Quantitative Methods in Finance

Tutorial, Part 12:
Vector autoregressive models.

Example 1: Consider the following vector autoregressive model:

$$y_t = \beta_0 + \sum_{i=1}^{k} \beta_i y_{t-i} + u_t ,$$

where y_t is a $g \times 1$ vector of variables determined by k lags of all g variables in the system, u_t is a $g \times 1$ vector of disturbance terms, β_0 is a $g \times 1$ vector of constant term coefficients, and β_i are $g \times g$ matrices of coefficients on the i-th lag of y.

If $g = 3$ and $k = 2$, write out all the equations of the VAR model in full.

■

Example 2: In the data set `stockexchange.dta`, there are data on three stock exchange indices: DAX30, FTSE100, and S&P500. Those trading days that did not contain index price information for all three stock exchange indices were left out. The programming code is given in Stata Do file `stockexchange-commands.do`.

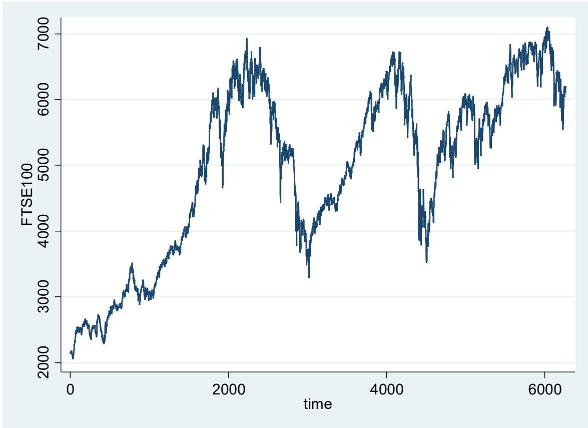
a) Inspect the three time series visually. Do they look stationary? Perform the Augmented Dickey-Fuller (ADF) test on each of the three time series.
b) Construct a set of growth rates. Check for stationarity of the newly generated time series.
c) Estimate the appropriate vector autoregressive model based on the growth rates of the three stock exchange indices.
d) Based on the estimated VAR model, perform all the appropriate diagnostics, Granger causality tests, and model interpretation.
e) Perform sensitivity analysis on the ordering of model variables by reversing the ordering.
f) Employ the estimated VAR model in order to compute dynamic forecasts of the growth rates of the three stock exchange indices for the following 8 days.
g) By choosing appropriate matrices **A** and **B** in the structural VAR (SVAR) model, reproduce the Cholesky decomposition that is regularly employed in the VAR framework to orthogonalise the (correlated) disturbance terms. In short, calculate the estimated orthogonalization matrix $\mathbf{A}^{-1}\mathbf{B}$ and show that you obtain the same values by employing the Cholesky decomposition on the variance-covariance matrix of the VAR model.
h) The SVAR model in g) was exactly (just) identified. Estimate an overidentified short-run SVAR model by imposing the restriction that the growth rate of FTSE100 does not affect the growth rate of S&P500 contemporaneously (i.e. $\mathbf{A}_{3,2} = 0$), only with lags.
i) Following the recursive logic from point g), estimate an overidentified long-run SVAR model by imposing the restriction that the long-run response of the growth rate of SP500 to a shock to (the equation for) the growth rate of FTSE100 is zero (i.e. $\mathbf{C}_{3,2} = 0$).

Computer printout of the results in Stata:

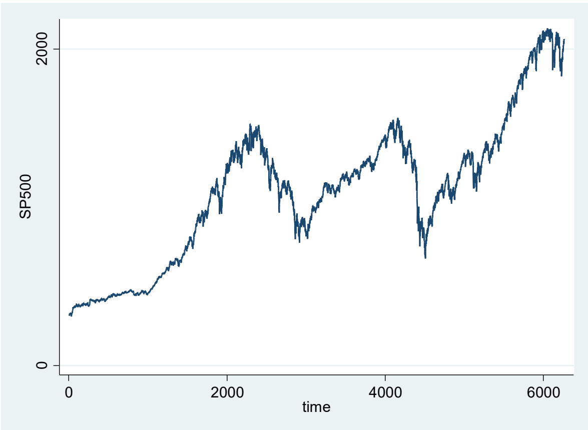
```
Testing for stationarity and generating stationary variables

. generate time=_n
. tsset time
        time variable:  time, 1 to 6262
                delta:  1 unit
```

`. twoway line DAX30 time`

`. twoway line FTSE100 time`



`. twoway line SP500 time`




```
. dfuller DAX30

Dickey-Fuller test for unit root                   Number of obs   =      6261

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value            Value
------------------------------------------------------------------------------
 Z(t)             -0.947            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7720

. dfuller FTSE100

Dickey-Fuller test for unit root                   Number of obs   =      6261
```

```
                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.241            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1918

. dfuller SP500

Dickey-Fuller test for unit root                   Number of obs   =      6261

                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.852            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8034

. generate rDAX30=DAX30/L.DAX30
(1 missing value generated)

. generate rFTSE100=FTSE100/L.FTSE100
(1 missing value generated)

. generate rSP500=SP500/L.SP500
(1 missing value generated)

. dfuller rDAX30

Dickey-Fuller test for unit root                   Number of obs   =      6260

                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -79.615            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

. dfuller rFTSE100

Dickey-Fuller test for unit root                   Number of obs   =      6260

                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -80.180            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

. dfuller rSP500

Dickey-Fuller test for unit root                   Number of obs   =      6260

                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -83.916            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Estimating a VAR model

. varsoc rDAX30 rFTSE100 rSP500, maxlag(10)

