The following VARs models:

$$Y_t = A_0 + A_1 Y_{t-1} + \epsilon_t \qquad (3)$$

where: $Y_t = \begin{pmatrix} rspot_t \\ rfuture_t \end{pmatrix}$, $A_0 = \begin{pmatrix} a_{10} \\ a_{20} \end{pmatrix}$, $A_1 = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$, $\epsilon_t = \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix}$

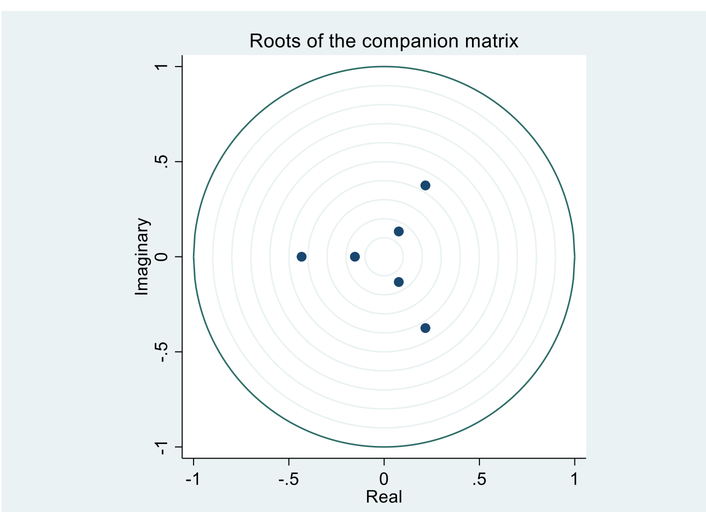
1. Estimate VARs models using spot return (rspot) and future return (rfuture) as endogenous variables and determine the most appropriated lags models using SBIC.

```
tsset t
        time variable:  time, 1 to 795
                delta:  1 unit

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

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

. varsoc rspot rfuture, maxlag(5)

   Selection-order criteria
   Sample:  7 - 795                                 Number of obs      =       789
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |   4758.6                        2.0e-08  -12.0573  -12.0527  -12.0455  |
  |  1 |  4824.49  131.78    4  0.000  1.7e-08  -12.2142  -12.2005  -12.1787  |
  |  2 |  4844.31  39.632    4  0.000  1.6e-08  -12.2543  -12.2315  -12.1951  |
  |  3 |  4868.62  48.629*   4  0.000  1.6e-08* -12.3058* -12.2739* -12.2229* |
  |  4 |  4870.79  4.3274    4  0.364  1.6e-08  -12.3011  -12.2601  -12.1946  |
  |  5 |  4872.67  3.7621    4  0.439  1.6e-08  -12.2957  -12.2457  -12.1655  |
  +---------------------------------------------------------------------------+
   Endogenous:  rspot rfuture
    Exogenous:  _cons

.
      From the tested result, the optimal lag is 3.
```

2. Perform stability test and Granger exogeneity test.

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

Vector autoregression

Sample:  5 - 795                                 Number of obs      =       791
Log likelihood =   4777.646                      AIC                =  -12.06484
FPE            =   1.97e-08                      HQIC               =  -12.05122
Det(Sigma_ml)  =   1.94e-08                      SBIC               =   -12.0294

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
rspot                 3     .018864   0.0043   3.394637   0.1832
```

```
rfuture              3     .022159   0.0005   .3590341   0.8357
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rspot        |
       rspot |
         L3. |  -.1449863   .1053298    -1.38   0.169    -.3514288    .0614563
             |
     rfuture |
         L3. |   .1535455   .0898626     1.71   0.088    -.0225819     .329673
             |
       _cons |  -.0003746   .0006696    -0.56   0.576     -.001687    .0009378
-------------+----------------------------------------------------------------
rfuture      |
       rspot |
         L3. |  -.0587468   .1237301    -0.47   0.635    -.3012534    .1837598
             |
     rfuture |
         L3. |   .0601902    .105561     0.57   0.569    -.1467054    .2670859
             |
       _cons |  -.0004712   .0007866    -0.60   0.549    -.0020129    .0010705
------------------------------------------------------------------------------

. varstable, graph

   Eigenvalue stability condition
  +----------------------------------------+
  |        Eigenvalue         |   Modulus    |
  |--------------------------+-------------|
  |   -.432995                |   .432995    |
  |   .2164975 +   .3749846i  |   .432995    |
  |   .2164975 -   .3749846i  |   .432995    |
  |  -.1534902                |    .15349    |
  |   .0767451 +   .1329264i  |    .15349    |
  |   .0767451 -   .1329264i  |    .15349    |
  +----------------------------------------+
   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 |  2.9196     1    0.088     |
  |              rspot                ALL |  2.9196     1    0.088     |
  |--------------------------------------+---------------------------|
  |            rfuture              rspot |  .22543     1    0.635     |
  |            rfuture                ALL |  .22543     1    0.635     |
  +------------------------------------------------------------------+

.
```

From stability test, we can conclude that the model is stable. However, H0 is accepted. Hence, we cannot conclude that the equations is exogenous.

3. Perform Impulse response function analysis (irf), Orthogonal impulse response function analysis (oirf), Cumulative impulse response function analysis (coirf), make interpretation of the analysis, and determine which variable has more impact (using Cholesky order – rspot rfuture).

