

1. 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, maxlag(10)

```

Selection-order criteria
Sample: 12 - 7684                                Number of obs   =   7673
+-----+-----+-----+-----+-----+-----+-----+-----+
|lag |      LL      LR      df      p      FPE      AIC      HQIC      SBIC  |
+-----+-----+-----+-----+-----+-----+-----+-----+
| 0 | 76671.7                7.2e-12 -19.9843 -19.9837 -19.9825 |
| 1 | 76840.9   338.5      4 0.000 6.9e-12 -20.0274 -20.0255 -20.0219 |
| 2 | 76931.4  180.85      4 0.000 6.7e-12 -20.0499 -20.0468 -20.0408 |
| 3 | 76963.2   63.709      4 0.000 6.7e-12 -20.0571 -20.0528 -20.0445 |
| 4 | 76979.4   32.291      4 0.000 6.7e-12 -20.0603 -20.0547 -20.044  |
| 5 | 77017.6   76.544      4 0.000 6.6e-12 -20.0692 -20.0624 -20.0493 |
| 6 | 77049.6   63.872      4 0.000 6.5e-12 -20.0765 -20.0684 -20.053* |
| 7 | 77059.6   20.054      4 0.000 6.5e-12 -20.0781 -20.0688 -20.0509 |
| 8 | 77070.3   21.332      4 0.000 6.5e-12 -20.0798 -20.0693* -20.0491 |
| 9 | 77076.4   12.37*      4 0.015 6.5e-12* -20.0804* -20.0686 -20.046  |
|10 | 77080.2   7.4487      4 0.114 6.5e-12 -20.0803 -20.0673 -20.0423 |
+-----+-----+-----+-----+-----+-----+-----+-----+
Endogenous:  rspot rfuture
Exogenous:   _cons

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Based on the SBIC of the maximum lag of 10, 6 lagged term is the most appropriated lags model from the lowest SBIC.

2. Perform stability test and Granger exogeneity test.

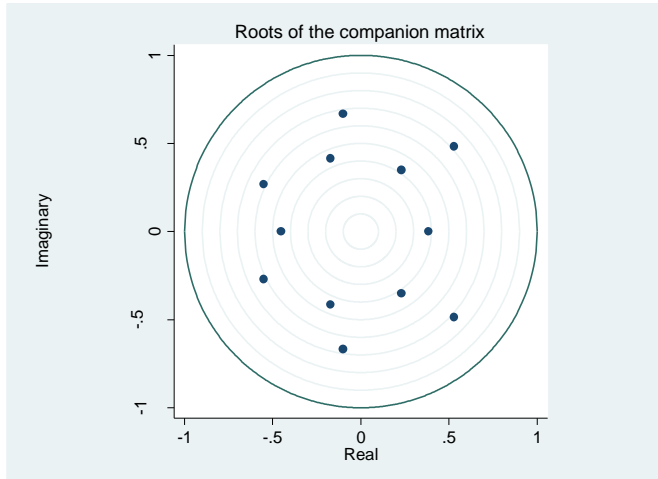
. varstable, graph

```

Eigenvalue stability condition
+-----+-----+-----+-----+
|      Eigenvalue      | Modulus |
+-----+-----+-----+-----+
| .5279554 + .4847924i | .716771 |
| .5279554 - .4847924i | .716771 |
| -.1022778 + .6675194i | .67531  |
| -.1022778 - .6675194i | .67531  |
| -.5513603 + .2689237i | .613448 |
| -.5513603 - .2689237i | .613448 |
| -.4536067              | .453607 |
| -.1726167 + .4151256i | .449584 |
| -.1726167 - .4151256i | .449584 |
| .2305361 + .3500458i  | .419141 |
| .2305361 - .3500458i  | .419141 |
| .3837855              | .383786 |
+-----+-----+-----+-----+

```

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.



All the eigenvalues lie inside the unit circle (<1). All the IRF will go to 0, therefore the system is stable (VAT stability condition is satisfied).

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. vargranger
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Granger causality Wald tests
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Equation	Excluded	chi2	df	Prob > chi2
rspot	rfuture	82.299	6	0.000
rspot	ALL	82.299	6	0.000
rfuture	rspot	148.42	6	0.000
rfuture	ALL	148.42	6	0.000

We see that the p-value results from Granger exogeneity test is equal to 0.000 (less than 0.05 significance level) in both rspot and rfuture. We rejected the null hypothesis that $H_0: a_{12} = 0$ and $a_{21} = 0$, implying that rspot cause rfuture, and at the same time rfuture cause rspot. Therefore, the result guarantees the endogeneity.

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

