Assignment 4 - Solutions

From the data set assign04.dta:

Part I

1. Test whether the series spot and future are stationary series.

```
. tsset t
        time variable:  t, 1 to 7684
                delta:  1 unit

. dfuller spot, trend lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7682

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.438            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3597

------------------------------------------------------------------------------
D.spot       |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        spot |
         L1. |   -.001489   .0006108    -2.44   0.015    -.0026862   -.0002917
         LD. |   .0440347   .0114011     3.86   0.000     .0216855    .0663839
      _trend |   .0000171   8.32e-06     2.05   0.040     7.62e-07    .0000334
       _cons |   .7447753    .302873     2.46   0.014     .1510615    1.338489
------------------------------------------------------------------------------

. dfuller spot, lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7682

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.325            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.6176

------------------------------------------------------------------------------
      D.spot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        spot |
         L1. |  -.0004809   .0003629    -1.33   0.185    -.0011923    .0002305
         LD. |   .0435503    .011401     3.82   0.000     .0212012    .0658993
             |
       _cons |   .2693479   .1950793     1.38   0.167    -.1130608    .6517565
------------------------------------------------------------------------------

. dfuller future, trend lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7682

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.563            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.2971

------------------------------------------------------------------------------
D.future     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      future |
         L1. |   -.001768   .0006898    -2.56   0.010    -.0031202   -.0004159
```

```
         LD. |  -.0275938   .0114077    -2.42   0.016    -.0499561   -.0052315
      _trend |   .0000222     .00001     2.22   0.026     2.62e-06    .0000418
       _cons |     .86276   .3338726     2.58   0.010     .2082785    1.517241
------------------------------------------------------------------------------

. dfuller future, lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7682

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.289            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.6341

------------------------------------------------------------------------------
    D.future |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      future |
         L1. |  -.0004968   .0003854    -1.29   0.197    -.0012523    .0002587
         LD. |  -.0282081   .0114073    -2.47   0.013    -.0505696   -.0058467
             |
       _cons |   .2758156   .2042151     1.35   0.177    -.1245016    .6761329
------------------------------------------------------------------------------
```

- ***spot and future are nonstationary.***

2. From spot and future, generate spot return (rspot) and future return (rfuture) and test whether they are stationary.

```
. g rspot=(spot/l.spot)-1
(1 missing value generated)

. g rfuture=(future/l.future)-1
(1 missing value generated)

. dfuller rspot, trend lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -63.787            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.rspot      |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       rspot |
         L1. |  -1.005168   .0157581   -63.79   0.000    -1.036058   -.9742776
         LD. |   .0517018   .0113974     4.54   0.000     .0293598    .0740439
      _trend |   9.56e-10   9.19e-09     0.10   0.917    -1.71e-08    1.90e-08
       _cons |   .0000199   .0000408     0.49   0.626      -.00006    .0000998
------------------------------------------------------------------------------

. dfuller rspot, lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -63.791            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
     D.rspot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
```

```
-------------+----------------------------------------------------------------
       rspot |
         L1. |  -1.005165   .0157571   -63.79   0.000    -1.036053   -.9742771
         LD. |   .0517007   .0113967     4.54   0.000     .0293601    .0740413
             |
       _cons |   .0000235   .0000204     1.15   0.248    -.0000164    .0000635
------------------------------------------------------------------------------

. dfuller rfuture, trend lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -65.070            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.rfuture    |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     rfuture |
         L1. |  -1.063572   .0163449   -65.07   0.000    -1.095612   -1.031531
         LD. |     .03575   .0114053     3.13   0.002     .0133924    .0581076
      _trend |   1.17e-09   1.06e-08     0.11   0.912    -1.96e-08    2.19e-08
       _cons |   .0000231    .000047     0.49   0.624    -.0000691    .0001152
------------------------------------------------------------------------------

. dfuller rfuture, lag(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -65.074            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
   D.rfuture |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     rfuture |
         L1. |  -1.063569   .0163439   -65.07   0.000    -1.095608   -1.031531
         LD. |   .0357488   .0114046     3.13   0.002     .0133927    .0581049
             |
       _cons |   .0000276   .0000235     1.17   0.241    -.0000185    .0000736
------------------------------------------------------------------------------
```