```
. irf create order3, order(rspot rfuture) step(5) set(irf01)
(file irf01.irf created)
(file irf01.irf now active)
(file irf01.irf updated)

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

                                                          Results from order3

+-------------------------------------------------------------------------------------
-------------------------------+
|        |    (1)         (1)         (1)     |    (2)         (2)         (2)     |
(3)          (3)         (3)     |
|  step  |    irf        Lower       Upper    |   irf        Lower       Upper    |
irf        Lower       Upper    |
|--------+-----------------------------------+-----------------------------------+----
-------------------------------|
|0       | 1           1           1          | 0           0           0          | 0
0           0          |
|1       | 0           0           0          | 0           0           0          | 0
0           0          |
|2       | 0           0           0          | 0           0           0          | 0
0           0          |
|3       | -.144986    -.351429    .061456    | -.058747    -.301253    .18376     |
.153546     -.022582    .329673    |
|4       | 0           0           0          | 0           0           0          | 0
0           0          |
|5       | 0           0           0          | 0           0           0          | 0
0           0          |
+-------------------------------------------------------------------------------------
-------------------------------+

+--------------------------------------------+
|        |    (4)         (4)         (4)     |
```

step	irf	Lower	Upper
0	1	1	1
1	0	0	0
2	0	0	0
3	.06019	-.146705	.267086
4	0	0	0
5	0	0	0

95% lower and upper bounds reported
(1) irfname = order3, impulse = rspot, and response = rspot
(2) irfname = order3, impulse = rspot, and response = rfuture
(3) irfname = order3, impulse = rfuture, and response = rspot
(4) irfname = order3, impulse = rfuture, and response = rfuture

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

Results from order3

	(1)	(1)	(1)	(2)	(2)	(2)	(3)	(3)	(3)
step	oirf	Lower	Upper	oirf	Lower	Upper	oirf	Lower	Upper
0	.018828	.0179	.019756	.02084	.019691	.02199	0	0	0
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	.00047	-.000842	.001783	.000148	-.001391	.001687	.001137	-.000168	.002443
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0

	(4)	(4)	(4)
step	oirf	Lower	Upper
0	.007406	.007041	.007771
1	0	0	0
2	0	0	0
3	.000446	-.001087	.001978
4	0	0	0
5	0	0	0

95% lower and upper bounds reported
(1) irfname = order3, impulse = rspot, and response = rspot
(2) irfname = order3, impulse = rspot, and response = rfuture
(3) irfname = order3, impulse = rfuture, and response = rspot
(4) irfname = order3, impulse = rfuture, and response = rfuture

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

Results from order3

step	(1) coirf	(1) Lower	(1) Upper	(2) coirf	(2) Lower	(2) Upper	(3) coirf	(3) Lower	(3) Upper
0	.018828	.0179	.019756	.02084	.019691	.02199	0	0	0
1	.018828	.0179	.019756	.02084	.019691	.02199	0	0	0
2	.018828	.0179	.019756	.02084	.019691	.02199	0	0	0
3	.019298	.017678	.020919	.020989	.019056	.022922	.001137	-.000168	.002443
4	.019298	.017678	.020919	.020989	.019056	.022922	.001137	-.000168	.002443
5	.019298	.017678	.020919	.020989	.019056	.022922	.001137	-.000168	.002443

step	(4) coirf	(4) Lower	(4) Upper
0	.007406	.007041	.007771
1	.007406	.007041	.007771
2	.007406	.007041	.007771
3	.007852	.006271	.009432
4	.007852	.006271	.009432
5	.007852	.006271	.009432

95% lower and upper bounds reported
(1) irfname = order3, impulse = rspot, and response = rspot
(2) irfname = order3, impulse = rspot, and response = rfuture
(3) irfname = order3, impulse = rfuture, and response = rspot
(4) irfname = order3, impulse = rfuture, and response = rfuture

.

From the fact that the equations are not exogenous, we can see that the direction is negative which is invalid for the test.

4. **Perform Forecast error variance decomposition (fevd) and determine variable that has more impact on each endogenous variable.**

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

Results from order3

step	(1) fevd	(1) Lower	(1) Upper	(2) fevd	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	1	1	1	0	0	0
2	1	1	1	0	0	0
3	1	1	1	0	0	0
4	.996368	.98805	1.00469	.003632	-.004686	.01195
5	.996368	.98805	1.00469	.003632	-.004686	.01195

95% lower and upper bounds reported
(1) irfname = order3, impulse = rspot, and response = rspot
(2) irfname = order3, impulse = rfuture, and response = rspot

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

Results from order3

step	(1) fevd	(1) Lower	(1) Upper	(2) fevd	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	.887876	.873151	.902602	.112124	.097398	.126849
2	.887876	.873151	.902602	.112124	.097398	.126849
3	.887876	.873151	.902602	.112124	.097398	.126849
4	.887521	.872548	.902494	.112479	.097506	.127452
5	.887521	.872548	.902494	.112479	.097506	.127452

95% lower and upper bounds reported
(1) irfname = order3, impulse = rspot, and response = rfuture
(2) irfname = order3, impulse = rfuture, and response = rfuture

.

5. Determine whether changing Cholesky order from – “rspot rfuture” to “rfuture rspot” will change the results of irf, oirf, coirf, and fevd. Why? or why not?

Yes it will because, when the order of the response is changed, the effect from such shock will be varied according to the correlation of each variable.