```
   Selection-order criteria
   Sample:  12 - 6262                            Number of obs      =      6251
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  59679.5                      1.0e-12  -19.0934  -19.0923  -19.0902  |
  |  1 |    60341  1322.9    9  0.000  8.3e-13  -19.3022  -19.2977  -19.2892  |
  |  2 |  60392.6  103.29    9  0.000  8.2e-13  -19.3158   -19.308  -19.2932* |
  |  3 |  60422.7  60.082    9  0.000  8.1e-13  -19.3226  -19.3114* -19.2902  |
  |  4 |  60428.4  11.352    9  0.252  8.2e-13  -19.3215  -19.3069  -19.2794  |
  |  5 |  60453.4  50.187    9  0.000  8.1e-13  -19.3267  -19.3087  -19.2749  |
  |  6 |    60463  19.003    9  0.025  8.1e-13  -19.3268  -19.3055  -19.2653  |
  |  7 |  60476.5  27.051    9  0.001  8.1e-13* -19.3283* -19.3036  -19.2571  |
  |  8 |  60482.5  12.017    9  0.212  8.1e-13  -19.3273  -19.2993  -19.2464  |
  |  9 |  60486.9  8.9106    9  0.446  8.1e-13  -19.3258  -19.2945  -19.2353  |
  | 10 |  60496.5  19.039*   9  0.025  8.1e-13   -19.326  -19.2913  -19.2257  |
  +---------------------------------------------------------------------------+
   Endogenous:  rDAX30 rFTSE100 rSP500
    Exogenous:  _cons
```

. var rDAX30 rFTSE100 rSP500, lags(1/3)

```
Vector autoregression

Sample:  5 - 6262                                  No. of obs      =      6258
Log likelihood =  60493.06                         AIC             = -19.32344
FPE            =  8.14e-13                         HQIC            = -19.31224
Det(Sigma_ml)  =  8.06e-13                         SBIC            = -19.29113

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
rDAX30               10     .014051   0.0728   491.5445   0.0000
rFTSE100             10     .010649   0.1224   872.4073   0.0000
rSP500               10     .011476   0.0064   40.60215   0.0000
----------------------------------------------------------------
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rDAX30       |
      rDAX30 |
         L1. |  -.1464566   .0197743    -7.41   0.000    -.1852136   -.1076996
         L2. |  -.0475436   .0199284    -2.39   0.017    -.0866026   -.0084846
         L3. |  -.0437496   .0197713    -2.21   0.027    -.0825007   -.0049986
             |
    rFTSE100 |
         L1. |  -.1095166   .0255905    -4.28   0.000    -.1596731   -.0593602
         L2. |  -.0533342   .0257767    -2.07   0.039    -.1038556   -.0028128
         L3. |  -.0210292   .0247012    -0.85   0.395    -.0694426    .0273843
             |
      rSP500 |
         L1. |   .4294045   .0197804    21.71   0.000     .3906357    .4681733
         L2. |   .1090047   .0219026     4.98   0.000     .0660764     .151933
         L3. |   .0897897   .0209804     4.28   0.000     .0486689    .1309106
             |
       _cons |   .7937616   .0312191    25.43   0.000     .7325733    .8549499
-------------+----------------------------------------------------------------
rFTSE100     |
      rDAX30 |
         L1. |  -.0738281   .0149872    -4.93   0.000    -.1032025   -.0444537
         L2. |  -.0497505    .015104    -3.29   0.001    -.0793538   -.0201472
         L3. |  -.0173996   .0149849    -1.16   0.246    -.0467695    .0119703
```

```
             |
    rFTSE100 |
         L1. |  -.1937018   .0193953    -9.99   0.000     -.231716   -.1556877
         L2. |  -.0675766   .0195365    -3.46   0.001    -.1058674   -.0292858
         L3. |  -.0647442   .0187213    -3.46   0.001    -.1014373    -.028051
             |
      rSP500 |
         L1. |   .4247581   .0149918    28.33   0.000     .3953748    .4541414
         L2. |   .1064824   .0166003     6.41   0.000     .0739465    .1390183
         L3. |   .0748367   .0159013     4.71   0.000     .0436707    .1060027
             |
       _cons |   .8610715   .0236613    36.39   0.000     .8146962    .9074469
-------------+----------------------------------------------------------------
rSP500       |
      rDAX30 |
         L1. |   .0257694   .0161512     1.60   0.111    -.0058864    .0574252
         L2. |    .004467    .016277     0.27   0.784    -.0274354    .0363694
         L3. |  -.0077052   .0161487    -0.48   0.633    -.0393561    .0239457
             |
    rFTSE100 |
         L1. |  -.0161221   .0209017    -0.77   0.441    -.0570886    .0248445
         L2. |  -.0176055   .0210538    -0.84   0.403    -.0588701    .0236592
         L3. |   .0057493   .0201753     0.28   0.776    -.0337937    .0452922
             |
      rSP500 |
         L1. |   -.071862   .0161561    -4.45   0.000    -.1035274   -.0401966
         L2. |  -.0457346   .0178895    -2.56   0.011    -.0807974   -.0106718
         L3. |   .0061645   .0171363     0.36   0.719     -.027422    .0397511
             |
       _cons |   1.117282    .025499    43.82   0.000     1.067305     1.16726
------------------------------------------------------------------------------
```

VAR model diagnostics and Granger causality tests

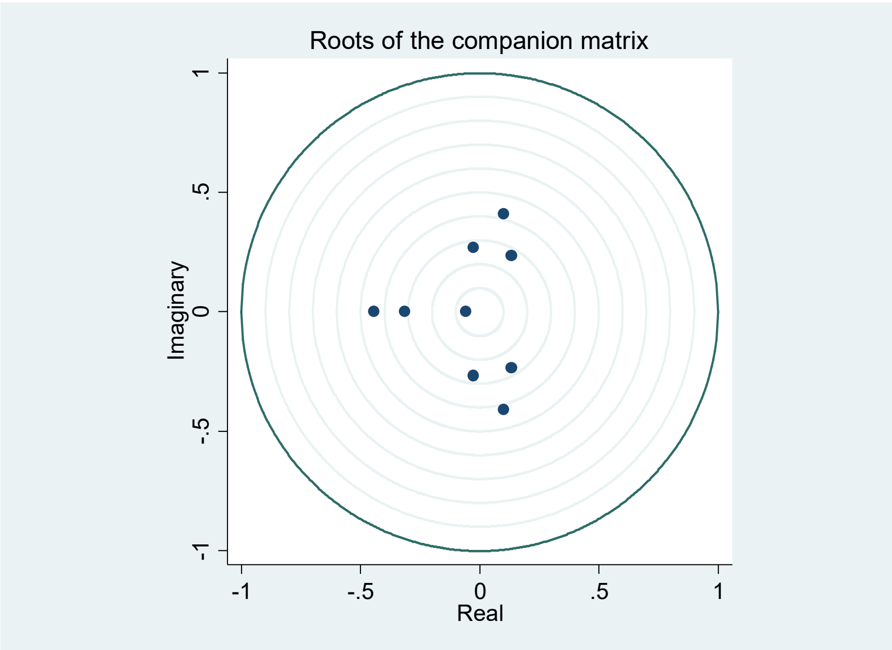
. varwle