- ***rspot and rfuture are stationary.***

3. Estimate Autoregressive Integrated Moving Average (ARIMA(p,d,q))model for spot return (rspot) and future return (rfuture) – determine the most appropriated order for p, d, and q using SBIC given the maximum lag equals 3.

```
. *Define Variable y
.         g y = rspot
(1 missing value generated)

. *Specify order p d q
. forvalue d = 0(1)0 {
  2.  forvalue p = 1(1)3 {
  3.  forvalue q = 1(1)3 {
  4.          display "estimate arima`p'`d'`q'"
  5.          capture: quietly arch y, arima(`p',`d',`q') nolog
  6.          if _rc~=0 {
  7.          display "flatlog when pdq =" `p'`d'`q'
  8.          continue
  9.          }
 10.          estimates store arima`p'`d'`q'
```

```
 11.          display "arima`p'`d'`q' already estimated"
 12.  }
 13.  }
 14.  estimates table arima1`d'1 arima1`d'2 arima1`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 15.  estimates table arima2`d'1 arima2`d'2 arima2`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 16.  estimates table arima3`d'1 arima3`d'2 arima3`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 17.  }
estimate arima101
arima101 already estimated
estimate arima102
arima102 already estimated
estimate arima103
arima103 already estimated
estimate arima201
arima201 already estimated
estimate arima202
arima202 already estimated
estimate arima203
arima203 already estimated
estimate arima301
arima301 already estimated
estimate arima302
arima302 already estimated
estimate arima303
arima303 already estimated

---------------------------------------------------------------
    Variable |   arima101        arima102        arima103
-------------+-------------------------------------------------
y            |
       _cons |  .00002357       .00002356       .00002358
-------------+-------------------------------------------------
ARMA         |
          ar |
         L1. | -.39238062***    .42864317***    .65166124**
             |
          ma |
         L1. |  .44532053***   -.38281172***   -.60615082**
         L2. |                 -.06806304***   -.07857703***
         L3. |                                  .01545964
-------------+-------------------------------------------------
SIGMA2       |
       _cons |  3.191e-06***    3.186e-06***    3.186e-06***
-------------+-------------------------------------------------
Statistics   |
         aic | -75418.287      -75428.587      -75426.961
         bic |   -75390.5      -75393.854      -75385.281
          ll |  37713.144       37719.294       37719.481
---------------------------------------------------------------
                           legend: * p<.1; ** p<.05; *** p<.01

---------------------------------------------------------------
    Variable |   arima201        arima202        arima203
-------------+-------------------------------------------------
y            |
       _cons |  .00002357       .00002358       .00002357
-------------+-------------------------------------------------
ARMA         |
          ar |
         L1. |  .38006412***     .4428295***    -.2977397
         L2. | -.06526084***    .06441512        .18380533
             |
          ma |
         L1. | -.33454996**    -.39711228***    .34370136
         L2. |                  -.1329568      -.21915882
         L3. |                                 -.04549931
-------------+-------------------------------------------------
SIGMA2       |
       _cons |  3.186e-06***    3.186e-06***    3.186e-06***
-------------+-------------------------------------------------
Statistics   |
         aic |  -75428.02      -75426.781      -75424.791
         bic | -75393.286      -75385.101      -75376.164
          ll |   37719.01       37719.391       37719.396
```

```
--------------------------------------------------------------
                           legend: * p<.1; ** p<.05; *** p<.01

--------------------------------------------------------------
    Variable |   arima301        arima302        arima303    
-------------+------------------------------------------------
y            |
       _cons |  .00002358       .00002359       .00002358    
-------------+------------------------------------------------
ARMA         |
          ar |
         L1. |  .77455424***    .75397066      -.00991889    
         L2. | -.08500848***   -.07160519       .14112537    
         L3. |  .02487315       .02348179       .27346678*   
             |
          ma |
         L1. |  -.7289429***   -.70834194        .0550623    
         L2. |                 -.01249418      -.19122019    
         L3. |                                 -.29971817**  
-------------+------------------------------------------------
SIGMA2       |
       _cons |  3.186e-06***    3.186e-06***    3.185e-06*** 
-------------+------------------------------------------------
Statistics   |
         aic |  -75427.18      -75425.182      -75425.679    
         bic | -75385.499      -75376.555      -75370.105    
          ll |   37719.59       37719.591        37720.84    
--------------------------------------------------------------
                           legend: * p<.1; ** p<.05; *** p<.01

. drop y

. *Define Variable y
.    g y = rfuture
(1 missing value generated)

. *Specify order p d q
. forvalue d = 0(1)0 {
  2.  forvalue p = 1(1)3 {
  3.  forvalue q = 1(1)3 {
  4.          display "estimate arima`p'`d'`q'"
  5.          capture: quietly arima y, arima(`p',`d',`q') nolog
  6.          if _rc~=0 {
  7.          display "flatlog when pdq =" `p'`d'`q'
  8.          continue
  9.          }
 10.          estimates store arima`p'`d'`q'
 11.          display "arima`p'`d'`q' already estimated"
 12.  }
 13.  }
 14.  estimates table arima1`d'1 arima1`d'2 arima1`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 15.  estimates table arima2`d'1 arima2`d'2 arima2`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 16.  estimates table arima3`d'1 arima3`d'2 arima3`d'3, star(0.1 0.05 0.01)
stat(aic bic ll)
 17.  }
estimate arima101
arima101 already estimated
estimate arima102
arima102 already estimated
estimate arima103
arima103 already estimated
estimate arima201
arima201 already estimated
estimate arima202
arima202 already estimated
estimate arima203
arima203 already estimated
estimate arima301
arima301 already estimated
estimate arima302
arima302 already estimated
estimate arima303
arima303 already estimated

--------------------------------------------------------------
```

