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.

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

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

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

6 . 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	4774.48				1.9e-08	-12.0975	-12.093	-12.0857
1	4837.65	126.33	4	0.000	1.6e-08	-12.2475	-12.2339	-12.212
2	4857.92	40.555	4	0.000	1.6e-08	-12.2888	-12.266	-12.2296
3	4882.17	48.486*	4	0.000	1.5e-08*	-12.3401*	-12.3082*	-12.2572*
4	4884.45	4.5566	4	0.336	1.5e-08	-12.3357	-12.2948	-12.2292
5	4886.05	3.2155	4	0.522	1.5e-08	-12.3297	-12.2796	-12.1994

```
   Endogenous:  rspot rfuture
    Exogenous:  _cons
```

Ans. From the VARSOC test, it founds out that lags=3 is the most appropriated. Its BIC is the lowest, its forecastability is the best, it has significant coefficients as the LR test is significant.

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

Vector autoregression

Sample:  5 - 795                               Number of obs     =        791
Log likelihood =   4893.31                      AIC               =  -12.33707
FPE            =  1.50e-08                      HQIC              =  -12.30527
Det(Sigma_ml)  =  1.45e-08                      SBIC              =  -12.25435
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
rspot	7	.018581	0.0169	13.624	0.0341
rfuture	7	.0217	0.0338	27.62952	0.0001

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
rspot						
rspot						
L1.	.1282088	.1145511	1.12	0.263	-.0963071	.3527248
L2.	.2334538	.118681	1.97	0.049	.0008434	.4660643
L3.	-.1169759	.1100791	-1.06	0.288	-.332727	.0987753
rfuture						
L1.	-.0590319	.0980706	-0.60	0.547	-.2512466	.1331829
L2.	-.1415632	.1041653	-1.36	0.174	-.3457234	.062597
L3.	.1057702	.096238	1.10	0.272	-.0828529	.2943933
_cons	-.000025	.0006579	-0.04	0.970	-.0013144	.0012644
rfuture						
rspot						
L1.	.5741704	.1337768	4.29	0.000	.3119727	.8363682
L2.	.5086657	.1385999	3.67	0.000	.237015	.7803165
L3.	.0617779	.1285544	0.48	0.631	-.190184	.3137398
rfuture						
L1.	-.520118	.1145303	-4.54	0.000	-.7445933	-.2956428
L2.	-.4253538	.1216479	-3.50	0.000	-.6637794	-.1869283
L3.	-.0947954	.1123902	-0.84	0.399	-.3150762	.1254854
_cons	.0000732	.0007683	0.10	0.924	-.0014326	.001579

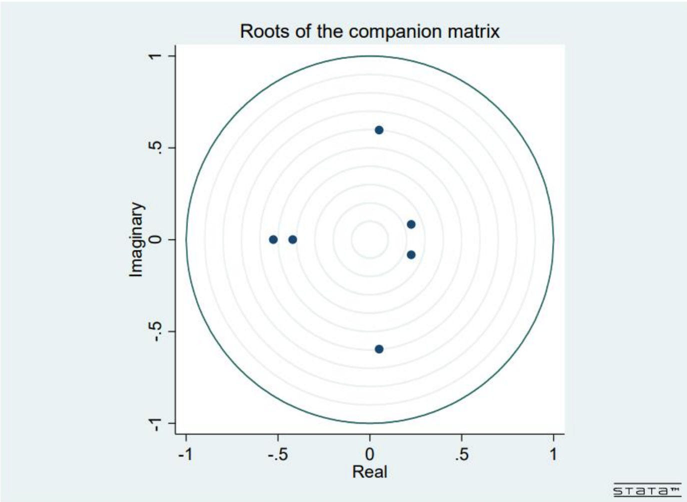
2. Perform stability test and Granger exogeneity test.

```
8 . varstable, graph

Eigenvalue stability condition
```

Eigenvalue	Modulus
.05126276 + .5960908i	.598291
.05126276 - .5960908i	.598291
-.5255917	.525592
-.4199276	.419928
.2255423 + .0823411i	.240103
.2255423 - .0823411i	.240103