```
   Equation: rDAX30
  +--------------------------------------+
  | lag |    chi2      df  Prob > chi2 |
  |-----+--------------------------------|
  |   1 |  472.3495     3     0.000    |
  |   2 |  29.83905     3     0.000    |
  |   3 |  20.44017     3     0.000    |
  +--------------------------------------+

   Equation: rFTSE100
  +--------------------------------------+
  | lag |    chi2      df  Prob > chi2 |
  |-----+--------------------------------|
  |   1 |  818.0678     3     0.000    |
  |   2 |  60.34163     3     0.000    |
  |   3 |  35.28578     3     0.000    |
  +--------------------------------------+

   Equation: rSP500
  +--------------------------------------+
  | lag |    chi2      df  Prob > chi2 |
  |-----+--------------------------------|
  |   1 |  26.47035     3     0.000    |
  |   2 |  15.82732     3     0.001    |
  |   3 |  .2906968     3     0.962    |
  +--------------------------------------+
```

```
  Equation: All
 +-------------------------------------+
 | lag |     chi2       df  Prob > chi2 |
 |-----+-------------------------------|
 |   1 |  1579.707      9      0.000    |
 |   2 |  129.4776      9      0.000    |
 |   3 |  60.68804      9      0.000    |
 +-------------------------------------+
```

```
. varstable, graph
```

```
  Eigenvalue stability condition
 +----------------------------------------+
 |        Eigenvalue         |   Modulus   |
 |---------------------------+-------------|
 |  -.4451482                |   .445148   |
 |  .09963105 +  .4097661i   |   .421704   |
 |  .09963105 -  .4097661i   |   .421704   |
 |  -.3150297                |    .31503   |
 | -.02736248 +    .26788i   |   .269274   |
 | -.02736248 -    .26788i   |   .269274   |
 |   .1309877 +   .234633i   |    .26872   |
 |   .1309877 -   .234633i   |    .26872   |
 | -.05835511                |   .058355   |
 +----------------------------------------+
  All the eigenvalues lie inside the unit circle.
  VAR satisfies stability condition.
```



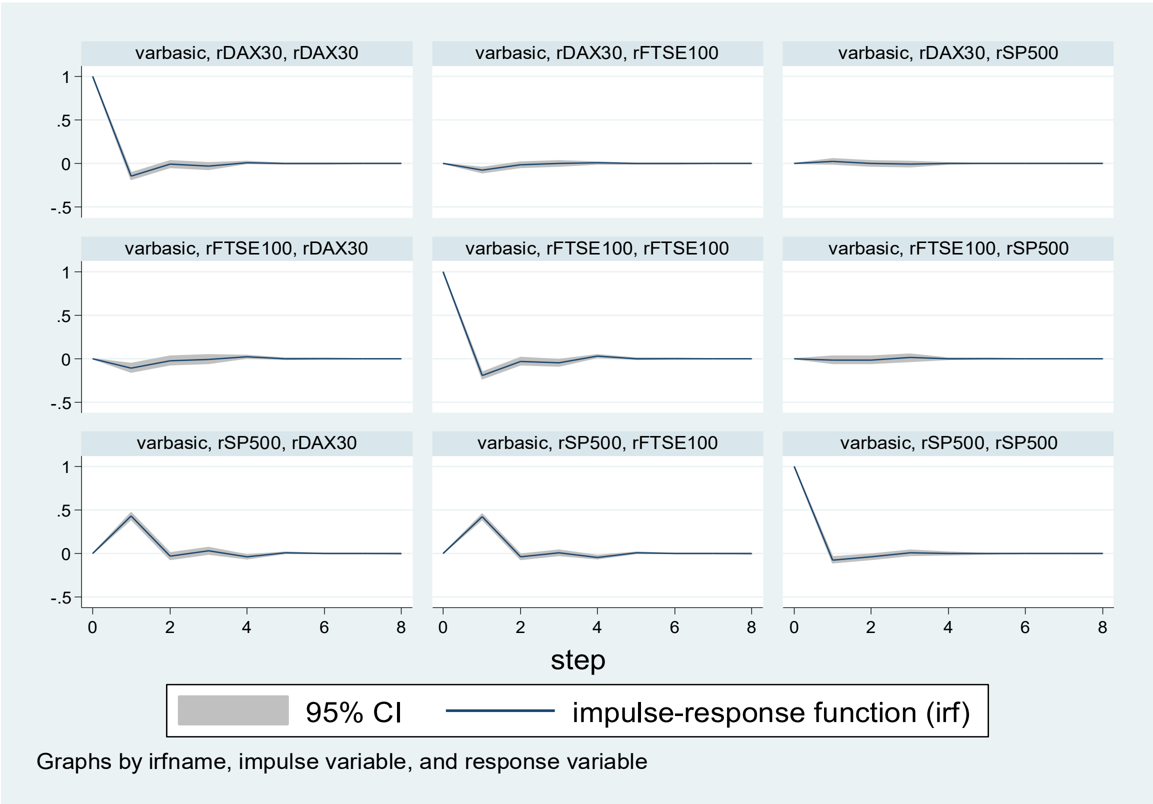

