

Assignment6_6004641236_files.R

Admin

2021-05-19

```
setwd("D:/MyGames/RStudio/Works")
cat(rep("\n",50))

#install.packages("vars")

library(quantmod)

## Loading required package: xts
## Loading required package: zoo
##
## Attaching package: 'zoo'
## The following objects are masked from 'package:base':
##
##   as.Date, as.Date.numeric
## Loading required package: TTR
## Registered S3 method overwritten by 'quantmod':
##   method           from
##   as.zoo.data.frame zoo
library(fBasics)

## Loading required package: timeDate
## Loading required package: timeSeries
##
## Attaching package: 'timeSeries'
## The following object is masked from 'package:zoo':
##
##   time<-
##
## Attaching package: 'fBasics'
## The following object is masked from 'package:TTR':
##
##   volatility
library(sn)

## Loading required package: stats4
##
## Attaching package: 'sn'
```

```

## The following object is masked from 'package:fBasics':
##
##      vech

## The following object is masked from 'package:stats':
##
##      sd

library(PerformanceAnalytics)

##
## Attaching package: 'PerformanceAnalytics'

## The following objects are masked from 'package:timeDate':
##
##      kurtosis, skewness

## The following object is masked from 'package:graphics':
##
##      legend

library(car)

## Loading required package: carData

##
## Attaching package: 'car'

## The following object is masked from 'package:fBasics':
##
##      densityPlot

library(tseries)
library(forecast)
library(fGarch)
library(Matrix)
library(tinytex)
library(fUnitRoots)

## Warning: package 'fUnitRoots' was built under R version 4.0.5

library(MTS)

## Warning: package 'MTS' was built under R version 4.0.5

##
## Attaching package: 'MTS'

## The following object is masked from 'package:TTR':
##
##      VMA

library(vars)

## Warning: package 'vars' was built under R version 4.0.5

## Loading required package: MASS

## Loading required package: strucchange

## Warning: package 'strucchange' was built under R version 4.0.5

## Loading required package: sandwich

```

```

## Loading required package: urca
##
## Attaching package: 'urca'
## The following objects are masked from 'package:fUnitRoots':
##
##   punitroot, qunitroot, unitrootTable
## Loading required package: lmtest
##
## Attaching package: 'vars'
## The following object is masked from 'package:MTS':
##
##   VAR
require(MTS)
require(vars)

da1=read.table("m-unrate-MIILIN.txt",header = T)

##detach("package:vars", unload = TRUE)

head(da1)

##           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

dim(da1)

## [1] 492  4

tail(da1)

##           Mon  MI  IL  IN
## 487 2016.583 4.5 5.8 4.6
## 488 2016.667 4.5 5.5 4.5
## 489 2016.750 4.6 5.5 4.5
## 490 2016.833 4.7 5.6 4.4
## 491 2016.917 4.9 5.6 4.2
## 492 2017.000 5.0 5.7 4.0

x=cbind(da1$MI,da1$IL,da1$IN)

head(x)

##      [,1] [,2] [,3]
## [1,] 10.0  6.9  7.0
## [2,] 10.0  6.8  6.8
## [3,]  9.9  6.7  6.5

```

```
## [4,] 9.7 6.6 6.2
## [5,] 9.6 6.5 6.0
## [6,] 9.4 6.5 5.8
```

```
dim(x)
```

```
## [1] 492 3
```

```
tail(x)
```

```
##          [,1] [,2] [,3]
## [487,]  4.5  5.8  4.6
## [488,]  4.5  5.5  4.5
## [489,]  4.6  5.5  4.5
## [490,]  4.7  5.6  4.4
## [491,]  4.9  5.6  4.2
## [492,]  5.0  5.7  4.0
```

```
x_log = log(x)
```

```
dim(x_log)
```

```
## [1] 492 3
```

```
head(x_log)
```

```
##          [,1]      [,2]      [,3]
## [1,] 2.302585 1.931521 1.945910
## [2,] 2.302585 1.916923 1.916923
## [3,] 2.292535 1.902108 1.871802
## [4,] 2.272126 1.887070 1.824549
## [5,] 2.261763 1.871802 1.791759
## [6,] 2.240710 1.871802 1.757858
```

```
tail(x_log)
```

```
##          [,1]      [,2]      [,3]
## [487,] 1.504077 1.757858 1.526056
## [488,] 1.504077 1.704748 1.504077
## [489,] 1.526056 1.704748 1.504077
## [490,] 1.547563 1.722767 1.481605
## [491,] 1.589235 1.722767 1.435085
## [492,] 1.609438 1.740466 1.386294
```

```
zt1=diffM(x_log)
```

```
tail(zt1)
```

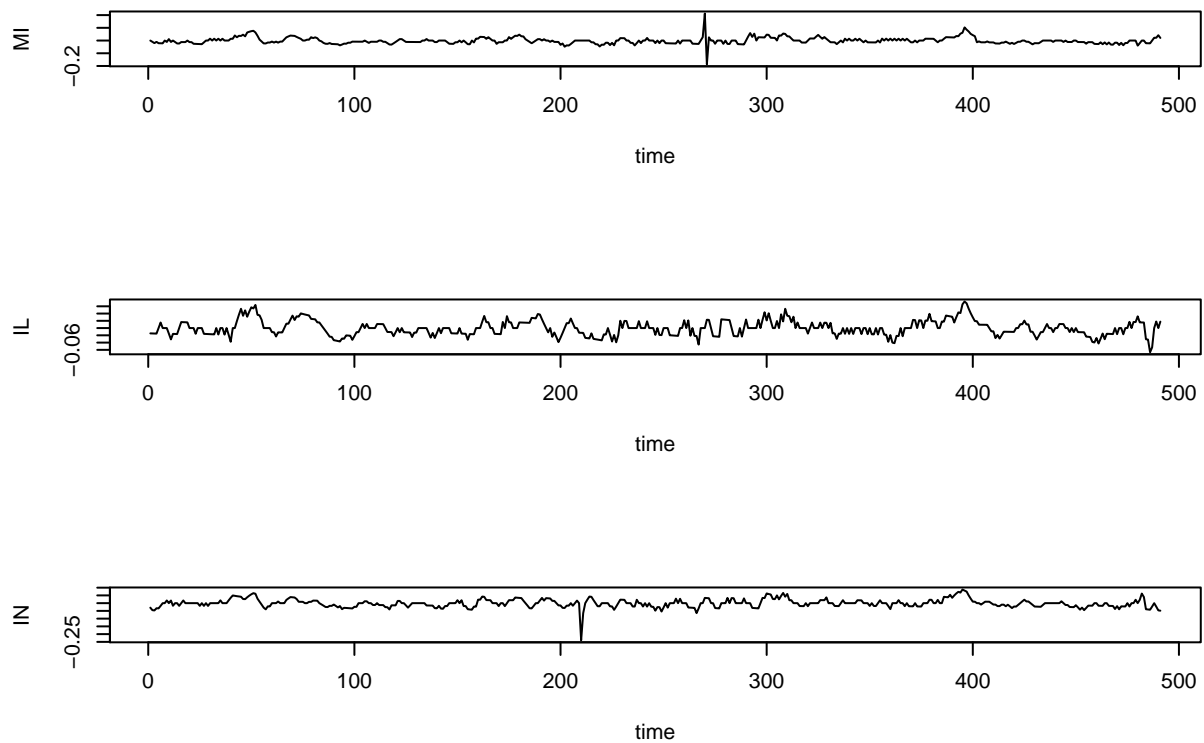
```
##          [,1]      [,2]      [,3]
## [486,] -0.02197891 -0.06669137 -0.04255961
## [487,]  0.00000000 -0.05310983 -0.02197891
## [488,]  0.02197891  0.00000000  0.00000000
## [489,]  0.02150621  0.01801851 -0.02247286
## [490,]  0.04167270  0.00000000 -0.04652002
## [491,]  0.02020271  0.01769958 -0.04879016
```

```
head(zt1)
```

```
##          [,1]      [,2]      [,3]
## [1,]  0.00000000 -0.01459880 -0.02898754
```

```
## [2,] -0.01005034 -0.01481509 -0.04512044
## [3,] -0.02040887 -0.01503788 -0.04725288
## [4,] -0.01036279 -0.01526747 -0.03278982
## [5,] -0.02105341  0.00000000 -0.03390155
## [6,] -0.02150621  0.01526747 -0.01739174
```

```
colnames(x)<-c("MI","IL","IN")
colnames(x_log)<-c("MI","IL","IN")
colnames(zt1)<-c("MI","IL","IN")
MTSplot(zt1)
```



```
VARorder(zt1)
```

```
## selected order: aic = 6
## selected order: bic = 2
## selected order: hq = 6
## Summary table:
```

