***
## factor(ctylabel)Bolivia                2.08e-07 ***
## factor(ctylabel)Botswana               5.09e-08 ***
## factor(ctylabel)Brazil                 6.10e-08 ***
## factor(ctylabel)Bulgaria               1.32e-07 ***
## factor(ctylabel)Burundi                8.79e-08 ***
## factor(ctylabel)Cambodia               5.25e-08 ***
## factor(ctylabel)Cameroon               1.74e-07 ***
## factor(ctylabel)CentralAfricanRepublic 1.62e-07 ***
## factor(ctylabel)Chad                   2.85e-07 ***
## factor(ctylabel)Chile                  2.39e-07 ***
## factor(ctylabel)China                  1.30e-07 ***
## factor(ctylabel)Colombia               1.01e-07 ***
## factor(ctylabel)Congo                  1.51e-07 ***
## factor(ctylabel)CostaRica              1.70e-07 ***
## factor(ctylabel)Coted'Ivoire           1.74e-07 ***
## factor(ctylabel)Cyprus                 2.10e-07 ***
## factor(ctylabel)DominicanRepublic      1.57e-07 ***
## factor(ctylabel)Ecuador                1.10e-07 ***
## factor(ctylabel)Egypt                  6.34e-08 ***
## factor(ctylabel)ElSalvador             2.27e-07 ***
## factor(ctylabel)Estonia                6.21e-07 ***
## factor(ctylabel)Ethiopia               2.23e-07 ***
## factor(ctylabel)Fiji                   2.52e-07 ***
## factor(ctylabel)Gabon                  1.16e-07 ***
## factor(ctylabel)Gambia                 4.90e-07 ***
## factor(ctylabel)Ghana                  3.03e-07 ***
## factor(ctylabel)Guatemala              2.67e-07 ***
## factor(ctylabel)Guinea                 3.55e-07 ***
## factor(ctylabel)Guyana                 2.36e-07 ***
## factor(ctylabel)Haiti                  2.50e-07 ***
## factor(ctylabel)Honduras               4.58e-07 ***
## factor(ctylabel)Hungary                2.13e-07 ***
## factor(ctylabel)India                  6.50e-09 ***
## factor(ctylabel)Indonesia              2.23e-07 ***
## factor(ctylabel)Israel                 4.02e-07 ***
## factor(ctylabel)Jamaica                1.50e-07 ***
## factor(ctylabel)Jordan                 3.01e-07 ***
## factor(ctylabel)Kenya                  9.36e-08 ***
## factor(ctylabel)Korea                  3.13e-07 ***
## factor(ctylabel)Kuwait                 2.40e-06 ***
## factor(ctylabel)Latvia                 3.83e-07 ***
## factor(ctylabel)Lesotho                1.61e-07 ***
## factor(ctylabel)Lithuania              3.74e-07 ***
## factor(ctylabel)Madagascar             5.56e-07 ***
## factor(ctylabel)Malawi                 2.17e-07 ***
## factor(ctylabel)Malaysia               2.65e-07 ***
## factor(ctylabel)Mali                   1.29e-07 ***
## factor(ctylabel)Mauritania             3.09e-07 ***
## factor(ctylabel)Mauritius              2.04e-08 ***
## factor(ctylabel)Mexico                 3.47e-07 ***
## factor(ctylabel)Mongolia               3.36e-07 ***
## factor(ctylabel)Morocco                1.24e-07 ***
## factor(ctylabel)Mozambique             2.13e-07 ***
```

