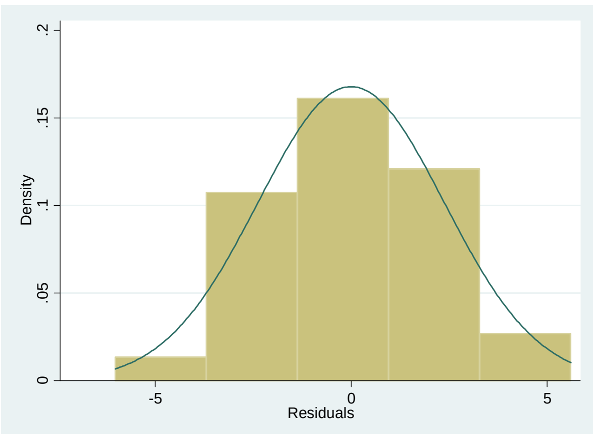
<u>Primer 1:</u> V vzorec smo izbrali 32 evropskih držav in za leto 2003 pridobili naslednje podatke (datoteka `zdravstvo.dta`):

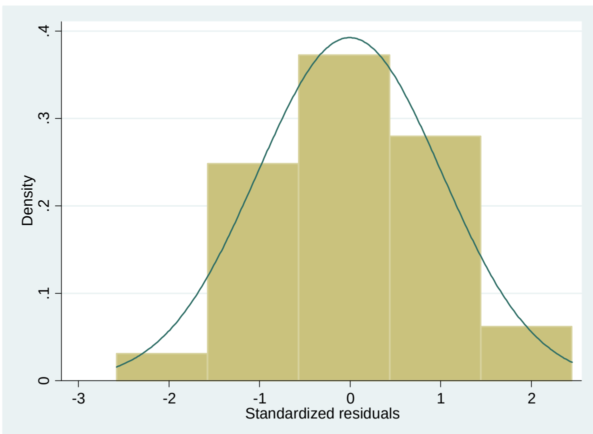
- pričakovana življenjska doba (*PZD*; v letih);
- izdatki za zdravstvo na prebivalca (*IZDATKI*; v ameriških dolarjih);
- odstotek kadilcev med odraslimi prebivalci (*TOBAK*);
- poraba čistega alkohola na prebivalca (*ALKO*; v litrih – upoštevane žgane pijače).

a) Ocenite linearni regresijski model: $PZD_i = \beta_1 + \beta_2 IZDATKI_i + \beta_3 TOBAK_i + u_i$ in preverite predpostavko, da se slučajna spremenljivka u porazdeljuje normalno.

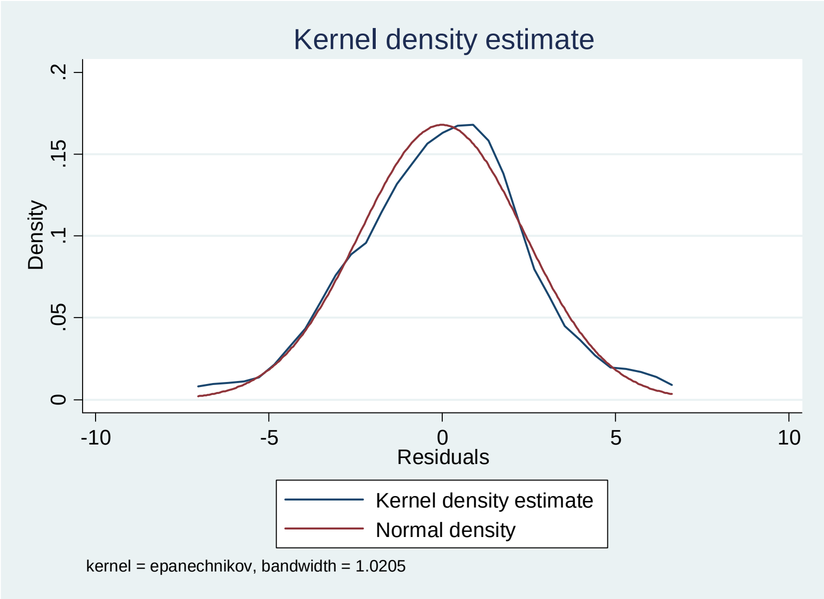
Izpis rezultatov obdelav v programskem paketu Stata:

```
. regress pzd izdatki tobak

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  2,    29) =   31.97
       Model |  385.751827     2  192.875914           Prob > F      =  0.0000
    Residual |   174.97295    29  6.03354999           R-squared     =  0.6880
-------------+------------------------------           Adj R-squared =  0.6664
       Total |  560.724777    31   18.087896           Root MSE      =  2.4563

------------------------------------------------------------------------------
         pzd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |   .0023323   .0003709     6.29   0.000     .0015736    .0030909
       tobak |  -.2503555   .0889983    -2.81   0.009    -.4323774   -.0683335
       _cons |   79.62409   2.796632    28.47   0.000     73.90433    85.34384
------------------------------------------------------------------------------

. predict epzd, resid

. predict epzdstd, rstandard

. histogram epzd, normal
(bin=5, start=-6.0237689, width=2.3258684)

. histogram epzdstd, normal
(bin=5, start=-2.5803783, width=1.0055467)
```





```
. kdensity epzd, normal
(n() set to 32)
```




```
. swilk epzd

                   Shapiro-Wilk W test for normal data

    Variable |    Obs       W           V         z       Prob>z
-------------+--------------------------------------------------
        epzd |     32    0.98011      0.663    -0.852    0.80279

. sktest epzd

                    Skewness/Kurtosis tests for Normality
                                                     ------- joint ------
    Variable |    Obs   Pr(Skewness)   Pr(Kurtosis)  adj chi2(2)    Prob>chi2
-------------+---------------------------------------------------------------
        epzd |     32      0.8230         0.3139        1.13         0.5680

. sum epzd, detail

                          Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -6.023769      -6.023769
 5%    -3.561575      -3.561575
10%    -2.820123      -2.855744       Obs                  32
25%    -1.700531      -2.820123       Sum of Wgt.          32

50%     .2013203                      Mean           1.28e-08
                        Largest       Std. Dev.      2.375771
75%     1.358591        2.43306
90%      2.43306       2.645627       Variance       5.644289
95%     4.427194       4.427194       Skewness      -.0833723
99%     5.605573       5.605573       Kurtosis       3.410826

. return list

scalars:
                  r(N) =  32
              r(sum_w) =  32
               r(mean) =  1.28056854010e-08
```

```
              r(Var) =  5.644288676812403
               r(sd) =  2.37577117517921
         r(skewness) =  -.0833723127091076
         r(kurtosis) =  3.410825630496252

                        ...

. scalar opaz=r(N)
. scalar s=r(skewness)
. scalar k=r(kurtosis)

. scalar jb=opaz*(s^2/6 + (k-3)^2/24)
. display jb
.26210863

. display chi2tail(2,jb)
.87717013

. jb6 epzd
Jarque-Bera normality test:  .2621 Chi(2)  .8772
Jarque-Bera test for Ho: normality: (epzd)
```

■

b) Ocenite linearni regresijski model: $PZD_i = \beta_1 + \beta_2 IZDATKI_i + \beta_3 TOBAK_i + \beta_4 ALKO_i + u_i$ in analizirajte morebitno prisotnost multikolinearnosti.