##	p	AIC	BIC	HQ	M(p)	p-value
## [1,]	0	-23.0409	-23.0409	-23.0409	0.0000	0.0000
## [2,]	1	-24.5291	-24.4522	-24.4989	722.0353	0.0000
## [3,]	2	-24.6624	-24.5086	-24.6020	79.9726	0.0000
## [4,]	3	-24.6982	-24.4674	-24.6076	33.8750	0.0001
## [5,]	4	-24.7093	-24.4016	-24.5884	22.1688	0.0084
## [6,]	5	-24.7122	-24.3276	-24.5612	18.2649	0.0322
## [7,]	6	-24.7893	-24.3278	-24.6080	52.1535	0.0000
## [8,]	7	-24.7795	-24.2410	-24.5680	12.2266	0.2008
## [9,]	8	-24.7513	-24.1359	-24.5096	3.8389	0.9217

```
## [10,] 9 -24.7574 -24.0651 -24.4856 19.2322 0.0233
## [11,] 10 -24.7663 -23.9971 -24.4642 20.3222 0.0160
## [12,] 11 -24.7535 -23.9074 -24.4212 10.5898 0.3049
## [13,] 12 -24.7375 -23.8145 -24.3750 9.1179 0.4265
## [14,] 13 -24.7216 -23.7216 -24.3289 9.0746 0.4304
```

```
head(zt1)
```

```
##           MI           IL           IN
## [1,] 0.00000000 -0.01459880 -0.02898754
## [2,] -0.01005034 -0.01481509 -0.04512044
## [3,] -0.02040887 -0.01503788 -0.04725288
## [4,] -0.01036279 -0.01526747 -0.03278982
## [5,] -0.02105341 0.00000000 -0.03390155
## [6,] -0.02150621 0.01526747 -0.01739174
```

```
zt1
```

```
##           MI           IL           IN
## [1,] 0.000000000 -0.014598799 -0.028987537
## [2,] -0.010050336 -0.014815086 -0.045120435
## [3,] -0.020408872 -0.015037877 -0.047252885
## [4,] -0.010362787 -0.015267472 -0.032789823
## [5,] -0.021053409 0.000000000 -0.033901552
## [6,] -0.021506205 0.015267472 -0.017391743
## [7,] -0.021978907 0.000000000 0.000000000
## [8,] 0.000000000 0.000000000 0.000000000
## [9,] -0.011173301 0.000000000 0.017391743
## [10,] 0.011173301 -0.015267472 0.000000000
## [11,] -0.011173301 -0.031252544 0.017094433
## [12,] 0.000000000 -0.016000341 -0.017094433
## [13,] -0.011299555 -0.016260521 0.000000000
## [14,] -0.022989518 -0.016529302 0.000000000
## [15,] -0.023530497 0.000000000 -0.017391743
## [16,] -0.011976191 0.016529302 0.000000000
## [17,] -0.012121361 0.016260521 0.017391743
## [18,] -0.012270093 0.016000341 0.000000000
## [19,] 0.000000000 0.015748357 0.000000000
## [20,] -0.012422520 0.000000000 0.000000000
## [21,] -0.012578782 0.000000000 0.000000000
## [22,] -0.025642431 0.000000000 0.000000000
## [23,] -0.026317308 -0.015748357 0.000000000
## [24,] -0.027028672 0.000000000 0.000000000
## [25,] -0.027779564 0.000000000 -0.017391743
## [26,] -0.028573372 0.000000000 0.000000000
## [27,] -0.014598799 -0.016000341 -0.017699577
## [28,] 0.000000000 -0.016260521 0.000000000
## [29,] 0.000000000 -0.016529302 -0.018018506
## [30,] 0.014598799 -0.016807118 0.000000000
## [31,] 0.000000000 -0.017094433 0.000000000
## [32,] 0.014388737 -0.017391743 0.000000000
## [33,] 0.000000000 0.000000000 0.000000000
## [34,] 0.014184635 -0.017699577 0.000000000
## [35,] 0.000000000 0.000000000 0.018018506
## [36,] 0.013986242 0.000000000 0.000000000
## [37,] 0.000000000 -0.018018506 0.000000000
```

```

## [38,] 0.00000000 0.00000000 0.00000000
## [39,] 0.00000000 -0.018349139 0.017699577
## [40,] 0.013793322 -0.037740328 0.034486176
## [41,] 0.013605652 0.000000000 0.049596941
## [42,] 0.039740329 0.000000000 0.047252885
## [43,] 0.025642431 0.019048195 0.045120435
## [44,] 0.037271395 0.037041272 0.043172172
## [45,] 0.035932009 0.053109825 0.041385216
## [46,] 0.045985113 0.033901552 0.026668247
## [47,] 0.033152207 0.048790164 0.025975486
## [48,] 0.063178902 0.031252544 0.037740328
## [49,] 0.068992871 0.045120435 0.048202102
## [50,] 0.073427469 0.057158414 0.057158414
## [51,] 0.076633226 0.054067221 0.064538521
## [52,] 0.063513406 0.063715814 0.060624622
## [53,] 0.037740328 0.036367644 0.028987537
## [54,] 0.007380107 0.035091320 0.009478744
## [55,] -0.007380107 0.022728251 -0.009478744
## [56,] -0.022472856 0.000000000 -0.028987537
## [57,] -0.022989518 0.000000000 -0.040005335
## [58,] -0.015625318 0.000000000 -0.020619287
## [59,] -0.015873349 0.000000000 -0.021053409
## [60,] -0.008032172 -0.011299555 0.000000000
## [61,] -0.016260521 -0.011428696 0.000000000
## [62,] -0.008230499 -0.023256862 0.000000000
## [63,] -0.016667052 -0.011834458 0.010582109
## [64,] -0.008438869 -0.011976191 0.000000000
## [65,] -0.008510690 -0.012121361 0.000000000
## [66,] 0.008510690 0.000000000 0.000000000
## [67,] 0.025105921 0.012121361 0.020834087
## [68,] 0.032523192 0.011976191 0.030459207
## [69,] 0.039220713 0.023530497 0.039220713
## [70,] 0.037740328 0.034289073 0.037740328
## [71,] 0.036367644 0.022223137 0.036367644
## [72,] 0.028170877 0.032435276 0.026433257
## [73,] 0.020619287 0.031416196 0.008658063
## [74,] 0.013513719 0.040409538 0.008583744
## [75,] 0.000000000 0.038839833 0.008510690
## [76,] 0.000000000 0.037387532 0.000000000
## [77,] 0.006688988 0.036039936 0.000000000
## [78,] 0.006644543 0.034786116 0.008438869
## [79,] 0.026145280 0.025317808 0.008368250
## [80,] 0.019169916 0.024692613 0.016529302
## [81,] 0.025001302 0.024097552 0.016260521
## [82,] 0.018349139 0.015748357 0.016000341
## [83,] 0.000000000 0.015504187 0.000000000
## [84,] -0.006079046 0.007662873 -0.007968170
## [85,] -0.018462063 0.000000000 -0.016129382
## [86,] -0.025158560 -0.007662873 -0.024692613
## [87,] -0.025807884 -0.015504187 -0.025317808
## [88,] -0.019802627 -0.023716527 -0.017241806
## [89,] -0.027028672 -0.024292693 -0.017544310
## [90,] -0.027779564 -0.033336420 -0.008888947
## [91,] -0.028573372 -0.034486176 -0.018018506

```

[92,] -0.029413885 -0.035718083 -0.027651531
[93,] -0.038027396 -0.037041272 -0.018868484
[94,] -0.031498667 -0.028710106 -0.038839833
[95,] -0.024292693 -0.029558802 -0.030153038
[96,] -0.024897552 -0.020202707 -0.031090587
[97,] -0.016949558 -0.020619287 -0.032088315
[98,] -0.017241806 -0.021053409 -0.033152207
[99,] -0.008733680 -0.032435276 -0.034289073
[100,] -0.008810630 -0.022223137 -0.023530497
[101,] -0.008888947 -0.011299555 -0.024097552
[102,] -0.008968670 -0.011428696 0.000000000
[103,] -0.009049836 0.000000000 0.000000000
[104,] -0.009132484 0.011428696 0.000000000
[105,] 0.000000000 0.000000000 0.012121361
[106,] -0.009216655 0.011299555 0.011976191
[107,] -0.018692133 0.000000000 0.000000000
[108,] -0.009478744 0.000000000 0.000000000
[109,] -0.009569451 0.000000000 -0.011976191
[110,] -0.009661911 0.000000000 -0.012121361
[111,] -0.009756175 0.011173301 0.000000000
[112,] 0.000000000 0.011049836 -0.012270093
[113,] 0.000000000 0.010929071 -0.012422520
[114,] -0.009852296 0.010810916 -0.012578782
[115,] -0.009950331 0.000000000 -0.025642431
[116,] -0.020202707 -0.010810916 -0.026317308
[117,] -0.031090587 -0.010929071 -0.040821995
[118,] -0.032088315 -0.011049836 -0.013986242
[119,] -0.021978907 -0.022472856 -0.014184635
[120,] -0.011173301 -0.011428696 -0.014388737
[121,] 0.000000000 0.000000000 0.014388737
[122,] 0.011173301 -0.011560822 0.014184635
[123,] 0.011049836 0.000000000 0.000000000
[124,] 0.000000000 -0.011696040 0.000000000
[125,] -0.011049836 -0.011834458 -0.014184635
[126,] -0.011173301 -0.011976191 -0.028987537
[127,] -0.011299555 -0.012121361 -0.014815086
[128,] -0.011428696 -0.024692613 0.000000000
[129,] -0.011560822 -0.012578782 0.000000000
[130,] -0.011696040 -0.012739026 0.000000000
[131,] -0.011834458 0.000000000 0.000000000
[132,] -0.011976191 0.000000000 0.000000000
[133,] 0.000000000 0.000000000 0.000000000
[134,] 0.000000000 0.000000000 0.000000000
[135,] 0.011976191 0.000000000 -0.015037877
[136,] 0.000000000 -0.012903405 -0.015267472
[137,] 0.000000000 -0.026317308 -0.015504187
[138,] 0.000000000 -0.013423020 -0.015748357
[139,] -0.011976191 -0.027398974 -0.032260862
[140,] -0.012121361 -0.013986242 -0.033336420
[141,] 0.000000000 0.000000000 -0.017094433
[142,] 0.000000000 -0.014184635 -0.035091320
[143,] 0.000000000 0.000000000 -0.036367644
[144,] 0.000000000 0.000000000 -0.018692133
[145,] -0.012270093 0.000000000 -0.019048195

[146,] -0.025001302 0.000000000 0.000000000
[147,] -0.025642431 -0.014388737 0.000000000
[148,] -0.026317308 -0.014598799 0.000000000
[149,] -0.013423020 -0.014815086 0.000000000
[150,] -0.013605652 -0.015037877 0.019048195
[151,] 0.000000000 0.000000000 0.000000000
[152,] -0.013793322 -0.015267472 0.018692133
[153,] 0.000000000 -0.015504187 -0.018692133
[154,] -0.013986242 -0.015748357 -0.019048195
[155,] -0.028573372 -0.032260862 -0.039220713
[156,] -0.029413885 -0.016529302 -0.040821995
[157,] 0.000000000 -0.016807118 -0.042559614
[158,] -0.015037877 -0.017094433 -0.021978907
[159,] 0.015037877 0.000000000 -0.022472856
[160,] 0.014815086 0.000000000 0.022472856
[161,] 0.028987537 0.000000000 0.021978907
[162,] 0.028170877 0.017094433 0.042559614
[163,] 0.027398974 0.033336420 0.040821995
[164,] 0.013423020 0.016260521 0.019802627
[165,] 0.026317308 0.016000341 0.019418086
[166,] 0.012903405 0.000000000 0.019048195
[167,] 0.000000000 0.000000000 0.000000000
[168,] 0.000000000 -0.016000341 0.000000000
[169,] -0.025975486 -0.016260521 0.000000000
[170,] -0.013245227 -0.016529302 -0.019048195
[171,] -0.013423020 -0.016807118 0.000000000
[172,] -0.013605652 0.016807118 0.000000000
[173,] 0.000000000 0.000000000 -0.019418086
[174,] 0.000000000 0.032789823 0.000000000
[175,] 0.027028672 0.016000341 0.019418086
[176,] 0.013245227 0.015748357 0.019048195
[177,] 0.025975486 0.000000000 0.018692133
[178,] 0.037740328 0.000000000 0.036367644
[179,] 0.036367644 0.000000000 0.035091320
[180,] 0.046520016 0.015504187 0.033901552
[181,] 0.033522692 0.015267472 0.032789823
[182,] 0.032435276 0.015037877 0.016000341
[183,] 0.010582109 0.014815086 0.000000000
[184,] 0.000000000 0.014598799 -0.016000341
[185,] -0.010582109 0.014388737 -0.032789823
[186,] -0.021506205 0.028170877 -0.033901552
[187,] -0.010929071 0.027398974 -0.017391743
[188,] 0.000000000 0.026668247 0.000000000
[189,] 0.010929071 0.038714512 0.000000000
[190,] 0.010810916 0.037271395 0.017391743
[191,] 0.000000000 0.024097552 0.033901552
[192,] 0.010695289 0.011834458 0.016529302
[193,] 0.000000000 0.000000000 0.032260862
[194,] 0.000000000 -0.011834458 0.031252544
[195,] -0.010695289 0.000000000 0.030305349
[196,] 0.000000000 -0.024097552 0.014815086
[197,] -0.010810916 -0.012270093 0.014598799
[198,] -0.010929071 -0.025001302 0.000000000
[199,] -0.011049836 -0.038714512 -0.014598799