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

Ans. The system is stable as all eigen values are less than one.




```
9 . vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
rspot	rfuture	4.8624	3	0.182
rspot	ALL	4.8624	3	0.182
rfuture	rspot	25.19	3	0.000
rfuture	ALL	25.19	3	0.000

Ans. We reject the null hypothesis for whether rspot cause rfuture; it actually causes. But we accept the null hypothesis for rfuture does not cause rspot. Thus, we cannot conclude that they cause each other or interdependent.

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).

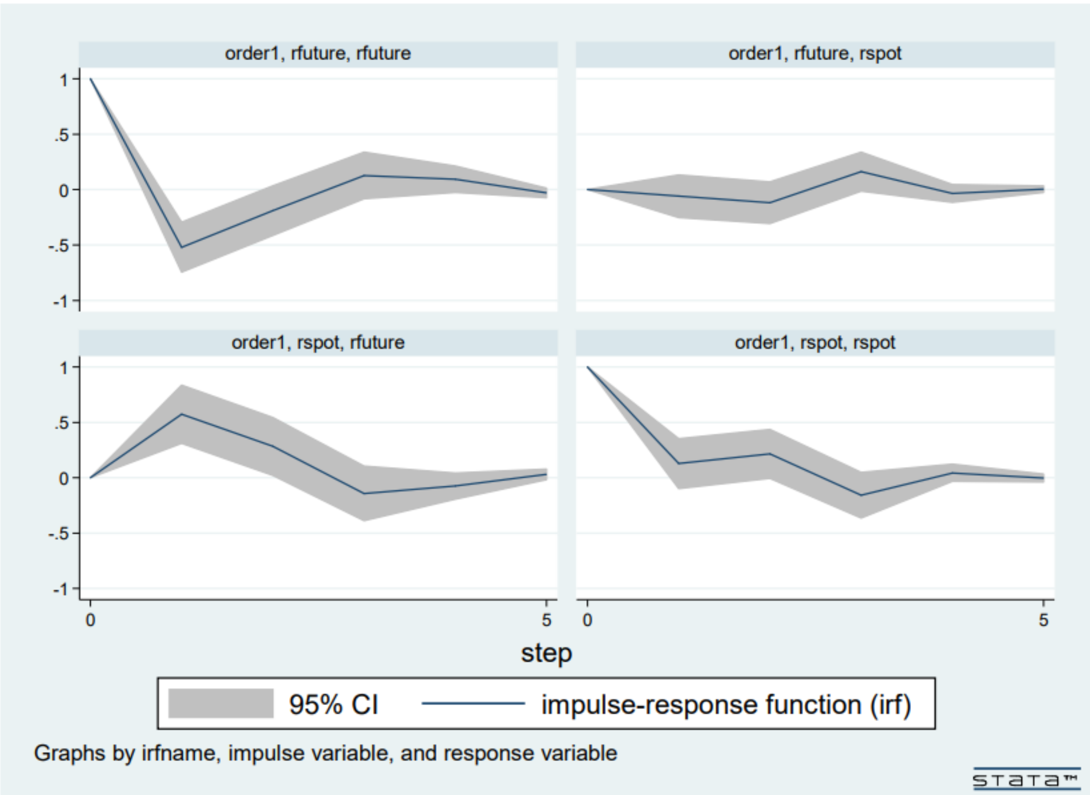
```
10 . irf create order1, order(rspot rfuture) step(5) set(sf)
   (file sf.irf created)
   (file sf.irf now active)
   (file sf.irf updated)

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

Results from order1

step	(1) irf	(1) Lower	(1) Upper	(2) irf	(2) Lower	(2) Upper
0	1	1	1	0	0	0
1	.128209	-.096307	.352725	.57417	.311973	.836368
2	.215997	-.004582	.436576	.283643	.022104	.545182
3	-.157378	-.363594	.048839	-.140741	-.388189	.106707
4	.044136	-.033389	.12166	-.074446	-.192648	.043755
5	-.002029	-.037484	.033426	.03033	-.017472	.078132

step	(3) irf	(3) Lower	(3) Upper	(4) irf	(4) Lower	(4) Upper
0	0	0	0	1	1	1
1	-.059032	-.251247	.133183	-.520118	-.744593	-.295643
2	-.118428	-.30696	.070103	-.188725	-.412415	.034964
3	.161576	-.013545	.336696	.126573	-.084013	.337158
4	-.035795	-.116425	.044835	.092632	-.027457	.212721
5	.003637	-.027138	.034412	-.029808	-.073835	.014219

```
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
```