Variable	arima101	arima102	arima103
y			
_cons	.00002616	.00002615	.00002616
ARMA			
ar			
L1.	.57862596***	.1646139	-.99197318***
ma			
L1.	-.61250239***	-.19269514	.96410655***
L2.		-.03060977**	-.06340363***
L3.			-.03781342***
sigma			
_cons	.00205937***	.00205903***	.00205869***
Statistics			
aic	-73232.774	-73233.366	-73233.777
bic	-73204.987	-73198.632	-73192.096
ll	36620.387	36621.683	36622.888

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima201	arima202	arima203
y			
_cons	.00002615	.00002616	.00002616
ARMA			
ar			
L1.	.1969293	.15226368	-.89495618***
L2.	-.02961053**	.01296947	.09640361
ma			
L1.	-.22502128	-.18034761	.86721517***
L2.		-.04390959	-.15687072
L3.			-.03517174***
sigma			
_cons	.00205903***	.00205902***	.00205868***
Statistics			
aic	-73233.346	-73231.368	-73231.866
bic	-73198.612	-73189.687	-73183.239
ll	36621.673	36621.684	36622.933

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima301	arima302	arima303
y			
_cons	.00002616	.00002616	.00002616
ARMA			
ar			
L1.	.43838803	-.86034043***	-.52724741***
L2.	-.02297431	.09649443	-.4038636**
L3.	.0095455	-.03406132***	.5173196***
ma			
L1.	-.46647099	.83256382***	.49684324***
L2.		-.15575814	.36070844**
L3.			-.55352477***
sigma			
_cons	.00205902***	.00205869***	.00205829***
Statistics			
aic	-73231.387	-73231.797	-73232.791
bic	-73189.706	-73183.17	-73177.217
ll	36621.693	36622.898	36624.395

legend: * p<.1; ** p<.05; *** p<.01

- ***The most appropriated order for rspot is ARIMA(1,0,2).***
- ***The most appropriated order for rfuture is ARIMA(1,0,1).***

Part II

4. Estimate VARs models using spot return (rspot) and future return (rfuture) as endogenous variables and determine the most appropriated lags models using SBIC.

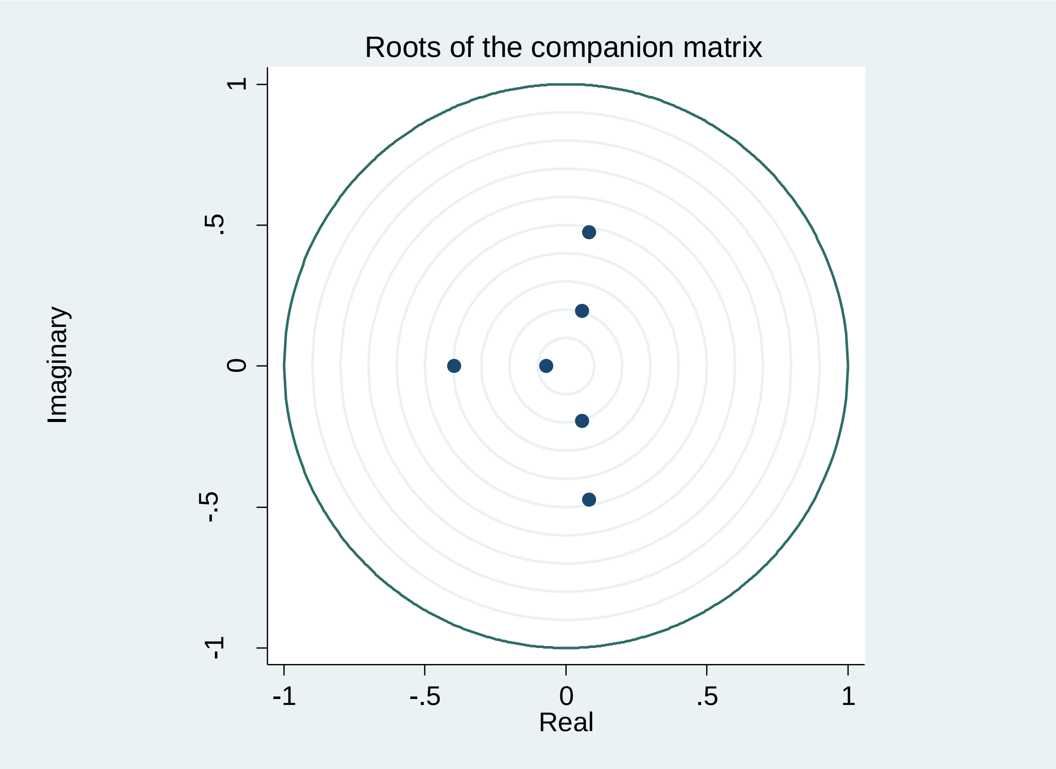
```
. varsoc rspot rfuture

   Selection-order criteria
   Sample:  6 - 7684                              Number of obs      =      7679
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  76705.7                      7.2e-12  -19.9775  -19.9769  -19.9757  |
  |  1 |  76876.4  341.45    4  0.000  6.9e-12  -20.0209  -20.0191  -20.0155  |
  |  2 |  76966.2  179.52    4  0.000  6.8e-12  -20.0433  -20.0402  -20.0342  |
  |  3 |  76999.2   66.06    4  0.000  6.7e-12  -20.0508  -20.0465  -20.0382* |
  |  4 |  77015.7  32.907*   4  0.000  6.7e-12* -20.0541* -20.0485* -20.0378  |
  +---------------------------------------------------------------------------+
   Endogenous:  rspot rfuture
    Exogenous:  _cons
```

