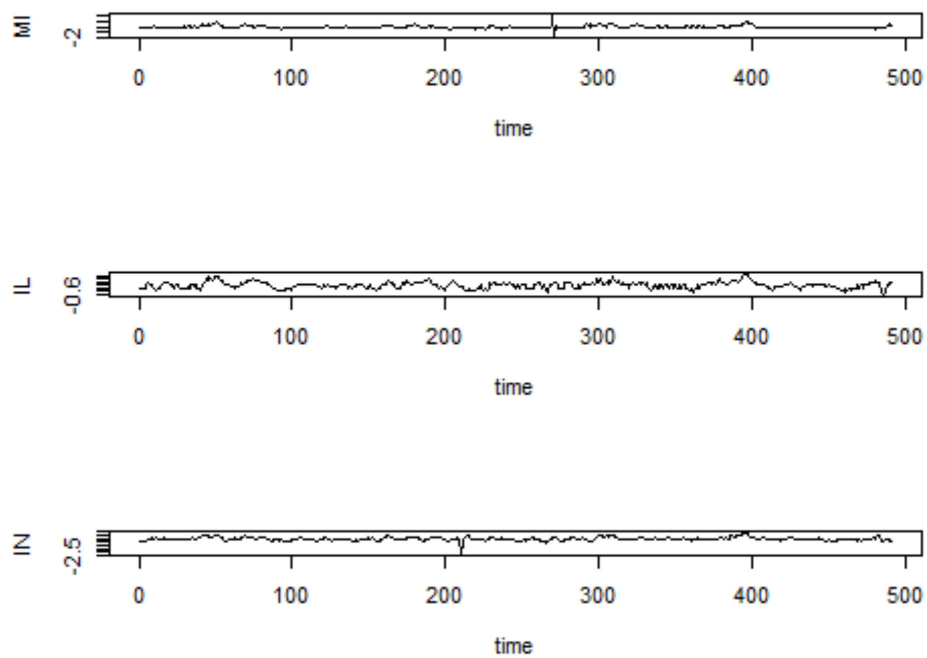
Assignment-6.R

Krittaphong

2021-05-20

```
setwd("D:/")
#install.packages('MTS')
require(MTS)

## Loading required package: MTS

da2=read.table('m-unrate-MIILIN.txt',header=T)
head(da2)

##        Mon   MI  IL  IN
## 1 1976.083 10.0 6.9 7.0
## 2 1976.167 10.0 6.8 6.8
## 3 1976.250  9.9 6.7 6.5
## 4 1976.333  9.7 6.6 6.2
## 5 1976.417  9.6 6.5 6.0
## 6 1976.500  9.4 6.5 5.8

x=cbind(da2$MI, da2$IL, da2$IN)
x=log(x,base=exp(10))
rt= diffM(x)*100
colnames(rt) <- c("MI", "IL", "IN")
tdx=
dim(da2)
#Question 1
MTSplot(rt,)
```




```
VARorder(rt)

## selected order: aic =  6
## selected order: bic =  2
## selected order: hq =  6
## Summary table:
##          p     AIC      BIC      HQ     M(p) p-value
##  [1,]  0  -9.2254  -9.2254  -9.2254   0.0000  0.0000
##  [2,]  1 -10.7136 -10.6367 -10.6834 722.0353  0.0000
##  [3,]  2 -10.8469 -10.6931 -10.7865  79.9726  0.0000
##  [4,]  3 -10.8827 -10.6519 -10.7921  33.8750  0.0001
##  [5,]  4 -10.8938 -10.5861 -10.7729  22.1688  0.0084
##  [6,]  5 -10.8967 -10.5121 -10.7456  18.2649  0.0322
##  [7,]  6 -10.9738 -10.5122 -10.7925  52.1535  0.0000
##  [8,]  7 -10.9640 -10.4255 -10.7525  12.2266  0.2008
##  [9,]  8 -10.9358 -10.3204 -10.6941   3.8389  0.9217
## [10,]  9 -10.9419 -10.2496 -10.6700  19.2322  0.0233
## [11,] 10 -10.9508 -10.1816 -10.6487  20.3222  0.0160
## [12,] 11 -10.9380 -10.0918 -10.6057  10.5898  0.3049
## [13,] 12 -10.9220  -9.9990 -10.5595   9.1179  0.4265
## [14,] 13 -10.9061  -9.9061 -10.5134   9.0746  0.4304

# BIC suggests that we should use 2-lag
m1 = VAR(rt,p=2)

## Constant term:
## Estimates:  -0.004308488 0.002069438 -0.001722694
```

```
## Std.Error:  0.008968027 0.005526058 0.008400675
## AR coefficient matrix
## AR( 1 )-matrix
##       [,1]  [,2]  [,3]
## [1,] 0.199 0.276 0.131
## [2,] 0.106 0.528 0.101
## [3,] 0.151 0.274 0.568
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0445 0.0735 0.0497
## [2,] 0.0274 0.0453 0.0306
## [3,] 0.0417 0.0689 0.0466
## AR( 2 )-matrix
##          [,1]   [,2]     [,3]
## [1,]  0.30910 -0.106  0.00562
## [2,]  0.04956  0.183 -0.08484
## [3,] -0.00612 -0.170  0.01388
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0454 0.0720 0.0501
## [2,] 0.0280 0.0444 0.0309
## [3,] 0.0425 0.0675 0.0470
##
## Residuals cov-mtx:
##             [,1]        [,2]        [,3]
## [1,] 0.038551679 0.003071579 0.007144333
## [2,] 0.003071579 0.014637954 0.004019971
## [3,] 0.007144333 0.004019971 0.033828113
##
## det(SSE) =  1.757694e-05
## AIC =  -10.8756
## BIC =  -10.72176
## HQ  =  -10.81519

#Matrix Form
#
#
#
#
#
#
```

$y_t = \Delta \ln(ML) \times 100$

$x_t = \Delta \ln(IL) \times 100$

$z_t = \Delta \ln(IN) \times 100$

$$\begin{bmatrix} \hat{y}_t \\ \hat{x}_t \\ \hat{z}_t \end{bmatrix} = \begin{bmatrix} -0.0043 \\ (0.008968) \\ 0.002069 \\ (0.005526) \\ -0.001723 \\ (0.0084) \end{bmatrix} + \begin{bmatrix} 0.199 & 0.276 & 0.131 \\ (.0445) & (.0735) & (.0497) \\ 0.106 & 0.528 & 0.101 \\ (.0274) & (.0453) & (.0306) \\ 0.151 & 0.274 & 0.568 \\ (.0417) & (.0689) & (.0466) \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \\ z_{t-1} \end{bmatrix}$$

$$+ \begin{bmatrix} 0.30910 & -.106 & 0.00562 \\ (.0454) & (.0720) & (.0501) \\ 0.04956 & 0.183 & -0.08484 \\ (.0280) & (.0444) & (.0309) \\ -0.00612 & -0.170 & 0.01388 \\ (.0425) & (.0675) & (.0470) \end{bmatrix} \begin{bmatrix} y_{t-2} \\ x_{t-2} \\ z_{t-2} \end{bmatrix}$$

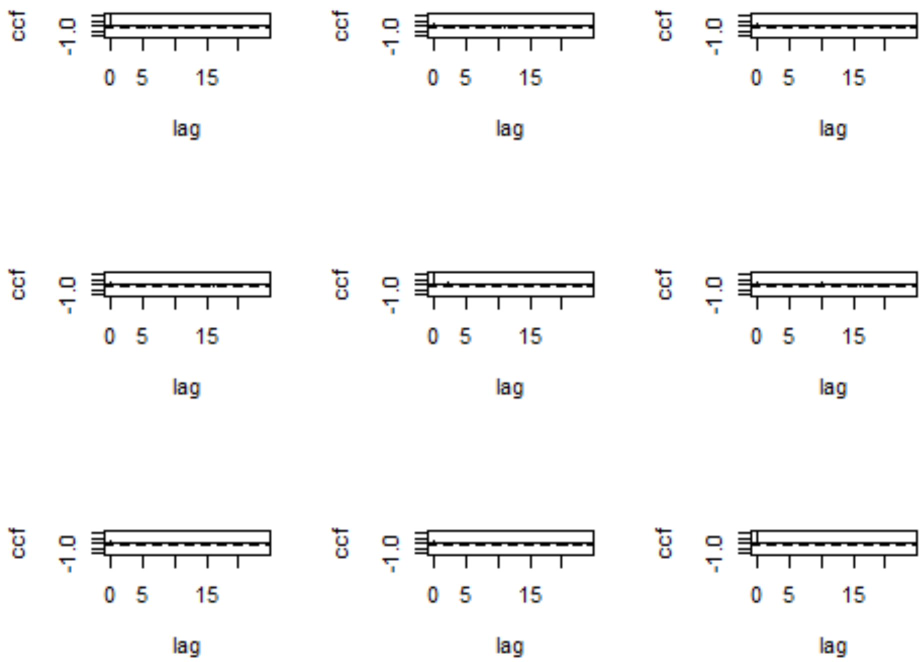
Cross-correlation matrix

```
MTSdiag(m1)

## [1] "Covariance matrix:"
##         MI      IL      IN
## MI 0.03863 0.00308 0.00716
## IL 0.00308 0.01467 0.00403
## IN 0.00716 0.00403 0.03390
## CCM at lag:  0
##       [,1]  [,2]  [,3]
```