```
. irf create order1, order(rspot rfuture) step(6) 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 order1
```

step	(1) irf	(1) Lower	(1) Upper
0	1	1	1
1	-.042989	-.074543	-.011434
2	-.101957	-.133505	-.070409

3		-.034997	-.066566	-.003428	
4		-.02148	-.052956	.009995	
5		-.033647	-.06485	-.002443	
6		-.010717	-.041519	.020085	

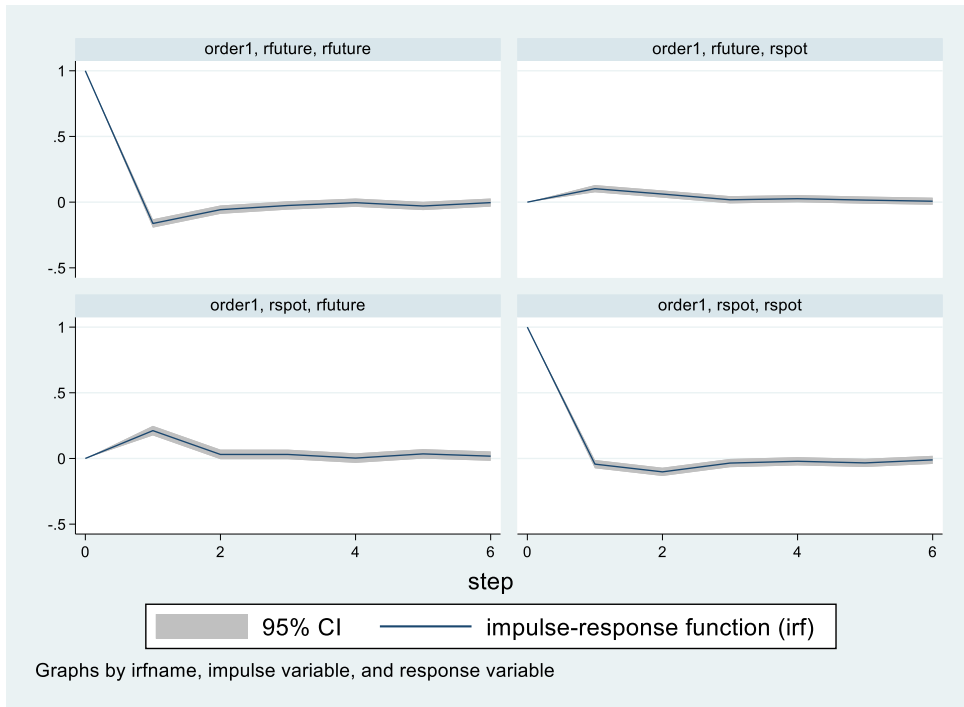
+-----+					
		(2)	(2)	(2)	
	step	irf	Lower	Upper	
+-----+					
0		0	0	0	
1		.211774	.175513	.248035	
2		.030833	-.00561	.067276	
3		.030738	-.005677	.067153	
4		.002714	-.033596	.039023	
5		.034962	-.001046	.070971	
6		.017646	-.017933	.053226	

+-----+					
		(3)	(3)	(3)	
	step	irf	Lower	Upper	
+-----+					
0		0	0	0	
1		.102511	.075055	.129966	
2		.061675	.034224	.089126	
3		.018216	-.009265	.045697	
4		.026291	-.001106	.053688	
5		.01553	-.011653	.042713	
6		.006933	-.01982	.033686	

+-----+					
		(4)	(4)	(4)	
	step	irf	Lower	Upper	
+-----+					
0		1	1	1	
1		-.162359	-.19391	-.130809	
2		-.057352	-.089063	-.025641	
3		-.025324	-.057023	.006376	
4		-.004062	-.035665	.027541	
5		-.029332	-.060699	.002035	
6		-.003566	-.034475	.027344	

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

Results from order1

step	(1) oirf	(1) Lower	(1) Upper
0	.001775	.001747	.001803
1	.000072	.000032	.000112
2	-.000092	-.000132	-.000052
3	-.000036	-.000076	4.1e-06
4	-1.8e-07	-.00004	.00004
5	-.000037	-.000077	2.5e-06
6	-9.0e-06	-.000049	.000031

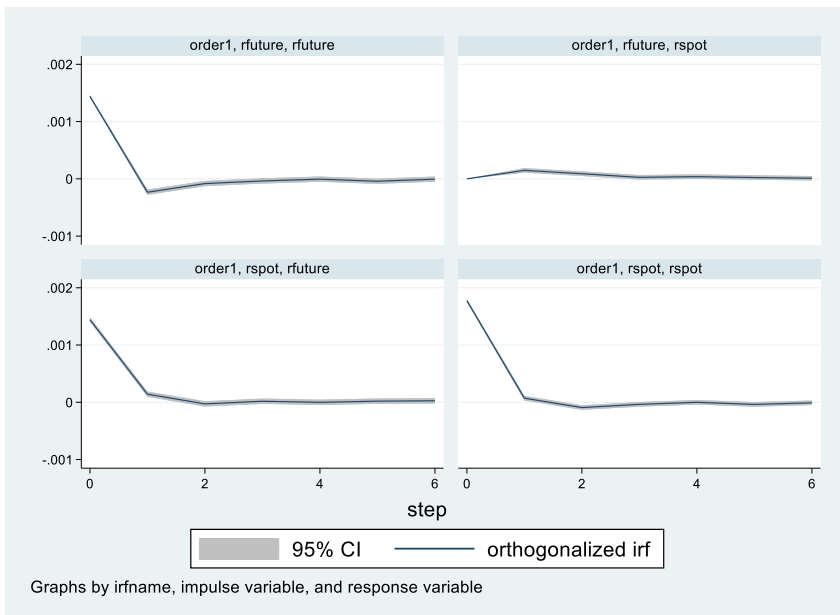
step	(2) oirf	(2) Lower	(2) Upper
0	.001444	.001404	.001483
1	.000142	.000096	.000188
2	-.000028	-.000074	.000018
3	.000018	-.000028	.000064
4	-1.0e-06	-.000047	.000045
5	.00002	-.000026	.000066
6	.000026	-.00002	.000072

step	(3) oirf	(3) Lower	(3) Upper
0	0	0	0
1	.000148	.000108	.000187
2	.000089	.000049	.000128
3	.000026	-.000013	.000066
4	.000038	-1.6e-06	.000077
5	.000022	-.000017	.000062
6	1.0e-05	-.000029	.000049

step	(4) oirf	(4) Lower	(4) Upper
0	.001441	.001419	.001464
1	-.000234	-.00028	-.000188
2	-.000083	-.000128	-.000037
3	-.000037	-.000082	9.2e-06
4	-5.9e-06	-.000051	.00004
5	-.000042	-.000087	2.9e-06
6	-5.1e-06	-.00005	.000039

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

Results from order1

step	(1) coirf	(1) Lower	(1) Upper
0	.001775	.001747	.001803