- ***According to SBIC, the most appropriated lag order is 3.***

5. Perform stability test and Granger exogeneity test.

```
. var rspot rfuture, lag(1/3)

Vector autoregression

Sample:  5 - 7684                                    No. of obs      =      7680
Log likelihood =  77010.15                           AIC             = -20.05108
FPE            =  6.71e-12                           HQIC            = -20.04674
Det(Sigma_ml)  =  6.69e-12                           SBIC            = -20.03842

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
rspot                 7     .001779   0.0122   95.07421   0.0000
rfuture               7     .002044   0.0181   141.3296   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
       rspot |
         L1. |  -.0323987   .0159661    -2.03   0.042    -.0636918   -.0011057
         L2. |  -.1099664   .0160841    -6.84   0.000    -.1414905   -.0784422
         L3. |  -.0418984   .0159205    -2.63   0.008    -.0731019   -.0106949
             |
     rfuture |
         L1. |   .0933035   .0138966     6.71   0.000     .0660668    .1205403
         L2. |   .0688434   .0141336     4.87   0.000     .0411421    .0965447
         L3. |   .0317131   .0139194     2.28   0.023     .0044315    .0589946
             |
       _cons |   .0000231   .0000203     1.14   0.256    -.0000167    .0000629
-------------+----------------------------------------------------------------
rfuture      |
       rspot |
         L1. |   .2004382   .0183405    10.93   0.000     .1644915    .2363849
         L2. |   .0600679    .018476     3.25   0.001     .0238557    .0962801
         L3. |   .0609707    .018288     3.33   0.001     .0251268    .0968146
             |
     rfuture |
         L1. |  -.1528221   .0159632    -9.57   0.000    -.1841093   -.1215349
         L2. |  -.0926647   .0162354    -5.71   0.000    -.1244855   -.0608439
         L3. |  -.0524571   .0159894    -3.28   0.001    -.0837958   -.0211184
             |
```

```
       _cons |   .0000262   .0000233     1.12   0.262    -.0000195    .0000719
------------------------------------------------------------------------------

. varstable, graph

   Eigenvalue stability condition
  +----------------------------------------+
  |        Eigenvalue         |   Modulus  |
  |---------------------------+------------|
  |   .0829301 +  .4737693i   |   .480973  |
  |   .0829301 -  .4737693i   |   .480973  |
  |  -.3959128                |   .395913  |
  |   .0571976 +  .1954789i   |   .203675  |
  |   .0571976 -  .1954789i   |   .203675  |
  | -.06956342                |   .069563  |
  +----------------------------------------+
   All the eigenvalues lie inside the unit circle.
   VAR satisfies stability condition.
```




```
. vargranger

   Granger causality Wald tests
  +------------------------------------------------------------------+
  |          Equation           Excluded |   chi2     df Prob > chi2 |
  |--------------------------------------+---------------------------|
  |             rspot            rfuture |  58.069     3    0.000    |
  |             rspot                ALL |  58.069     3    0.000    |
  |--------------------------------------+---------------------------|
  |           rfuture              rspot |   125.3     3    0.000    |
  |           rfuture                ALL |   125.3     3    0.000    |
  +------------------------------------------------------------------+
```