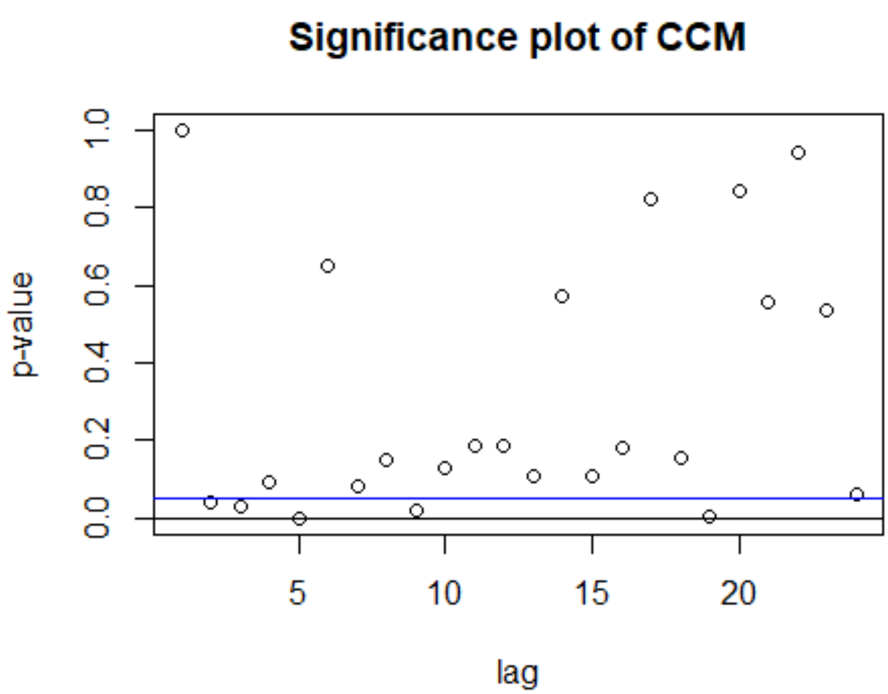
```
## CCM at lag:  0
##        [,1]  [,2]  [,3]
## [1,] 1.000 0.129 0.198
## [2,] 0.129 1.000 0.181
## [3,] 0.198 0.181 1.000
## Simplified matrix:
## CCM at lag:  1
## . . .
## . . .
## . . .
## CCM at lag:  2
## . + .
## . + .
## . . .
## CCM at lag:  3
## . - .
## . . .
## . . .
## CCM at lag:  4
## . . .
## . - .
## . . .
## CCM at lag:  5
## - . .
## . - -
## . . -
## CCM at lag:  6
## . . .
## . . .
## . . .
## CCM at lag:  7
## . . .
## . . .
## . . .
## CCM at lag:  8
## . + .
## . . .
## + . .
## CCM at lag:  9
## . . +
## . . +
## . . .
## CCM at lag:  10
## . . .
## . . +
## . . .
## CCM at lag:  11
## . . .
## . . .
## . . .
## CCM at lag:  12
## - . .
```

CCM — +
— • insignificant (value → 0)
— −

```
## . . .
## . . .
## CCM at lag:  13
## . . .
## . . .
## . . .
## CCM at lag:  14
## . . .
## . . .
## . . .
## CCM at lag:  15
## . . .
## . . .
## . . .
## CCM at lag:  16
## . . .
## . . .
## . . .
## CCM at lag:  17
## . . .
## . . .
## . . .
## CCM at lag:  18
## . . .
## . . .
## . + .
## CCM at lag:  19
## . . .
## . . -
## . . .
## CCM at lag:  20
## . . .
## . . .
## . . .
## CCM at lag:  21
## . . -
## . . .
## . . .
## CCM at lag:  22
## . . .
## . . .
## . . .
## CCM at lag:  23
## . . .
## . . .
## . . .
## CCM at lag:  24
## . . .
## . . .
## . . .
```




```
## Hit Enter for p-value plot of individual ccm:
```

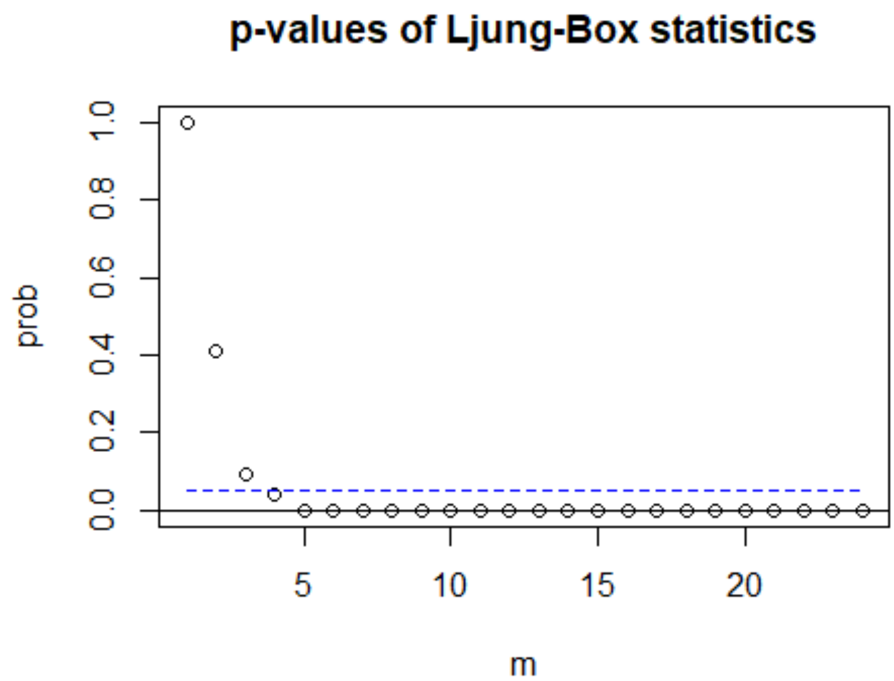


```
## Hit Enter to compute MQ-statistics:
##
## Ljung-Box Statistics:
##            m       Q(m)     df    p-value
##  [1,]   1.00       1.05    9.00      1.00
##  [2,]   2.00      18.67   18.00      0.41
##  [3,]   3.00      37.04   27.00      0.09
##  [4,]   4.00      52.00   36.00      0.04
##  [5,]   5.00      91.25   45.00      0.00
##  [6,]   6.00      98.16   54.00      0.00
##  [7,]   7.00     113.64   63.00      0.00
##  [8,]   8.00     126.92   72.00      0.00
##  [9,]   9.00     146.75   81.00      0.00
## [10,]  10.00     160.63   90.00      0.00
## [11,]  11.00     173.15   99.00      0.00
## [12,]  12.00     185.71  108.00      0.00
## [13,]  13.00     200.17  117.00      0.00
## [14,]  14.00     207.83  126.00      0.00
## [15,]  15.00     222.28  135.00      0.00
## [16,]  16.00     234.92  144.00      0.00
## [17,]  17.00     240.10  153.00      0.00
## [18,]  18.00     253.31  162.00      0.00
## [19,]  19.00     277.28  171.00      0.00
## [20,]  20.00     282.19  180.00      0.00
## [21,]  21.00     290.01  189.00      0.00
## [22,]  22.00     293.54  198.00      0.00
## [23,]  23.00     301.58  207.00      0.00
## [24,]  24.00     317.81  216.00      0.00
```

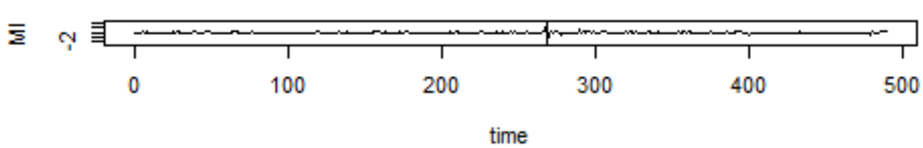
Is there any correlation left?