[200,] -0.033901552 -0.026668247 -0.014815086
[201,] -0.023256862 -0.013605652 -0.030305349
[202,] -0.048202102 0.000000000 -0.031252544
[203,] -0.037740328 0.013605652 -0.016000341
[204,] -0.039220713 0.013423020 -0.016260521
[205,] -0.027028672 0.026317308 0.000000000
[206,] -0.013793322 0.012903405 -0.016529302
[207,] 0.000000000 0.000000000 0.000000000
[208,] 0.000000000 0.000000000 0.016529302
[209,] 0.000000000 -0.012903405 0.000000000
[210,] 0.000000000 -0.013072082 -0.239672853
[211,] 0.000000000 -0.013245227 -0.064538521
[212,] 0.000000000 -0.027028672 0.000000000
[213,] 0.000000000 -0.027779564 0.021978907
[214,] 0.000000000 -0.028573372 0.042559614
[215,] -0.013986242 -0.014598799 0.040821995
[216,] -0.014184635 -0.029852963 0.019802627
[217,] -0.028987537 -0.030771659 0.000000000
[218,] -0.029852963 -0.031748698 -0.019802627
[219,] -0.046520016 -0.032789823 -0.020202707
[220,] -0.032260862 -0.033901552 0.000000000
[221,] -0.033336420 -0.017391743 0.000000000
[222,] -0.017094433 -0.017699577 0.000000000
[223,] -0.017391743 0.000000000 0.000000000
[224,] -0.035718083 -0.018018506 -0.020619287
[225,] -0.018349139 -0.037041272 -0.021053409
[226,] -0.037740328 -0.019048195 -0.043485112
[227,] 0.000000000 -0.039220713 -0.022472856
[228,] 0.000000000 -0.020202707 0.000000000
[229,] 0.019048195 0.020202707 0.022472856
[230,] 0.018692133 0.000000000 0.021978907
[231,] 0.018349139 0.019802627 0.021506205
[232,] 0.000000000 0.019418086 0.000000000
[233,] 0.000000000 0.000000000 0.000000000
[234,] -0.018349139 0.000000000 0.000000000
[235,] -0.018692133 0.000000000 -0.021506205
[236,] -0.038466281 0.000000000 -0.021978907
[237,] -0.019802627 0.000000000 0.021978907
[238,] 0.000000000 0.019048195 0.000000000
[239,] -0.020202707 0.000000000 0.000000000
[240,] 0.000000000 0.000000000 -0.021978907
[241,] 0.000000000 0.000000000 0.000000000
[242,] 0.020202707 0.018692133 -0.022472856
[243,] 0.000000000 0.000000000 0.000000000
[244,] 0.000000000 0.000000000 -0.022989518
[245,] 0.000000000 0.000000000 -0.023530497
[246,] -0.020202707 -0.018692133 -0.048790164
[247,] 0.000000000 0.000000000 -0.025317808
[248,] -0.020619287 -0.019048195 -0.025975486
[249,] 0.000000000 -0.019418086 -0.054067221
[250,] 0.000000000 0.000000000 -0.028170877
[251,] -0.021053409 0.000000000 0.000000000
[252,] -0.021506205 0.000000000 -0.028987537
[253,] -0.021978907 -0.019802627 0.000000000

```

## [254,] -0.022472856 -0.020202707 0.000000000
## [255,] -0.022989518 -0.020619287 0.000000000
## [256,] -0.023530497 -0.021053409 0.028987537
## [257,] 0.000000000 -0.021506205 0.000000000
## [258,] -0.024097552 0.000000000 0.028170877
## [259,] 0.000000000 0.000000000 0.000000000
## [260,] 0.000000000 0.021506205 0.000000000
## [261,] 0.000000000 0.000000000 0.000000000
## [262,] 0.000000000 0.021053409 -0.028170877
## [263,] 0.000000000 -0.021053409 -0.028987537
## [264,] -0.024692613 0.000000000 -0.029852963
## [265,] -0.025317808 -0.021506205 -0.030771659
## [266,] -0.025975486 -0.021978907 -0.064538521
## [267,] -0.026668247 -0.045462374 -0.033901552
## [268,] 0.000000000 0.000000000 0.000000000
## [269,] 0.026668247 0.000000000 0.000000000
## [270,] 0.212561442 0.000000000 0.033901552
## [271,] -0.186585956 0.022989518 0.032789823
## [272,] 0.025317808 0.022472856 0.031748698
## [273,] 0.000000000 0.000000000 0.000000000
## [274,] 0.000000000 -0.022472856 0.000000000
## [275,] -0.025317808 -0.022989518 -0.031748698
## [276,] 0.000000000 -0.023530497 -0.032789823
## [277,] 0.000000000 -0.024097552 -0.033901552
## [278,] 0.000000000 0.024097552 0.000000000
## [279,] -0.025975486 0.023530497 0.000000000
## [280,] 0.000000000 0.022989518 0.000000000
## [281,] -0.026668247 0.022472856 0.033901552
## [282,] -0.027398974 0.021978907 0.000000000
## [283,] 0.000000000 0.000000000 0.032789823
## [284,] 0.000000000 -0.021978907 0.031748698
## [285,] 0.000000000 -0.022472856 0.000000000
## [286,] -0.028170877 -0.022989518 0.000000000
## [287,] -0.028987537 0.000000000 0.000000000
## [288,] -0.029852963 -0.023530497 0.000000000
## [289,] -0.030771659 0.000000000 0.030771659
## [290,] 0.000000000 0.023530497 0.000000000
## [291,] 0.030771659 0.000000000 0.000000000
## [292,] 0.058840500 0.000000000 0.000000000
## [293,] 0.028170877 0.000000000 -0.030771659
## [294,] 0.054067221 0.000000000 -0.031748698
## [295,] 0.000000000 0.000000000 -0.032789823
## [296,] 0.025975486 0.022989518 -0.033901552
## [297,] 0.025317808 0.000000000 0.000000000
## [298,] 0.024692613 0.022472856 0.033901552
## [299,] 0.024097552 0.043485112 0.032789823
## [300,] 0.046520016 0.021053409 0.062520357
## [301,] 0.044451763 0.040821995 0.058840500
## [302,] 0.021506205 0.019802627 0.055569851
## [303,] 0.021053409 0.000000000 0.026668247
## [304,] 0.020619287 0.000000000 0.025975486
## [305,] 0.000000000 0.019418086 0.050010421
## [306,] 0.040005335 0.000000000 0.024097552
## [307,] 0.038466281 0.037740328 0.046520016

```

```

## [308,] 0.055059777 0.018349139 0.065957968
## [309,] 0.052185753 0.053109825 0.041672696
## [310,] 0.033336420 0.033901552 0.059423420
## [311,] 0.032260862 0.032789823 0.019048195
## [312,] 0.015748357 0.016000341 0.018692133
## [313,] 0.000000000 0.031252544 0.000000000
## [314,] 0.000000000 0.000000000 0.000000000
## [315,] 0.000000000 0.015267472 0.000000000
## [316,] 0.000000000 0.000000000 -0.018692133
## [317,] -0.015748357 0.000000000 -0.019048195
## [318,] -0.016000341 0.000000000 -0.019418086
## [319,] -0.016260521 0.000000000 0.000000000
## [320,] 0.000000000 -0.015267472 -0.019802627
## [321,] 0.016260521 0.000000000 0.000000000
## [322,] 0.016000341 0.015267472 0.000000000
## [323,] 0.015748357 0.000000000 0.000000000
## [324,] 0.030771659 0.000000000 0.000000000
## [325,] 0.044451763 0.000000000 0.000000000
## [326,] 0.028573372 0.015037877 0.019802627
## [327,] 0.013986242 0.000000000 0.019418086
## [328,] 0.027398974 0.014815086 0.019048195
## [329,] 0.013423020 0.014598799 0.037041272
## [330,] 0.000000000 0.000000000 0.000000000
## [331,] -0.013423020 0.014388737 0.000000000
## [332,] -0.013605652 -0.014388737 0.000000000
## [333,] -0.013793322 -0.014598799 -0.018349139
## [334,] -0.028170877 -0.029852963 -0.018692133
## [335,] -0.014388737 -0.015267472 -0.019048195
## [336,] 0.000000000 -0.015504187 0.000000000
## [337,] -0.014598799 0.000000000 0.019048195
## [338,] 0.014598799 -0.015748357 0.000000000
## [339,] 0.000000000 0.000000000 0.000000000
## [340,] 0.014388737 -0.016000341 0.000000000
## [341,] 0.000000000 0.000000000 0.000000000
## [342,] 0.000000000 -0.016260521 0.000000000
## [343,] 0.014184635 0.000000000 0.000000000
## [344,] 0.000000000 0.000000000 0.018692133
## [345,] 0.013986242 0.000000000 0.018349139
## [346,] 0.000000000 -0.016529302 0.018018506
## [347,] -0.013986242 0.000000000 0.000000000
## [348,] 0.000000000 0.000000000 0.000000000
## [349,] -0.014184635 -0.016807118 0.000000000
## [350,] -0.014388737 0.000000000 -0.018018506
## [351,] -0.014598799 -0.017094433 0.000000000
## [352,] -0.014815086 -0.017391743 -0.018349139
## [353,] -0.015037877 0.000000000 -0.018692133
## [354,] 0.000000000 -0.017699577 0.000000000
## [355,] -0.015267472 0.000000000 0.018692133
## [356,] 0.015267472 0.000000000 0.000000000
## [357,] 0.000000000 -0.018018506 0.000000000
## [358,] 0.015037877 -0.018349139 0.000000000
## [359,] 0.000000000 -0.037740328 -0.018692133
## [360,] 0.014815086 -0.019418086 -0.038466281
## [361,] 0.000000000 -0.040005335 0.000000000

```

```

## [362,] 0.014598799 -0.041672696 0.000000000
## [363,] 0.000000000 -0.021506205 0.000000000
## [364,] 0.014388737 -0.021978907 0.019418086
## [365,] 0.000000000 0.000000000 0.000000000
## [366,] 0.014184635 -0.022472856 0.000000000
## [367,] 0.000000000 0.000000000 -0.019418086
## [368,] 0.013986242 0.000000000 0.000000000
## [369,] 0.000000000 0.000000000 -0.019802627
## [370,] -0.013986242 0.000000000 -0.020202707
## [371,] -0.014184635 0.022472856 -0.020619287
## [372,] 0.000000000 0.021978907 0.000000000
## [373,] -0.014388737 0.000000000 -0.021053409
## [374,] 0.000000000 0.021506205 -0.021506205
## [375,] 0.000000000 0.021053409 -0.021978907
## [376,] 0.000000000 0.000000000 0.000000000
## [377,] 0.014388737 0.020619287 0.000000000
## [378,] 0.014184635 0.020202707 0.000000000
## [379,] 0.013986242 0.039220713 0.021978907
## [380,] 0.013793322 0.019048195 0.021506205
## [381,] 0.013605652 0.018692133 0.000000000
## [382,] 0.000000000 0.018349139 0.000000000
## [383,] -0.013605652 0.000000000 0.021053409
## [384,] 0.000000000 0.000000000 0.000000000
## [385,] 0.000000000 0.018018506 0.000000000
## [386,] 0.013605652 0.017699577 0.040821995
## [387,] 0.026668247 0.034486176 0.039220713
## [388,] 0.025975486 0.033336420 0.037740328
## [389,] 0.025317808 0.032260862 0.054067221
## [390,] 0.024692613 0.031252544 0.034486176
## [391,] 0.024097552 0.015267472 0.049596941
## [392,] 0.035091320 0.029852963 0.062520357
## [393,] 0.033901552 0.043172172 0.073025135
## [394,] 0.054067221 0.041385216 0.068053463
## [395,] 0.061243625 0.065382759 0.088107268
## [396,] 0.103378354 0.073203404 0.080969063
## [397,] 0.085522173 0.068208250 0.074901308
## [398,] 0.071176278 0.053488685 0.050261835
## [399,] 0.052056362 0.040821995 0.028987537
## [400,] 0.042559614 0.029558802 0.009478744
## [401,] 0.034133006 0.019231362 0.009389740
## [402,] -0.013513719 0.018868484 0.000000000
## [403,] -0.006825965 0.009302393 0.000000000
## [404,] -0.013793322 0.009216655 -0.009389740
## [405,] -0.013986242 0.009132484 0.000000000
## [406,] -0.014184635 0.009049836 0.009389740
## [407,] -0.007168489 0.008968670 0.009302393
## [408,] -0.014493007 0.000000000 0.009216655
## [409,] -0.014706147 -0.008968670 0.000000000
## [410,] -0.014925650 -0.009049836 -0.009216655
## [411,] -0.022814678 -0.027651531 -0.009302393
## [412,] -0.023347364 -0.018868484 -0.018868484
## [413,] -0.023905521 -0.028987537 -0.019231362
## [414,] -0.016260521 -0.019802627 -0.009756175
## [415,] -0.016529302 -0.010050336 -0.009852296