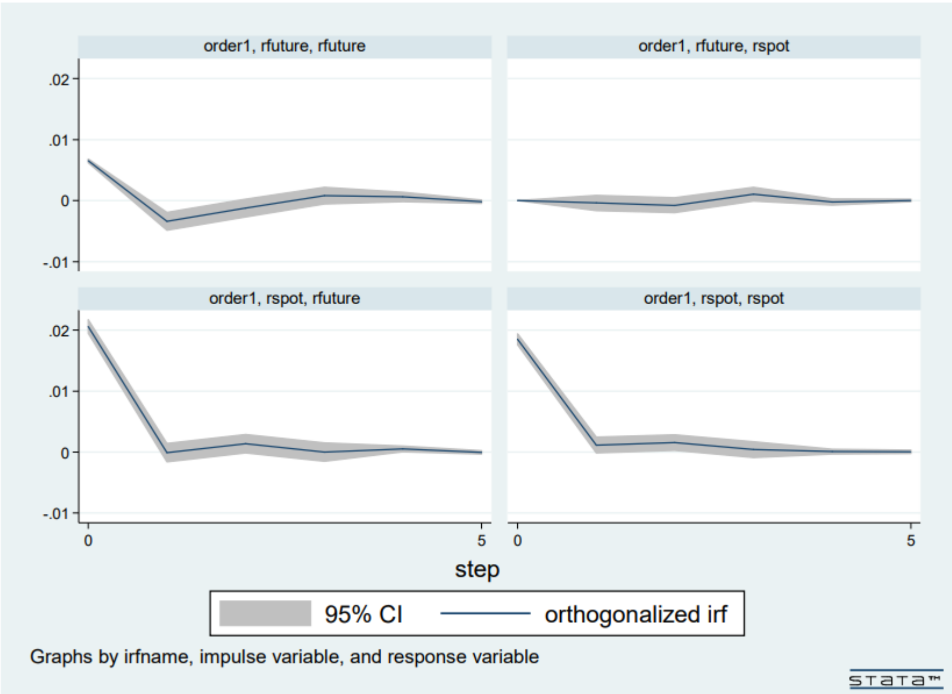
From above irf we can we see that mostly the impulse on another variable is insignificant and it does not collapse to zero; positive impact. It seems that the system is not stable.