```
. varlmar
```

```
  Lagrange-multiplier test
 +--------------------------------------+
 | lag  |       chi2     df    Prob > chi2 |
 |------+-------------------------------|
 |   1  |     6.9372      9      0.64366   |
 |   2  |    16.6934      9      0.05374   |
 +--------------------------------------+
  H0: no autocorrelation at lag order
```

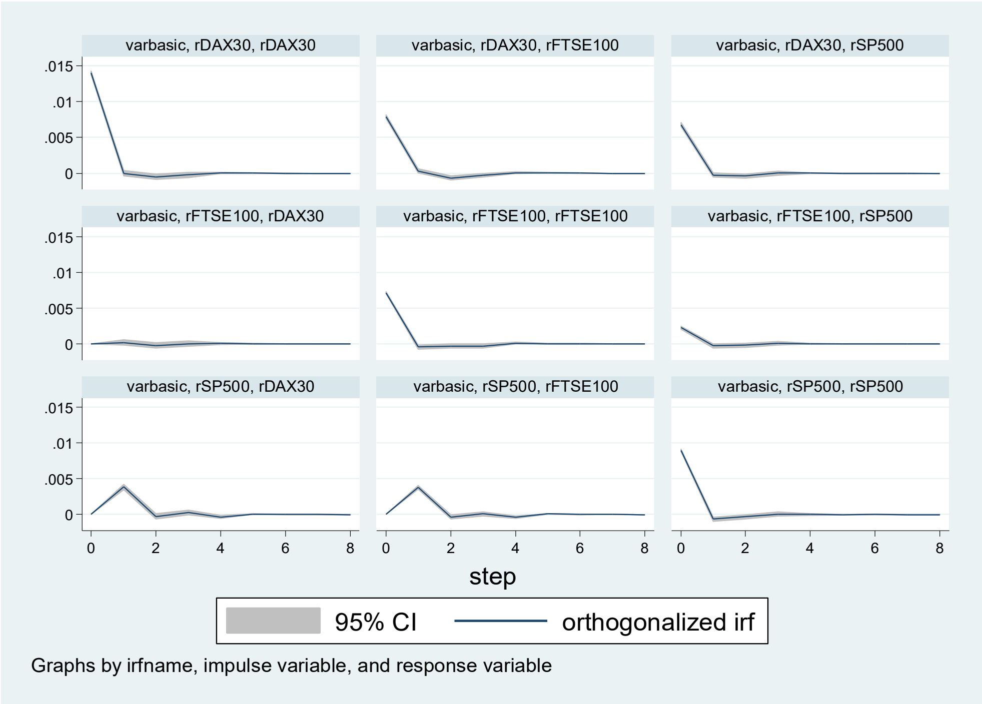
```
. vargranger