Izpis rezultatov obdelav v programskem paketu Stata:

```
. regress pzd izdatki tobak alko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  3,    28) =   26.30
       Model |  413.850212     3  137.950071           Prob > F      =  0.0000
    Residual |  146.874565    28  5.24552017           R-squared     =  0.7381
-------------+------------------------------           Adj R-squared =  0.7100
       Total |  560.724777    31   18.087896           Root MSE      =  2.2903

------------------------------------------------------------------------------
         pzd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |   .0018569   .0004023     4.62   0.000     .0010329    .0026809
       tobak |  -.2238391   .0837702    -2.67   0.012    -.3954346   -.0522436
        alko |  -.6493606   .2805689    -2.31   0.028     -1.22408   -.0746412
       _cons |   81.42053   2.720683    29.93   0.000     75.84746    86.99359
------------------------------------------------------------------------------

. pwcorr izdatki tobak alko, sig

             |  izdatki    tobak     alko
-------------+---------------------------
     izdatki |   1.0000
             |
             |
       tobak |  -0.3017   1.0000
             |   0.0933
             |
        alko |  -0.5510   0.2751   1.0000
             |   0.0011   0.1276
```

```
. regress izdatki tobak alko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  2,    29) =    7.08
       Model |    15822811     2  7911405.51           Prob > F      =  0.0031
    Residual |    32415407    29  1117772.65           R-squared     =  0.3280
-------------+------------------------------           Adj R-squared =  0.2817
       Total |    48238218    31  1556071.55           Root MSE      =  1057.2

------------------------------------------------------------------------------
     izdatki |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       tobak |  -38.96759   37.98675    -1.03   0.313    -116.6592    38.72404
        alko |  -356.1345   111.3588    -3.20   0.003    -583.8887   -128.3802
       _cons |   3602.096    1062.97     3.39   0.002     1428.078    5776.114
------------------------------------------------------------------------------

. scalar R2izdatki=e(r2)
. scalar Fizdatki=(R2izdatki/(4-2))/((1-R2izdatki)/(32-4+1))
. scalar pFizdatki=Ftail(4-2,32-4+1,Fizdatki)
. scalar vifizdatki=1/(1-R2izdatki)
. scalar toleranceizdatki=1/vifizdatki

. display Fizdatki, pFizdatki, vifizdatki, toleranceizdatki
7.0778306 .00313851 1.4881262 .671986


. regress tobak izdatki alko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  2,    29) =    1.76
       Model |  90.5229799     2    45.26149           Prob > F      =  0.1906
    Residual |  747.496685    29  25.7757477           R-squared     =  0.1080
-------------+------------------------------           Adj R-squared =  0.0465
       Total |  838.019664    31  27.0328924           Root MSE      =   5.077

------------------------------------------------------------------------------
       tobak |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |  -.0008986    .000876    -1.03   0.313    -.0026902     .000893
        alko |    .458065   .6160993     0.74   0.463    -.8019995    1.718129
       _cons |   28.65308   2.839478    10.09   0.000     22.84569    34.46046
------------------------------------------------------------------------------

. scalar R2tobak=e(r2)
. scalar Ftobak=(R2tobak/(4-2))/((1-R2tobak)/(32-4+1))
. scalar pFtobak=Ftail(4-2,32-4+1,Ftobak)
. scalar viftobak=1/(1-R2tobak)
. scalar tolerancetobak=1/viftobak

. display Ftobak, pFtobak, viftobak, tolerancetobak
1.7559719 .19061119 1.1211015 .89197989


. regress alko izdatki tobak

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  2,    29) =    6.72
       Model |  30.8785495     2  15.4392748           Prob > F      =  0.0040
    Residual |  66.6360968    29  2.29779644           R-squared     =  0.3167
-------------+------------------------------           Adj R-squared =  0.2695
       Total |  97.5146463    31  3.14563375           Root MSE      =  1.5158
```

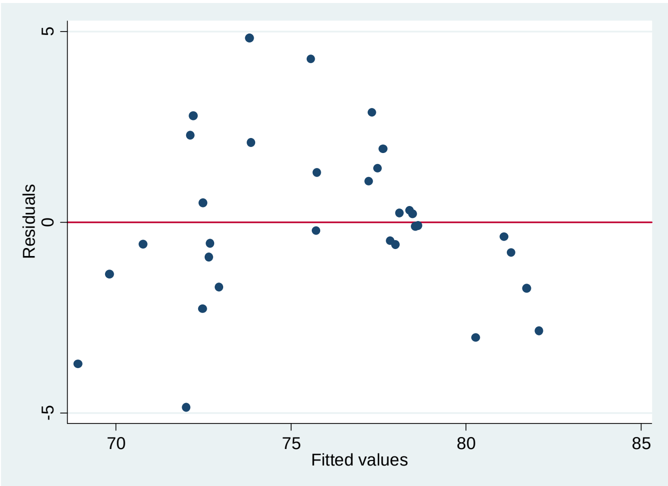
```
------------------------------------------------------------------------------
        alko |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |  -.0007321   .0002289    -3.20   0.003    -.0012003   -.0002639
       tobak |   .0408345   .0549226     0.74   0.463    -.0714948    .1531638
       _cons |   2.766477   1.725856     1.60   0.120    -.7632956     6.29625
------------------------------------------------------------------------------

. scalar R2alko=e(r2)
. scalar Falko=(R2alko/(4-2))/((1-R2alko)/(32-4+1))
. scalar pFalko=Ftail(4-2,32-4+1,Falko)
. scalar vifalko=1/(1-R2alko)
. scalar tolerancealko=1/vifalko

. display Falko, pFalko, vifalko, tolerancealko
6.7191656 .00400199 1.4633907 .6833445


. qui regress pzd izdatki tobak alko
. estat vif

    Variable |       VIF       1/VIF  
-------------+----------------------
     izdatki |      1.49    0.671986
        alko |      1.46    0.683345
       tobak |      1.12    0.891980
-------------+----------------------
    Mean VIF |      1.36


. collin izdatki tobak alko, corr rinv
(obs=32)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
   izdatki      1.49    1.22     0.6720      0.3280
     tobak      1.12    1.06     0.8920      0.1080
      alko      1.46    1.21     0.6833      0.3167
----------------------------------------------------
  Mean VIF      1.36

                           Cond
        Eigenval          Index
---------------------------------
    1     1.7677          1.0000
    2     0.7842          1.5014
    3     0.4481          1.9862
---------------------------------
 Condition Number         1.9862 
 Eigenvalues & Cond Index computed from deviation sscp (no intercept)
 Det(correlation matrix)    0.6211

Inverse of correlation matrix

             izdatki       tobak        alko
izdatki    1.4881262
  tobak    .24169899   1.1211015
   alko    .75351706  -.17517811   1.4633907
```