```

[416,] -0.008368250 -0.010152371 -0.020000667
[417,] -0.016949558 -0.010256500 -0.010152371
[418,] -0.025975486 -0.010362787 -0.020619287
[419,] -0.017699577 -0.010471300 -0.031748698
[420,] -0.027150989 -0.010582109 -0.021739987
[421,] -0.018519048 0.000000000 -0.022223137
[422,] -0.009389740 0.000000000 -0.011299555
[423,] -0.009478744 0.010582109 0.000000000
[424,] 0.000000000 0.010471300 0.011299555
[425,] 0.000000000 0.020619287 0.022223137
[426,] -0.009569451 0.010152371 0.010929071
[427,] -0.009661911 0.010050336 0.010810916
[428,] -0.019608471 -0.010050336 0.000000000
[429,] -0.030153038 -0.010152371 -0.010810916
[430,] -0.020619287 -0.020619287 -0.021978907
[431,] -0.021053409 -0.031748698 -0.022472856
[432,] -0.021506205 -0.021739987 -0.022989518
[433,] -0.010929071 -0.011049836 -0.023530497
[434,] 0.000000000 -0.011173301 -0.011976191
[435,] 0.000000000 0.000000000 0.000000000
[436,] 0.000000000 0.011173301 0.000000000
[437,] 0.000000000 0.000000000 0.000000000
[438,] 0.000000000 0.000000000 0.000000000
[439,] -0.011049836 -0.011173301 0.000000000
[440,] 0.000000000 0.000000000 0.000000000
[441,] 0.000000000 0.000000000 0.000000000
[442,] 0.000000000 0.011173301 0.000000000
[443,] 0.000000000 0.011049836 0.011976191
[444,] -0.011173301 0.010929071 0.000000000
[445,] 0.000000000 0.000000000 -0.011976191
[446,] -0.011299555 0.000000000 -0.012121361
[447,] -0.011428696 -0.010929071 -0.024692613
[448,] -0.011560822 0.000000000 -0.025317808
[449,] 0.000000000 -0.011049836 -0.025975486
[450,] 0.000000000 0.000000000 -0.013245227
[451,] -0.011696040 -0.011173301 -0.027028672
[452,] -0.011834458 -0.011299555 -0.041964199
[453,] -0.011976191 -0.011428696 -0.028987537
[454,] -0.012121361 -0.011560822 -0.045120435
[455,] -0.024692613 -0.023530497 -0.031252544
[456,] -0.012578782 -0.024097552 -0.016000341
[457,] -0.012739026 -0.024692613 -0.016260521
[458,] -0.012903405 -0.038221213 -0.016529302
[459,] -0.026317308 -0.039740329 0.000000000
[460,] -0.027028672 -0.027398974 0.000000000
[461,] -0.027779564 -0.042559614 -0.016807118
[462,] -0.014184635 -0.029413885 -0.017094433
[463,] -0.028987537 -0.015037877 -0.017391743
[464,] -0.014815086 -0.030771659 0.000000000
[465,] -0.030305349 -0.015748357 0.000000000
[466,] -0.015504187 -0.016000341 -0.017699577
[467,] -0.031748698 -0.016260521 -0.018018506
[468,] -0.032789823 -0.016529302 -0.018349139
[469,] -0.016807118 0.000000000 -0.037740328

```

## [470,] -0.017094433 -0.016807118 -0.019418086
## [471,] -0.035091320  0.000000000 -0.040005335
## [472,] -0.018018506  0.000000000 -0.020619287
## [473,] -0.037041272 -0.017094433 -0.021053409
## [474,] -0.019048195  0.000000000 -0.021506205
## [475,] -0.019418086  0.000000000  0.000000000
## [476,]  0.000000000  0.017094433 -0.021978907
## [477,]  0.000000000  0.000000000  0.000000000
## [478,]  0.000000000  0.016807118  0.000000000
## [479,]  0.000000000  0.016529302  0.021978907
## [480,] -0.040005335  0.032260862  0.000000000
## [481,] -0.020619287  0.015748357  0.021506205
## [482,]  0.000000000  0.015504187  0.061875404
## [483,]  0.000000000  0.015267472  0.039220713
## [484,] -0.021053409 -0.030771659 -0.039220713
## [485,] -0.021506205 -0.031748698 -0.040821995
## [486,] -0.021978907 -0.066691374 -0.042559614
## [487,]  0.000000000 -0.053109825 -0.021978907
## [488,]  0.021978907  0.000000000  0.000000000
## [489,]  0.021506205  0.018018506 -0.022472856
## [490,]  0.041672696  0.000000000 -0.046520016
## [491,]  0.020202707  0.017699577 -0.048790164

```

```

detach("package:vars", unload = TRUE)
#BIC has the least value, the optimal lag is 2 periods

```

```

m1=VAR(zt1,2)

```

```

## Constant term:
## Estimates:  -0.0004308488  0.0002069438 -0.0001722694
## Std.Error:  0.0008968027  0.0005526058  0.0008400675
## 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,] 3.855168e-04 3.071579e-05 7.144333e-05
## [2,] 3.071579e-05 1.463795e-04 4.019971e-05
## [3,] 7.144333e-05 4.019971e-05 3.382811e-04
##
## det(SSE) = 1.757694e-11
## AIC = -24.69111
## BIC = -24.53727
## HQ = -24.6307

```

```
m1
```

```

## $data
##           MI           IL           IN
## [1,] 0.00000000 -0.014598799 -0.028987537
## [2,] -0.010050336 -0.014815086 -0.045120435
## [3,] -0.020408872 -0.015037877 -0.047252885
## [4,] -0.010362787 -0.015267472 -0.032789823
## [5,] -0.021053409 0.000000000 -0.033901552
## [6,] -0.021506205 0.015267472 -0.017391743
## [7,] -0.021978907 0.000000000 0.000000000
## [8,] 0.000000000 0.000000000 0.000000000
## [9,] -0.011173301 0.000000000 0.017391743
## [10,] 0.011173301 -0.015267472 0.000000000
## [11,] -0.011173301 -0.031252544 0.017094433
## [12,] 0.000000000 -0.016000341 -0.017094433
## [13,] -0.011299555 -0.016260521 0.000000000
## [14,] -0.022989518 -0.016529302 0.000000000
## [15,] -0.023530497 0.000000000 -0.017391743
## [16,] -0.011976191 0.016529302 0.000000000
## [17,] -0.012121361 0.016260521 0.017391743
## [18,] -0.012270093 0.016000341 0.000000000
## [19,] 0.000000000 0.015748357 0.000000000
## [20,] -0.012422520 0.000000000 0.000000000
## [21,] -0.012578782 0.000000000 0.000000000
## [22,] -0.025642431 0.000000000 0.000000000
## [23,] -0.026317308 -0.015748357 0.000000000
## [24,] -0.027028672 0.000000000 0.000000000
## [25,] -0.027779564 0.000000000 -0.017391743
## [26,] -0.028573372 0.000000000 0.000000000
## [27,] -0.014598799 -0.016000341 -0.017699577
## [28,] 0.000000000 -0.016260521 0.000000000
## [29,] 0.000000000 -0.016529302 -0.018018506
## [30,] 0.014598799 -0.016807118 0.000000000
## [31,] 0.000000000 -0.017094433 0.000000000
## [32,] 0.014388737 -0.017391743 0.000000000
## [33,] 0.000000000 0.000000000 0.000000000
## [34,] 0.014184635 -0.017699577 0.000000000
## [35,] 0.000000000 0.000000000 0.018018506
## [36,] 0.013986242 0.000000000 0.000000000
## [37,] 0.000000000 -0.018018506 0.000000000
## [38,] 0.000000000 0.000000000 0.000000000
## [39,] 0.000000000 -0.018349139 0.017699577
## [40,] 0.013793322 -0.037740328 0.034486176
## [41,] 0.013605652 0.000000000 0.049596941
## [42,] 0.039740329 0.000000000 0.047252885