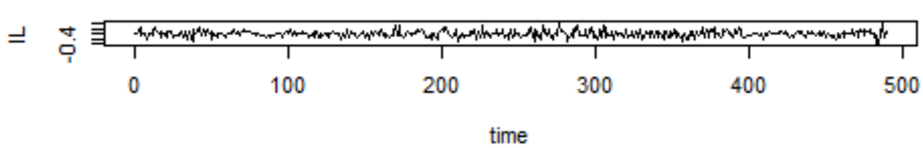
✓ ✓ adequecy

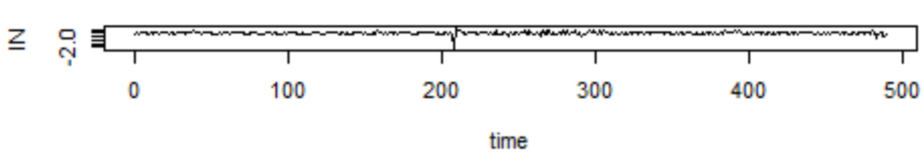
significant at 90% LC




```
## Hit Enter to obtain residual plots:
```







```r
require(vars)

## Loading required package: vars

## Loading required package: MASS

## Loading required package: strucchange

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Loading required package: sandwich

## Loading required package: urca

## Loading required package: lmtest

##
## Attaching package: 'vars'

## The following object is masked from 'package:MTS':
##
##     VAR

Varfit= VAR(rt,p=2)
summary(Varfit)

##
## VAR Estimation Results:
## =========================
## Endogenous variables: MI, IL, IN
## Deterministic variables: const
## Sample size: 489
## Log Likelihood: 595.429
## Roots of the characteristic polynomial:
## 0.8686 0.6789 0.4943 0.4486 0.3738 0.0756
## Call:
## VAR(y = rt, p = 2)
##
##
## Estimation results for equation MI:
```

y_t

```r
## ===================================
## MI = MI.l1 + IL.l1 + IN.l1 + MI.l2 + IL.l2 + IN.l2 + const
##
##          Estimate Std. Error t value Pr(>|t|)
## MI.l1  0.198967   0.044522   4.469 9.81e-06 ***
## IL.l1  0.275604   0.073512   3.749 0.000199 ***
```

$$\hat{y}_t = \underset{(.004308)}{-0.004308} + \underset{(.044522)}{0.198967}\,y_{t-1} + \underset{(.073512)}{0.275604}\,x_{t-1} + \underset{(.049704)}{0.130995}\,z_{t-1}$$

$$+ \underset{(.045360)}{0.0309097}\,y_{t-2} + \underset{(.072016)}{(-.106027)}\,x_{t-2} + \underset{(.050137)}{(0.005618)}\,z_{t-2}$$

```
## IN.l1  0.130995   0.049704   2.635 0.008673 **
## MI.l2  0.309097   0.045360   6.814 2.84e-11 ***
## IL.l2 -0.106027   0.072016  -1.472 0.141604
## IN.l2  0.005618   0.050137   0.112 0.910836
## const -0.004308   0.008968  -0.480 0.631141
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1978 on 482 degrees of freedom
## Multiple R-Squared: 0.4075,  Adjusted R-squared: 0.4001
## F-statistic: 55.24 on 6 and 482 DF,  p-value: < 2.2e-16
##
##
```

x_t

```
## Estimation results for equation IL:
```

The same pattern

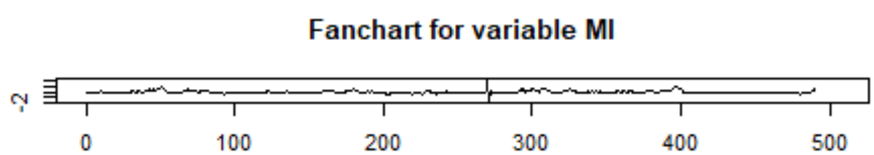
```
## ===================================
## IL = MI.l1 + IL.l1 + IN.l1 + MI.l2 + IL.l2 + IN.l2 + const
##
##        Estimate Std. Error t value Pr(>|t|)
## MI.l1  0.105798   0.027434   3.856 0.000131 ***
## IL.l1  0.527999   0.045298  11.656  < 2e-16 ***
## IN.l1  0.100898   0.030628   3.294 0.001059 **
## MI.l2  0.049559   0.027950   1.773 0.076841 .
## IL.l2  0.183033   0.044376   4.125 4.37e-05 ***
## IN.l2 -0.084841   0.030894  -2.746 0.006255 **
## const  0.002069   0.005526   0.374 0.708207
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1219 on 482 degrees of freedom
## Multiple R-Squared: 0.6581,  Adjusted R-squared: 0.6539
## F-statistic: 154.7 on 6 and 482 DF,  p-value: < 2.2e-16
##
##
```

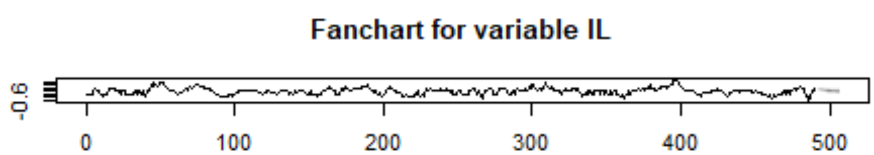
z_t

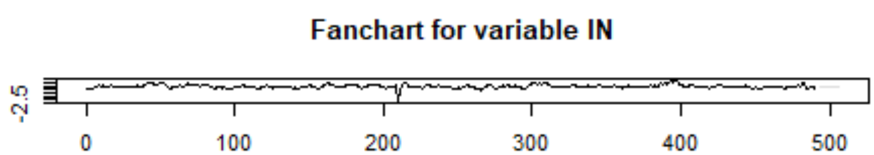
```
## Estimation results for equation IN:
## ===================================
## IN = MI.l1 + IL.l1 + IN.l1 + MI.l2 + IL.l2 + IN.l2 + const
##
##        Estimate Std. Error t value Pr(>|t|)
## MI.l1  0.151449   0.041706   3.631 0.000312 ***
## IL.l1  0.273801   0.068861   3.976 8.08e-05 ***
## IN.l1  0.568094   0.046560  12.201  < 2e-16 ***
## MI.l2 -0.006117   0.042490  -0.144 0.885584
## IL.l2 -0.169976   0.067460  -2.520 0.012069 *
## IN.l2  0.013880   0.046965   0.296 0.767705
## const -0.001723   0.008401  -0.205 0.837607
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
##
## Residual standard error: 0.1853 on 482 degrees of freedom
## Multiple R-Squared: 0.5205,  Adjusted R-squared: 0.5145
## F-statistic:  87.2 on 6 and 482 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##           MI       IL       IN
## MI 0.039112 0.003116 0.007248
## IL 0.003116 0.014851 0.004078
## IN 0.007248 0.004078 0.034319
##
## Correlation matrix of residuals:
##        MI     IL     IN
## MI 1.0000 0.1293 0.1978
## IL 0.1293 1.0000 0.1807
## IN 0.1978 0.1807 1.0000
```

```
#t-value cut at t=1.645
varfit.prd <- predict(Varfit, n.ahead=15, ci=.90)
fanchart(varfit.prd)
```







Question 1

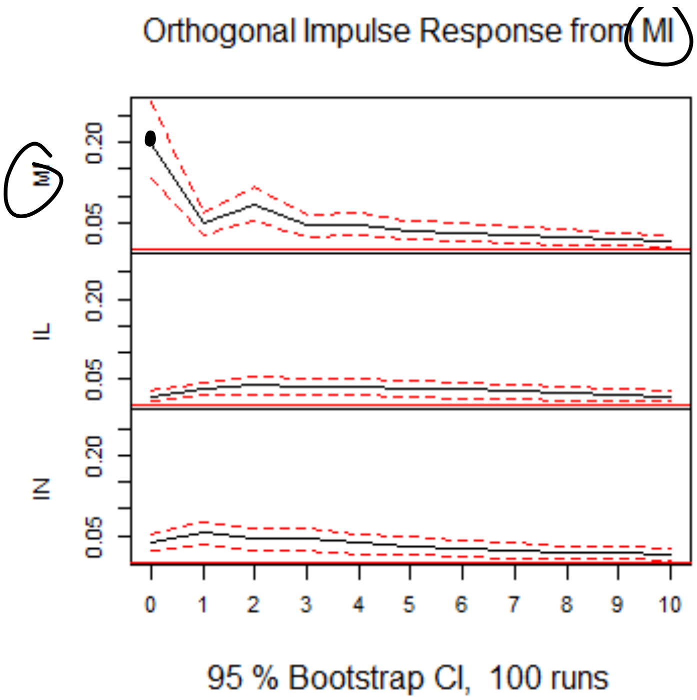
cut off

```
mrefine = refVAR(m1, thres = 1.645)

## Constant term:
## Estimates:  0 0 0
## Std.Error:  0 0 0
## AR coefficient matrix
## AR( 1 )-matrix
##       [,1]  [,2]  [,3]
## [1,] 0.192 0.206 0.130
## [2,] 0.105 0.528 0.101
## [3,] 0.152 0.273 0.574
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0441 0.0563 0.0427
## [2,] 0.0274 0.0453 0.0306
## [3,] 0.0405 0.0678 0.0392
## AR( 2 )-matrix
##        [,1]   [,2]    [,3]
## [1,] 0.3035  0.000  0.0000
## [2,] 0.0491  0.183 -0.0849
## [3,] 0.0000 -0.168  0.0000
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0444 0.0000 0.0000
## [2,] 0.0279 0.0443 0.0309
## [3,] 0.0000 0.0661 0.0000
##
## Residuals cov-mtx:
##             [,1]        [,2]        [,3]
## [1,] 0.038745260 0.003062712 0.007153133
## [2,] 0.003062712 0.014642213 0.004016425
## [3,] 0.007153133 0.004016425 0.033837769
##
## det(SSE) =  1.768107e-05
## AIC =  -10.88599
## BIC =  -10.76634
## HQ  =  -10.839

#require(vars)
#Varfit= VAR(rt,p=2)
#summary(Varfit)
#t-value cut at t=1.645
#varfit.prd <- predict(Varfit, n.ahead=15, ci=.90)
#fanchart(varfit.prd)
#impresp=irf(Varfit)
#plot(impresp)
```