■

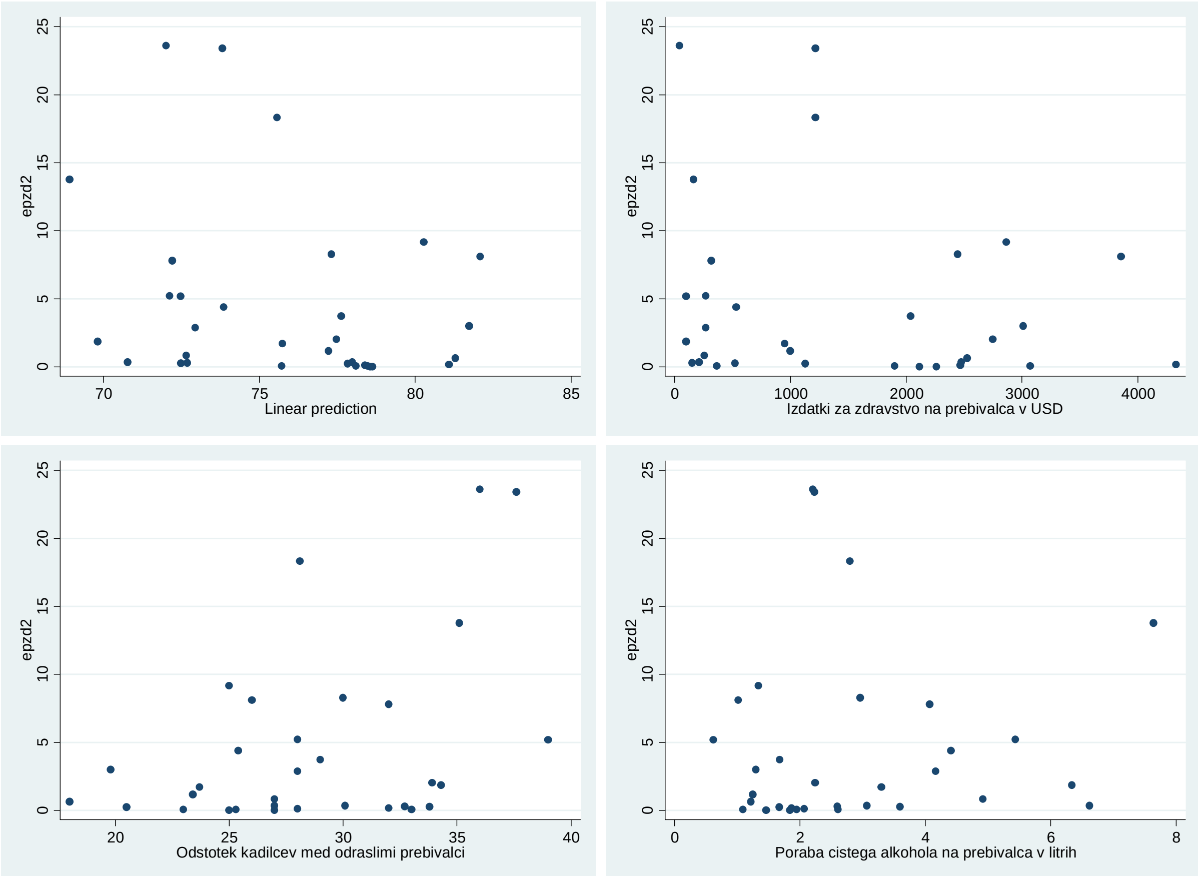
c) Ocenite linearni regresijski model: $PZD_i = \beta_1 + \beta_2 IZDATKI_i + \beta_3 TOBAK_i + \beta_4 ALKO_i + u_i$ in analizirajte morebitno prisotnost heteroskedastičnosti.