```

```
## [43,] 0.025642431 0.019048195 0.045120435
## [44,] 0.037271395 0.037041272 0.043172172
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## [396,] 0.103378354 0.073203404 0.080969063
## [397,] 0.085522173 0.068208250 0.074901308
## [398,] 0.071176278 0.053488685 0.050261835
## [399,] 0.052056362 0.040821995 0.028987537
## [400,] 0.042559614 0.029558802 0.009478744
## [401,] 0.034133006 0.019231362 0.009389740
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## [403,] -0.006825965 0.009302393 0.000000000
## [404,] -0.013793322 0.009216655 -0.009389740
## [405,] -0.013986242 0.009132484 0.000000000
## [406,] -0.014184635 0.009049836 0.009389740
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## [415,] -0.016529302 -0.010050336 -0.009852296
## [416,] -0.008368250 -0.010152371 -0.020000667
## [417,] -0.016949558 -0.010256500 -0.010152371
## [418,] -0.025975486 -0.010362787 -0.020619287
## [419,] -0.017699577 -0.010471300 -0.031748698
## [420,] -0.027150989 -0.010582109 -0.021739987

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## [475,] -0.019418086  0.000000000  0.000000000
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## [484,] -0.021053409 -0.030771659 -0.039220713
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## [490,]  0.041672696  0.000000000 -0.046520016
## [491,]  0.020202707  0.017699577 -0.048790164
##
## $cnst
## [1] TRUE
##
## $order
## [1] 2
##
## $coef
##           [,1]           [,2]           [,3]
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## [2,]  0.1989672213  0.1057980281  0.1514488174
## [3,]  0.2756039973  0.5279992862  0.2738006889
## [4,]  0.1309946125  0.1008975084  0.5680942143
## [5,]  0.3090973598  0.0495592959 -0.0061172881
## [6,] -0.1060265979  0.1830326679 -0.1699764757
## [7,]  0.0056175190 -0.0848405884  0.0138803149
##
## $aic
## [1] -24.69111
##
## $bic
## [1] -24.53727
##
## $hq
## [1] -24.6307
##
## $residuals
##           [,1]           [,2]           [,3]
## [1,] -9.369728e-03 -1.593884e-03 -1.794856e-02
## [2,]  6.252335e-03 -1.225823e-03 -5.185933e-04
## [3,] -5.078282e-03  1.201395e-02 -1.137694e-02
## [4,] -1.067695e-02  2.123463e-02  3.024946e-03
## [5,] -1.250058e-02 -6.070896e-03  9.471037e-03
## [6,]  1.316790e-02 -1.085758e-03  6.205903e-03
## [7,] -3.948830e-03  8.823153e-04  1.742956e-02
## [8,]  1.154905e-02 -1.604709e-02 -8.015696e-03
## [9,] -5.401857e-03 -2.255112e-02  1.944501e-02

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## [10,] 3.955621e-03 1.992068e-03 -1.891102e-02
## [11,] -4.175661e-03 1.429769e-03 8.646599e-03
## [12,] -1.742940e-02 -5.476948e-03 3.853310e-03
## [13,] -1.220133e-02 1.448897e-02 -1.204503e-02
## [14,] 7.681338e-04 2.473137e-02 1.066586e-02
## [15,] -6.492271e-03 8.283804e-03 1.494952e-02
## [16,] -1.073282e-02 4.303616e-03 -9.587924e-03
## [17,] 3.835467e-03 7.491441e-03 9.800922e-05
## [18,] -1.084287e-02 -1.084255e-02 -1.495020e-03
## [19,] -8.006514e-03 -1.775130e-03 4.730496e-03
## [20,] -1.886905e-02 1.739518e-03 2.001319e-03
## [21,] -1.689639e-02 -1.261899e-02 3.978837e-03
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## [30,] 1.323643e-02 -6.220092e-03 2.085227e-03
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## [32,] 8.323976e-03 -1.543636e-02 -2.695898e-03
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## [35,] -2.453174e-03 -1.817647e-02 -2.196033e-03
## [36,] 1.073710e-03 8.613666e-03 5.191306e-03
## [37,] -1.479592e-03 -1.525811e-02 1.480912e-02
## [38,] 1.696272e-02 -3.004478e-02 2.962742e-02
## [39,] 1.513104e-02 1.964118e-02 3.505756e-02
## [40,] 2.250848e-02 2.499350e-03 1.037959e-02
## [41,] 7.492300e-03 1.340265e-02 1.182480e-02
## [42,] 8.890873e-03 2.155090e-02 8.200076e-03
## [43,] 6.923171e-03 2.411669e-02 4.013311e-03
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## [77,] 1.631509e-02 -1.738608e-03 -6.174642e-04
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## [79,] 7.203249e-03 1.937261e-03 1.725690e-03
## [80,] 1.633975e-03 -5.535058e-03 6.357583e-04
## [81,] -1.492050e-02 -8.437097e-04 -1.198504e-02
## [82,] -1.401302e-02 -3.164626e-03 -9.473950e-03
## [83,] -1.624596e-02 -5.643588e-03 -9.972530e-03
## [84,] -1.620526e-02 -6.066459e-03 -1.118536e-02
## [85,] -9.227607e-03 -6.965449e-03 -5.098531e-03
## [86,] 4.553439e-04 -9.897883e-03 4.353325e-03
## [87,] -7.387281e-03 -6.173778e-03 -5.261861e-04
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## [89,] -6.385871e-03 -8.958209e-03 -3.512767e-03
## [90,] -6.331040e-03 -6.151075e-03 -9.186272e-03
## [91,] -1.300118e-02 -6.287719e-03 5.460266e-03
## [92,] -5.361200e-03 2.217057e-03 -1.791471e-02
## [93,] 3.338589e-03 -2.919310e-04 -1.551670e-03
## [94,] -6.265402e-04 4.330605e-03 -6.549851e-03
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## [115,] -1.699344e-02 -2.317488e-03 -1.938425e-02
## [116,] -1.186570e-02 2.669129e-03 1.548189e-02
## [117,] -1.605469e-03 -1.196159e-02 3.370748e-04
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## [127,] 2.400451e-04 2.982772e-03 6.740155e-03
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## [142,] 3.887992e-03 3.081544e-03 2.164089e-04
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[438,] 5.708810e-03 6.861602e-03 4.905011e-03
[439,] 2.661657e-03 2.385757e-03 -1.794524e-03
[440,] 4.308488e-04 1.096636e-02 1.722694e-04
[441,] -2.648558e-03 4.943398e-03 9.089203e-03

```

## [442,] -1.417198e-02  1.634374e-03 -7.757590e-03
## [443,]  7.461739e-04 -5.801786e-03 -1.139215e-02
## [444,] -4.687480e-03 -4.452120e-04 -3.356152e-03
## [445,] -7.094497e-03 -9.733596e-03 -1.575673e-02
## [446,]  9.514117e-04  8.795769e-03 -6.295433e-03
## [447,]  8.560089e-03 -7.007325e-03 -1.125430e-02
## [448,]  1.059452e-02  6.673192e-03  4.989717e-03
## [449,] -1.055580e-02 -1.022513e-02 -2.084953e-02
## [450,] -2.382058e-03 -2.766194e-03 -2.142264e-02
## [451,]  2.002996e-03  1.482609e-04 -1.685088e-03
## [452,]  3.350440e-04 -2.447168e-03 -2.494813e-02
## [453,] -1.010037e-02 -1.157234e-02 -2.060004e-03
## [454,]  6.118492e-03 -7.225986e-03  1.069572e-02
## [455,]  4.245053e-03 -6.351747e-03 -2.212470e-03
## [456,]  4.204851e-04 -1.872551e-02 -2.380235e-03
## [457,] -9.209067e-03 -1.296224e-02  1.793228e-02
## [458,] -1.038015e-02  2.394125e-03  8.692715e-03
## [459,] -1.049855e-02 -1.686229e-02 -1.195544e-02
## [460,]  1.115415e-02  3.839866e-03  3.663373e-03
## [461,] -1.121999e-02  1.125179e-02 -4.477217e-03
## [462,] -8.321363e-04 -1.358063e-02  1.371076e-02
## [463,] -1.098274e-02  4.573019e-03  8.349290e-03
## [464,] -3.386567e-03  1.680526e-03 -1.394677e-02
## [465,] -1.380716e-02 -2.087647e-04 -3.924450e-03
## [466,] -1.600496e-02 -7.784112e-04 -1.249065e-03
## [467,]  5.297621e-03  1.686195e-02 -2.036032e-02
## [468,]  1.100394e-04 -8.334306e-03  1.984178e-03
## [469,] -1.867642e-02  1.006603e-02 -2.119000e-02
## [470,] -1.754227e-03  9.818085e-03  4.902463e-03
## [471,] -1.925295e-02 -1.496960e-02 -6.097938e-03
## [472,]  1.907132e-03  1.400567e-02  1.092686e-03
## [473,] -2.624911e-03  7.156636e-03  1.243463e-02
## [474,]  1.030297e-02  1.806130e-02 -1.868380e-02
## [475,]  4.600752e-03 -6.052829e-03  7.859105e-03
## [476,]  2.366780e-03  1.160663e-02  3.382995e-03
## [477,] -4.201260e-03  7.448212e-03  1.754938e-02
## [478,] -4.522714e-02  1.803259e-02 -1.398274e-02
## [479,] -1.949083e-02  1.579488e-03  2.140871e-02
## [480,]  1.316196e-02  3.071523e-03  5.387984e-02
## [481,] -4.025211e-03  5.952675e-04  2.249070e-03
## [482,] -2.867177e-02 -4.058532e-02 -6.373325e-02
## [483,] -1.869489e-03 -8.990485e-03 -4.704134e-03
## [484,]  2.937635e-04 -4.039277e-02 -1.206155e-02
## [485,]  3.227004e-02 -8.070768e-03  1.899859e-02
## [486,]  3.988780e-02  3.973780e-02  1.632019e-02
## [487,]  1.205638e-02  2.334237e-02 -3.435161e-02
## [488,]  2.900874e-02 -1.081782e-02 -4.163716e-02
## [489,]  1.382510e-02  1.150708e-02 -2.499521e-02
##
## $secoef
##           [,1]           [,2]           [,3]
## [1,] 0.0008968027 0.0005526058 0.0008400675
## [2,] 0.0445222992 0.0274344419 0.0417056434
## [3,] 0.0735116295 0.0452975378 0.0688609945

```

```

## [4,] 0.0497042240 0.0306275208 0.0465597392
## [5,] 0.0453596761 0.0279504298 0.0424900445
## [6,] 0.0720163380 0.0443761458 0.0674603011
## [7,] 0.0501371101 0.0308942633 0.0469652392
##
## $Sigma
##           [,1]      [,2]      [,3]
## [1,] 3.855168e-04 3.071579e-05 7.144333e-05
## [2,] 3.071579e-05 1.463795e-04 4.019971e-05
## [3,] 7.144333e-05 4.019971e-05 3.382811e-04
##
## $Phi
##           [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## [1,] 0.1989672 0.2756040 0.1309946 0.309097360 -0.1060266 0.005617519
## [2,] 0.1057980 0.5279993 0.1008975 0.049559296 0.1830327 -0.084840588
## [3,] 0.1514488 0.2738007 0.5680942 -0.006117288 -0.1699765 0.013880315
##
## $Ph0
## [1] -0.0004308488 0.0002069438 -0.0001722694
##
## $fixed
## NULL

```

```
summary(m1)
```

```

##           Length Class  Mode
## data      1473  -none-  numeric
## cnst         1  -none-  logical
## order        1  -none-  numeric
## coef        21  -none-  numeric
## aic          1  -none-  numeric
## bic          1  -none-  numeric
## hq           1  -none-  numeric
## residuals 1467  -none-  numeric
## secoef      21  -none-  numeric
## Sigma        9  -none-  numeric
## Phi         18  -none-  numeric
## Ph0          3  -none-  numeric
## fixed        0  -none-  NULL

```

```
m1a=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,] 3.874526e-04 3.062712e-05 7.153133e-05
## [2,] 3.062712e-05 1.464221e-04 4.016425e-05
## [3,] 7.153133e-05 4.016425e-05 3.383777e-04
##
## det(SSE) = 1.768107e-11
## AIC = -24.7015
## BIC = -24.58185
## HQ = -24.65451

```

m1a

```

## $data
##      MI IL IN
## [1,] 0.000000000 -0.014598799 -0.028987537
## [2,] -0.010050336 -0.014815086 -0.045120435
## [3,] -0.020408872 -0.015037877 -0.047252885
## [4,] -0.010362787 -0.015267472 -0.032789823
## [5,] -0.021053409 0.000000000 -0.033901552
## [6,] -0.021506205 0.015267472 -0.017391743
## [7,] -0.021978907 0.000000000 0.000000000
## [8,] 0.000000000 0.000000000 0.000000000
## [9,] -0.011173301 0.000000000 0.017391743
## [10,] 0.011173301 -0.015267472 0.000000000
## [11,] -0.011173301 -0.031252544 0.017094433
## [12,] 0.000000000 -0.016000341 -0.017094433
## [13,] -0.011299555 -0.016260521 0.000000000
## [14,] -0.022989518 -0.016529302 0.000000000
## [15,] -0.023530497 0.000000000 -0.017391743
## [16,] -0.011976191 0.016529302 0.000000000
## [17,] -0.012121361 0.016260521 0.017391743
## [18,] -0.012270093 0.016000341 0.000000000
## [19,] 0.000000000 0.015748357 0.000000000
## [20,] -0.012422520 0.000000000 0.000000000
## [21,] -0.012578782 0.000000000 0.000000000
## [22,] -0.025642431 0.000000000 0.000000000
## [23,] -0.026317308 -0.015748357 0.000000000
## [24,] -0.027028672 0.000000000 0.000000000
## [25,] -0.027779564 0.000000000 -0.017391743
## [26,] -0.028573372 0.000000000 0.000000000
## [27,] -0.014598799 -0.016000341 -0.017699577
## [28,] 0.000000000 -0.016260521 0.000000000

```