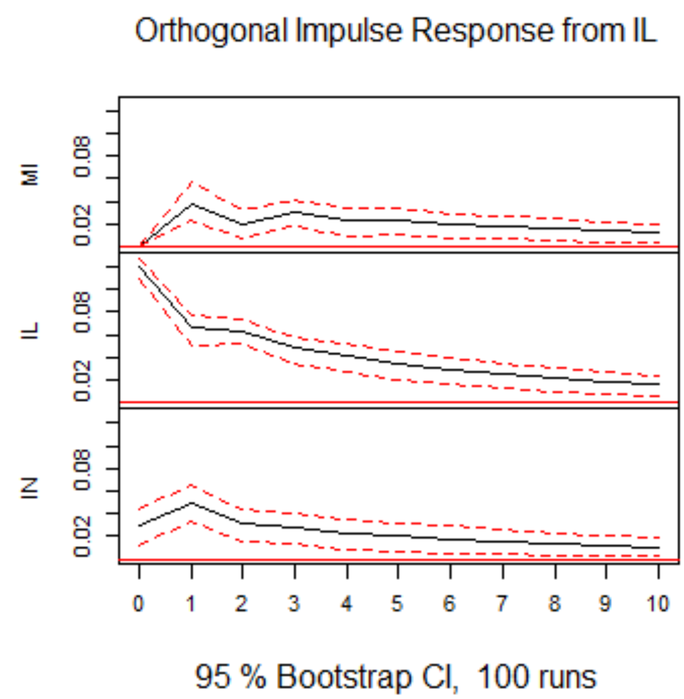
$$\begin{bmatrix} \hat{y}_t \\ \hat{x}_t \\ \hat{z}_t \end{bmatrix} = \underline{\underline{0}} + \begin{bmatrix} 0.192 & 0.206 & 0.130 \\ 0.105 & 0.528 & 0.101 \\ 0.152 & 0.273 & 0.574 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} 0.3035 & 0.000 & 0.0000 \\ 0.0491 & 0.183 & -0.0849 \\ 0.0000 & -0.168 & 0.0000 \end{bmatrix} \begin{bmatrix} y_{t-2} \\ x_{t-2} \\ z_{t-2} \end{bmatrix}$$

Question 1.2

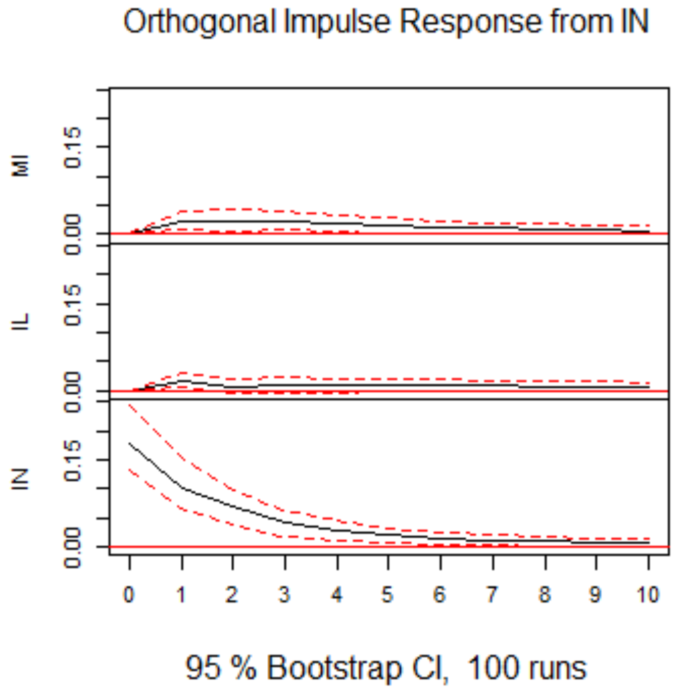
```
impresp=irf(Varfit)
plot(impresp)
```



if there is a unit change of shock of y_t, MI is going to increase, then it lies down to steady state (positive impact)



if there is a unit change of shock of x_t, MI is going to increase, then it lies down to steady state (positive impact)



if there is a unit change of shock of y_t,
MI is going to increase, then it lies down slightly to steady state
Oositive impact)

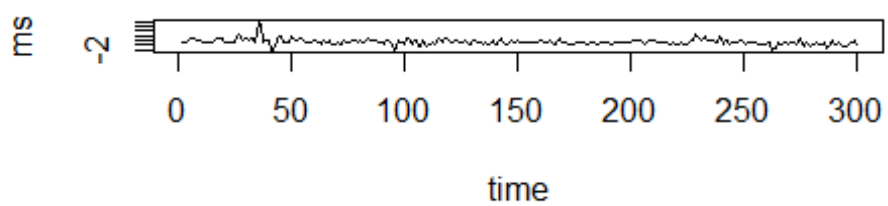
Question 2

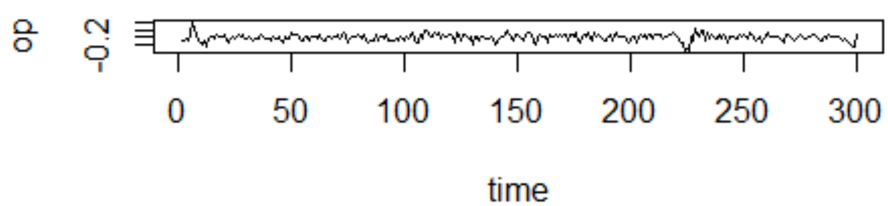
Assignment-6.r

Krittaphong

2021-05-20

```
setwd("D:/")
#install.packages('MTS')
require(MTS)

## Loading required package: MTS

da1=read.table("m-m1cnwti.txt",header = F)
#Question2.1

zt=da1
colnames(zt) <- c('ms','op')
MTSplot(zt)
```