Izpis rezultatov obdelav v programskem paketu Stata:

```
. regress pzd izdatki tobak alko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  3,    28) =   26.30
       Model |  413.850212     3  137.950071           Prob > F      =  0.0000
    Residual |  146.874565    28  5.24552017           R-squared     =  0.7381
-------------+------------------------------           Adj R-squared =  0.7100
       Total |  560.724777    31   18.087896           Root MSE      =  2.2903

------------------------------------------------------------------------------
         pzd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |   .0018569   .0004023     4.62   0.000     .0010329    .0026809
       tobak |  -.2238391   .0837702    -2.67   0.012    -.3954346   -.0522436
        alko |  -.6493606   .2805689    -2.31   0.028     -1.22408   -.0746412
       _cons |   81.42053   2.720683    29.93   0.000     75.84746    86.99359
------------------------------------------------------------------------------

. predict epzd, resid
. gen epzd2=epzd^2
. predict pzdfit, xb

. scatter epzd pzdfit, yline(0) // Graficna metoda //
. rvfplot, yline(0)
```




```
. scatter epzd2 pzdfit

. scatter epzd2 izdatki
. scatter epzd2 tobak
. scatter epzd2 alko
```




```
. gen lepzd2=log(epzd2) // Parkov test //
. gen ltobak=log(tobak)

. regress lepzd2 ltobak

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  1,    30) =    2.41
       Model |  11.4621035     1  11.4621035           Prob > F      =  0.1310
    Residual |  142.658707    30  4.75529025           R-squared     =  0.0744
-------------+------------------------------           Adj R-squared =  0.0435
       Total |  154.120811    31  4.97163906           Root MSE      =  2.1807

------------------------------------------------------------------------------
      lepzd2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      ltobak |   3.247315    2.09161     1.55   0.131    -1.024323    7.518952
       _cons |  -10.80284   6.993418    -1.54   0.133     -25.0853    3.479628
------------------------------------------------------------------------------

. matrix b=e(b)
. scalar gama=b[1,1]
. display gama
3.2473145

. gen td=tobak^(gama/2)

. gen pzdt=pzd/td
. gen izdatkit=izdatki/td
. gen tobakt=tobak/td
. gen alkot=alko/td
. gen kt=1/td
```

```
. regress pzdt izdatkit tobakt alkot kt, nocons

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  4,    28) =14429.77
       Model |  4.51785874     4  1.12946469           Prob > F      =  0.0000
    Residual |   .00219165    28  .000078273           R-squared     =  0.9995
-------------+------------------------------           Adj R-squared =  0.9994
       Total |  4.52005039    32  .141251575           Root MSE      =  .00885

------------------------------------------------------------------------------
        pzdt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    izdatkit |   .0014821   .0003596     4.12   0.000     .0007454    .0022188
      tobakt |   -.188303   .0731545    -2.57   0.016    -.3381531   -.0384529
       alkot |   -.645842   .2847907    -2.27   0.031    -1.229209   -.0624747
          kt |   81.00636   2.023667    40.03   0.000     76.86107    85.15165
------------------------------------------------------------------------------

. gen pzdtfit=_b[izdatkit]*izdatki+_b[tobakt]*tobak+_b[alkot]*alko+_b[kt]

. correlate pzd pzdtfit
(obs=32)

             |      pzd  pzdtfit
-------------+------------------
         pzd |   1.0000
     pzdtfit |   0.8582   1.0000

. scalar r2p=r(rho)^2
. display r2p
.73655337


. gen epzdabs=abs(epzd) // Glejserjev test, tip 1 //

. regress epzdabs tobak

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  1,    30) =    5.37
       Model |  9.27158784     1  9.27158784           Prob > F      =  0.0275
    Residual |  51.8361261    30  1.72787087           R-squared     =  0.1517
-------------+------------------------------           Adj R-squared =  0.1234
       Total |   61.107714    31  1.97121658           Root MSE      =  1.3145

------------------------------------------------------------------------------
     epzdabs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       tobak |   .1051841   .0454076     2.32   0.028     .0124494    .1979188
       _cons |  -1.376059   1.321378    -1.04   0.306    -4.074673    1.322555
------------------------------------------------------------------------------

. drop td pzdt izdatkit tobakt alkot kt

. gen td=tobak

. gen pzdt=pzd/td
. gen izdatkit=izdatki/td
. gen tobakt=tobak/td
. gen alkot=alko/td
. gen kt=1/td
```

```
. regress pzdt izdatkit tobakt alkot kt, nocons

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  4,    28) =11573.99
       Model |  254.693933     4  63.6734833           Prob > F      =  0.0000
    Residual |  .154040031    28   .00550143           R-squared     =  0.9994
-------------+------------------------------           Adj R-squared =  0.9993
       Total |  254.847973    32  7.96399916           Root MSE      =  .07417

------------------------------------------------------------------------------
        pzdt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    izdatkit |     .00162   .0003794     4.27   0.000     .0008429    .0023972
      tobakt |  -.2004833   .0766647    -2.62   0.014    -.3575239   -.0434427
       alkot |   -.645394   .2851847    -2.26   0.032    -1.229568   -.0612197
          kt |    81.1065   2.257711    35.92   0.000     76.48178    85.73121
------------------------------------------------------------------------------

. gen pzdtfit=_b[izdatkit]*izdatki+_b[tobakt]*tobak+_b[alkot]*alko+_b[kt]

. correlate pzd pzdtfit
(obs=32)

             |      pzd  pzdtfit
-------------+------------------
         pzd |   1.0000
     pzdtfit |   0.8588   1.0000

. scalar r2p=r(rho)^2
. display r2p
.73754759


. sort tobak // Goldfeld-Quandtov test //

. regress pzd izdatki tobak alko if _n<12

      Source |       SS       df       MS              Number of obs =      11
-------------+------------------------------           F(  3,     7) =   10.95
       Model |  20.2529385     3  6.75097949           Prob > F      =  0.0049
    Residual |  4.31434095     7  .616334421           R-squared     =  0.8244
-------------+------------------------------           Adj R-squared =  0.7491
       Total |  24.5672794    10  2.45672794           Root MSE      =  .78507

------------------------------------------------------------------------------
         pzd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |   .0009321   .0002513     3.71   0.008     .0003378    .0015264
       tobak |  -.3057149   .0968223    -3.16   0.016    -.5346631   -.0767666
        alko |  -.0050445   .2681035    -0.02   0.986    -.6390085    .6289195
       _cons |   83.37934    2.32514    35.86   0.000     77.88126    88.87742
------------------------------------------------------------------------------

. regress pzd izdatki tobak alko if _n>21

      Source |       SS       df       MS              Number of obs =      11
-------------+------------------------------           F(  3,     7) =    7.38
       Model |  216.141738     3  72.0472461           Prob > F      =  0.0143
    Residual |  68.3337503     7  9.76196433           R-squared     =  0.7598
-------------+------------------------------           Adj R-squared =  0.6568
       Total |  284.475489    10  28.4475489           Root MSE      =  3.1244
```

```
------------------------------------------------------------------------------
         pzd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    izdatki |   .0021626    .000849     2.55   0.038     .0001551    .0041701
       tobak |  -.4032599   .5313328    -0.76   0.473    -1.659662    .8531426
        alko |   -.897014   .5719266    -1.57   0.161    -2.249405    .4553774
       _cons |   87.74734   19.80264     4.43   0.003     40.92154    134.5731
------------------------------------------------------------------------------

. display invFtail(11-4,11-4,0.05)
3.7870435

. display Ftail(11-4,11-4,15.84)
.00084464


. sum epzd2 // Breusch-Paganov test //

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
       epzd2 |        32     4.58983    6.604705   .0065448   23.59118

. regress epzd2 izdatki tobak alko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  3,    28) =    2.23
       Model |  260.467412     3  86.8224706           Prob > F      =  0.1071
    Residual |  1091.81868    28  38.9935243           R-squared     =  0.1926
-------------+------------------------------           Adj R-squared =  0.1061
       Total |  1352.28609    31   43.622132           Root MSE      =  6.2445

------------------------------------------------------------------------------
       epzd2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |  -.0006253   .0010968    -0.57   0.573    -.0028719    .0016214
       tobak |   .5341499   .2283976     2.34   0.027     .0662985    1.002001
        alko |   -.421685   .7649648    -0.55   0.586    -1.988644    1.145274
       _cons |  -8.587893    7.41788    -1.16   0.257    -23.78273    6.606947
------------------------------------------------------------------------------

. display invchi2tail(3,0.05)
7.8147279

. display chi2tail(3,6.1816)
.10310161

. qui regress pzd izdatki tobak alko
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of pzd

         chi2(1)      =     2.38
         Prob > chi2  =   0.1228

. estat hettest izdatki tobak alko

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: izdatki tobak alko

         chi2(3)      =     6.18
         Prob > chi2  =   0.1031
```

```
. drop td pzdt izdatkit tobakt alkot kt

. qui regress epzd2 izdatki tobak alko
. predict sigma2fit, xb // Ali imamo negativne vrednosti? //

. inspect sigma2fit

sigma2fit:  Linear prediction                   Number of Observations
-----------------------------                ------------------------------
                                             Total   Integers   Nonintegers
|      #                     Negative            2          -             2
|      #                     Zero                -          -             -
|      #   #                 Positive           30          -            30
|      #   #                                 -----      -----         -----
|  #   #   #   #             Total              32          -            32
|  #   #   #   #   #         Missing             -
+----------------------                      -----
-1.067699      11.91998                         32
  (32 unique values)

. gen lepzd2=log(epzd2)

. qui regress lepzd2 izdatki tobak alko
. predict lsigma2fit, xb

. gen td=sqrt(exp(lsigma2fit)) // Drugace bi imeli: td=sqrt(sigma2fit) //

. gen pzdt=pzd/td
. gen izdatkit=izdatki/td
. gen tobakt=tobak/td
. gen alkot=alko/td
. gen kt=1/td

. regress pzdt izdatkit tobakt alkot kt, nocons

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  4,    28) =16321.53
       Model |   244957.55     4  61239.3874           Prob > F      =  0.0000
    Residual |  105.057752    28  3.75206259           R-squared     =  0.9996
-------------+------------------------------           Adj R-squared =  0.9995
       Total |  245062.607    32  7658.20648           Root MSE      =   1.937

------------------------------------------------------------------------------
        pzdt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    izdatkit |   .0014166   .0003208     4.42   0.000     .0007594    .0020738
      tobakt |  -.1645484   .0679864    -2.42   0.022    -.3038122   -.0252847
       alkot |  -.5066243   .3168255    -1.60   0.121    -1.155612    .1423633
          kt |   80.22607   1.850711    43.35   0.000     76.43506    84.01707
------------------------------------------------------------------------------

. gen pzdtfit=_b[izdatkit]*izdatki+_b[tobakt]*tobak+_b[alkot]*alko+_b[kt]

. correlate pzd pzdtfit
(obs=32)

             |      pzd  pzdtfit
-------------+------------------
         pzd |   1.0000
     pzdtfit |   0.8590   1.0000

. scalar r2p=r(rho)^2
. display r2p
.7379611
```

```
. gen izdatki2=izdatki^2 // Whiteov test //
. gen tobak2=tobak^2
. gen alko2=alko^2

. gen izdatkitobak=izdatki*tobak
. gen izdatkialko=izdatki*alko
. gen tobakalko=tobak*alko

. regress epzd2 izdatki tobak alko izdatki2 tobak2 alko2 izdatkitobak
  izdatkialko tobakalko

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  9,    22) =    1.04
       Model |  402.532362     9  44.7258179           Prob > F      =  0.4438
    Residual |  949.753731    22  43.1706241           R-squared     =  0.2977
-------------+------------------------------           Adj R-squared =  0.0104
       Total |  1352.28609    31   43.622132           Root MSE      =  6.5704

------------------------------------------------------------------------------
       epzd2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     izdatki |   .0114336   .0095815     1.19   0.245    -.0084373    .0313044
       tobak |  -.3025298   3.262414    -0.09   0.927    -7.068361    6.463302
        alko |   1.533835   6.999168     0.22   0.829    -12.98155    16.04922
    izdatki2 |  -8.67e-07   1.14e-06    -0.76   0.454    -3.22e-06    1.49e-06
      tobak2 |    .020024   .0528495     0.38   0.708    -.0895791     .129627
       alko2 |   -.423106   .5022296    -0.84   0.409    -1.464666    .6184544
izdatkitobak |  -.0002152   .0002898    -0.74   0.466    -.0008163    .0003859
 izdatkialko |  -.0011785   .0017937    -0.66   0.518    -.0048985    .0025415
   tobakalko |   .0669286   .2121938     0.32   0.755    -.3731345    .5069917
       _cons |  -10.39574    49.6634    -0.21   0.836    -113.3913    92.59986
------------------------------------------------------------------------------

. scalar theta=e(N)*e(r2)
. display theta, invchi2tail(e(rank)-1,0.05), chi2tail(e(rank)-1,theta)
9.5253775 16.918978 .39025498

. qui regress pzd izdatki tobak alko
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(9)      =      9.53
         Prob > chi2  =    0.3903

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |       9.53      9    0.3903
            Skewness |       0.64      3    0.8880
            Kurtosis |       0.00      1    0.9908
---------------------+-----------------------------
               Total |      10.16     13    0.6806
---------------------------------------------------

. drop td pzdt izdatkit tobakt alkot kt pzdtfit

. qui regress epzd2 izdatki tobak alko izdatki2 tobak2 alko2 izdatkitobak
  izdatkialko tobakalko

. predict sigma2fit, xb
```

```
. inspect sigma2fit

sigma2fit:  Linear prediction                  Number of Observations
----------------------------               ------------------------------
                                            Total   Integers   Nonintegers
|      #                    Negative            2         -            2
|      #                    Zero                -         -            -
|      #                    Positive           30         -           30
|  #   #                                    -----     -----        -----
|  #   #       #            Total              32         -           32
|  #   #   #   #   #        Missing             -
+----------------------                     -----
-.6239722      13.05528                        32
  (32 unique values)

. gen lepzd2=log(epzd2)

. qui regress lepzd2 izdatki tobak alko izdatki2 tobak2 alko2 izdatkitobak
  izdatkialko tobakalko

. predict lsigma2fit, xb

. gen td=sqrt(exp(lsigma2fit))

. gen pzdt=pzd/td
. gen izdatkit=izdatki/td
. gen tobakt=tobak/td
. gen alkot=alko/td
. gen kt=1/td

. regress pzdt izdatkit tobakt alkot kt, nocons

      Source |       SS       df       MS              Number of obs =      32
-------------+------------------------------           F(  4,    28) =20701.82
       Model |   322321.11     4  80580.2775           Prob > F      =  0.0000
    Residual |  108.987909    28  3.89242533           R-squared     =  0.9997
-------------+------------------------------           Adj R-squared =  0.9996
       Total |  322430.098    32  10075.9406           Root MSE      =  1.9729

------------------------------------------------------------------------------
        pzdt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    izdatkit |   .0016064   .0002551     6.30   0.000     .0010838    .0021289
      tobakt |  -.1398504   .0838447    -1.67   0.106    -.3115986    .0318978
       alkot |  -.5312401   .2600169    -2.04   0.051    -1.063861    .0013804
          kt |   79.61737   1.960614    40.61   0.000     75.60124    83.63351
------------------------------------------------------------------------------

. gen pzdtfit=_b[izdatkit]*izdatki+_b[tobakt]*tobak+_b[alkot]*alko+_b[kt]

. correlate pzd pzdtfit
(obs=32)

             |      pzd  pzdtfit
-------------+------------------
         pzd |   1.0000
     pzdtfit |   0.8568   1.0000

. scalar r2p=r(rho)^2
. display r2p
.7341573
```