1	.001847	.001798	.001896
2	.001755	.001691	.001819
3	.001719	.001644	.001794
4	.001719	.001635	.001803
5	.001682	.001589	.001774
6	.001673	.001573	.001772

step	(2) coirf	(2) Lower	(2) Upper
0	.001444	.001404	.001483
1	.001585	.001527	.001644
2	.001557	.001484	.00163
3	.001575	.001491	.001659
4	.001574	.00148	.001668
5	.001594	.001491	.001697
6	.00162	.001509	.001731

step	(3) coirf	(3) Lower	(3) Upper
0	0	0	0
1	.000148	.000108	.000187
2	.000237	.00018	.000294
3	.000263	.000194	.000332
4	.000301	.000223	.000379
5	.000323	.000238	.000409
6	.000333	.000242	.000424

step	(4) coirf	(4) Lower	(4) Upper
0	.001441	.001419	.001464
1	.001207	.001158	.001257
2	.001125	.001059	.00119
3	.001088	.00101	.001166
4	.001082	.000995	.00117
5	.00104	.000945	.001136
6	.001035	.000934	.001136

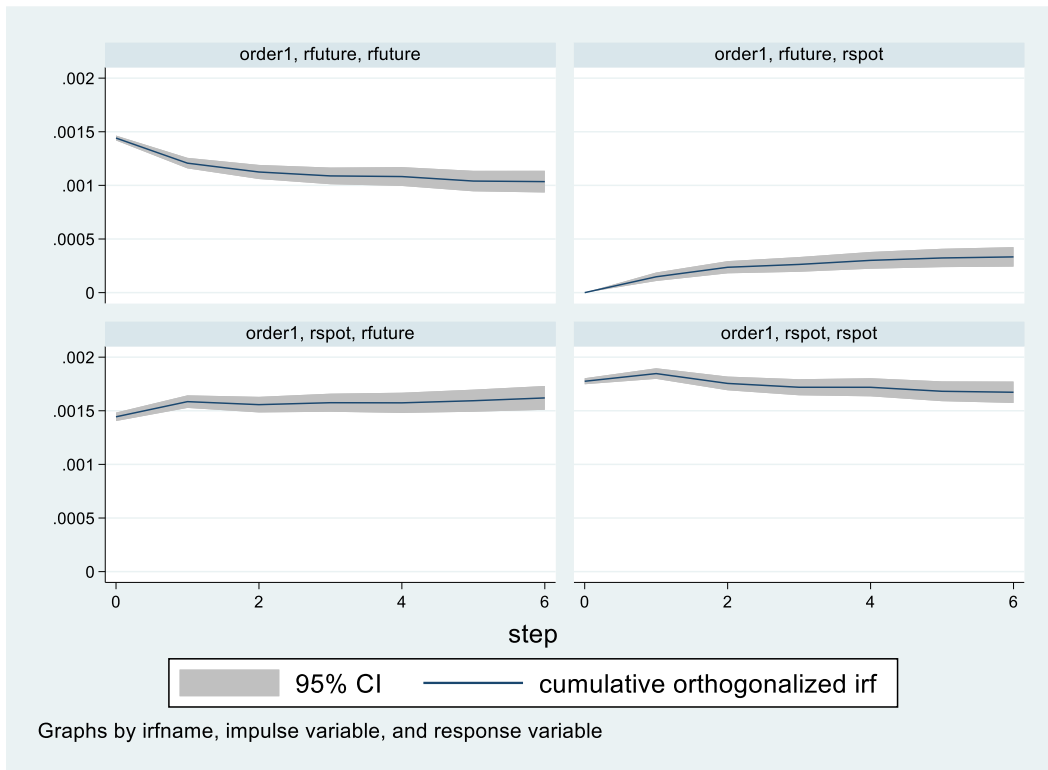
95% lower and upper bounds reported

(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 COIRF analysis, the direction of the impacts of rspot on rspot, rspot on rfuture, rfuture on rspot, rfuture on rfuture, are all positive direction.

The magnitude of rspot on rfuture are more than rspot on rspot due to the bigger, gray-shaded confidence interval area, therefore the effect of rspot on rfuture is more than the effect of rspot on rspot. The impulsive impact of all responses are significantly different from 0 since the 95% confidence interval is all positive.

The duration of the impact takes 8-9 periods to go to 0.

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

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

Results from order1

step	(1) fevd	(1) Lower	(1) Upper
0	0	0	0
1	1	1	1
2	.993131	.989465	.996798
3	.990693	.98638	.995006
4	.990483	.986145	.994821
5	.990038	.98565	.994426

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|6      | .989888   .985487   .994289   |
+-----+
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```
+-----+
|      |      (2)      (2)      (2)      |
| step | fevd   Lower   Upper   |
+-----+
|0     | 0       0         0         |
|1     | 0       0         0         |
|2     | .006869 .003202 .010535   |
|3     | .009307 .004994 .01362    |
|4     | .009517 .005179 .013855   |
|5     | .009962 .005574 .01435    |
|6     | .010112 .005711 .014513   |
+-----+
```