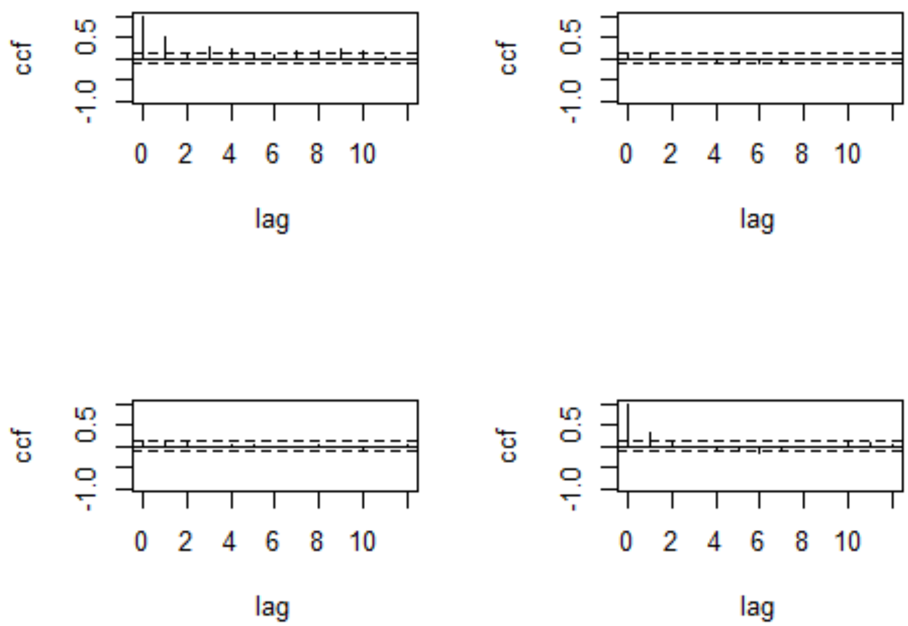




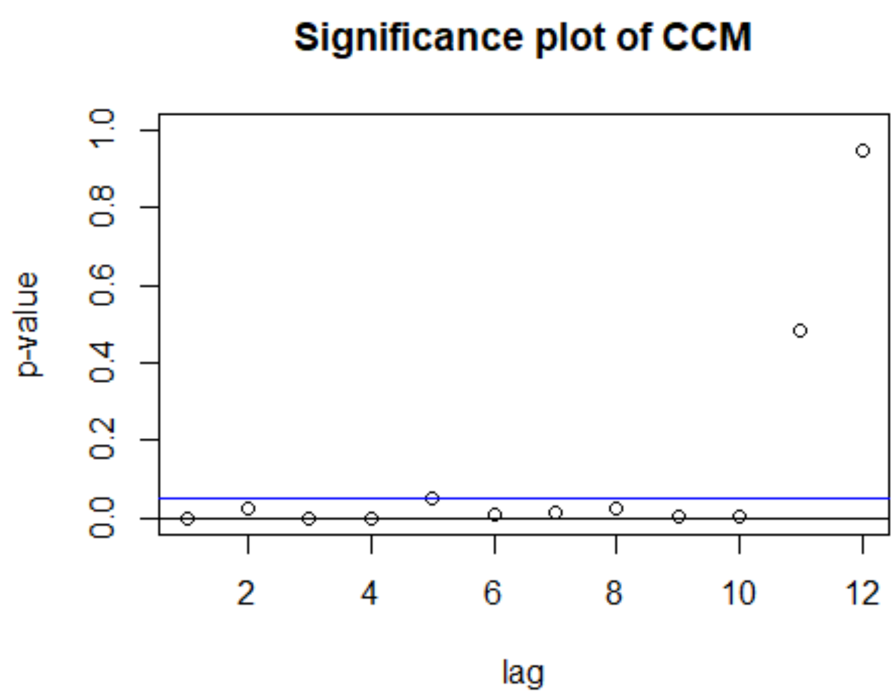

```
ccm(zt)

## [1] "Covariance matrix:"
##          ms      op
## ms 1.4767 0.01254
## op 0.0125 0.00718
```

```
## CCM at lag:  0
##       [,1]  [,2]
## [1,] 1.000 0.122
## [2,] 0.122 1.000
## Simplified matrix:
## CCM at lag:  1
## + .
## + +
## CCM at lag:  2
## + .
## + .
## CCM at lag:  3
## + .
## . .
## CCM at lag:  4
## + .
## . .
## CCM at lag:  5
## . .
## . .
## CCM at lag:  6
## . -
## . -
## CCM at lag:  7
## + .
## . .
## CCM at lag:  8
## + .
## . .
## CCM at lag:  9
## + .
## . .
## CCM at lag:  10
## + .
## . .
## CCM at lag:  11
## . .
## . .
## CCM at lag:  12
## . .
## . .
```

no significant correlation $\Rightarrow$ Weakly stationary




```
## Hit Enter for p-value plot of individual ccm:
```



```
#The model is stationary no significant correlation found in the first 10-lag
VARorder(zt)

## selected order: aic =  13
## selected order: bic =  3
## selected order: hq =  3
## Summary table:
##          p     AIC     BIC      HQ     M(p) p-value
##  [1,]  0 -4.6600 -4.6600 -4.6600   0.0000  0.0000
##  [2,]  1 -4.9979 -4.9485 -4.9781 103.3453  0.0000
##  [3,]  2 -5.0163 -4.9175 -4.9768  12.6928  0.0129
##  [4,]  3 -5.1555 -5.0073 -5.0962  46.3600  0.0000
##  [5,]  4 -5.1507 -4.9532 -5.0717   6.0751  0.1936
##  [6,]  5 -5.1371 -4.8902 -5.0383   3.5990  0.4630
##  [7,]  6 -5.1348 -4.8385 -5.0162   6.6570  0.1552
##  [8,]  7 -5.1516 -4.8059 -5.0132  11.7915  0.0190
##  [9,]  8 -5.1278 -4.7327 -4.9696   0.7736  0.9420
## [10,]  9 -5.1665 -4.7220 -4.9886  17.4902  0.0016
## [11,] 10 -5.1692 -4.6753 -4.9715   7.7943  0.0994
## [12,] 11 -5.1484 -4.6051 -4.9310   1.5447  0.8187
## [13,] 12 -5.1491 -4.5565 -4.9119   7.1662  0.1274
## [14,] 13 -5.1824 -4.5404 -4.9255  15.5661  0.0037
```

Appropriate model (optimal)

```
#BIC suggests that we should use 3-lag model

#Question 2.2
m1=VAR(zt,p=3)

## Constant term:
## Estimates:  0.4973633 -0.002715112
## Std.Error:  0.1030757 0.008624222
## AR coefficient matrix
## AR( 1 )-matrix
##          [,1]  [,2]
## [1,] 0.66841 0.701
## [2,] 0.00347 0.297
## standard error
##          [,1]   [,2]
## [1,] 0.05465 0.7026
## [2,] 0.00457 0.0588
## AR( 2 )-matrix
##          [,1]    [,2]
## [1,] -0.4045 -1.0184
## [2,]  0.0075  0.0298
## standard error
##          [,1]   [,2]
## [1,] 0.06295 0.7365
## [2,] 0.00527 0.0616
## AR( 3 )-matrix
##           [,1]    [,2]
```

fitted

$$\begin{bmatrix} \hat{m}_t \\ \hat{op}_t \end{bmatrix} = \begin{bmatrix} .4973633 \\ (.1030757) \\ (-.002715) \\ (.008624) \end{bmatrix} + \begin{bmatrix} 0.66841 & 0.701 \\ 0.00347 & 0.297 \end{bmatrix} \begin{bmatrix} m_{t-1} \\ op_{t-1} \end{bmatrix} + \begin{bmatrix} -0.4045 & -1.0184 \\ 0.0075 & 0.0298 \end{bmatrix} \begin{bmatrix} m_{t-2} \\ op_{t-2} \end{bmatrix} + \begin{bmatrix} 0.37999 & -0.4399 \\ -0.00712 & -0.0572 \end{bmatrix} \begin{bmatrix} m_{t-3} \\ op_{t-3} \end{bmatrix}$$

```
## [1,]  0.37999 -0.4399
## [2,] -0.00712 -0.0572
## standard error
##         [,1]   [,2]
## [1,] 0.05474 0.7154
## [2,] 0.00458 0.0599
##
## Residuals cov-mtx:
##             [,1]        [,2]
## [1,] 0.906072927 0.007912593
## [2,] 0.007912593 0.006342935
##
## det(SSE) =  0.005684552
## AIC =  -5.090003
## BIC =  -4.941852
## HQ  =  -5.030713
```