■

<u>Primer 2:</u> Analiziramo produkcijske funkcije za podjetja industrijske dejavnosti v RS v podskupini DL 30.02 – *Proizvodnja računalnikov in druge opreme za obdelavo podatkov* na podlagi podatkov iz zaključnih računov za leto 1998 (datoteka `proizvod.dta`).

a) S pomočjo Jarque–Berra testa proučite predpostavko o normalnosti porazdelitve slučajne spremenljivke za linearno in Cobb-Douglasovo produkcijsko funkcijo.
b) Analizirajte še prisotnost multikolinearnosti v modelu linearne in Cobb-Douglasove produkcijske funkcije.

a) Preverjanje predpostavke o normalnosti porazdelitve slučajne spremenljivke:

```
. regress q l k

      Source |       SS       df       MS              Number of obs =      81
-------------+------------------------------           F(  2,    78) =   52.90
       Model |  6.9350e+12     2  3.4675e+12           Prob > F      =  0.0000
    Residual |  5.1130e+12    78  6.5551e+10           R-squared     =  0.5756
-------------+------------------------------           Adj R-squared =  0.5647
       Total |  1.2048e+13    80  1.5060e+11           Root MSE      =  2.6e+05

------------------------------------------------------------------------------
           q |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           l |   9687.383   3640.852     2.66   0.009     2439.003    16935.76
           k |    2.27941   .7553228     3.02   0.003      .775678    3.783142
       _cons |  -11875.29   34865.13    -0.34   0.734    -81286.43    57535.85
------------------------------------------------------------------------------

. predict eq, resid
. sum eq, detail

                          Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -928124.7      -928124.7
 5%    -205781.2      -693306.2
10%    -149066.2        -520897       Obs                  81
25%     -30861.5      -258838.8       Sum of Wgt.          81

50%    -3095.372                      Mean          -.0010632
                        Largest       Std. Dev.      252809.1
75%     7945.411         350021
90%      60822.5       778072.3       Variance       6.39e+10
95%     166468.2       816731.7       Skewness        1.55663
99%      1310726        1310726       Kurtosis       14.98543

. scalar opaz=r(N)
. scalar slin=r(skewness)
. scalar klin=r(kurtosis)

. scalar jblin=opaz*(slin^2/6 + (klin-3)^2/24)
. display jblin
517.53233

. display chi2tail(2,jblin)
4.16e-113

. jb6 eq
Jarque-Bera normality test:  517.5 Chi(2)  4.e-113
Jarque-Bera test for Ho: normality: (eq)
```

```
. gen lq=log(q)
. gen ll=log(l)
. gen lk=log(k)

. regress lq ll lk

      Source |       SS       df       MS              Number of obs =      81
-------------+------------------------------           F(  2,    78) =  190.75
       Model |  178.261263     2  89.1306313           Prob > F      =  0.0000
    Residual |    36.44752    78  .467275898           R-squared     =  0.8302
-------------+------------------------------           Adj R-squared =  0.8259
       Total |  214.708783    80  2.68385978           Root MSE      =  .68358

------------------------------------------------------------------------------
          lq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          ll |   .9645479   .1199229     8.04   0.000     .7257997    1.203296
          lk |   .1885438   .0673358     2.80   0.006     .0544886     .322599
       _cons |   7.546026   .4617465    16.34   0.000      6.62676    8.465293
------------------------------------------------------------------------------

. predict elq, resid
. sum elq, detail

                          Residuals
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -1.225007      -1.225007
 5%    -1.015222      -1.073147
10%    -.8845653      -1.022881       Obs                  81
25%    -.4654464      -1.018599       Sum of Wgt.          81

50%    -.0882534                      Mean          -1.24e-09
                        Largest       Std. Dev.       .674977
75%     .4299134       1.258059
90%     1.020899       1.329013       Variance        .455594
95%     1.214762       1.409848       Skewness       .4283599
99%     1.786791       1.786791       Kurtosis       2.619945

. scalar opaz=r(N)
. scalar slog=r(skewness)
. scalar klog=r(kurtosis)

. scalar jb=opaz*(slog^2/6 + (klog-3)^2/24)
. display jblog
2.9646371

. display chi2tail(2,jblog)
.22711051

. jb6 elq
Jarque-Bera normality test:  2.965 Chi(2)  .2271
Jarque-Bera test for Ho: normality: (elq)
```