  Granger causality Wald tests
 +------------------------------------------------------------------+
 |          Equation           Excluded |   chi2     df Prob > chi2 |
 |--------------------------------------+---------------------------|
 |            rDAX30           rFTSE100 |  20.911     3    0.000    |
 |            rDAX30             rSP500 |  482.09     3    0.000    |
 |            rDAX30                ALL |  483.18     6    0.000    |
 |--------------------------------------+---------------------------|
 |          rFTSE100             rDAX30 |  33.114     3    0.000    |
 |          rFTSE100             rSP500 |  815.65     3    0.000    |
 |          rFTSE100                ALL |  833.48     6    0.000    |
 |--------------------------------------+---------------------------|
 |            rSP500             rDAX30 |  2.8103     3    0.422    |
 |            rSP500           rFTSE100 |  1.3015     3    0.729    |
 |            rSP500                ALL |  3.7582     6    0.709    |
 +------------------------------------------------------------------+
```

Model interpretation (IRFs, OIRFs and FEVDs)

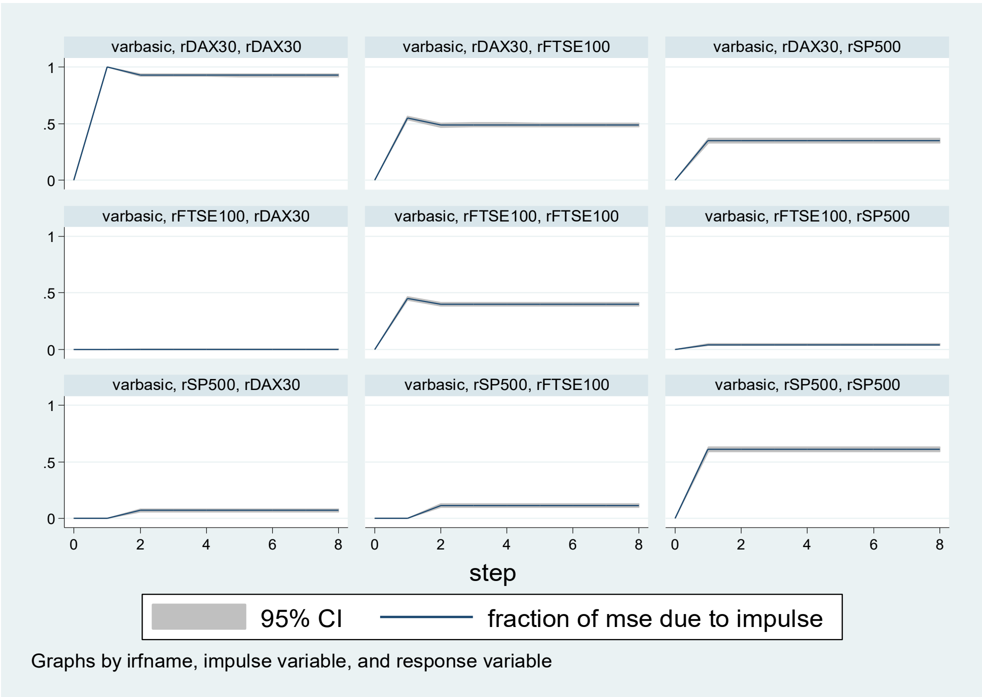
```
. varbasic rDAX30 rFTSE100 rSP500, lags(1/3) irf
```



```
. varbasic rDAX30 rFTSE100 rSP500, lags(1/3)
```



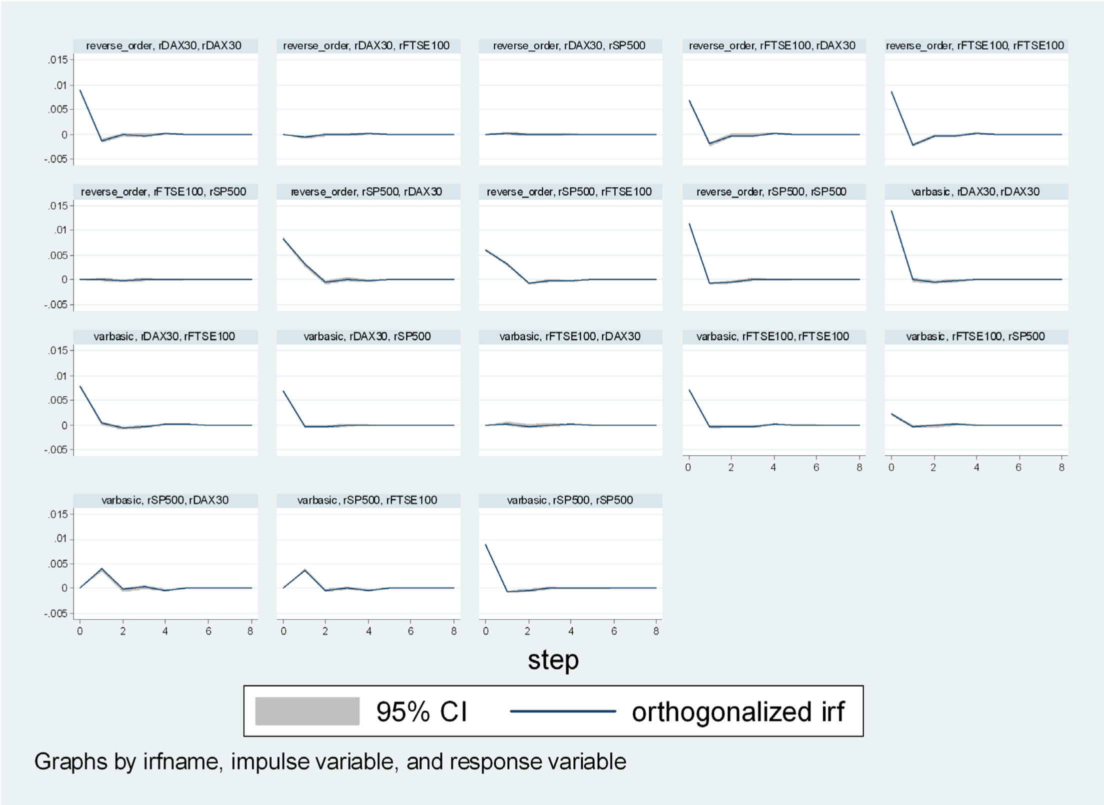

