Exercise 7

To examine the quantity theory of money, Brumm (2005) [''Money Growth, Output Growth, and Inflation: A Reexamination of the Modern Quantity Theory's Linchpin Prediction,'' *Southern Economic Journal*, 71(3), 661–667] specifies the equation:

$$Inflation = \beta_0 + \beta_1 * Money + \beta_2 * Output + u$$

where *INFLAT* is the growth rate of the general price level, *MONEY* is the growth rate of the money supply, and *OUTPUT* is the growth rate of national output. According to theory we should observe that $\beta_0 = 0, \beta_1 = 1$, and $\beta_2 = -1$. The data used in this paper is contained in the file *brumm.gdt*. It consists of 1995 year data on 76 countries.

a) Estimate the model by OLS and interpret all the parameters.

ols Inflation const Money Output

```
Model 1: OLS, using observations 1-76
Dependent variable: Inflation

             coefficient   std. error   t-ratio     p-value
  ---------------------------------------------------------
  const       -0.234214    0.979925     -0.2390    0.8118
  Money        1.03313     0.00904221   114.3      4.65e-084 ***
  Output      -1.66201     0.250566      -6.633    4.95e-09  ***

Mean dependent var   25.35395   S.D. dependent var   58.94767
Sum squared resid    1356.034   S.E. of regression   4.309966
R-squared            0.994797   Adjusted R-squared   0.994654
F(2, 73)             6978.325   P-value(F)           4.41e-84
Log-likelihood      -217.3396   Akaike criterion     440.6792
Schwarz criterion    447.6714   Hannan-Quinn         443.4736
```

b) Test the joint hypothesis that $\beta_0 = 0, \beta_1 = 1$ and $\beta_2 = -1$. What do you conclude?

restrict
b[1] = 0
b[2] = 1
b[3] = -1
end restrict

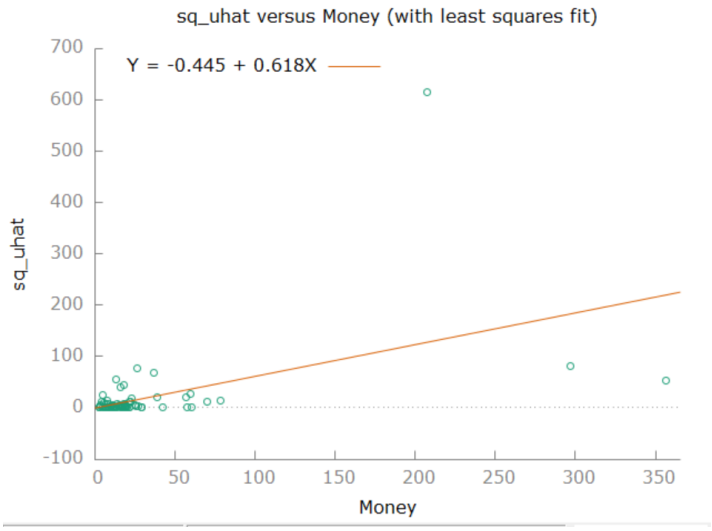
```
Restriction set
 1: b[const] = 0
 2: b[Money] = 1
 3: b[Output] = -1

Test statistic: F(3, 73) = 10.5158, with p-value = 7.88962e-006

Restricted estimates:

             coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------
  const        0.000000    0.000000      NA        NA
  Money        1.00000     0.000000      NA        NA
  Output      -1.00000     0.000000      NA        NA

  Standard error of the regression = 5.05503
```

We reject H0, therefore, restrictions do not hold

c) Examine the least squares residuals for the presence of heteroskedasticity related to the variable *Money*.