- ***According to stability test, the system is stable since all the eigenvalues lie inside the unit circle.***
- ***According to Granger exogeneity, both rspot and rfuture are all endogenous variables since all the tests are significant.***

6. Perform Impulse response analysis and determine which variable has more impact.

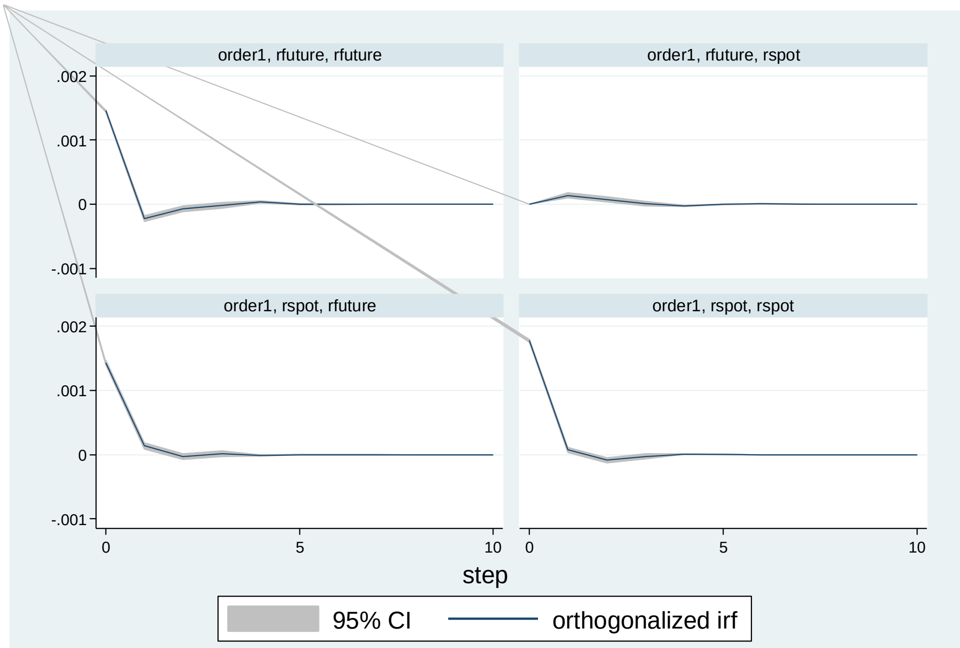
```
. irf create order1, o(rspot rfuture) step(10) set(irf01)
(file irf01.irf created)
(file irf01.irf now active)
(file irf01.irf updated)

. irf table oirf, impulse(rspot rfuture) response(rspot rfuture)
```

Results from order1

step	(1) oirf	(1) Lower	(1) Upper	(2) oirf	(2) Lower	(2) Upper	(3) oirf	(3) Lower	(3) Upper
0	.001778	.00175	.001806	.001434	.001395	.001474	0	0	0
1	.000076	.000036	.000116	.000137	.000091	.000183	.000136	.000096	.000175
2	-.000086	-.000126	-.000047	-.000032	-.000078	.000014	.000075	.000036	.000114
3	-.000028	-.000068	.000012	.000013	-.000033	.000058	6.6e-06	-.000032	.000045
4	.000011	3.5e-06	.000018	-.000012	-.00002	-4.5e-06	-.000028	-.00004	-.000016
5	5.1e-06	3.5e-07	9.8e-06	-2.5e-06	-7.0e-06	2.1e-06	-3.4e-06	-.00001	3.3e-06
6	-8.3e-07	-2.8e-06	1.1e-06	8.0e-07	-1.0e-06	2.6e-06	4.7e-06	2.1e-06	7.3e-06
7	-1.5e-06	-2.7e-06	-2.5e-07	1.5e-06	1.3e-07	2.9e-06	2.1e-06	-3.3e-07	4.6e-06
8	4.6e-08	-4.1e-07	5.0e-07	-2.1e-07	-5.6e-07	1.3e-07	-9.4e-07	-1.5e-06	-3.4e-07
9	3.1e-07	6.8e-08	5.4e-07	-2.8e-07	-5.2e-07	-3.8e-08	-5.7e-07	-1.1e-06	-4.2e-08
10	5.4e-08	-1.0e-07	2.1e-07	-4.3e-08	-1.9e-07	1.0e-07	9.1e-08	-1.3e-07	3.1e-07