```
## factor(ctylabel)Namibia                6.53e-08 ***
## factor(ctylabel)Nepal                  2.40e-07 ***
## factor(ctylabel)Nicaragua              2.98e-07 ***
## factor(ctylabel)Niger                  1.54e-07 ***
## factor(ctylabel)Nigeria                1.14e-07 ***
## factor(ctylabel)Oman                   9.84e-07 ***
## factor(ctylabel)Pakistan               5.61e-09 ***
## factor(ctylabel)Panama                 2.23e-07 ***
## factor(ctylabel)PapuaNewGuinea         1.17e-07 ***
## factor(ctylabel)Paraguay               3.05e-07 ***
## factor(ctylabel)Peru                   7.08e-08 ***
## factor(ctylabel)Philippines            1.17e-07 ***
## factor(ctylabel)Poland                 2.40e-07 ***
## factor(ctylabel)Romania                2.90e-07 ***
## factor(ctylabel)Russia                 2.82e-07 ***
## factor(ctylabel)Rwanda                 6.33e-08 ***
## factor(ctylabel)SaudiArabia            9.44e-07 ***
## factor(ctylabel)Senegal                4.57e-07 ***
## factor(ctylabel)SierraLeone            1.55e-07 ***
## factor(ctylabel)Singapore              1.25e-06 ***
## factor(ctylabel)Slovenia               2.54e-07 ***
## factor(ctylabel)SouthAfrica            3.08e-07 ***
## factor(ctylabel)SriLanka               9.00e-08 ***
## factor(ctylabel)Swaziland              5.64e-07 ***
## factor(ctylabel)Syria                  7.18e-07 ***
## factor(ctylabel)Tanzania               1.51e-07 ***
## factor(ctylabel)Thailand               4.83e-08 ***
## factor(ctylabel)Togo                   3.27e-07 ***
## factor(ctylabel)Trinidad&Tobago        1.54e-07 ***
## factor(ctylabel)Tunisia                1.40e-07 ***
## factor(ctylabel)Turkey                 1.30e-07 ***
## factor(ctylabel)Uganda                 3.61e-07 ***
## factor(ctylabel)Ukraine                3.05e-07 ***
## factor(ctylabel)Uruguay                7.82e-08 ***
## factor(ctylabel)Venezuela              1.05e-07 ***
## factor(ctylabel)Zambia                 1.60e-07 ***
## factor(ctylabel)Zimbabwe               3.77e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.626 on 589 degrees of freedom
##   (4676 observations deleted due to missingness)
## Multiple R-squared:  0.9331, Adjusted R-squared:  0.9212
## F-statistic: 78.24 on 105 and 589 DF,  p-value: < 2.2e-16
```

Bonferonni p-value for most extreme observations.

Car package.

install.packages("car")

```
library(car)
outlierTest(main)
```

```
##       rstudent unadjusted p-value Bonferonni p
```

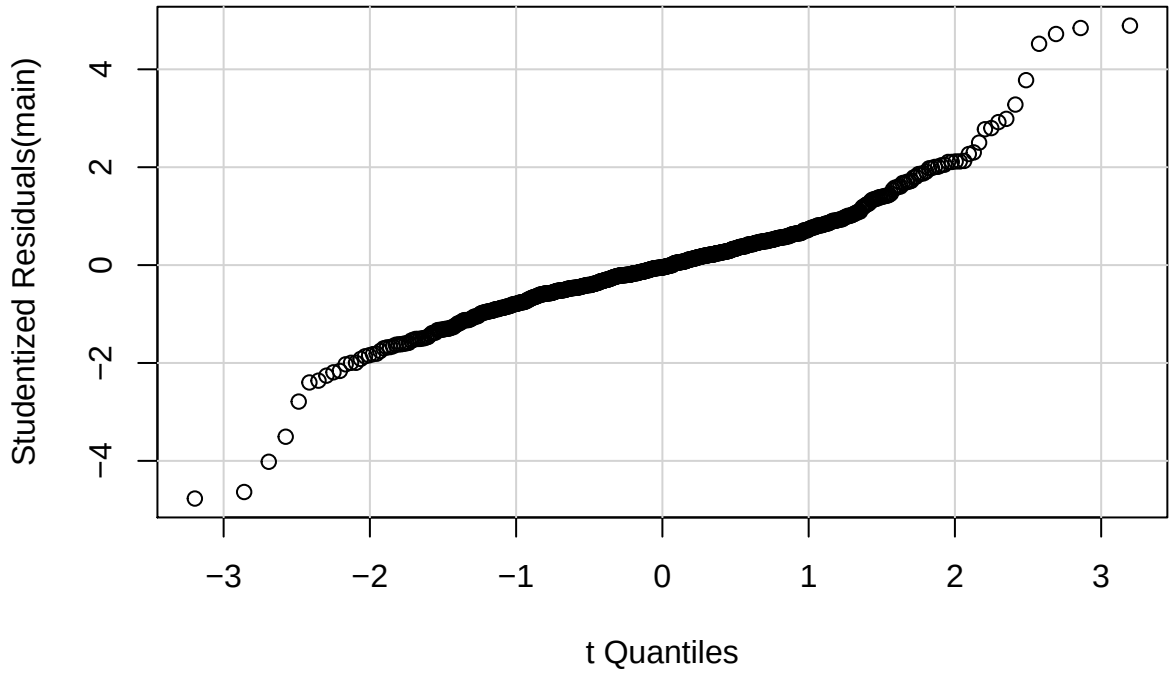
```
## 2057  4.892424         1.2876e-06   0.00087946
## 2058  4.844044         1.6292e-06   0.00111270
## 1859 -4.769636         2.3303e-06   0.00159160
## 1849  4.721338         2.9323e-06   0.00200280
## 1858 -4.636186         4.3757e-06   0.00298860
## 225   4.521444         7.4306e-06   0.00507510
## 1857 -4.018578         6.6158e-05   0.04518600
```

QQ Plot