■

b) Analiza prisotnosti multikolinearnosti:

```
. collin l k, corr
(obs=81)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
         l      3.55    1.88    0.2817      0.7183
         k      3.55    1.88    0.2817      0.7183
----------------------------------------------------
  Mean VIF      3.55

                           Cond
        Eigenval          Index
---------------------------------
    1     1.8476          1.0000
    2     0.1524          3.4813
---------------------------------
 Condition Number         3.4813
 Eigenvalues & Cond Index computed from deviation sscp (no intercept)
 Det(correlation matrix)    0.2817
```

```
. collin ll lk, corr
(obs=81)

  Collinearity Diagnostics

                        SQRT                   R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
        ll      3.45    1.86    0.2896      0.7104
        lk      3.45    1.86    0.2896      0.7104
----------------------------------------------------
  Mean VIF      3.45

                           Cond
        Eigenval          Index
---------------------------------
    1     1.8428          1.0000
    2     0.1572          3.4242
---------------------------------
 Condition Number         3.4242
 Eigenvalues & Cond Index computed from deviation sscp (no intercept)
 Det(correlation matrix)    0.2896
```

■

Primer 3: Za ZDA imamo v datoteki `novogradnje.dta` zbrane naslednje podatke za obdobje 1963–1985:

- *STAN*: število novogradenj (v 1.000);
- *BNPP*: realni bruto nacionalni proizvod na prebivalca (v USD);
- *OM*: hipotekarna obrestna mera (v %).

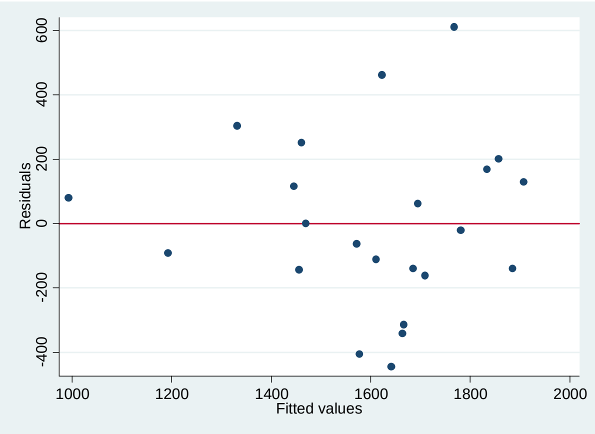
Ocenite linearni regresijski model:

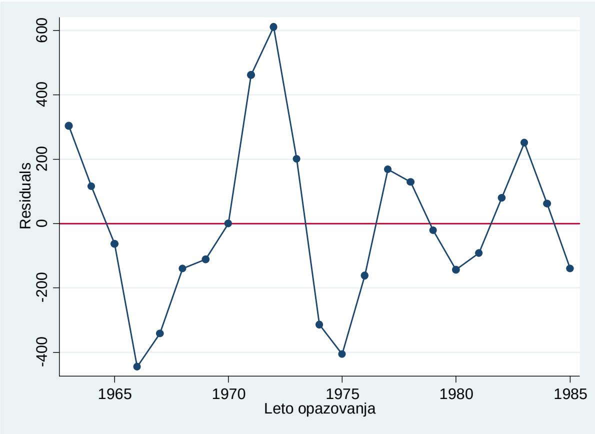
$$STAN_t = \beta_1 + \beta_2 BNPP_t + \beta_3 OM_t + u_t$$

in na različne načine analizirajte prisotnost avtokorelacije. Morebitno prisotnost avtokorelacije skušajte tudi odpraviti.

Izpis rezultatov obdelav v programskem paketu Stata:

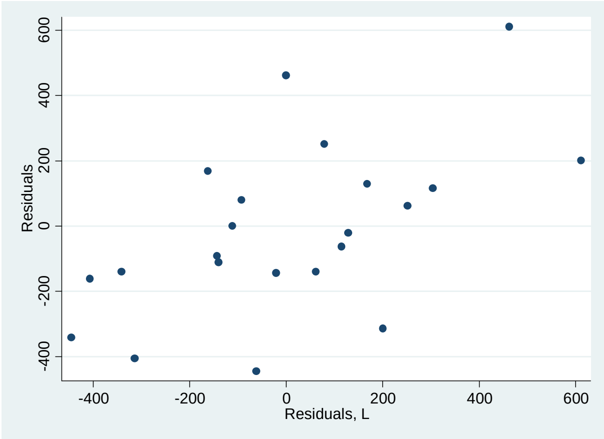
```
. tsset year
        time variable:  year, 1963 to 1985
                delta:  1 unit

. regress stan bnpp om

      Source |       SS       df       MS              Number of obs =      23
-------------+------------------------------           F(  2,    20) =    7.05
       Model |  1085450.62     2  542725.309           Prob > F      =  0.0048
    Residual |  1540261.16    20  77013.0582           R-squared     =  0.4134
-------------+------------------------------           Adj R-squared =  0.3547
       Total |  2625711.78    22  119350.536           Root MSE      =  277.51

------------------------------------------------------------------------------
        stan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bnpp |   .2709164   .0776772     3.49   0.002     .1088845    .4329483
          om |   -145.484   39.45199    -3.69   0.001    -227.7794   -63.18864
       _cons |  -493.4081   708.4372    -0.70   0.494    -1971.182     984.366
------------------------------------------------------------------------------

. predict estan, resid

. * Analiza prisotnosti avtokorelacije - Graficna metoda

. rvfplot, yline(0)
. twoway connected estan year, yline(0)
```






```
. gen estan1=estan[_n-1]
(1 missing value generated)
```

```
. scatter estan estan1
. scatter estan l.estan
```




```
. * Analiza prisotnosti avtokorelacije - Ocenjevanje koeficienta AK 1. reda

. gen eestantt1=estan*estan1
(1 missing value generated)

. qui sum eestantt1, detail
. scalar rhostevec=r(N)*r(mean)

. gen estan2=estan^2
. qui sum estan2, detail
. scalar rhoimenovalec1=r(N)*r(mean)

. scalar rhoapprox1=rhostevec/rhoimenovalec1

. display rhostevec, rhoimenovalec1, rhoapprox1
833617.99 1540261.2 .54121859

. corrgram estan

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.5412   0.5498   7.6558  0.0057          |----              |----
2       -0.1973  -0.7579   8.7217  0.0128         -|             ------|
3       -0.5627   0.1016   17.825  0.0005      ----|                   |
4       -0.4197  -0.2881   23.157  0.0001       ---|                 --|
5       -0.1720  -0.2908   24.102  0.0002         -|                 --|
6       -0.0254  -0.1121   24.123  0.0005          |                   |
7        0.0479  -0.4631   24.206  0.0010          |                ---|
8        0.1326   0.0389   24.881  0.0016          |-                  |
9        0.1550  -0.0640   25.868  0.0021          |-                  |

. gen estan12=estan1^2
(1 missing value generated)

. qui sum estan12, detail
. scalar rhoimenovalec2=r(N)*r(mean)

. scalar rhoapprox2=rhostevec/rhoimenovalec2

. display rhostevec, rhoimenovalec2, rhoapprox2
833617.99 1520544.2 .5482366
```

```
. regress estan estan1, nocons

      Source |       SS       df       MS              Number of obs =      22
-------------+------------------------------           F(  1,    21) =    9.68
       Model |  457019.897     1  457019.897           Prob > F      =  0.0053
    Residual |  991179.278    21  47199.0132           R-squared     =  0.3156
-------------+------------------------------           Adj R-squared =  0.2830
       Total |  1448199.17    22  65827.2352           Root MSE      =  217.25

------------------------------------------------------------------------------
       estan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      estan1 |   .5482366   .1761842     3.11   0.005     .1818415    .9146317
------------------------------------------------------------------------------

. scalar rho=_b[estan1]
. display rho
.5482366


. * Analiza prisotnosti avtokorelacije - Durbin-Watsonov d-test

. gen estantt12=(estan-estan1)^2
(1 missing value generated)

. qui sum estantt12, detail
. scalar dwstevec=r(N)*r(mean)

. qui sum estan2, detail
. scalar dwimenovalec=r(N)*r(mean)

. scalar dw=dwstevec/dwimenovalec
. display dwstevec, dwimenovalec, dw
1301507.4 1540261.2 .84499136

. scalar dwapprox1=2*(1-rhoapprox1)
. scalar dwapprox2=2*(1-rhoapprox2)
. display dwapprox1, dwapprox2
.91756282 .90352681

. qui regress stan bnpp om
. estat dwatson

Durbin-Watson d-statistic(  3,    23) =  .8449914


. * Analiza prisotnosti avtokorelacije - Breusch-Godfreyev test (LM-test)

. regress estan bnpp om estan1

      Source |       SS       df       MS              Number of obs =      22
-------------+------------------------------           F(  3,    18) =    2.90
       Model |   470198.88     3   156732.96           Prob > F      =  0.0636
    Residual |  973815.658    18  54100.8699           R-squared     =  0.3256
-------------+------------------------------           Adj R-squared =  0.2132
       Total |  1444014.54    21  68762.5971           Root MSE      =   232.6

------------------------------------------------------------------------------
       estan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bnpp |  -.0117229   .0736547    -0.16   0.875    -.1664656    .1430198
          om |    12.3709   34.74172     0.36   0.726    -60.61875    85.36054
      estan1 |     .55949   .1954605     2.86   0.010     .1488428    .9701372
       _cons |   16.87095   690.7988     0.02   0.981    -1434.443    1468.185
------------------------------------------------------------------------------
```

```
. scalar lm=e(N)*e(r2)
. display lm, invchi2tail(1,0.05), chi2tail(1,lm)
7.1636227 3.8414588 .00743968

. qui regress stan bnpp om
. estat bgodfrey

Breusch-Godfrey LM test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          7.257               1                   0.0071
---------------------------------------------------------------------------
                        H0: no serial correlation

. estat bgodfrey, lags(1 2 3 4 5 6 7 8 9 10 11 12)
. estat bgodfrey, lags(1/12)

Breusch-Godfrey LM test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          7.257               1                   0.0071
       2     |         15.665               2                   0.0004
       3     |         15.694               3                   0.0013
       4     |         15.697               4                   0.0035
       5     |         17.074               5                   0.0044
       6     |         17.074               6                   0.0090
       7     |         17.134               7                   0.0166
       8     |         17.391               8                   0.0263
       9     |         17.840               9                   0.0371
      10     |         17.922              10                   0.0563
      11     |         18.251              11                   0.0759
      12     |         18.967              12                   0.0893
---------------------------------------------------------------------------
                        H0: no serial correlation


. * Odpravljanje avtokorelacije 1. reda - Cenilka PNK-PDE

. gen stant=stan-rho*stan[_n-1]
(1 missing value generated)

. gen bnppt=bnpp-rho*bnpp[_n-1]
(1 missing value generated)

. gen omt=om-rho*om[_n-1]
(1 missing value generated)

. regress stant bnppt omt

      Source |       SS       df       MS              Number of obs =      22
-------------+------------------------------           F(  2,    19) =    8.70
       Model |  876102.682     2  438051.341           Prob > F      =  0.0021
    Residual |  956460.586    19  50340.0308           R-squared     =  0.4781
-------------+------------------------------           Adj R-squared =  0.4231
       Total |  1832563.27    21  87264.9175           Root MSE      =  224.37

------------------------------------------------------------------------------
       stant |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       bnppt |   .3419223      .0995     3.44   0.003      .1336664    .5501782
         omt |    -171.81   43.49847    -3.95   0.001     -262.8533   -80.76664
       _cons |  -544.8987   500.8833    -1.09   0.290     -1593.259    503.4621
------------------------------------------------------------------------------
```

```
. scalar b1=_b[_cons]/(1-rho)
. display b1
-1206.1594

. gen stantfit=b1+_b[bnppt]*bnpp+_b[omt]*om

. correlate stan stantfit
(obs=23)

             |     stan stantfit
-------------+------------------
        stan |   1.0000
    stantfit |   0.6388   1.0000

. scalar r2p=r(rho)^2
. display r2p
.40808428


. * Newey-Westova metoda korekcije MNKVD standardnih napak

. regress stan bnpp om

      Source |       SS       df       MS              Number of obs =      23
-------------+------------------------------           F(  2,    20) =    7.05
       Model |  1085450.62     2  542725.309           Prob > F      =  0.0048
    Residual |  1540261.16    20  77013.0582           R-squared     =  0.4134
-------------+------------------------------           Adj R-squared =  0.3547
       Total |  2625711.78    22  119350.536           Root MSE      =  277.51

------------------------------------------------------------------------------
        stan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bnpp |   .2709164   .0776772     3.49   0.002     .1088845    .4329483
          om |   -145.484   39.45199    -3.69   0.001    -227.7794   -63.18864
       _cons |  -493.4081   708.4372    -0.70   0.494    -1971.182     984.366
------------------------------------------------------------------------------

. newey stan bnpp om, lag(9)

Regression with Newey-West standard errors          Number of obs  =        23
maximum lag: 9                                      F(  2,    20)  =     11.13
                                                    Prob > F       =    0.0006

------------------------------------------------------------------------------
             |             Newey-West
        stan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        bnpp |   .2709164   .0577467     4.69   0.000     .1504589    .3913738
          om |   -145.484   31.70648    -4.59   0.000    -211.6226   -79.34547
       _cons |  -493.4081   465.5597    -1.06   0.302    -1464.549    477.7324
------------------------------------------------------------------------------
```

■

<u>Primer 4:</u> Datoteka `denar_povprasevanje1.dta` vsebuje za slovensko gospodarstvo mesečne podatke o naslednjih spremenljivkah (obdobje 1999m1–2006m12):

- *HM1*: harmonizirana količina denarja v obtoku (v mio EUR);
- *PPR*: prejemki prebivalstva (v mio EUR);
- *PGO*: prejemki gospodarstva (v mio EUR);

- *PDR*: prejemki države (v mio EUR);
- *RVP*: obrestna mera za vpogledne vloge (na letni ravni);
- *RVV*: obrestna mera za vezane vloge (do 90 dni, na letni ravni);
- *CZP*: indeks cen življenjskih potrebščin (2000 = 100).