95% lower and upper bounds reported

- (1) irfname = order1, impulse = rspot, and response = rspot
- (2) irfname = order1, impulse = rfuture, and response = rspot

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

Results from order1

```
+-----+
|      |      (1)      (1)      (1)      |
| step | fevd   Lower   Upper   |
+-----+
|0     | 0       0         0         |
|1     | .500791 .484986 .516596   |
|2     | .496679 .480799 .512558   |
|3     | .495972 .480066 .511879   |
|4     | .495855 .479951 .511176   |
|5     | .495851 .479947 .511756   |
|6     | .495689 .479783 .511594   |
+-----+
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```
+-----+
|      |      (2)      (2)      (2)      |
| step | fevd   Lower   Upper   |
+-----+
|0     | 0       0         0         |
|1     | .499209 .483404 .515014   |
|2     | .503321 .487442 .519201   |
|3     | .504028 .488121 .519934   |
|4     | .504145 .48824  .520049   |
|5     | .504149 .488244 .520053   |
|6     | .504311 .488406 .520217   |
+-----+
```

95% lower and upper bounds reported

- (1) irfname = order1, impulse = rspot, and response = rfuture
- (2) irfname = order1, impulse = rfuture, and response = rfuture

According to FEVD, for variation of r_{spot} in 6 period, about 99% of variation in r_{spot} causes by r_{spot} itself and less than 1% cause by r_{future} .

For variation of r_{future} in 6 period, about 49% of variation on r_{future} causes by r_{spot} and about 51% causes by r_{future} itself.