```
. varbasic rDAX30 rFTSE100 rSP500, lags(1/3) fevd
```



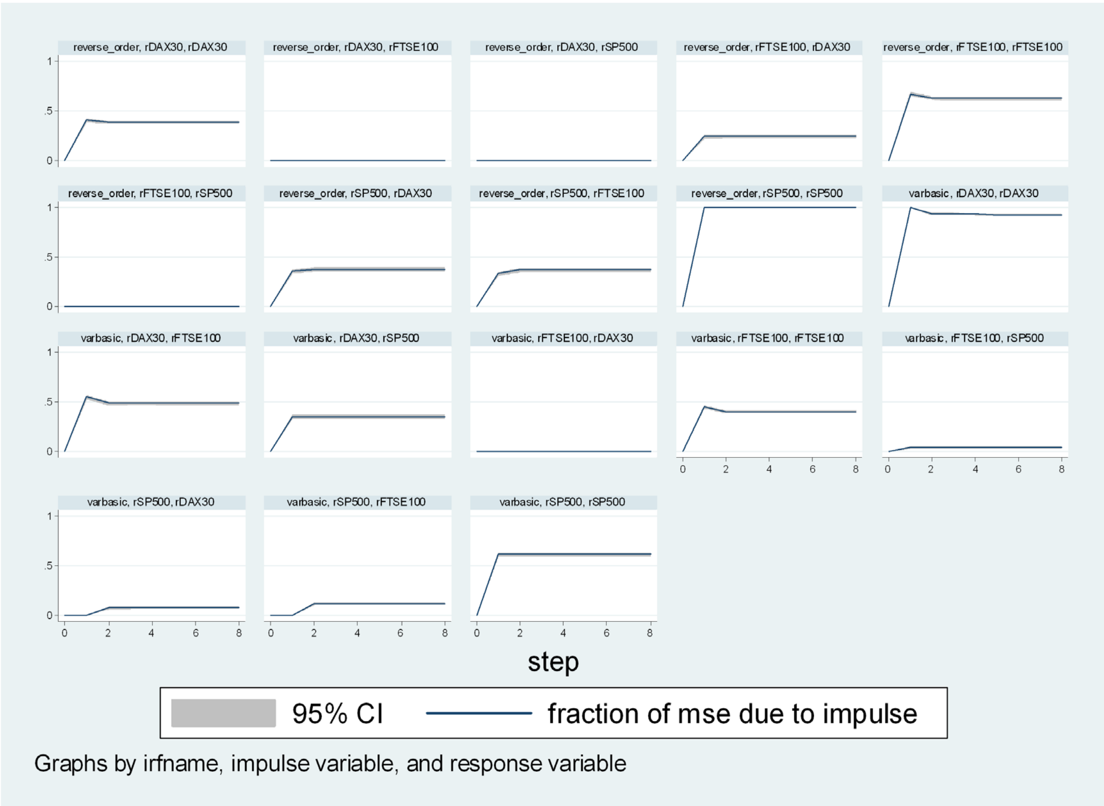
Sensitivity analysis: Changing the ordering of variables

```
. irf create reverse_order, replace order(rSP500 rFTSE100 rDAX30)
irfname reverse_order not found in _varbasic.irf
(file _varbasic.irf updated)
```

```
. irf graph oirf
```

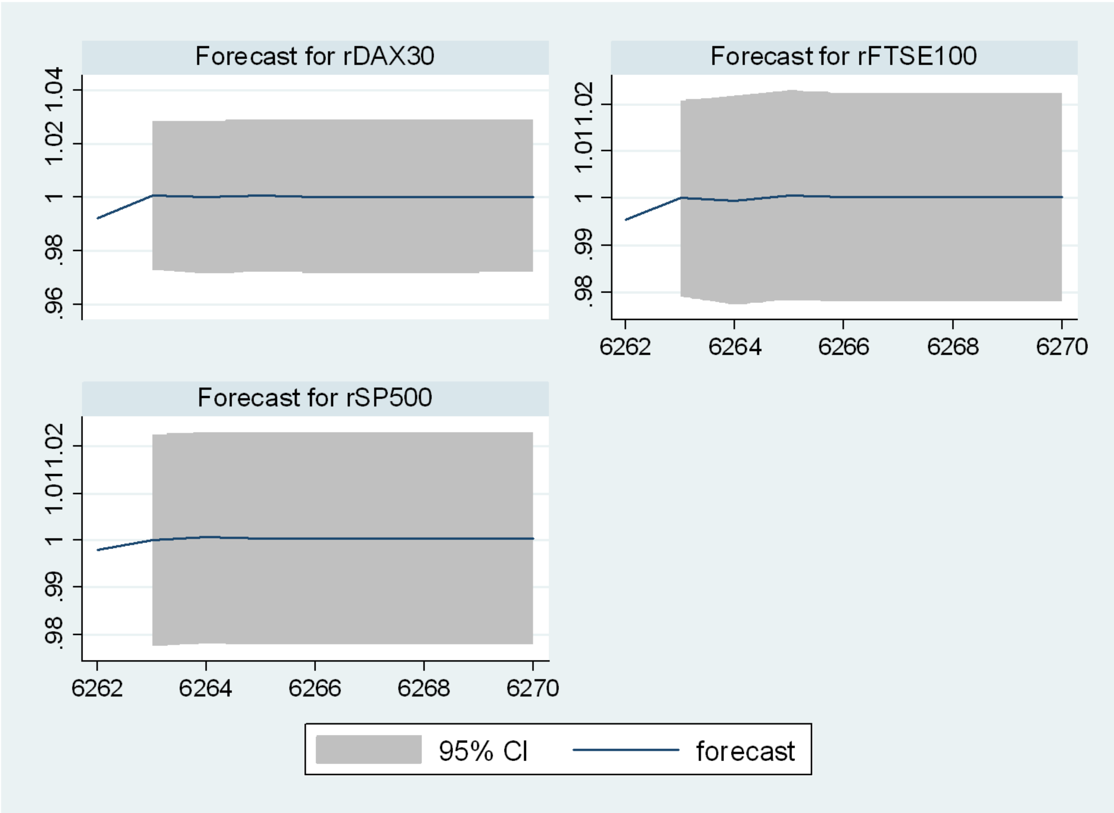



```
. irf graph fevd
```



Forecasting based on VAR(3) for the next 8 time periods (days)

```
. qui var rDAX30 rFTSE100 rSP500, lags(1/3)

. fcast compute f_, step(8)
. fcast graph f_rDAX30 f_rFTSE100 f_rSP500
```



Reproducing the Cholesky decomposition in a short-run SVAR model

```
. matrix A=(1,0,0\.,1,0\.,.,1)
. matrix B=(.,0,0\0,.,0\0,0,.)