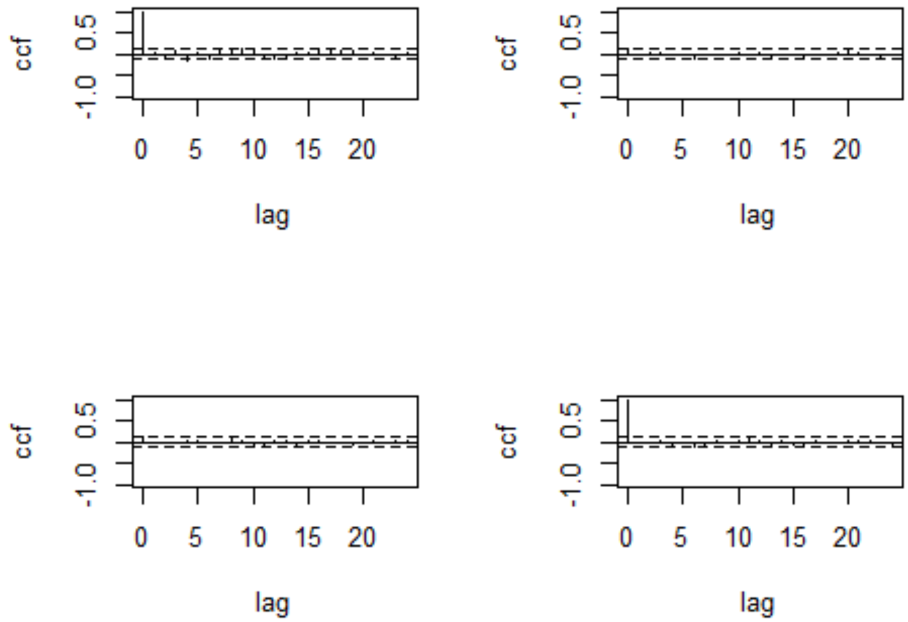
```
MTSdiag(m1)
```

simplified

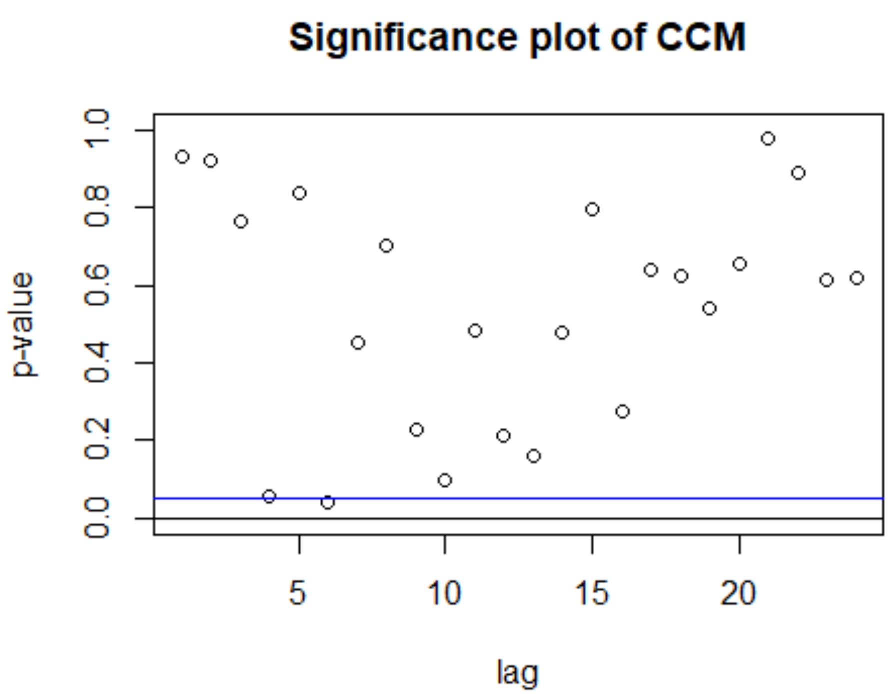
```
## [1] "Covariance matrix:"
##         ms      op
## ms 0.90913 0.00794
## op 0.00794 0.00636
## CCM at lag:  0
##       [,1]  [,2]
## [1,] 1.000 0.104
## [2,] 0.104 1.000
## Simplified matrix:
## CCM at lag:  1
## . .
## . .
## CCM at lag:  2
## . .
## . .
## CCM at lag:  3
## . .
## . .
## CCM at lag:  4
## - .
## . .
## CCM at lag:  5
## . .
## . .
## CCM at lag:  6
## - .
## . .
## CCM at lag:  7
## . .
## . .
## CCM at lag:  8
```

ok

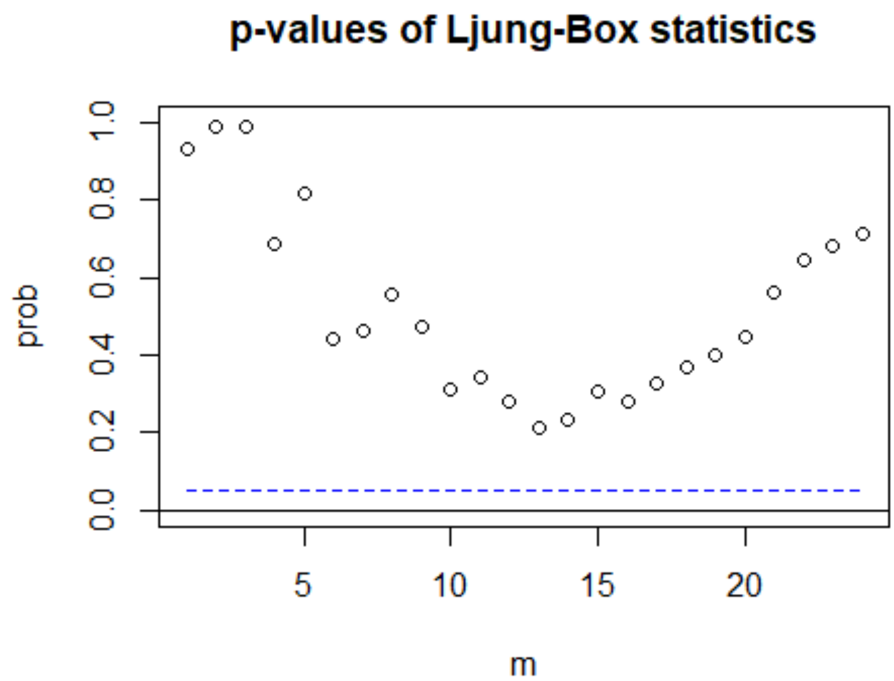
```
## . .
## . .
## CCM at lag:  9
## + .
## . .
## CCM at lag:  10
## . .
## . .
## CCM at lag:  11
## . .
## . .
## CCM at lag:  12
## . .
## . .
## CCM at lag:  13
## . .
## . .
## CCM at lag:  14
## . .
## . .
## CCM at lag:  15
## . .
## . .
## CCM at lag:  16
## . .
## . .
## CCM at lag:  17
## . .
## . .
## CCM at lag:  18
## . .
## . .
## CCM at lag:  19
## . .
## . .
## CCM at lag:  20
## . .
## . .
## CCM at lag:  21
## . .
## . .
## CCM at lag:  22
## . .
## . .
## CCM at lag:  23
## . .
## . .
## CCM at lag:  24
## . .
## . .
```



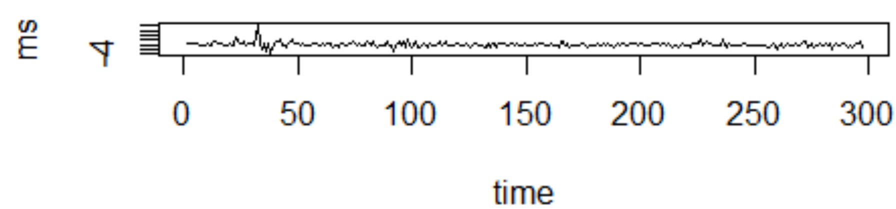

```
## Hit Enter for p-value plot of individual ccm:
```

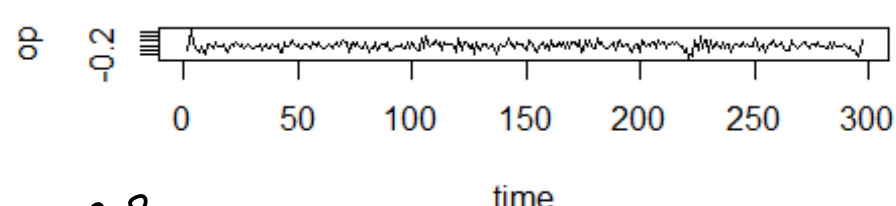


```
## Hit Enter to compute MQ-statistics:
##
## Ljung-Box Statistics:
##           m       Q(m)     df    p-value
##  [1,]  1.000     0.838   4.000     0.93
##  [2,]  2.000     1.780   8.000     0.99
##  [3,]  3.000     3.646  12.000     0.99
##  [4,]  4.000    12.783  16.000     0.69
##  [5,]  5.000    14.217  20.000     0.82
##  [6,]  6.000    24.328  24.000     0.44
##  [7,]  7.000    28.024  28.000     0.46
##  [8,]  8.000    30.207  32.000     0.56
##  [9,]  9.000    35.865  36.000     0.47
## [10,] 10.000    43.789  40.000     0.31
## [11,] 11.000    47.257  44.000     0.34
## [12,] 12.000    53.144  48.000     0.28
## [13,] 13.000    59.729  52.000     0.22
## [14,] 14.000    63.254  56.000     0.24
## [15,] 15.000    64.941  60.000     0.31
## [16,] 16.000    70.101  64.000     0.28
## [17,] 17.000    72.663  68.000     0.33
## [18,] 18.000    75.318  72.000     0.37
## [19,] 19.000    78.471  76.000     0.40
## [20,] 20.000    80.935  80.000     0.45
## [21,] 21.000    81.394  84.000     0.56
## [22,] 22.000    82.501  88.000     0.65
## [23,] 23.000    85.145  92.000     0.68
## [24,] 24.000    87.817  96.000     0.71
```




```
## Hit Enter to obtain residual plots:
```





Question 2.3

```
m2=refVAR(m1)
```

```
## Constant term:
## Estimates:  0.4891295 0
## Std.Error:  0.1025398 0
## AR coefficient matrix
## AR( 1 )-matrix
##       [,1]  [,2]
## [1,] 0.675 0.000
## [2,] 0.000 0.303
## standard error
##        [,1]   [,2]
## [1,] 0.0543 0.0000
## [2,] 0.0000 0.0554
## AR( 2 )-matrix
##          [,1]   [,2]
## [1,] -0.40569 -0.932
## [2,]  0.00964  0.000
## standard error
##        [,1]  [,2]
## [1,] 0.0628 0.675
## [2,] 0.0041 0.000
## AR( 3 )-matrix
##          [,1] [,2]
## [1,]  0.38094    0
## [2,] -0.00794    0
## standard error
##        [,1] [,2]
## [1,] 0.0545    0
## [2,] 0.0041    0
##
## Residuals cov-mtx:
##             [,1]        [,2]
## [1,] 0.910272862 0.008033071
## [2,] 0.008033071 0.006379513
##
## det(SSE) =  0.005742567
## AIC =  -5.113182
## BIC =  -5.026761
## HQ  =  -5.078596
```