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

                              Results from order1
```

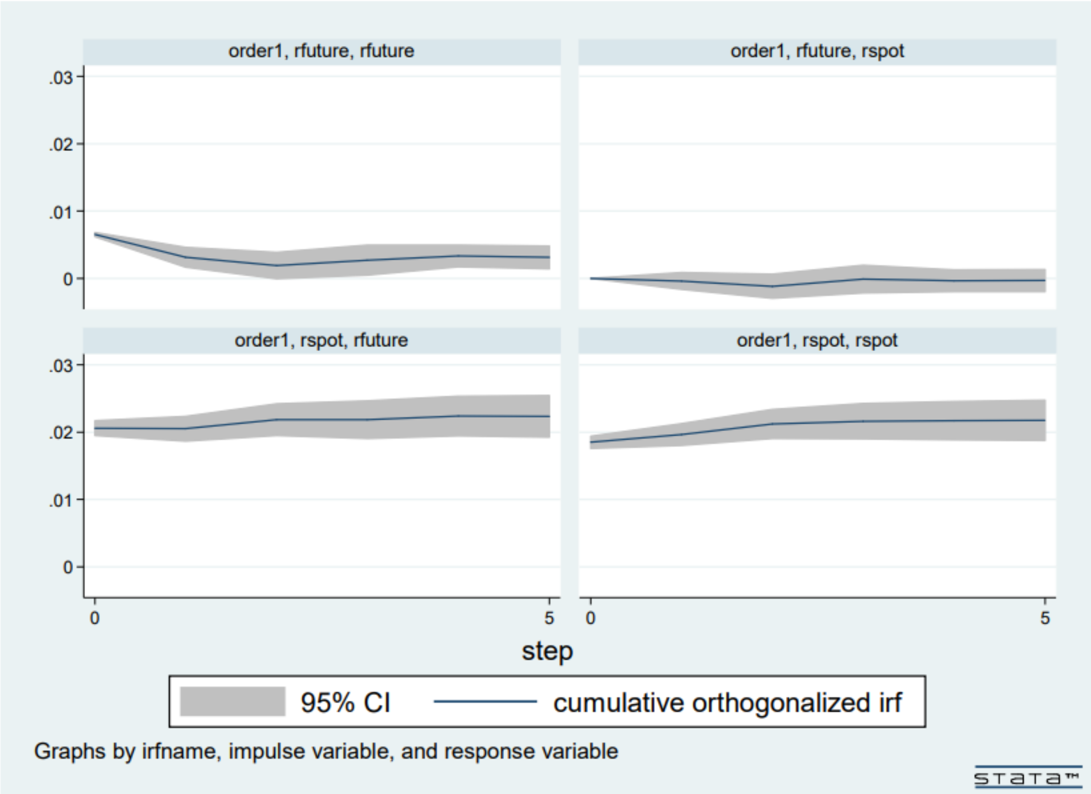
step	(1) oirf	(1) Lower	(1) Upper	(2) oirf	(2) Lower	(2) Upper
0	.018499	.017587	.019411	.020599	.019487	.021711
1	.001156	-.000134	.002445	-.000092	-.001615	.00143
2	.001556	.000268	.002844	.00136	-.000159	.002878
3	.000417	-.000872	.001706	3.7e-06	-.001515	.001522
4	.000079	-.000334	.000492	.000531	.000055	.001007
5	.000037	-.000242	.000317	-.000053	-.000327	.000222

step	(3) oirf	(3) Lower	(3) Upper	(4) oirf	(4) Lower	(4) Upper
0	0	0	0	.006512	.006191	.006833
1	-.000384	-.001636	.000867	-.003387	-.004858	-.001916
2	-.000771	-.002	.000457	-.001229	-.002687	.000229
3	.001052	-.000089	.002194	.000824	-.000548	.002196
4	-.000233	-.000758	.000292	.000603	-.000179	.001386
5	.000024	-.000177	.000224	-.000194	-.000481	.000093