```
qqPlot(main)
```

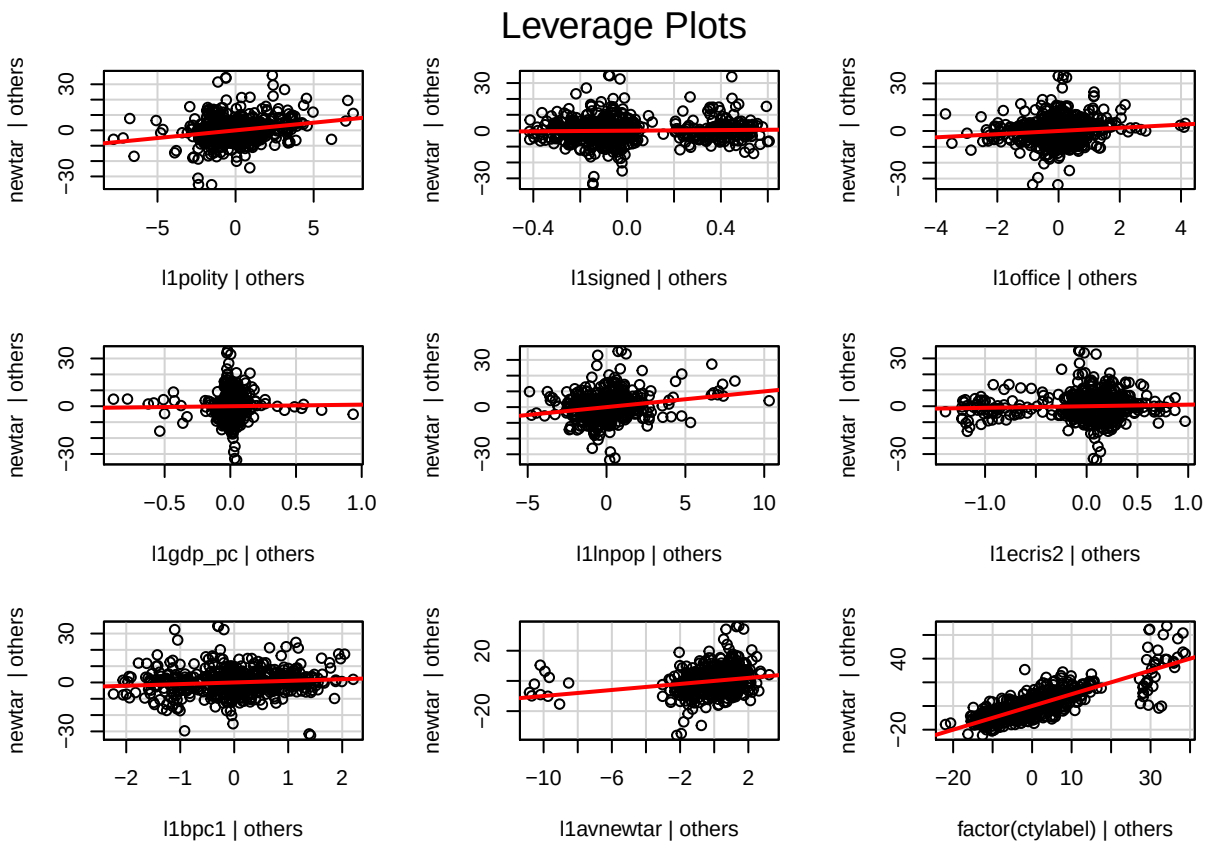
```
## Warning in matrix(yhat, n, reps): data length [694] is not a sub-multiple
## or multiple of the number of rows [683]
```

```
## Error in model.frame.default(formula = Y ~ X - 1, drop.unused.levels = TRUE): variable lengths diffe
```



Leverage Plots

```
leveragePlots(main)
```



Non-constance error variance test

```
ncvTest(main)
```

```
## Non-constant Variance Score Test
## Variance formula: ~ fitted.values
## Chisquare = 386.6928    Df = 1     p = 4.343731e-86
```

2. Robustness of regressions

Robust linear regression is a tool that discounts the influence of outliers. If you have outliers in your data, then they will not have as strong an influence in robust linear regression as in regular linear regression.