Revised/Simplified

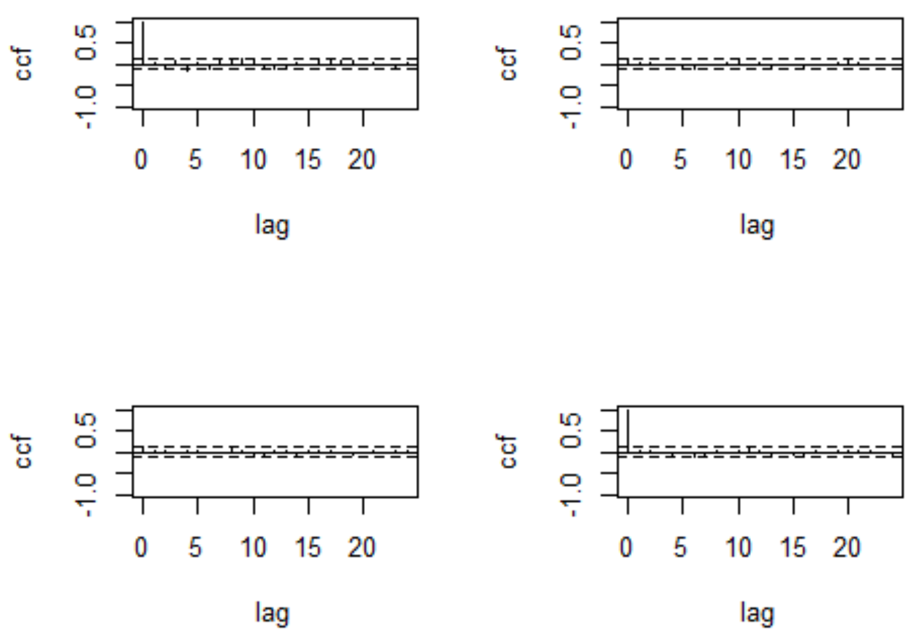
$$\begin{bmatrix}\hat{m}_t\\ \hat{op}_t\end{bmatrix} = \begin{bmatrix}0.4891295\\ 0\end{bmatrix} + \begin{bmatrix}0.675 & 0.000\\ 0.000 & 0.303\end{bmatrix}\begin{bmatrix}m_{t-1}\\ op_{t-1}\end{bmatrix} \begin{bmatrix}-0.40569 & -0.932\\ 0.00964 & 0.000\end{bmatrix}\begin{bmatrix}m_{t-2}\\ op_{t-2}\end{bmatrix} \begin{bmatrix}0.38094 & 0\\ -0.00794 & 0\end{bmatrix}\begin{bmatrix}m_{t-3}\\ op_{t-3}\end{bmatrix}$$

```
MTSdiag(m2)
```

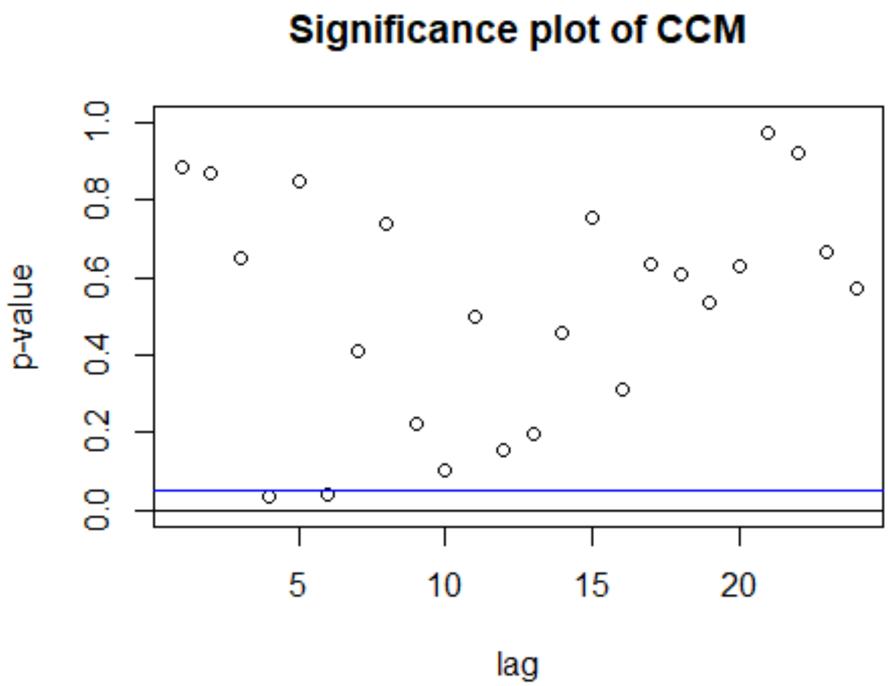
```
## [1] "Covariance matrix:"
##         ms      op
## ms 0.91335 0.00806
## op 0.00806 0.00640
## CCM at lag:  0
##       [,1]  [,2]
## [1,] 1.000 0.105
## [2,] 0.105 1.000
## Simplified matrix:
```

```
## CCM at lag:  1
## . .
## . .
## CCM at lag:  2
## . .
## . .
## CCM at lag:  3
## . .
## . .
## CCM at lag:  4
## - .
## . .
## CCM at lag:  5
## . .
## . .
## CCM at lag:  6
## . .
## . .
## CCM at lag:  7
## . .
## . .
## CCM at lag:  8
## . .
## . .
## CCM at lag:  9
## + .
## . .
## CCM at lag:  10
## + .
## . .
## CCM at lag:  11
## . .
## . .
## CCM at lag:  12
## - .
## . .
## CCM at lag:  13
## . .
## . .
## CCM at lag:  14
## . .
## . .
## CCM at lag:  15
## . .
## . .
## CCM at lag:  16
## . .
## . .
## CCM at lag:  17
## . .
```

```
## . .
## CCM at lag:  18
## . .
## . .
## CCM at lag:  19
## . .
## . .
## CCM at lag:  20
## . .
## . .
## CCM at lag:  21
## . .
## . .
## CCM at lag:  22
## . .
## . .
## CCM at lag:  23
## . .
## . .
## CCM at lag:  24
## . .
## . .
```

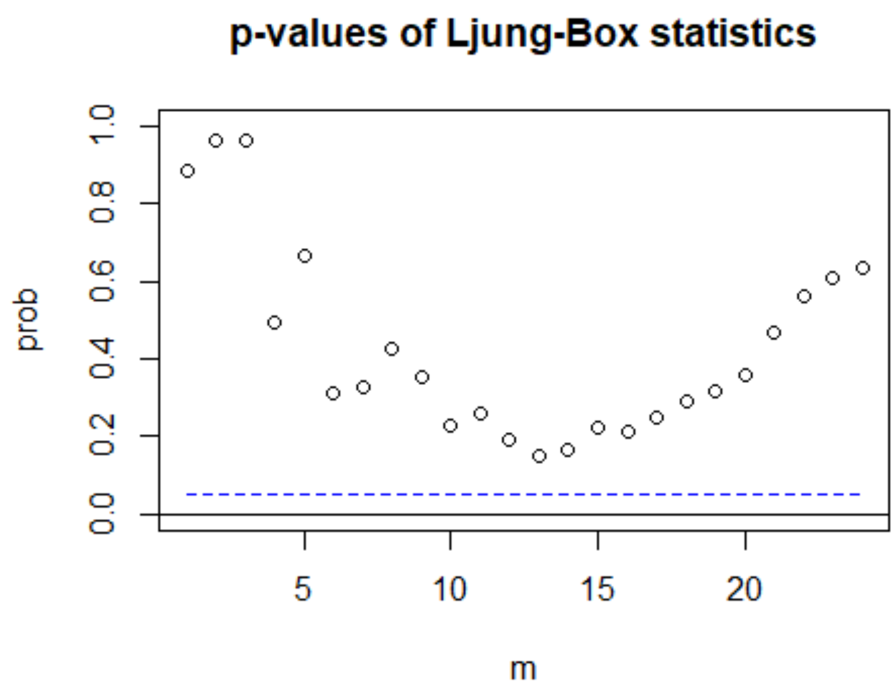



```
## Hit Enter for p-value plot of individual ccm:
```