step	(4) oirf	(4) Lower	(4) Upper
0	.001454	.001431	.001477
1	-.000222	-.000268	-.000177
2	-.000074	-.000119	-.000028
3	-.000021	-.000066	.000024
4	.000036	.00002	.000052
5	-3.4e-07	-6.6e-06	5.9e-06
6	-4.1e-06	-6.9e-06	-1.4e-06
7	-2.2e-06	-4.9e-06	5.1e-07
8	1.2e-06	5.8e-07	1.9e-06
9	4.6e-07	-5.3e-08	9.7e-07
10	-1.1e-07	-3.1e-07	8.6e-08

```
95% lower and upper bounds reported
(1) irfname = order1, impulse = rspot, and response = rspot
(2) irfname = order1, impulse = rspot, and response = rfuture
(3) irfname = order1, impulse = rfuture, and response = rspot
(4) irfname = order1, impulse = rfuture, and response = rfuture

. irf graph oirf, impulse(rspot rfuture) response(rspot rfuture)
```



Graphs by irfname, impulse variable, and response variable

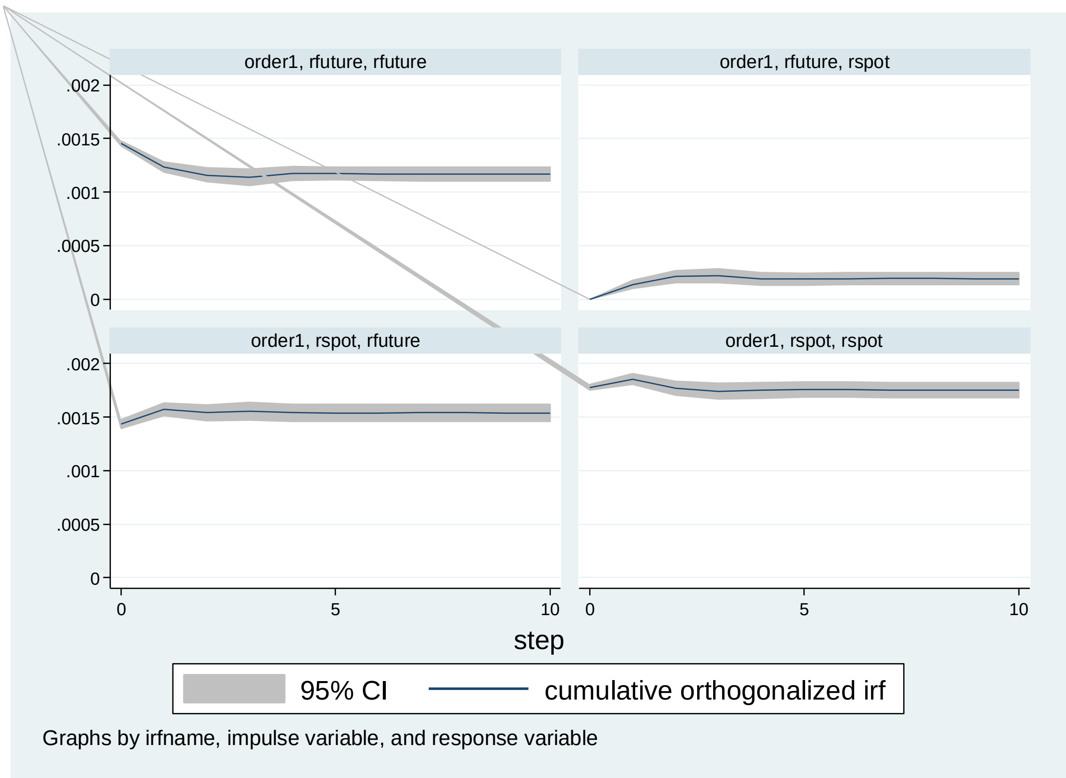
```
. irf table coirf, impulse(rspot rfuture) response(rspot rfuture)
```

Results from order1

step	(1) coirf	(1) Lower	(1) Upper	(2) coirf	(2) Lower	(2) Upper	(3) coirf	(3) Lower	(3) Upper
0	.001778	.00175	.001806	.001434	.001395	.001474	0	0	0
1	.001855	.001805	.001904	.001572	.001513	.00163	.000136	.000096	.000175
2	.001768	.001704	.001832	.00154	.001467	.001613	.000211	.000154	.000268
3	.00174	.001665	.001815	.001552	.001468	.001637	.000217	.00015	.000285
4	.00175	.001676	.001825	.00154	.001457	.001623	.000189	.000132	.000247
5	.001756	.001684	.001827	.001538	.001457	.001618	.000186	.000132	.00024
6	.001755	.001683	.001826	.001538	.001458	.001619	.00019	.000135	.000245
7	.001753	.001681	.001825	.00154	.001459	.001621	.000192	.000136	.000249
8	.001753	.001681	.001825	.00154	.001459	.001621	.000192	.000135	.000248
9	.001754	.001682	.001826	.001539	.001459	.00162	.000191	.000135	.000247
10	.001754	.001682	.001826	.001539	.001459	.00162	.000191	.000135	.000247