```
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
```



From oirf, the impulse is still insignificant and not collapse to zero but the magnitude is smaller; positive impact. The system seems more stable.



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

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

Results from order1

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	.99957	.99677	1.00237	.00043	-.00237	.00323
3	.997858	.991698	1.00402	.002142	-.004018	.008302
4	.994684	.985216	1.00415	.005316	-.004153	.014784
5	.994529	.984823	1.00424	.005471	-.004235	.015177

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

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

Results from order1

step	(1) fevd	(1) Lower	(1) Upper	(2) fevd	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	.909133	.897058	.921209	.090867	.078791	.102942
2	.887324	.863844	.910804	.112676	.089196	.136156
3	.884973	.861047	.908899	.115027	.091101	.138953
4	.883726	.859086	.908366	.116274	.091634	.140914
5	.883128	.858185	.908071	.116872	.091929	.141815

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

When impulse of rspot rfuture on rspotr, it is insignificant.

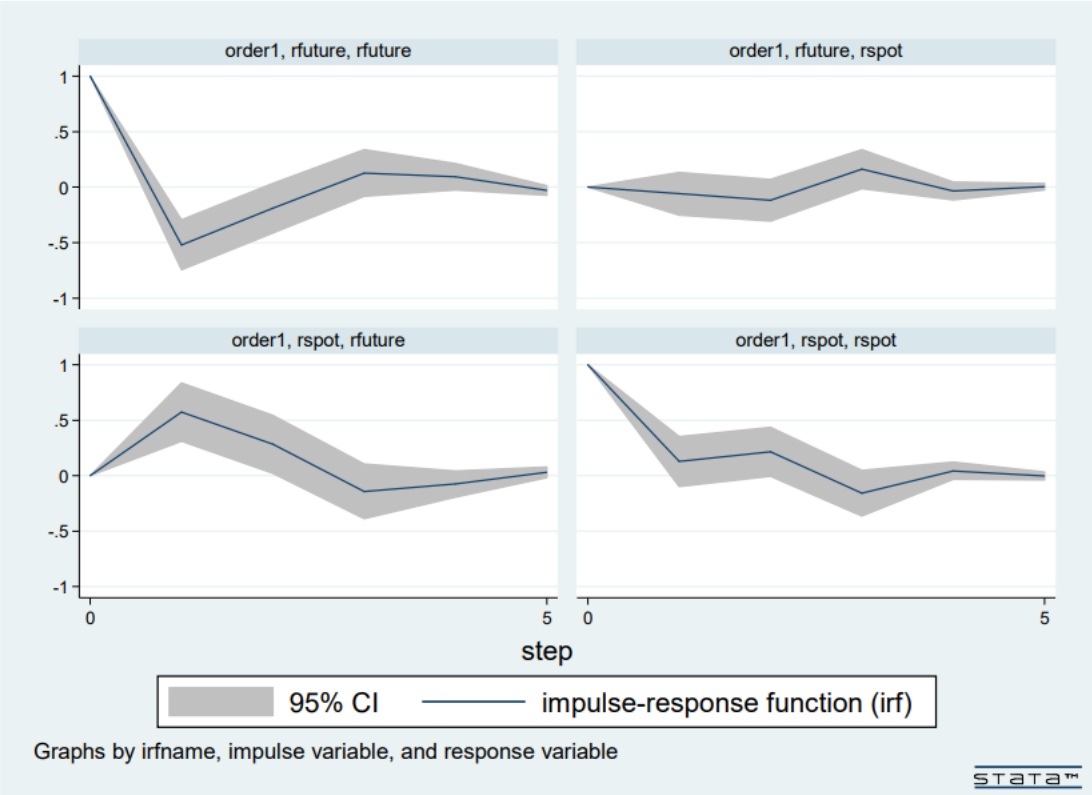
5. Determine whether changing Cholesky order from – "rspot rfuture" to "rfuture rspot" will change the results of irf, oirf, coirf, and fevd. Why? or why not?

```
   (2) irfname = order1, impulse = rfuture, and response = rfuture

15 . irf create order1, order( rfuture rspot) step(5) set(fs)
   (file fs.irf created)
   (file fs.irf now active)
   (file fs.irf updated)

16 . ird table irf, impulse(rfuture rspot) response(rfuture rspot)
   command ird is unrecognized
   r(199);