```
library(MASS)
robust1=rlm(newtar ~ l1polity + l1signed + l1office + l1gdp_pc + l1lnpop + l1ecris2 + l1bpc1 + l1avnewta
```

```
## Error in rlm.default(x, y, weights, method = method, wt.method = wt.method, : 'x' is singular: singul
```

```
summary(robust)
```

```
## Error in summary(robust): object 'robust' not found
```

Bootstrapping is an important robustness check. It relies on a very simple trick.

We need a new package.

install.packages("boot")

```
library(boot)
```

```
##
## Attaching package: 'boot'
##
## The following object is masked from 'package:car':
##
##     logit
```

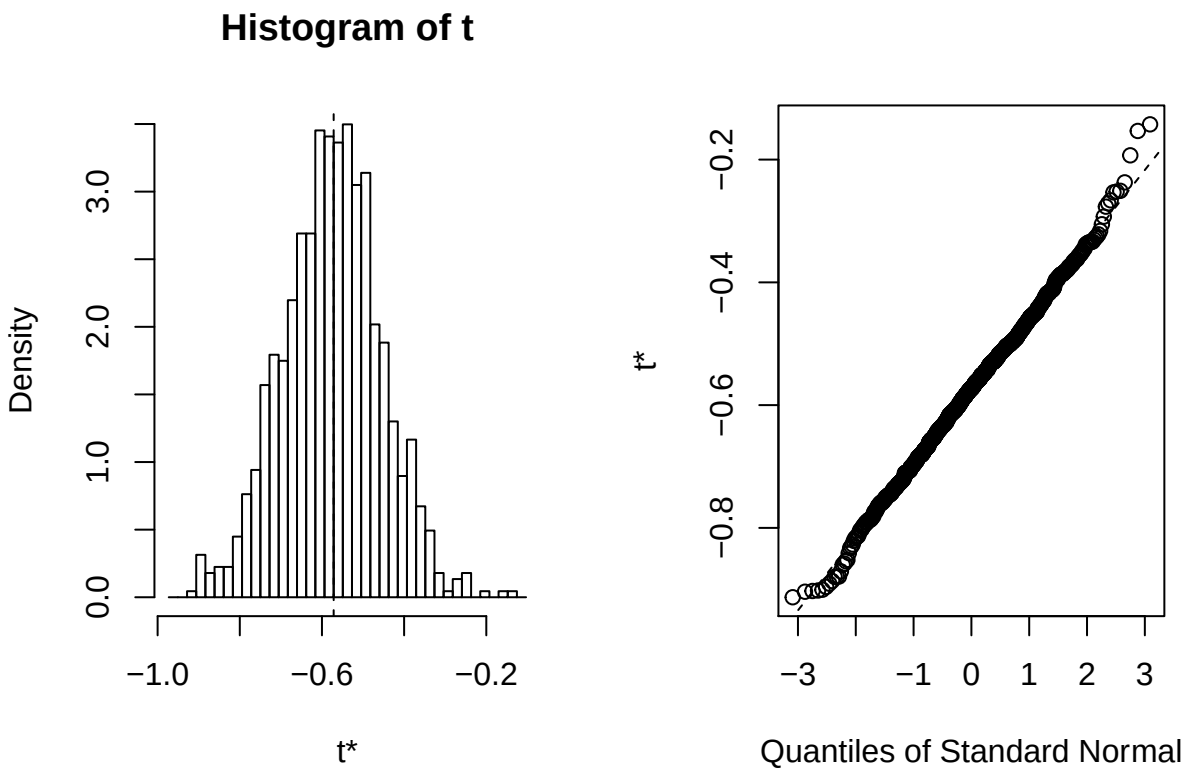
```
# you have to write a function that gets out the statistic(s) of interest
boot.function<-function(formula, data, indices){
    d<-data[indices,] # allows boot to select a sample
    fit <-lm(formula, data=d)
    return(coef(fit))
}