```

## [29,] 0.00000000 -0.016529302 -0.018018506
## [30,] 0.014598799 -0.016807118 0.000000000
## [31,] 0.000000000 -0.017094433 0.000000000
## [32,] 0.014388737 -0.017391743 0.000000000
## [33,] 0.000000000 0.000000000 0.000000000
## [34,] 0.014184635 -0.017699577 0.000000000
## [35,] 0.000000000 0.000000000 0.018018506
## [36,] 0.013986242 0.000000000 0.000000000
## [37,] 0.000000000 -0.018018506 0.000000000
## [38,] 0.000000000 0.000000000 0.000000000
## [39,] 0.000000000 -0.018349139 0.017699577
## [40,] 0.013793322 -0.037740328 0.034486176
## [41,] 0.013605652 0.000000000 0.049596941
## [42,] 0.039740329 0.000000000 0.047252885
## [43,] 0.025642431 0.019048195 0.045120435
## [44,] 0.037271395 0.037041272 0.043172172
## [45,] 0.035932009 0.053109825 0.041385216
## [46,] 0.045985113 0.033901552 0.026668247
## [47,] 0.033152207 0.048790164 0.025975486
## [48,] 0.063178902 0.031252544 0.037740328
## [49,] 0.068992871 0.045120435 0.048202102
## [50,] 0.073427469 0.057158414 0.057158414
## [51,] 0.076633226 0.054067221 0.064538521
## [52,] 0.063513406 0.063715814 0.060624622
## [53,] 0.037740328 0.036367644 0.028987537
## [54,] 0.007380107 0.035091320 0.009478744
## [55,] -0.007380107 0.022728251 -0.009478744
## [56,] -0.022472856 0.000000000 -0.028987537
## [57,] -0.022989518 0.000000000 -0.040005335
## [58,] -0.015625318 0.000000000 -0.020619287
## [59,] -0.015873349 0.000000000 -0.021053409
## [60,] -0.008032172 -0.011299555 0.000000000
## [61,] -0.016260521 -0.011428696 0.000000000
## [62,] -0.008230499 -0.023256862 0.000000000
## [63,] -0.016667052 -0.011834458 0.010582109
## [64,] -0.008438869 -0.011976191 0.000000000
## [65,] -0.008510690 -0.012121361 0.000000000
## [66,] 0.008510690 0.000000000 0.000000000
## [67,] 0.025105921 0.012121361 0.020834087
## [68,] 0.032523192 0.011976191 0.030459207
## [69,] 0.039220713 0.023530497 0.039220713
## [70,] 0.037740328 0.034289073 0.037740328
## [71,] 0.036367644 0.022223137 0.036367644
## [72,] 0.028170877 0.032435276 0.026433257
## [73,] 0.020619287 0.031416196 0.008658063
## [74,] 0.013513719 0.040409538 0.008583744
## [75,] 0.000000000 0.038839833 0.008510690
## [76,] 0.000000000 0.037387532 0.000000000
## [77,] 0.006688988 0.036039936 0.000000000
## [78,] 0.006644543 0.034786116 0.008438869
## [79,] 0.026145280 0.025317808 0.008368250
## [80,] 0.019169916 0.024692613 0.016529302
## [81,] 0.025001302 0.024097552 0.016260521
## [82,] 0.018349139 0.015748357 0.016000341

```

```

## [83,] 0.00000000 0.015504187 0.000000000
## [84,] -0.006079046 0.007662873 -0.007968170
## [85,] -0.018462063 0.000000000 -0.016129382
## [86,] -0.025158560 -0.007662873 -0.024692613
## [87,] -0.025807884 -0.015504187 -0.025317808
## [88,] -0.019802627 -0.023716527 -0.017241806
## [89,] -0.027028672 -0.024292693 -0.017544310
## [90,] -0.027779564 -0.033336420 -0.008888947
## [91,] -0.028573372 -0.034486176 -0.018018506
## [92,] -0.029413885 -0.035718083 -0.027651531
## [93,] -0.038027396 -0.037041272 -0.018868484
## [94,] -0.031498667 -0.028710106 -0.038839833
## [95,] -0.024292693 -0.029558802 -0.030153038
## [96,] -0.024897552 -0.020202707 -0.031090587
## [97,] -0.016949558 -0.020619287 -0.032088315
## [98,] -0.017241806 -0.021053409 -0.033152207
## [99,] -0.008733680 -0.032435276 -0.034289073
## [100,] -0.008810630 -0.022223137 -0.023530497
## [101,] -0.008888947 -0.011299555 -0.024097552
## [102,] -0.008968670 -0.011428696 0.000000000
## [103,] -0.009049836 0.000000000 0.000000000
## [104,] -0.009132484 0.011428696 0.000000000
## [105,] 0.000000000 0.000000000 0.012121361
## [106,] -0.009216655 0.011299555 0.011976191
## [107,] -0.018692133 0.000000000 0.000000000
## [108,] -0.009478744 0.000000000 0.000000000
## [109,] -0.009569451 0.000000000 -0.011976191
## [110,] -0.009661911 0.000000000 -0.012121361
## [111,] -0.009756175 0.011173301 0.000000000
## [112,] 0.000000000 0.011049836 -0.012270093
## [113,] 0.000000000 0.010929071 -0.012422520
## [114,] -0.009852296 0.010810916 -0.012578782
## [115,] -0.009950331 0.000000000 -0.025642431
## [116,] -0.020202707 -0.010810916 -0.026317308
## [117,] -0.031090587 -0.010929071 -0.040821995
## [118,] -0.032088315 -0.011049836 -0.013986242
## [119,] -0.021978907 -0.022472856 -0.014184635
## [120,] -0.011173301 -0.011428696 -0.014388737
## [121,] 0.000000000 0.000000000 0.014388737
## [122,] 0.011173301 -0.011560822 0.014184635
## [123,] 0.011049836 0.000000000 0.000000000
## [124,] 0.000000000 -0.011696040 0.000000000
## [125,] -0.011049836 -0.011834458 -0.014184635
## [126,] -0.011173301 -0.011976191 -0.028987537
## [127,] -0.011299555 -0.012121361 -0.014815086
## [128,] -0.011428696 -0.024692613 0.000000000
## [129,] -0.011560822 -0.012578782 0.000000000
## [130,] -0.011696040 -0.012739026 0.000000000
## [131,] -0.011834458 0.000000000 0.000000000
## [132,] -0.011976191 0.000000000 0.000000000
## [133,] 0.000000000 0.000000000 0.000000000
## [134,] 0.000000000 0.000000000 0.000000000
## [135,] 0.011976191 0.000000000 -0.015037877
## [136,] 0.000000000 -0.012903405 -0.015267472

```

```

## [137,] 0.000000000 -0.026317308 -0.015504187
## [138,] 0.000000000 -0.013423020 -0.015748357
## [139,] -0.011976191 -0.027398974 -0.032260862
## [140,] -0.012121361 -0.013986242 -0.033336420
## [141,] 0.000000000 0.000000000 -0.017094433
## [142,] 0.000000000 -0.014184635 -0.035091320
## [143,] 0.000000000 0.000000000 -0.036367644
## [144,] 0.000000000 0.000000000 -0.018692133
## [145,] -0.012270093 0.000000000 -0.019048195
## [146,] -0.025001302 0.000000000 0.000000000
## [147,] -0.025642431 -0.014388737 0.000000000
## [148,] -0.026317308 -0.014598799 0.000000000
## [149,] -0.013423020 -0.014815086 0.000000000
## [150,] -0.013605652 -0.015037877 0.019048195
## [151,] 0.000000000 0.000000000 0.000000000
## [152,] -0.013793322 -0.015267472 0.018692133
## [153,] 0.000000000 -0.015504187 -0.018692133
## [154,] -0.013986242 -0.015748357 -0.019048195
## [155,] -0.028573372 -0.032260862 -0.039220713
## [156,] -0.029413885 -0.016529302 -0.040821995
## [157,] 0.000000000 -0.016807118 -0.042559614
## [158,] -0.015037877 -0.017094433 -0.021978907
## [159,] 0.015037877 0.000000000 -0.022472856
## [160,] 0.014815086 0.000000000 0.022472856
## [161,] 0.028987537 0.000000000 0.021978907
## [162,] 0.028170877 0.017094433 0.042559614
## [163,] 0.027398974 0.033336420 0.040821995
## [164,] 0.013423020 0.016260521 0.019802627
## [165,] 0.026317308 0.016000341 0.019418086
## [166,] 0.012903405 0.000000000 0.019048195
## [167,] 0.000000000 0.000000000 0.000000000
## [168,] 0.000000000 -0.016000341 0.000000000
## [169,] -0.025975486 -0.016260521 0.000000000
## [170,] -0.013245227 -0.016529302 -0.019048195
## [171,] -0.013423020 -0.016807118 0.000000000
## [172,] -0.013605652 0.016807118 0.000000000
## [173,] 0.000000000 0.000000000 -0.019418086
## [174,] 0.000000000 0.032789823 0.000000000
## [175,] 0.027028672 0.016000341 0.019418086
## [176,] 0.013245227 0.015748357 0.019048195
## [177,] 0.025975486 0.000000000 0.018692133
## [178,] 0.037740328 0.000000000 0.036367644
## [179,] 0.036367644 0.000000000 0.035091320
## [180,] 0.046520016 0.015504187 0.033901552
## [181,] 0.033522692 0.015267472 0.032789823
## [182,] 0.032435276 0.015037877 0.016000341
## [183,] 0.010582109 0.014815086 0.000000000
## [184,] 0.000000000 0.014598799 -0.016000341
## [185,] -0.010582109 0.014388737 -0.032789823
## [186,] -0.021506205 0.028170877 -0.033901552
## [187,] -0.010929071 0.027398974 -0.017391743
## [188,] 0.000000000 0.026668247 0.000000000
## [189,] 0.010929071 0.038714512 0.000000000
## [190,] 0.010810916 0.037271395 0.017391743

```