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

                              Results from order1
```

step	(1) irf	(1) Lower	(1) Upper	(2) irf	(2) Lower	(2) Upper
0	1	1	1	0	0	0
1	-.520118	-.744593	-.295643	-.059032	-.251247	.133183
2	-.188725	-.412415	.034964	-.118428	-.30696	.070103
3	.126573	-.084013	.337158	.161576	-.013545	.336696
4	.092632	-.027457	.212721	-.035795	-.116425	.044835
5	-.029808	-.073835	.014219	.003637	-.027138	.034412

step	(3) irf	(3) Lower	(3) Upper	(4) irf	(4) Lower	(4) Upper
0	0	0	0	1	1	1
1	.57417	.311973	.836368	.128209	-.096307	.352725
2	.283643	.022104	.545182	.215997	-.004582	.436576
3	-.140741	-.388189	.106707	-.157378	-.363594	.048839
4	-.074446	-.192648	.043755	.044136	-.033389	.12166
5	.03033	-.017472	.078132	-.002029	-.037484	.033426

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



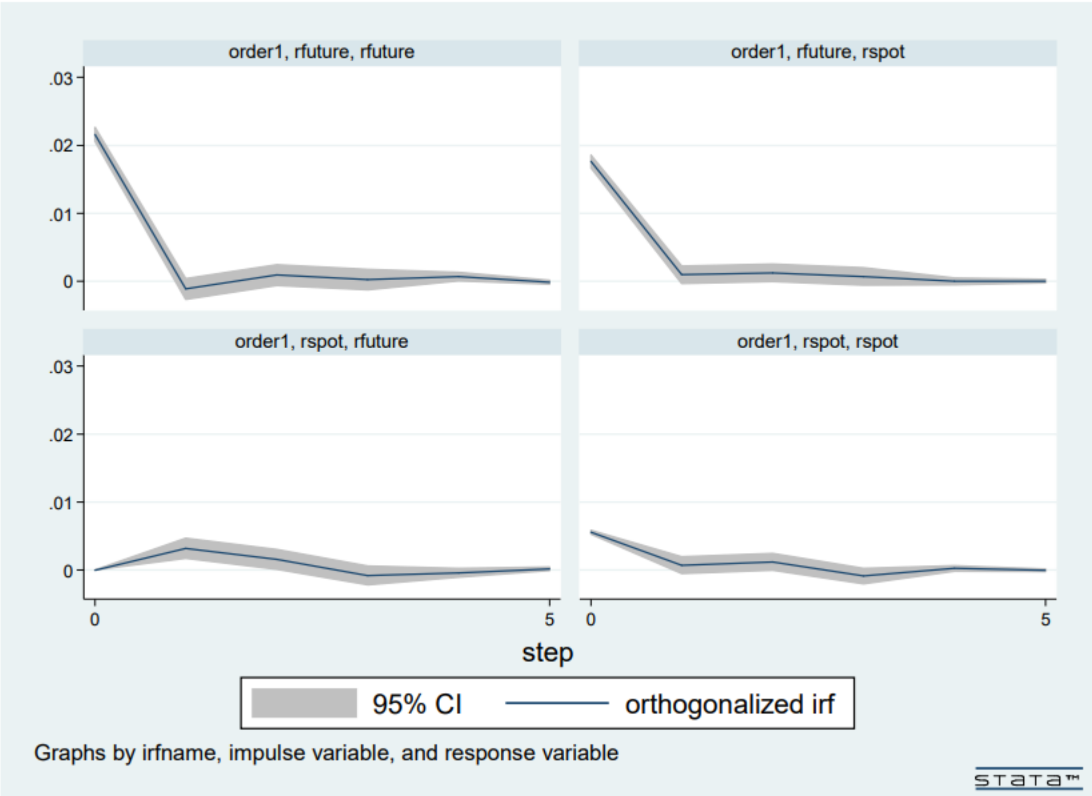