Ocenite linearni regresijski model: $HM1_t = \beta_1 + \beta_2 PPR_t + \beta_3 RVP_t + \beta_4 RVV_t + \beta_5 CZP_t + u_t$ in nato opravite naslednje diagnostične procedure.

a) Preverite predpostavko o normalnosti porazdelitve slučajne spremenljivke.
b) Preverite predpostavko o odsotnosti multikolinearnosti.
c) Preverite predpostavko o homoskedastičnosti. V kolikor v modelu odkrijete prisotnost heteroskedastičnosti, s pomočjo Huber/White robustne cenilke variance izračunajte nepristranske standardne napake ocen parametrov. Katero predpostavko klasičnega linearnega regresijskega modela ste pri tem sprostili in kako?
d) Preverite predpostavko o odsotnosti avtokorelacije. V kolikor v modelu odkrijete prisotnost avtokorelacije, s pomočjo Newey–Westove robustne cenilke variance izračunajte nepristranske standardne napake ocen parametrov. Katero predpostavko klasičnega linearnega regresijskega modela ste pri tem sprostili?

Izpis rezultatov obdelav v programskem paketu Stata:

```
. tsset time
        time variable:  time, 1999m1 to 2006m12
                delta:  1 month

. regress hm1 ppr rvp rvv czp

      Source |       SS       df       MS              Number of obs =      96
-------------+------------------------------           F(  4,    91) =  527.72
       Model |  11431132.5     4  2857783.12           Prob > F      =  0.0000
    Residual |  492791.936    91    5415.296           R-squared     =  0.9587
-------------+------------------------------           Adj R-squared =  0.9569
       Total |  11923924.4    95  125514.994           Root MSE      =  73.589

------------------------------------------------------------------------------
         hm1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ppr |   1.697766    .513892     3.30   0.001     .6769831     2.71855
         rvp |  -311.6847   45.25178    -6.89   0.000    -401.5718   -221.7976
         rvv |  -11.57513    5.33166    -2.17   0.033    -22.16582    -.98444
         czp |   11.50168   1.472604     7.81   0.000     8.576535    14.42683
       _cons |  -229.2038   125.2134    -1.83   0.070    -477.9248    19.51725
------------------------------------------------------------------------------

. predict res, resid

. jb6 res
Jarque-Bera normality test:  .2311 Chi(2)  .8909
Jarque-Bera test for Ho: normality: (res)
```

```
. collin ppr rvp rvv czp, corr rinv
(obs=96)

  Collinearity Diagnostics

                        SQRT                    R-
  Variable      VIF     VIF    Tolerance    Squared
----------------------------------------------------
       ppr      8.68    2.95    0.1153      0.8847
       rvp      3.80    1.95    0.2633      0.7367
       rvv      3.98    2.00    0.2510      0.7490
       czp      7.87    2.81    0.1270      0.8730
----------------------------------------------------
  Mean VIF      6.08

                           Cond
        Eigenval          Index
---------------------------------
    1     3.4058          1.0000
    2     0.3612          3.0708
    3     0.1677          4.5061
    4     0.0653          7.2201
---------------------------------
 Condition Number         7.2201
 Eigenvalues & Cond Index computed from deviation sscp (no intercept)
 Det(correlation matrix)    0.0135

Inverse of correlation matrix

            ppr         rvp         rvv         czp
ppr   8.6761158
rvp   1.5693019   3.7979472
rvv   .22247678  -2.2901349   3.9843427
czp  -6.7590031  -.44144296   1.1761676   7.8723717

. qui regress hm1 ppr rvp rvv czp
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(14)     =     53.83
         Prob > chi2  =    0.0000

Cameron & Trivedi's decomposition of IM-test

---------------------------------------------------
              Source |       chi2     df      p
---------------------+-----------------------------
  Heteroskedasticity |      53.83     14    0.0000
            Skewness |       4.68      4    0.3213
            Kurtosis |       0.01      1    0.9136
---------------------+-----------------------------
               Total |      58.53     19    0.0000
---------------------------------------------------

. regress hm1 ppr rvp rvv czp, robust

Linear regression                                      Number of obs =      96
                                                       F(  4,    91) = 1000.25
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.9587
                                                       Root MSE      =  73.589
```

hm1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ppr	1.697766	.5633882	3.01	0.003	.5786649	2.816868
rvp	-311.6847	44.33028	-7.03	0.000	-399.7413	-223.6281
rvv	-11.57513	3.532513	-3.28	0.001	-18.59203	-4.558225
czp	11.50168	1.32376	8.69	0.000	8.872196	14.13117
_cons	-229.2038	58.25138	-3.93	0.000	-344.913	-113.4945

```
. qui regress hm1 ppr rvp rvv czp
. estat bgodfrey, lags(1/12)
```

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	70.771	1	0.0000
2	70.773	2	0.0000
3	71.397	3	0.0000
4	71.398	4	0.0000
5	71.639	5	0.0000
6	71.641	6	0.0000
7	73.403	7	0.0000
8	73.536	8	0.0000
9	74.066	9	0.0000
10	74.112	10	0.0000
11	74.164	11	0.0000
12	76.742	12	0.0000

H0: no serial correlation

```
. estat bgodfrey, lags(1/90)
```

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	70.771	1	0.0000
2	70.773	2	0.0000
3	71.397	3	0.0000
4	71.398	4	0.0000
5	71.639	5	0.0000
6	71.641	6	0.0000
7	73.403	7	0.0000
8	73.536	8	0.0000
9	74.066	9	0.0000
10	74.112	10	0.0000
11	74.164	11	0.0000
12	76.742	12	0.0000

...

lags(p)	chi2	df	Prob > chi2
40	88.387	40	0.0000
41	88.902	41	0.0000
42	89.282	42	0.0000
43	89.287	43	0.0000
44	89.390	44	0.0001
45	89.410	45	0.0001
46	89.685	46	0.0001
47	90.072	47	0.0002
48	90.076	48	0.0002
49	90.143	49	0.0003
50	90.540	50	0.0004

```
      51     |         90.698            51                     0.0005
      52     |         90.766            52                     0.0007

...

      65     |         93.323            65                     0.0122
      66     |         93.368            66                     0.0150
      67     |         93.564            67                     0.0177
      68     |         93.572            68                     0.0216
      69     |         93.768            69                     0.0254
      70     |         93.813            70                     0.0303
      71     |         93.846            71                     0.0361
      72     |         93.849            72                     0.0429
      73     |         93.995            73                     0.0496
      74     |         94.011            74                     0.0582
      75     |         94.011            75                     0.0680
      76     |         94.012            76                     0.0789
      77     |         94.379            77                     0.0869
      78     |         94.403            78                     0.0996
      79     |         95.140            79                     0.1042
      80     |         95.440            80                     0.1147

...

      85     |         95.601            85                     0.2026
      86     |         95.607            86                     0.2244
      87     |         95.651            87                     0.2465
      88     |         95.920            88                     0.2644
      89     |         95.920            89                     0.2893
      90     |         95.919            90                     0.3152
---------------------------------------------------------------------------
                       H0: no serial correlation
```

. newey hm1 ppr rvp rvv czp, lag(78)

```
Regression with Newey-West standard errors          Number of obs  =        96
maximum lag: 78                                     F(  4,    91)  =    859.25
                                                    Prob > F       =    0.0000

------------------------------------------------------------------------------
             |             Newey-West
         hm1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ppr |   1.697766   .3108188     5.46   0.000     1.080363     2.31517
         rvp |  -311.6847   64.70783    -4.82   0.000    -440.2189   -183.1505
         rvv |  -11.57513   6.148327    -1.88   0.063    -23.78802     .637769
         czp |   11.50168    .672376    17.11   0.000     10.16609    12.83727
       _cons |  -229.2038   71.30645    -3.21   0.002    -370.8453   -87.56224
------------------------------------------------------------------------------
```

■