. matrix list A

A[3,3]
    c1  c2  c3
r1   1   0   0
r2   .   1   0
r3   .   .   1

. matrix list B

symmetric B[3,3]
    c1  c2  c3
r1   .
r2   0   .
r3   0   0   .

. svar rDAX30 rFTSE100 rSP500, lags(1/3) aeq(A) beq(B)
Estimating short-run parameters

Iteration 0:   log likelihood = -19708.556
Iteration 1:   log likelihood =  31170.466
```

```
Iteration 2:   log likelihood =  44871.694
Iteration 3:   log likelihood =  51596.374
Iteration 4:   log likelihood =  56993.194
Iteration 5:   log likelihood =  60066.687
Iteration 6:   log likelihood =  60474.684
Iteration 7:   log likelihood =  60493.043
Iteration 8:   log likelihood =  60493.057
Iteration 9:   log likelihood =  60493.057

Structural vector autoregression

 ( 1)  [a_1_1]_cons = 1
 ( 2)  [a_1_2]_cons = 0
 ( 3)  [a_1_3]_cons = 0
 ( 4)  [a_2_2]_cons = 1
 ( 5)  [a_2_3]_cons = 0
 ( 6)  [a_3_3]_cons = 1
 ( 7)  [b_1_2]_cons = 0
 ( 8)  [b_1_3]_cons = 0
 ( 9)  [b_2_1]_cons = 0
 (10)  [b_2_3]_cons = 0
 (11)  [b_3_1]_cons = 0
 (12)  [b_3_2]_cons = 0

Sample:  5 - 6262                               Number of obs     =      6,258
Exactly identified model                        Log likelihood    =   60493.06

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /a_1_1 |          1  (constrained)
      /a_2_1 |  -.5622149   .0064251   -87.50   0.000     -.574808   -.5496219
      /a_3_1 |  -.3043617   .0120314   -25.30   0.000    -.3279428   -.2807806
      /a_1_2 |          0  (constrained)
      /a_2_2 |          1  (constrained)
      /a_3_2 |  -.3182253   .0158744   -20.05   0.000    -.3493385   -.2871121
      /a_1_3 |          0  (constrained)
      /a_2_3 |          0  (constrained)
      /a_3_3 |          1  (constrained)
-------------+----------------------------------------------------------------
      /b_1_1 |   .0140395   .0001255   111.87   0.000     .0137936    .0142855
      /b_2_1 |          0  (constrained)
      /b_3_1 |          0  (constrained)
      /b_1_2 |          0  (constrained)
      /b_2_2 |    .007136   .0000638   111.87   0.000      .007011     .007261
      /b_3_2 |          0  (constrained)
      /b_1_3 |          0  (constrained)
      /b_2_3 |          0  (constrained)
      /b_3_3 |   .0089612   .0000801   111.87   0.000     .0088042    .0091182
------------------------------------------------------------------------------
```

. matrix Aest=e(A)
. matrix Best=e(B)

. matrix list Aest

```
Aest[3,3]
             rDAX30    rFTSE100      rSP500
  rDAX30          1           0           0
rFTSE100  -.56221492          1           0
  rSP500  -.30436171  -.31822526           1
```

```
. matrix list Best

symmetric Best[3,3]
             rDAX30   rFTSE100     rSP500
  rDAX30  .01403954
rFTSE100          0  .00713597
  rSP500          0          0  .00896123

. matrix ortmat_est=inv(Aest)*Best
. matrix list ortmat_est

ortmat_est[3,3]
             rDAX30   rFTSE100     rSP500
  rDAX30  .01403954          0          0
rFTSE100  .00789324  .00713597          0
  rSP500  .00678493  .00227085  .00896123

. qui var rDAX30 rFTSE100 rSP500, lags(1/3)
. matrix sig_var=e(Sigma)

. matrix ortmat_var=cholesky(sig_var)
. matrix list ortmat_var

ortmat_var[3,3]
             rDAX30   rFTSE100     rSP500
  rDAX30  .01403954          0          0
rFTSE100  .00789324  .00713597          0
  rSP500  .00678493  .00227085  .00896123
```

Short-run overidentified SVAR model

```
. matrix A=(1,0,0\.,1,0\.,0,1)
. matrix B=(.,0,0\0,.,0\0,0,.)

. matrix list A

A[3,3]
    c1  c2  c3
r1   1   0   0
r2   .   1   0
r3   .   0   1

. matrix list B

symmetric B[3,3]
    c1  c2  c3
r1   .
r2   0   .
r3   0   0   .