```

## [191,] 0.00000000 0.024097552 0.033901552
## [192,] 0.010695289 0.011834458 0.016529302
## [193,] 0.000000000 0.000000000 0.032260862
## [194,] 0.000000000 -0.011834458 0.031252544
## [195,] -0.010695289 0.000000000 0.030305349
## [196,] 0.000000000 -0.024097552 0.014815086
## [197,] -0.010810916 -0.012270093 0.014598799
## [198,] -0.010929071 -0.025001302 0.000000000
## [199,] -0.011049836 -0.038714512 -0.014598799
## [200,] -0.033901552 -0.026668247 -0.014815086
## [201,] -0.023256862 -0.013605652 -0.030305349
## [202,] -0.048202102 0.000000000 -0.031252544
## [203,] -0.037740328 0.013605652 -0.016000341
## [204,] -0.039220713 0.013423020 -0.016260521
## [205,] -0.027028672 0.026317308 0.000000000
## [206,] -0.013793322 0.012903405 -0.016529302
## [207,] 0.000000000 0.000000000 0.000000000
## [208,] 0.000000000 0.000000000 0.016529302
## [209,] 0.000000000 -0.012903405 0.000000000
## [210,] 0.000000000 -0.013072082 -0.239672853
## [211,] 0.000000000 -0.013245227 -0.064538521
## [212,] 0.000000000 -0.027028672 0.000000000
## [213,] 0.000000000 -0.027779564 0.021978907
## [214,] 0.000000000 -0.028573372 0.042559614
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## [491,] 0.020202707 0.017699577 -0.048790164
##
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##
## $cnst
## [1] TRUE
##
## $coef
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## [3,] 0.2056664 0.52828289 0.2730865
## [4,] 0.1295983 0.10084743 0.5744539
## [5,] 0.3035141 0.04911547 0.0000000
## [6,] 0.0000000 0.18316135 -0.1678176
## [7,] 0.0000000 -0.08486853 0.0000000
##
## $aic
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##
## $bic
## [1] -24.58185
##

```

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##
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## [2,]  5.826979e-03 -1.028430e-03 -9.282824e-04
## [3,] -5.477748e-03  1.221127e-02 -1.184730e-02
## [4,] -9.920819e-03  2.142845e-02  2.715305e-03
## [5,] -1.234139e-02 -5.887489e-03  9.084432e-03
## [6,]  1.075187e-02 -8.990320e-04  5.896887e-03
## [7,] -4.502393e-03  1.079504e-03  1.739174e-02
## [8,]  1.106692e-02 -1.584345e-02 -8.295492e-03
## [9,] -6.789594e-03 -2.234014e-02  1.956851e-02
## [10,]  2.968491e-03  2.211475e-03 -1.924664e-02
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## [14,]  1.778050e-03  2.492056e-02  1.078700e-02
## [15,] -6.077173e-03  8.470651e-03  1.469489e-02
## [16,] -1.190356e-02  4.494843e-03 -9.818270e-03
## [17,]  2.746633e-03  7.682271e-03  2.209970e-04
## [18,] -1.193728e-02 -1.064758e-02 -1.615525e-03
## [19,] -1.019112e-02 -1.574859e-03  4.527651e-03
## [20,] -1.945433e-02  1.936243e-03  1.908509e-03
## [21,] -1.757089e-02 -1.242722e-02  3.890584e-03
## [22,] -1.094863e-02  1.235350e-02  8.293642e-03
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## [24,] -1.277650e-02  6.010070e-03  1.420559e-02
## [25,] -6.753903e-04 -1.309963e-02 -1.336430e-02
## [26,]  1.706294e-02 -3.080400e-03  1.675206e-02
## [27,]  7.775185e-03 -5.793613e-03 -1.626312e-02
## [28,]  2.033349e-02 -3.279552e-03  1.213593e-02
## [29,]  6.507108e-04 -8.256258e-03 -3.991051e-04
## [30,]  1.347355e-02 -5.999658e-03  1.847729e-03
## [31,]  8.113232e-04  1.080188e-02 -3.024195e-04
## [32,]  9.817451e-03 -1.522079e-02 -2.918640e-03
## [33,]  9.138637e-04  7.854983e-03  2.069986e-02
## [34,]  7.345839e-03  7.280736e-04 -1.332110e-02
## [35,] -2.688214e-03 -1.796379e-02 -2.122055e-03
## [36,] -5.392193e-04  8.831927e-03  4.920610e-03
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## [38,]  1.527329e-02 -2.983175e-02  2.932949e-02
## [39,]  1.424709e-02  1.986857e-02  3.492050e-02
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[307,] 1.760614e-02 2.610621e-02 -3.248445e-03
[308,] -9.728933e-03 -4.327057e-03 1.614225e-02
[309,] -4.659230e-03 -3.381038e-03 -2.049107e-02
[310,] -9.782766e-03 -9.447600e-03 -4.101209e-04
[311,] -1.853173e-02 1.328079e-02 -1.199395e-02
[312,] -1.120745e-02 -1.862794e-02 -5.849509e-03
[313,] 0.000000e+00 9.543214e-03 5.244725e-03
[314,] -3.140007e-03 -8.065544e-03 -2.286147e-02
[315,] -1.332589e-02 -9.113574e-04 -5.748276e-03
[316,] -1.050483e-02 1.994842e-03 -6.086364e-03
[317,] -5.888791e-03 2.801979e-03 1.358244e-02
[318,] 7.981668e-03 -1.441534e-02 -1.733551e-02
[319,] 2.690221e-02 1.086123e-02 1.554504e-02

[320,] 1.287500e-02 1.466901e-02 -5.029268e-03
[321,] 4.597721e-03 -1.055101e-02 -6.596983e-03
[322,] 2.288843e-02 -5.242529e-03 1.727391e-04
[323,] 3.375747e-02 -4.017558e-03 -4.668813e-03
[324,] 1.068993e-02 8.840233e-03 1.305821e-02
[325,] -1.065659e-02 -1.513688e-02 -3.995316e-04
[326,] 1.352179e-02 8.905204e-03 8.294964e-03
[327,] -1.603776e-03 2.923817e-03 1.789607e-02
[328,] -1.869890e-02 -1.530559e-02 -2.481561e-02
[329,] -1.749710e-02 1.419916e-02 2.449935e-03
[330,] -1.398497e-02 -2.057495e-02 -1.892769e-03
[331,] -4.144903e-03 -7.539297e-03 -9.940776e-03
[332,] -1.600974e-02 -1.553235e-02 -4.486562e-03
[333,] 3.774510e-03 7.152413e-03 1.666291e-03
[334,] 1.692445e-02 1.264398e-03 1.228492e-02
[335,] -7.042924e-03 1.007712e-02 2.072003e-02
[336,] 1.493614e-02 -1.329049e-02 -1.132919e-02
[337,] 4.863900e-03 9.114144e-03 2.085669e-03
[338,] 9.957796e-03 -1.383288e-02 -2.642851e-03
[339,] 5.251586e-04 6.935789e-03 2.186354e-03
[340,] -4.367184e-03 -1.403659e-02 -2.685138e-03
[341,] 1.752888e-02 8.590155e-03 4.440528e-03
[342,] -2.726345e-03 1.482899e-03 1.381118e-02
[343,] 7.258538e-03 -2.581739e-03 7.611369e-03
[344,] -5.066230e-03 -1.826788e-02 5.355716e-03
[345,] -1.716691e-02 7.785351e-03 -5.836873e-03
[346,] 2.688214e-03 6.031218e-03 -6.518522e-04
[347,] -9.939614e-03 -1.612018e-02 0.000000e+00
[348,] -8.205732e-03 1.037431e-02 -1.127655e-02
[349,] -5.192821e-03 -9.985296e-03 9.713395e-03
[350,] -4.126200e-03 -7.644477e-03 -1.146589e-02
[351,] -1.804501e-03 1.644815e-02 -4.022883e-03
[352,] 9.809397e-03 -1.187329e-02 1.010074e-02
[353,] -7.063055e-03 8.502602e-03 2.352565e-02
[354,] 1.577948e-02 2.966382e-03 -1.139162e-02
[355,] 1.699422e-03 -1.729182e-02 -2.316449e-03
[356,] 1.410979e-02 -9.580140e-03 4.920610e-03
[357,] 8.834600e-04 -2.633185e-02 -1.898667e-02
[358,] 2.043527e-02 5.026798e-03 -2.050145e-02
[359,] 6.131291e-03 -2.210354e-02 1.881862e-02
[360,] 1.832997e-02 -2.097415e-02 7.666220e-03
[361,] 5.764726e-03 6.297135e-03 2.451658e-03
[362,] 1.438090e-02 -3.701746e-03 1.829773e-02
[363,] -7.618012e-04 1.207500e-02 -1.094490e-02
[364,] 9.817451e-03 -1.750589e-02 -3.688446e-03
[365,] 1.895567e-03 1.037662e-02 -1.543321e-02
[366,] 1.219756e-02 5.377738e-03 7.383456e-03
[367,] -2.688214e-03 -3.122469e-03 -2.192468e-02
[368,] -1.566488e-02 1.310103e-03 -8.827010e-03
[369,] -8.878186e-03 2.430411e-02 -6.891707e-03
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[374,] -1.481552e-03 -1.466995e-02 1.048559e-02
[375,] 1.438874e-02 1.489780e-02 3.533132e-03
[376,] 7.178365e-03 7.792973e-03 -7.813972e-03
[377,] 2.737693e-03 2.256920e-02 1.776994e-02
[378,] -4.114941e-03 -9.759478e-03 -5.619967e-04
[379,] 4.755757e-06 -9.990367e-04 -1.306699e-02
[380,] -1.064587e-02 4.698884e-03 -3.972257e-03
[381,] -2.150896e-02 -1.378546e-02 1.917938e-02
[382,] -1.134226e-04 -4.049674e-03 -6.950596e-03
[383,] 4.129507e-03 2.047353e-02 0.000000e+00
[384,] 9.899850e-03 8.180709e-03 3.590138e-02
[385,] 1.512252e-02 1.628434e-02 1.189635e-02
[386,] 4.544647e-03 7.905560e-03 4.716201e-03
[387,] 4.837596e-04 3.807595e-03 2.512968e-02
[388,] -1.699495e-03 1.909263e-03 -3.629852e-03
[389,] 7.702701e-04 -9.887580e-03 2.291904e-02
[390,] 1.339743e-02 1.023498e-02 3.144840e-02
[391,] 5.600626e-03 1.762613e-02 2.619557e-02
[392,] 1.855750e-02 5.754239e-03 1.418031e-02
[393,] 2.323092e-02 2.758163e-02 3.675367e-02
[394,] 5.033133e-02 1.886076e-02 1.015336e-02
[395,] 2.151519e-02 2.965999e-03 3.684802e-03
[396,] -3.734508e-04 -1.072804e-02 -1.208326e-02
[397,] -5.095871e-03 -1.034444e-02 -1.384525e-02
[398,] -1.201285e-03 -9.445333e-03 -1.724308e-02
[399,] 2.845351e-03 -9.400412e-03 -3.734157e-03
[400,] -3.816381e-02 -2.536401e-03 -1.086412e-02
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[402,] -1.029293e-02 2.229736e-03 -7.727969e-03
[403,] -9.941995e-03 5.295982e-03 6.530918e-03
[404,] -9.188199e-03 3.892223e-03 1.056455e-02
[405,] -3.275264e-03 3.750489e-03 5.121779e-03
[406,] -1.186009e-02 -5.084388e-03 4.029993e-03
[407,] -1.093926e-02 -8.871386e-03 -1.590500e-03
[408,] -5.855682e-03 -1.267426e-03 -4.536151e-03
[409,] -1.242667e-02 -1.800265e-02 -7.769753e-04
[410,] -7.539577e-03 6.911387e-04 -4.030606e-03
[411,] -6.167548e-03 -9.259665e-03 -4.337605e-03
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[413,] -8.111811e-04 7.960577e-03 -1.237493e-03
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[416,] -1.675268e-02 -1.560618e-03 -1.111839e-02
[417,] -2.759050e-03 1.670487e-03 -1.485403e-02
[418,] -9.596960e-03 1.441365e-03 3.041498e-04
[419,] -2.934595e-03 1.073793e-02 -4.482484e-03
[420,] 5.290485e-03 5.620224e-03 2.500542e-03
[421,] -5.888026e-04 1.173507e-02 7.915727e-03
[422,] 2.495387e-03 5.382444e-03 9.847882e-03
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[424,] -1.669023e-02 -3.940552e-03 -5.710679e-03
[425,] -1.132701e-02 2.703081e-03 6.672391e-03
[426,] -1.831504e-02 -1.589339e-02 -5.785290e-03
[427,] -2.138467e-02 -3.224526e-03 -3.404598e-03

[428,] -5.383223e-03 -8.182945e-03 -1.010773e-02
[429,] -8.493017e-04 -1.404260e-02 -2.791434e-03
[430,] -1.759324e-03 2.442236e-03 -1.675719e-03
[431,] 7.045105e-03 9.962674e-03 -6.452153e-03
[432,] 1.395014e-02 1.276441e-03 2.568413e-03
[433,] 7.167193e-03 7.674122e-03 8.076691e-03
[434,] 0.000000e+00 1.220342e-02 -1.875076e-03
[435,] -2.297973e-03 -5.902664e-03 -3.051277e-03
[436,] 0.000000e+00 -2.046517e-03 1.875076e-03
[437,] -1.104984e-02 -1.117330e-02 0.000000e+00
[438,] 4.421797e-03 7.067581e-03 4.727808e-03
[439,] 3.353781e-03 2.589235e-03 -1.875076e-03
[440,] 0.000000e+00 1.117330e-02 0.000000e+00
[441,] -2.297973e-03 5.147173e-03 8.924914e-03
[442,] -1.499797e-02 1.837346e-03 -8.022255e-03
[443,] -1.001886e-04 -5.603209e-03 -1.141115e-02
[444,] -6.356208e-03 -2.452334e-04 -3.407500e-03
[445,] -7.685967e-03 -9.531821e-03 -1.601503e-02
[446,] -4.867430e-04 8.994947e-03 -6.414445e-03
[447,] 8.971952e-03 -6.810329e-03 -1.151160e-02
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[453,] -1.050269e-02 -1.137357e-02 -2.254656e-03
[454,] 4.735953e-03 -7.028324e-03 1.018503e-02
[455,] 4.202898e-03 -6.152281e-03 -2.528668e-03
[456,] 5.487033e-04 -1.852007e-02 -2.556334e-03
[457,] -9.967757e-03 -1.275304e-02 1.774693e-02
[458,] -9.880760e-03 2.601224e-03 8.431335e-03
[459,] -8.961818e-03 -1.666426e-02 -1.189304e-02
[460,] 1.028955e-02 4.039176e-03 3.799747e-03
[461,] -9.564844e-03 1.145359e-02 -4.529338e-03
[462,] 4.084015e-04 -1.338412e-02 1.355935e-02
[463,] -1.233101e-02 4.771731e-03 8.127515e-03
[464,] -1.943877e-03 1.877984e-03 -1.396488e-02
[465,] -1.398606e-02 -1.539316e-05 -3.771923e-03
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[467,] 4.908937e-03 1.704789e-02 -2.043945e-02
[468,] 9.792180e-04 -8.148478e-03 2.038138e-03
[469,] -2.073129e-02 1.026186e-02 -2.166710e-02
[470,] -9.007858e-04 1.000393e-02 4.865617e-03
[471,] -2.025511e-02 -1.478712e-02 -6.474731e-03
[472,] -2.156027e-04 1.419397e-02 8.763337e-04
[473,] -1.727230e-03 7.340549e-03 1.237566e-02
[474,] 9.513632e-03 1.825193e-02 -1.903271e-02
[475,] 5.226339e-03 -5.860452e-03 7.957611e-03
[476,] 0.000000e+00 1.181076e-02 2.868746e-03
[477,] -3.456660e-03 7.650389e-03 1.738911e-02
[478,] -4.625329e-02 1.823378e-02 -1.431927e-02
[479,] -1.956507e-02 1.760804e-03 2.153989e-02
[480,] 1.007922e-02 3.245458e-03 5.376280e-02
[481,] -4.949392e-03 7.903360e-04 2.085010e-03