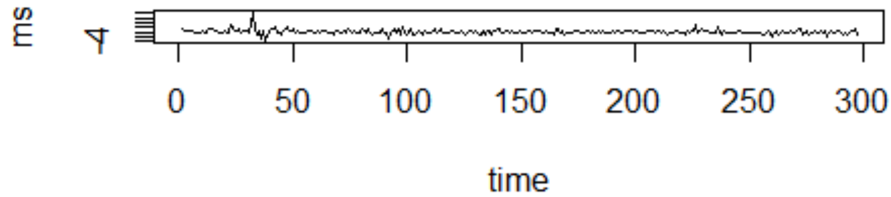


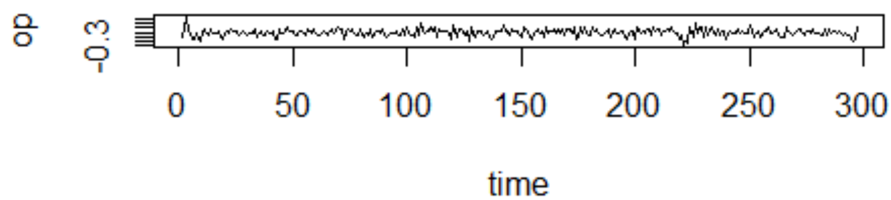

```
## Hit Enter to compute MQ-statistics:
##
## Ljung-Box Statistics:
##          m       Q(m)     df    p-value
##  [1,]  1.00       1.16    4.00     0.89
##  [2,]  2.00       2.42    8.00     0.97
##  [3,]  3.00       4.90   12.00     0.96
##  [4,]  4.00      15.40   16.00     0.50
##  [5,]  5.00      16.77   20.00     0.67
##  [6,]  6.00      26.82   24.00     0.31
##  [7,]  7.00      30.78   28.00     0.33
##  [8,]  8.00      32.79   32.00     0.43
##  [9,]  9.00      38.53   36.00     0.36
## [10,] 10.00      46.23   40.00     0.23
## [11,] 11.00      49.62   44.00     0.26
## [12,] 12.00      56.33   48.00     0.19
## [13,] 13.00      62.42   52.00     0.15
## [14,] 14.00      66.07   56.00     0.17
## [15,] 15.00      67.98   60.00     0.22
## [16,] 16.00      72.79   64.00     0.21
## [17,] 17.00      75.38   68.00     0.25
## [18,] 18.00      78.11   72.00     0.29
## [19,] 19.00      81.29   76.00     0.32
## [20,] 20.00      83.91   80.00     0.36
## [21,] 21.00      84.41   84.00     0.47
## [22,] 22.00      85.31   88.00     0.56
```

```
## [23,] 23.00     87.65   92.00     0.61
## [24,] 24.00     90.58   96.00     0.64
```




```
## Hit Enter to obtain residual plots:

#Question 2.3
detach("package:MTS", unload=TRUE)
library('vars')

## Loading required package: MASS

## Loading required package: strucchange

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Loading required package: sandwich

## Loading required package: urca

## Loading required package: lmtest
```






```
require(vars)

VARselect(zt,lag.max=15)

## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##     13      3      3     13
##
## $criteria
##                   1            2            3            4           5
## AIC(n) -4.970147947 -4.988138078 -5.126020779 -5.119397493 -5.10485079
## HQ(n)  -4.939322852 -4.936762919 -5.054095557 -5.026922207 -4.99182544
## SC(n)  -4.893253438 -4.859980563 -4.946600258 -4.888713966 -4.82290425
## FPE(n)  0.006942132  0.006818397  0.005940268  0.005979876  0.00606771
##                  6            7            8            9          10
## AIC(n) -5.10159195 -5.118880680 -5.093389026 -5.131751412 -5.13446067
## HQ(n)  -4.96801654 -4.964755204 -4.918713487 -4.936525809 -4.91868501
## SC(n)  -4.76838241 -4.734408135 -4.657653475 -4.644752855 -4.59619911
## FPE(n)  0.00608782  0.005983881  0.006138926  0.005908547  0.00589338
##                  11           12           13           14           15
## AIC(n) -5.112587182 -5.112547205 -5.143546545 -5.117546937 -5.118618621
## HQ(n)  -4.876261452 -4.855671412 -4.866120689 -4.819571017 -4.800092638
## SC(n)  -4.523062612 -4.471759630 -4.451495964 -4.374233350 -4.324042028
## FPE(n)  0.006024724  0.006026173  0.005843609  0.005999175  0.005994635
```

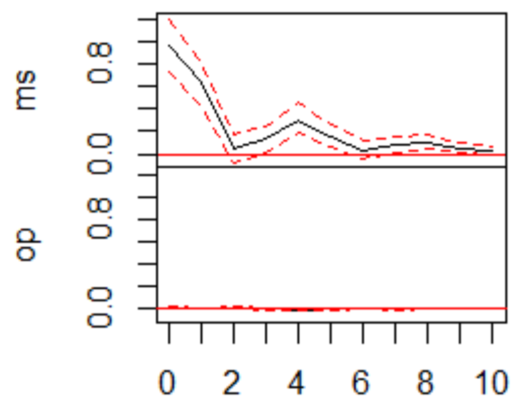
```r
#HQ and SN suggests 3-lagged model
m3=VAR(zt,p=3)
summary(m3)
```

```
##
## VAR Estimation Results:
## =========================
## Endogenous variables: ms, op
## Deterministic variables: const
## Sample size: 297
## Log Likelihood: -75.104
## Roots of the characteristic polynomial:
## 0.7754 0.6964 0.6964 0.4487 0.4487 0.3284
## Call:
## VAR(y = zt, p = 3)
##
##
## Estimation results for equation ms:
## ===================================
## ms = ms.l1 + op.l1 + ms.l2 + op.l2 + ms.l3 + op.l3 + const
##
##       Estimate Std. Error t value Pr(>|t|)
## ms.l1  0.66841    0.05465  12.230  < 2e-16 ***
## op.l1  0.70145    0.70262   0.998    0.319
## ms.l2 -0.40451    0.06295  -6.426 5.37e-10 ***
## op.l2 -1.01842    0.73654  -1.383    0.168
## ms.l3  0.37999    0.05474   6.942 2.53e-11 ***
## op.l3 -0.43989    0.71537  -0.615    0.539
## const  0.49736    0.10308   4.825 2.26e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.9633 on 290 degrees of freedom
## Multiple R-Squared: 0.3901,  Adjusted R-squared: 0.3775
## F-statistic: 30.91 on 6 and 290 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation op:
## ===================================
## op = ms.l1 + op.l1 + ms.l2 + op.l2 + ms.l3 + op.l3 + const
##
##        Estimate Std. Error t value Pr(>|t|)
## ms.l1  0.003467   0.004573   0.758    0.449
## op.l1  0.296716   0.058787   5.047 7.93e-07 ***
## ms.l2  0.007504   0.005267   1.425    0.155
## op.l2  0.029814   0.061626   0.484    0.629
## ms.l3 -0.007121   0.004580  -1.555    0.121
## op.l3 -0.057191   0.059854  -0.956    0.340
## const -0.002715   0.008624  -0.315    0.753
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.0806 on 290 degrees of freedom
## Multiple R-Squared: 0.1153,  Adjusted R-squared: 0.09701
## F-statistic:   6.3 on 6 and 290 DF,  p-value: 3.049e-06
##
##
##
## Covariance matrix of residuals:
##          ms       op
## ms 0.927944 0.008104
## op 0.008104 0.006496
##
## Correlation matrix of residuals:
##        ms     op
## ms 1.0000 0.1044
## op 0.1044 1.0000
```

```
#IRF
impls=irf(m3)
plot(impls)
```

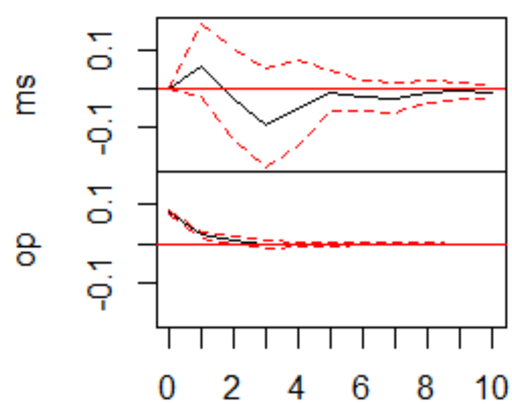
Orthogonal Impulse Response from ms



95 % Bootstrap CI, 100 runs

a unit change
in ms shock
↓
positive ms

Orthogonal Impulse Response from op



95 % Bootstrap CI, 100 runs

a unit change
op first positive
then negative. & back
to steady stead

```
## Hit Enter to compute MQ-statistics:
##
## Ljung-Box Statistics:
##           m       Q(m)     df    p-value
##  [1,]  1.000     0.838   4.000     0.93
##  [2,]  2.000     1.780   8.000     0.99
##  [3,]  3.000     3.646  12.000     0.99
##  [4,]  4.000    12.783  16.000     0.69
##  [5,]  5.000    14.217  20.000     0.82
##  [6,]  6.000    24.328  24.000     0.44
##  [7,]  7.000    28.024  28.000     0.46
##  [8,]  8.000    30.207  32.000     0.56
##  [9,]  9.000    35.865  36.000     0.47
## [10,] 10.000    43.789  40.000     0.31
## [11,] 11.000    47.257  44.000     0.34
## [12,] 12.000    53.144  48.000     0.28
## [13,] 13.000    59.729  52.000     0.22
## [14,] 14.000    63.254  56.000     0.24
## [15,] 15.000    64.941  60.000     0.31
## [16,] 16.000    70.101  64.000     0.28
## [17,] 17.000    72.663  68.000     0.33
## [18,] 18.000    75.318  72.000     0.37
## [19,] 19.000    78.471  76.000     0.40
## [20,] 20.000    80.935  80.000     0.45
## [21,] 21.000    81.394  84.000     0.56
## [22,] 22.000    82.501  88.000     0.65
## [23,] 23.000    85.145  92.000     0.68
## [24,] 24.000    87.817  96.000     0.71
```

```
#Forecasting
predictingm3 <- predict(m3,n.ahead=6,ci=.95)
fanchart(predictingm3)
```