#bootstrapping with 1000 reps
results<-boot(data=LDC, statistic=boot.function, R=1000, formula=main)

# check it out
results
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = LDC, statistic = boot.function, R = 1000, formula = main)
##
##
## Bootstrap Statistics :
##            original        bias     std. error
## t1*   -5.715319e-01 -0.0041623338 1.195621e-01
## t2*    6.267285e-01 -0.0060837284 7.483875e-01
## t3*   -2.010179e-01 -0.0027490150 6.081068e-02
## t4*   -1.476089e-04  0.0000493595 3.480943e-04
## t5*   -1.741015e+01 -0.1418896922 4.161003e+00
## t6*   -1.391332e+00 -0.0853248067 1.033428e+00
## t7*    2.283300e+00 -0.0306382379 1.000413e+00
## t8*    3.739093e-01  0.0222676897 9.151754e-02
## t9*    2.723362e+02 -2.9268398142 6.375626e+01
## t10*   3.100446e+02  1.6539713687 7.265110e+01
## t11*   3.167551e+02  1.5560899161 7.286316e+01
## t12*   2.206629e+02  0.7134569102 5.596118e+01
## t13*   3.782232e+02  2.1271938650 7.852512e+01
## t14*   2.839697e+02  2.0895191861 6.854904e+01
## t15*   2.925936e+02  1.7283864185 6.495319e+01
## t16*   2.837792e+02  1.7968555025 6.618032e+01
```

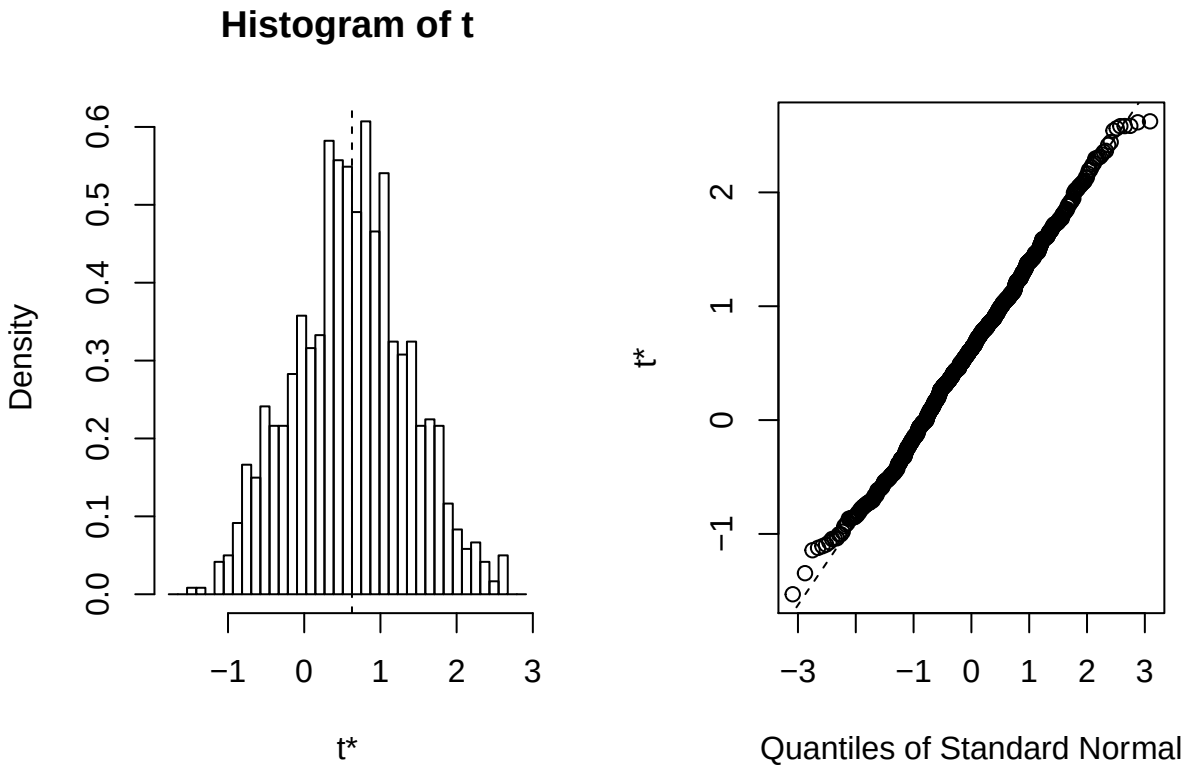
```
## t17*   2.694904e+02  1.5470445481 5.933698e+01
## t18*   3.542642e+02  1.9097560581 7.913252e+01
## t19*   2.924700e+02  2.6986460425 6.725017e+01
## t20*   2.909679e+02  2.4130982738 6.682196e+01
## t21*   3.094876e+02  4.0647525778 6.607842e+01
## t22*   2.962258e+02  2.0355853713 6.887700e+01
## t23*   2.733978e+02  2.2041046784 6.331302e+01
## t24*   2.829834e+02  0.2145345380 6.794502e+01
## t25*   2.954253e+02  1.7170511065 6.911968e+01
## t26*   3.852863e+02  2.5053285708 8.809551e+01
## t27*   3.219981e+02  1.9950817144 7.334742e+01
## t28*   2.695062e+02  1.9085433895 6.191052e+01
## t29*   2.715115e+02  1.5535672581 6.282998e+01
## t30*   2.958153e+02  1.7765519048 6.867060e+01
## t31*   2.459439e+02  3.8400221913 5.406674e+01
## t32*   2.892286e+02  1.9248673605 6.726714e+01
## t33*   2.985263e+02  1.7251376910 6.817807e+01
## t34*   3.361970e+02  1.9785021197 7.505641e+01
## t35*   2.790911e+02  1.6943680432 6.524547e+01
## t36*   2.469636e+02  0.8017056803 6.039915e+01
## t37*   3.226430e+02 -1.2543125135 7.430481e+01
## t38*   2.461828e+02  1.9833932861 5.726494e+01
## t39*   2.579171e+02  1.3197135479 5.902791e+01
## t40*   2.469898e+02  1.5343122614 5.922253e+01
## t41*   2.954109e+02  1.7625135389 6.978421e+01
## t42*   2.876902e+02  1.7187762066 6.760937e+01
## t43*   2.789949e+02  3.0439207428 6.680187e+01
## t44*   2.464358e+02  1.8559816575 5.700427e+01
## t45*   2.824929e+02  2.5789249431 6.555467e+01
## t46*   2.743367e+02  1.5237061077 6.492133e+01
## t47*   2.922602e+02  1.6672961940 6.823994e+01
## t48*   4.156098e+02  2.2057030135 8.693384e+01
## t49*   3.435490e+02  2.1605136538 8.022945e+01
## t50*   2.720238e+02  1.0187564188 6.462267e+01
## t51*   2.681176e+02  1.6119874990 6.187332e+01
## t52*   2.659293e+02  1.4401680075 6.281253e+01
## t53*   3.163085e+02  1.8487368577 7.147587e+01
## t54*   3.136829e+02  1.6193892384 7.404368e+01
## t55*   2.403583e+02  1.2821365103 6.178458e+01
## t56*   2.599025e+02  2.0799869085 6.195220e+01
## t57*   2.661825e+02  1.5983726435 6.075296e+01
## t58*   2.664380e+02  2.2136413313 6.382047e+01
## t59*   2.844186e+02  1.9382428840 6.911888e+01
## t60*   2.877834e+02  1.7260755844 6.729080e+01
## t61*   2.996286e+02  1.7263826410 7.053465e+01
## t62*   2.953977e+02  2.3788518125 6.752410e+01
## t63*   2.604432e+02  1.4051782044 6.123384e+01
## t64*   2.712178e+02  1.4348151510 5.848037e+01
## t65*   3.237832e+02  1.9321618381 7.679215e+01
## t66*   2.609103e+02  1.3141675165 6.107405e+01
## t67*   3.136302e+02  1.9050173869 7.220604e+01
## t68*   2.988974e+02  1.5453441844 6.983977e+01
## t69*   2.700519e+02  2.8215842758 6.061254e+01
## t70*   3.021847e+02  1.7733010741 7.063930e+01
```