```
18 . irf table oirf, impulse(rfuture rspot) response(rfuture rspot)
```

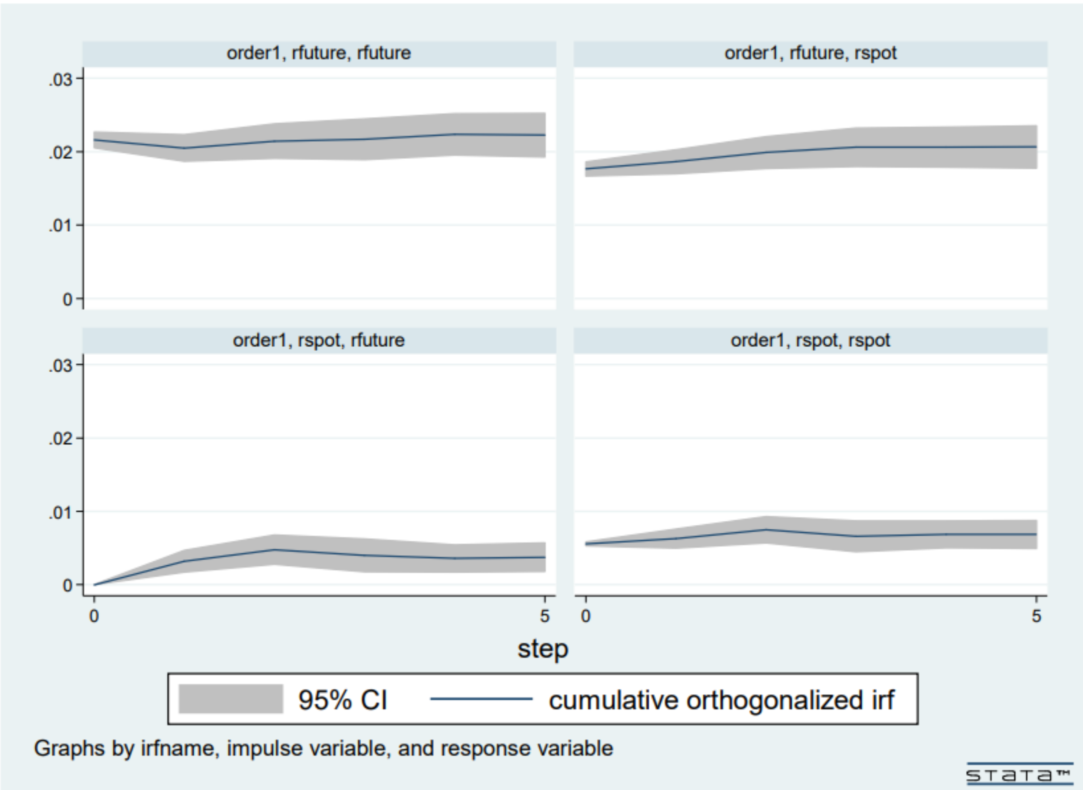
Results from order1

step	(1) oirf	(1) Lower	(1) Upper	(2) oirf	(2) Lower	(2) Upper
0	.021604	.020539	.022668	.017638	.016686	.018591
1	-.001109	-.00263	.000412	.000986	-.000304	.002276
2	.000926	-.000592	.002444	.001251	-.000035	.002538
3	.000252	-.001259	.001763	.000715	-.000566	.001995
4	.000688	.000053	.001323	5.2e-06	-.000504	.000515
5	-.000109	-.000403	.000185	.000043	-.000238	.000324

step	(3) oirf	(3) Lower	(3) Upper	(4) oirf	(4) Lower	(4) Upper
0	0	0	0	.005576	.005302	.005851
1	.003202	.001731	.004672	.000715	-.000538	.001967
2	.001582	.000121	.003042	.001204	-.000027	.002436
3	-.000785	-.002165	.000596	-.000878	-.002028	.000273
4	-.000415	-.001075	.000244	.000246	-.000186	.000679
5	.000169	-.000098	.000436	-.000011	-.000209	.000186

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

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

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


order1, rfuture, rfuture
order1, rfuture, rspot
order1, rspot, rfuture
order1, rspot, rspot
.03
.02
.01
0
0
5
step
95% CI
orthogonalized irf
Graphs by irfname, impulse variable, and response variable


order1, rfuture, rfuture
order1, rfuture, rspot
order1, rspot, rfuture
order1, rspot, rspot
.03
.02
.01
0
0
5
step
95% CI
cumulative orthogonalized irf
Graphs by irfname, impulse variable, and response variable

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

Results from order1

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	.978563	.95918	.997946	.021437	.002054	.04082
3	.973517	.952896	.994138	.026483	.005862	.047104
4	.972277	.95079	.993765	.027723	.006235	.04921
5	.971958	.950314	.993602	.028042	.006398	.049686

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

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

Results from order1

step	(1) fevd	(1) Lower	(1) Upper	(2) fevd	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	.909133	.897058	.921209	.090867	.078791	.102942
2	.908039	.894928	.921149	.091961	.078851	.105072
3	.904654	.889058	.92025	.095346	.07975	.110942
4	.902792	.886072	.919512	.097208	.080488	.113928
5	.902635	.885887	.919383	.097365	.080617	.114113

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

Ans. yes, in oirf, the result seems better as it much likely to collapse to zero. Rfuture seems to have more impact.