. svar rDAX30 rFTSE100 rSP500, lags(1/3) aeq(A) beq(B)
Estimating short-run parameters

Iteration 0:   log likelihood = -19707.394
Iteration 1:   log likelihood =  31491.505
Iteration 2:   log likelihood =  45977.397
Iteration 3:   log likelihood =  52920.253
Iteration 4:   log likelihood =  55493.852
Iteration 5:   log likelihood =  58854.138
Iteration 6:   log likelihood =  60284.729
Iteration 7:   log likelihood =  60298.307
Iteration 8:   log likelihood =  60298.314
Iteration 9:   log likelihood =  60298.314
```

```
Structural vector autoregression

 ( 1)  [a_1_1]_cons = 1
 ( 2)  [a_1_2]_cons = 0
 ( 3)  [a_1_3]_cons = 0
 ( 4)  [a_2_2]_cons = 1
 ( 5)  [a_2_3]_cons = 0
 ( 6)  [a_3_2]_cons = 0
 ( 7)  [a_3_3]_cons = 1
 ( 8)  [b_1_2]_cons = 0
 ( 9)  [b_1_3]_cons = 0
 (10)  [b_2_1]_cons = 0
 (11)  [b_2_3]_cons = 0
 (12)  [b_3_1]_cons = 0
 (13)  [b_3_2]_cons = 0

Sample:  5 - 6262                               Number of obs     =      6,258
Overidentified model                            Log likelihood    =   60298.31

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /a_1_1 |          1  (constrained)
      /a_2_1 |  -.5622149   .0064251   -87.50   0.000     -.574808   -.5496219
      /a_3_1 |  -.4832727   .0083236   -58.06   0.000    -.4995867   -.4669587
      /a_1_2 |          0  (constrained)
      /a_2_2 |          1  (constrained)
      /a_3_2 |          0  (constrained)
      /a_1_3 |          0  (constrained)
      /a_2_3 |          0  (constrained)
      /a_3_3 |          1  (constrained)
-------------+----------------------------------------------------------------
      /b_1_1 |   .0140395   .0001255   111.87   0.000     .0137936    .0142855
      /b_2_1 |          0  (constrained)
      /b_3_1 |          0  (constrained)
      /b_1_2 |          0  (constrained)
      /b_2_2 |    .007136   .0000638   111.87   0.000      .007011     .007261
      /b_3_2 |          0  (constrained)
      /b_1_3 |          0  (constrained)
      /b_2_3 |          0  (constrained)
      /b_3_3 |   .0092445   .0000826   111.87   0.000     .0090825    .0094064
------------------------------------------------------------------------------
LR test of identifying restrictions: chi2(1) = 389.5       Prob > chi2 = 0.000
```

Long-run overidentified SVAR model

```
. matrix C=(.,0,0\.,.,0\.,.,.)
. matrix list C

C[3,3]
    c1  c2  c3
r1   .   0   0
r2   .   .   0
r3   .   .   .

. svar rDAX30 rFTSE100 rSP500, lags(1/3) lreq(C)
Estimating long-run parameters

Iteration 0:   log likelihood = -21830.051
Iteration 1:   log likelihood =  29961.237
Iteration 2:   log likelihood =   53616.74
Iteration 3:   log likelihood =  60046.934
Iteration 4:   log likelihood =  60491.992
Iteration 5:   log likelihood =  60493.057
Iteration 6:   log likelihood =  60493.057
```

```
Structural vector autoregression

 ( 1)  [c_1_2]_cons = 0
 ( 2)  [c_1_3]_cons = 0
 ( 3)  [c_2_3]_cons = 0

Sample:  5 - 6262                               Number of obs     =      6,258
Exactly identified model                        Log likelihood    =   60493.06

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /c_1_1 |   .0138664   .0001239   111.87   0.000     .0136235    .0141093
      /c_2_1 |   .0079758   .0001074    74.27   0.000     .0077653    .0081863
      /c_3_1 |    .008072   .0001089    74.15   0.000     .0078587    .0082854
      /c_1_2 |          0  (constrained)
      /c_2_2 |   .0063526   .0000568   111.87   0.000     .0062414    .0064639
      /c_3_2 |   .0030708   .0000767    40.01   0.000     .0029204    .0032212
      /c_1_3 |          0  (constrained)
      /c_2_3 |          0  (constrained)
      /c_3_3 |   .0056697   .0000507   111.87   0.000     .0055703     .005769
------------------------------------------------------------------------------

. matrix C=(.,0,0\.,.,0\.,0,.)
. matrix list C

C[3,3]
    c1  c2  c3
r1   .   0   0
r2   .   .   0
r3   .   0   .

. svar rDAX30 rFTSE100 rSP500, lags(1/3) lreq(C)
Estimating long-run parameters

Iteration 0:   log likelihood = -21830.143
Iteration 1:   log likelihood =  29935.143
Iteration 2:   log likelihood =  53512.185
Iteration 3:   log likelihood =  59327.247
Iteration 4:   log likelihood =  59687.476
Iteration 5:   log likelihood =  59688.163
Iteration 6:   log likelihood =  59688.163

Structural vector autoregression

 ( 1)  [c_1_2]_cons = 0
 ( 2)  [c_1_3]_cons = 0
 ( 3)  [c_2_3]_cons = 0
 ( 4)  [c_3_2]_cons = 0

Sample:  5 - 6262                               Number of obs     =      6,258
Overidentified model                            Log likelihood    =   59688.16

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /c_1_1 |   .0138664   .0001239   111.87   0.000     .0136235    .0141093
      /c_2_1 |   .0079758   .0001074    74.27   0.000     .0077653    .0081863
      /c_3_1 |    .008072   .0001089    74.15   0.000     .0078587    .0082854
      /c_1_2 |          0  (constrained)
      /c_2_2 |   .0063526   .0000568   111.87   0.000     .0062414    .0064639
      /c_3_2 |          0  (constrained)
      /c_1_3 |          0  (constrained)
      /c_2_3 |          0  (constrained)
      /c_3_3 |   .0064479   .0000576   111.87   0.000     .0063349    .0065608
------------------------------------------------------------------------------
LR test of identifying restrictions: chi2(1) = 1610        Prob > chi2 = 0.000
```

■