```
## t71*   2.717609e+02  1.8146928654 6.427523e+01
## t72*   2.940612e+02  3.9762462159 6.922971e+01
## t73*   3.405713e+02  2.1721588525 7.759174e+01
## t74*   2.493555e+02  0.9232221146 6.157095e+01
## t75*   3.760545e+02  2.1818090856 7.779635e+01
## t76*   2.662004e+02  1.2047533707 6.258167e+01
## t77*   2.805286e+02  2.0994989135 6.510093e+01
## t78*   2.720685e+02  1.7746084516 6.432454e+01
## t79*   3.165682e+02  1.7632932604 7.116196e+01
## t80*   3.300178e+02  1.8962869373 7.560495e+01
## t81*   3.130321e+02  1.9289866605 7.343511e+01
## t82*   3.029500e+02  1.8117934112 7.162377e+01
## t83*   3.352986e+02  1.5726484305 7.884027e+01
## t84*   2.994572e+02  2.6632386519 6.714841e+01
## t85*   2.834781e+02  1.5387977061 6.995448e+01
## t86*   2.781176e+02  1.7635691232 6.680464e+01
## t87*   2.796897e+02  1.5345498725 6.442244e+01
## t88*   2.563542e+02  0.7439664040 6.356742e+01
## t89*   2.625040e+02  2.3755188328 6.310079e+01
## t90*   3.096157e+02  1.8065401359 7.318472e+01
## t91*   3.100614e+02  1.8664228416 7.011966e+01
## t92*   2.435134e+02  1.3845838663 5.830985e+01
## t93*   2.810147e+02  2.0368353133 6.937726e+01
## t94*   3.143911e+02  2.0759563449 7.229392e+01
## t95*   3.391473e+02  1.9861834793 7.506648e+01
## t96*   2.718198e+02  1.7139467452 6.442593e+01
## t97*   2.562632e+02  1.2931290717 5.905048e+01
## t98*   2.922568e+02  1.7117170802 6.715911e+01
## t99*   3.271659e+02  1.9037056145 7.496908e+01
## t100*  2.970655e+02  2.1227093436 7.081482e+01
## t101*  3.153697e+02  2.1897895342 7.500398e+01
## t102*  2.802118e+02  1.4600526304 6.308562e+01
## t103*  3.105764e+02  1.7878289864 7.064952e+01
## t104*  2.911504e+02  1.7902478074 6.706689e+01
## t105*  2.858628e+02  1.7850504601 6.825723e+01
```