step	(4) coirf	(4) Lower	(4) Upper
0	.001454	.001431	.001477
1	.001232	.001183	.001282
2	.001159	.001093	.001224
3	.001137	.001061	.001214
4	.001173	.001109	.001238
5	.001173	.001111	.001235
6	.001169	.001105	.001232
7	.001166	.001102	.001231
8	.001168	.001104	.001232
9	.001168	.001104	.001232
10	.001168	.001104	.001232

```
95% lower and upper bounds reported
(1) irfname = order1, impulse = rspot, and response = rspot
(2) irfname = order1, impulse = rspot, and response = rfuture
(3) irfname = order1, impulse = rfuture, and response = rspot
(4) irfname = order1, impulse = rfuture, and response = rfuture

. irf graph coirf, impulse(rspot rfuture) response(rspot rfuture)
```



- ***According to IRF analysis, rspot has more impact on rfuture.***

7. Perform Forecast error variance decomposition and determine variable that has more impact on each endogenous variable.

```
. irf table fevd, impulse(rspot rfuture) response(rspot rfuture)
```

Results from order1

step	(1) fevd	(1) Lower	(1) Upper	(2) fevd	(2) Lower	(2) Upper	(3) fevd	(3) Lower	(3) Upper
0	0	0	0	0	0	0	0	0	0
1	1	1	1	.493053	.47713	.508975	0	0	0
2	.994221	.990856	.997585	.48956	.473586	.505534	.005779	.002415	.009144
3	.992487	.988616	.996357	.489057	.473061	.505053	.007513	.003643	.011384
4	.992475	.988611	.996339	.489024	.47303	.505018	.007525	.003661	.011389
5	.992228	.988242	.996214	.488895	.472897	.504893	.007772	.003786	.011758
6	.992224	.988237	.996212	.488895	.472897	.504893	.007776	.003788	.011763
7	.992218	.988226	.996209	.488894	.472895	.504892	.007782	.003791	.011774
8	.992216	.988224	.996208	.488893	.472895	.504891	.007784	.003792	.011776
9	.992216	.988224	.996208	.488893	.472895	.504891	.007784	.003792	.011776
10	.992216	.988223	.996208	.488893	.472895	.504891	.007784	.003792	.011777

step	(4) fevd	(4) Lower	(4) Upper
0	0	0	0
1	.506947	.491025	.52287
2	.51044	.494466	.526414
3	.510943	.494947	.526939
4	.510976	.494982	.52697
5	.511105	.495107	.527103
6	.511105	.495107	.527103
7	.511106	.495108	.527105
8	.511107	.495109	.527105
9	.511107	.495109	.527105
10	.511107	.495109	.527105

```
95% lower and upper bounds reported
(1) irfname = order1, impulse = rspot, and response = rspot
(2) irfname = order1, impulse = rspot, and response = rfuture
(3) irfname = order1, impulse = rfuture, and response = rspot
(4) irfname = order1, impulse = rfuture, and response = rfuture
```

- ***According to Forecast error variance decomposition, rspot has more impact on rfuture.***

Part III

8. Estimate GARCH(p,q) for spot return (rspot) using future return (rfuture) as explanatory variable for mean equation – determine the most appropriated order p and q for variance equation using SBIC given the maximum lag equals to 2.

```
. reg rspot rfuture

      Source |       SS       df       MS              Number of obs =    7683
-------------+------------------------------           F(  1,  7681) = 6787.70
       Model |  .011539538     1  .011539538           Prob > F      =  0.0000
    Residual |  .013058198  7681  1.7001e-06           R-squared     =  0.4691
-------------+------------------------------           Adj R-squared =  0.4691
       Total |  .024597736  7682  3.2020e-06           Root MSE      =   .0013

------------------------------------------------------------------------------
       rspot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     rfuture |    .594594    .007217    82.39   0.000     .5804466    .6087413
       _cons |   8.01e-06   .0000149     0.54   0.590    -.0000212    .0000372
------------------------------------------------------------------------------

. estat archlm
LM test for autoregressive conditional heteroskedasticity (ARCH)
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          4.919               1                   0.0266
---------------------------------------------------------------------------
         H0: no ARCH effects      vs.  H1: ARCH(p) disturbance
```