series resid=$uhat

gnuplot sq_resid Money



modtest –white (this tests all explanatory variables for heteroskedasticity

Manually:

genr mout=Money*Output

ols sq_resid const Money Output sq_Money sq_Output mout

```
Model 2: OLS, using observations 1-76
Dependent variable: sq_resid

              coefficient    std. error    t-ratio   p-value
  ------------------------------------------------------------
  const       -16,4206       20,9162       -0,7851   0,4351
  Money         2,36862       0,540649      4,381    4,06e-05 ***
  Output       -5,08322      10,6932       -0,4754   0,6360
  sq_Money     -0,00569956    0,00156983   -3,631    0,0005   ***
  sq_Output     0,254486      1,13671       0,2239   0,8235
  mout         -0,0176535     0,136937     -0,1289   0,8978

Mean dependent var   17,84255   S.D. dependent var   71,65330
Sum squared resid    238967,9   S.E. of regression   58,42797
R-squared            0,379408   Adjusted R-squared   0,335080
F(5, 70)             8,559119   P-value(F)           2,30e-06
Log-likelihood      -413,8667   Akaike criterion     839,7333
Schwarz criterion    853,7177   Hannan-Quinn         845,3222

Excluding the constant, p-value was highest for variable 8 (mout)
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LM= R^2*n=0.3794*76=28.83

Critical value at 1% significance $\chi^2(5) = 15.086$

Therefore, we reject the hypothesis that there is no heteroskedasticity with respect to the variable Money

d) Obtain robust standard errors for the model and compare them to the OLS standard errors. Does your conclusion change in part (b) after using robust standard errors?

ols Inflation const Money Output –robust

```
Model 3: OLS, using observations 1-76
Dependent variable: Inflation
Heteroskedasticity-robust standard errors, variant HC1

            coefficient   std. error   t-ratio    p-value
  ---------------------------------------------------------
  const       -0.234214    0.619615    -0.3780   0.7065
  Money        1.03313     0.0236942   43.60     5.08e-054 ***
  Output      -1.66201     0.175914    -9.448    2.71e-014 ***

Mean dependent var   25.35395   S.D. dependent var   58.94767
Sum squared resid    1356.034   S.E. of regression   4.309966
R-squared            0.994797   Adjusted R-squared   0.994654
F(2, 73)             956.8215   P-value(F)           4.26e-53
Log-likelihood      -217.3396   Akaike criterion     440.6792
Schwarz criterion    447.6714   Hannan-Quinn         443.4736
```

Conclusion does not change – they are jointly not equal to the theoretical parameters

e) It is argued that *Output* may be endogenous. Four instrumental variables are proposed, *INITIAL* = initial level of real GDP, *SCHOOL* = a measure of the population's educational attainment, *INVEST* = average investment as a share of GDP, and *POPRATE* = average population growth rate. Using these instruments, obtain instrumental variables (2SLS) estimates of the inflation equation (do the two stage procedure).

First stage:

ols Output const initial poprate school invest Money

series Output_hat=$yhat

Second stage:

ols Inflation const Money Output_hat

```
Model 6: OLS, using observations 1-76
Dependent variable: Inflation

             coefficient   std. error   t-ratio    p-value
  ----------------------------------------------------------
  const       -1,09398     2,26858     -0,4822   0,6311
  Money        1,03506     0,0119309    86,75     2,16e-075 ***
  Out_hat     -1,39420     0,673298    -2,071     0,0419    **

Mean dependent var   25,35395   S.D. dependent var   58,94767
Sum squared resid    2052,737   S.E. of regression   5,302800
R-squared            0,992123   Adjusted R-squared   0,991908
F(2, 73)             4597,479   P-value(F)           1,65e-77
Log-likelihood      -233,0948   Akaike criterion     472,1896
Schwarz criterion    479,1818   Hannan-Quinn         474,9840
```

Alternatively, we can use Gretl command

tsls Inflation 0 Output Money ; 0 initial invest poprate school Money

OR

tsls Inflation const Output Money ; const initial invest poprate school Money

f) Are the instruments strong? **Only invest predicts the Output significantly, other variables are weak instruments. The theoretical parameters are again jointly rejected. The impact of output on the inflation is now lower than before.**

According to F test, instrument is weak because it falls below 10.27, where bias could have been roughly around 10% only but this is beyond the scope of our course

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Weak instrument test -
  First-stage F-statistic (4, 70) = 4,64206
  Critical values for TSLS bias relative to OLS:

     bias        5%       10%       20%       30%
    value    16,85     10,27      6,71      5,34
```