```
plot(results, index=1)
```




```
plot(results, index=2)
```




```
# 95% intervals
boot.ci(results, conf=0.95, type="norm", index=1) #intercept
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 1000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = results, conf = 0.95, type = "norm", index = 1)
##
## Intervals :
## Level      Normal
## 95%   (-0.8017, -0.3330 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(results, type="norm", index=2) #l1polity
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 1000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = results, type = "norm", index = 2)
##
## Intervals :
## Level      Normal
## 95%   (-0.8340,  2.0996 )
## Calculations and Intervals on Original Scale
```

3. Functional form specifications

4. Imputation of missing data

We often deal with missing data for some observations. Imputation allows us to make statistical inferences about the missing data values. Our guesses are based on the data that we have. For the imputation of missing data, we will use a package by Gary King called "Amelia".

install.packages("Amelia")

```
library(Amelia)
```

```
## Loading required package: Rcpp
## ##
## ## Amelia II: Multiple Imputation
## ## (Version 1.7.3, built: 2014-11-14)
## ## Copyright (C) 2005-2015 James Honaker, Gary King and Matthew Blackwell
## ## Refer to http://gking.harvard.edu/amelia/ for more information
## ##
```

We will demonstrate the imputation of missing data using our LDC dataset.

5. The most useful R packages for applied work

The following are some of the most useful packages for applied work. I recommend to get the related text books and download the documentations of these packages. These packages have many useful commands that can help you to deal with data management and data analysis.

1. car — Companion to Applied Regression

Associated with Fox & Weisberg's book "Companion to Applied Regression"

Most useful for regression diagnostics as demonstrated in this tutorial.

2. arm — Analysis of Regression and Multilevel Models

Associated with Gelman & Hill's book on "Regression and Multilevel/Hierarchical Models"

Most useful for simulations of regressions and plotting. (More in tutorial 13)

3. Zelig — by political science professor Gary King, see: http://zeligproject.org/

Has many different regression tools included

4. ggplot2 — introduced extensively in Chang's "R Graphics Cookbook"

Allows to produce nicer graphics for visual presentation

5. stargazer — by Marek Hlavac

Allows to easily generate LaTeX code of regression tables

6. reshape – by Hadley Wickham, see: http://had.co.nz/reshape/

Allows to reformat data