- ***According to ARCH-effect test, there exists significant ARCH effect.***

```
. arch rspot rfuture, arch(1/1) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 199294.69
Log likelihood =  40210.38                         Prob > chi2     =    0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6210687   .0013912   446.42   0.000      .618342    .6237954
       _cons |   9.98e-06   .0000141     0.71   0.479    -.0000177    .0000376
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1165902   .0073183    15.93   0.000     .1022466    .1309338
             |
       _cons |   1.52e-06   7.38e-09   206.28   0.000     1.51e-06    1.54e-06
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .    40210.38      4    -80412.77   -80384.98
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note

. arch rspot rfuture, arch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 129656.55
Log likelihood =  40497.51                         Prob > chi2     =    0.0000
```

```
------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6005692   .0016679   360.08   0.000     .5973002    .6038382
       _cons |  -7.86e-07   9.42e-06    -0.08   0.934    -.0000192    .0000177
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1095312   .0080469    13.61   0.000     .0937597    .1253028
         L2. |    .338373    .006708    50.44   0.000     .3252255    .3515205
             |
       _cons |   1.09e-06   1.08e-08   100.43   0.000     1.07e-06    1.11e-06
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .    40497.51      5    -80985.01   -80950.28
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note

. arch rspot rfuture, arch(1/1) garch(1/1) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 126853.27
Log likelihood =  40518.76                         Prob > chi2     =    0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6471703   .0018171   356.16   0.000     .6436089    .6507317
       _cons |   6.44e-07   .0000111     0.06   0.954    -.0000212    .0000225
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1834017   .0074922    24.48   0.000     .1687171    .1980862
             |
       garch |
         L1. |   .6065876   .0136353    44.49   0.000     .5798629    .6333124
             |
       _cons |   3.86e-07   1.45e-08    26.62   0.000     3.57e-07    4.14e-07
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .    40518.76      5    -81027.53    -80992.8
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note

. arch rspot rfuture, arch(1/1) garch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 131273.11
Log likelihood =  40536.75                         Prob > chi2     =    0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6400212   .0017665   362.32   0.000      .636559    .6434835
       _cons |  -2.53e-06   .0000106    -0.24   0.811    -.0000233    .0000182
-------------+----------------------------------------------------------------
ARCH         |
```

```
        arch |
         L1. |   .1704453   .0078813    21.63   0.000     .1549983    .1858922
             |
       garch |
         L1. |   .8490056   .0319153    26.60   0.000     .7864527    .9115585
         L2. |  -.2069829   .0208903    -9.91   0.000     -.247927   -.1660387
             |
       _cons |   3.50e-07   1.26e-08    27.84   0.000     3.26e-07    3.75e-07
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .    40536.75      6    -81061.51   -81019.83
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note

. arch rspot rfuture, arch(1/2) garch(1/1) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 127297.62
Log likelihood =   40581.4                         Prob > chi2     =    0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6259104   .0017543   356.79   0.000     .6224721    .6293488
       _cons |  -8.75e-06   9.74e-06    -0.90   0.369    -.0000278    .0000103
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1039058   .0084471    12.30   0.000     .0873498    .1204617
         L2. |   .2378366   .0060369    39.40   0.000     .2260044    .2496688
             |
       garch |
         L1. |    .340368   .0079195    42.98   0.000     .3248461    .3558899
             |
       _cons |   6.23e-07   1.10e-08    56.63   0.000     6.01e-07    6.44e-07
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .     40581.4      6     -81150.8   -81109.12
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note

. arch rspot rfuture, arch(1/2) garch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                                   Number of obs   =      7683
Distribution: Gaussian                             Wald chi2(1)    = 120951.20
Log likelihood =  40603.26                         Prob > chi2     =    0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
     rfuture |   .6237113   .0017934   347.78   0.000     .6201963    .6272263
       _cons |  -.0000106   9.47e-06    -1.12   0.262    -.0000292    7.93e-06
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1014148   .0082533    12.29   0.000     .0852386    .1175909
         L2. |   .2988765   .0063886    46.78   0.000      .286355    .3113979
             |
       garch |
```

```
         L1. |   .0765894   .0154151     4.97   0.000     .0463764    .1068024
         L2. |   .1771544   .0174298    10.16   0.000     .1429927    .2113161
             |
       _cons |   6.86e-07   1.36e-08    50.58   0.000     6.60e-07    7.13e-07
------------------------------------------------------------------------------

. estat ic

-----------------------------------------------------------------------------
       Model |    Obs    ll(null)   ll(model)     df          AIC         BIC
-------------+---------------------------------------------------------------
           . |   7683           .    40603.26      7    -81192.53    -81143.9
-----------------------------------------------------------------------------
               Note:  N=Obs used in calculating BIC; see [R] BIC note
```

- ***According BIC, the most appropriated lags order in this case is GARCH(2,2)***

9. From (8), predict the variance of spot return (rspot).

```
. predict sigmahat, v

. line sigmahat t
```