```

## [482,] -2.927635e-02 -4.038100e-02 -6.331867e-02
## [483,] -6.048019e-03 -8.785523e-03 -4.131711e-03
## [484,] 3.647825e-04 -4.019340e-02 -1.234013e-02
## [485,] 2.998370e-02 -7.861863e-03 1.868889e-02
## [486,] 4.242115e-02 3.995634e-02 1.593746e-02
## [487,] 1.728177e-02 2.356375e-02 -3.472035e-02
## [488,] 3.007485e-02 -1.059931e-02 -4.179402e-02
## [489,] 1.169452e-02 1.173388e-02 -2.536550e-02
##
## $secoef
##      [,1]      [,2]      [,3]
## [1,] 0.00000000 0.00000000 0.00000000
## [2,] 0.04405737 0.02739184 0.04045638
## [3,] 0.05634464 0.04525088 0.06782557
## [4,] 0.04265382 0.03059996 0.03918055
## [5,] 0.04442294 0.02790043 0.00000000
## [6,] 0.00000000 0.04433530 0.06612134
## [7,] 0.00000000 0.03086666 0.00000000
##
## $Sigma
##      [,1]      [,2]      [,3]
## [1,] 3.874526e-04 3.062712e-05 7.153133e-05
## [2,] 3.062712e-05 1.464221e-04 4.016425e-05
## [3,] 7.153133e-05 4.016425e-05 3.383777e-04
##
## $Phi
##      [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## [1,] 0.1922041 0.2056664 0.1295983 0.30351408 0.0000000 0.0000000
## [2,] 0.1054239 0.5282829 0.1008474 0.04911547 0.1831614 -0.08486853
## [3,] 0.1517244 0.2730865 0.5744539 0.00000000 -0.1678176 0.00000000
##
## $Ph0
## [1] 0 0 0
##
## $fixed
##      [,1] [,2] [,3]
## [1,] 0 0 0
## [2,] 1 1 1
## [3,] 1 1 1
## [4,] 1 1 1
## [5,] 1 1 0
## [6,] 0 1 1
## [7,] 0 1 0

```

*#apparently, there is an error says argument is of length zero
#oh I didnot know that I have to detach the vars library to work on MTS*

```

sig1=m1a$Sigma
U1=chol(sig1)
MTSdiag(m1a)

```

```

## [1] "Covariance matrix:"
##      MI      IL      IN
## MI 3.88e-04 3.08e-05 7.16e-05
## IL 3.08e-05 1.47e-04 4.03e-05

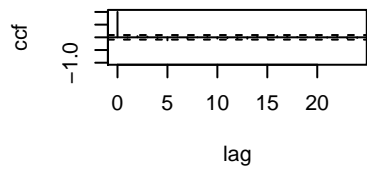
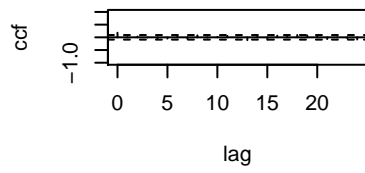
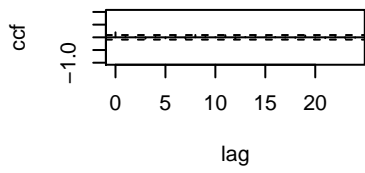
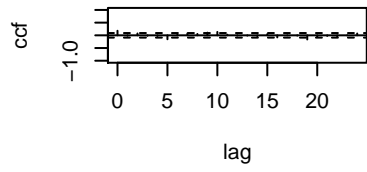
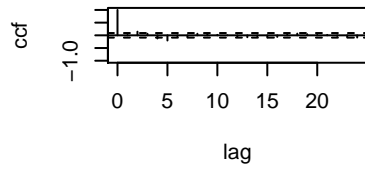
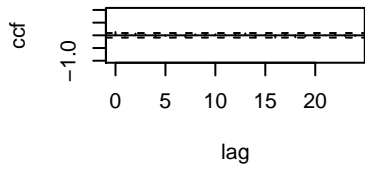
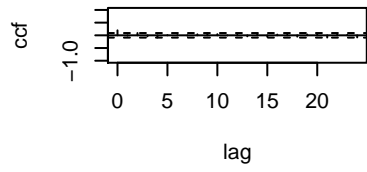
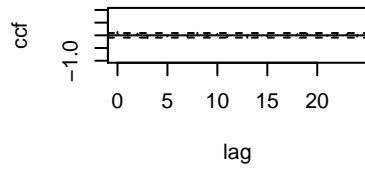
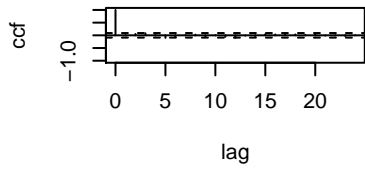
```

```

## IN 7.16e-05 4.03e-05 3.39e-04
## CCM at lag: 0
##      [,1] [,2] [,3]
## [1,] 1.000 0.129 0.197
## [2,] 0.129 1.000 0.181
## [3,] 0.197 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
## - . .
## . . .

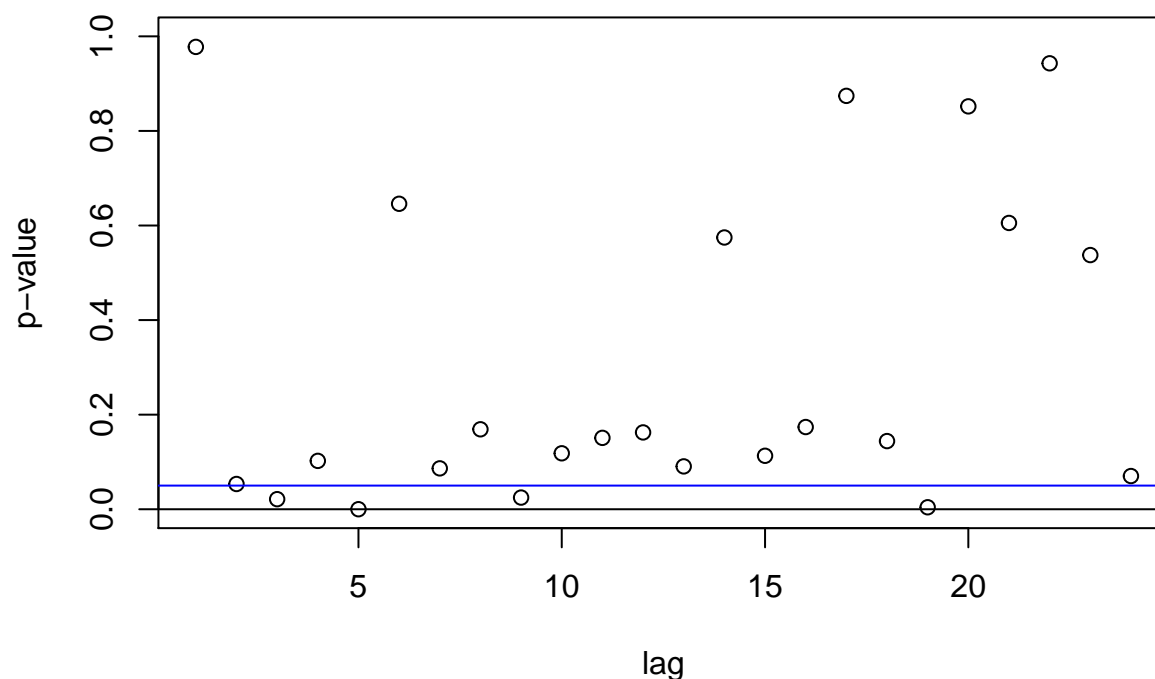
```

```
## . . .
## CCM 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:

Significance plot of CCM



Hit Enter to compute MQ-statistics:

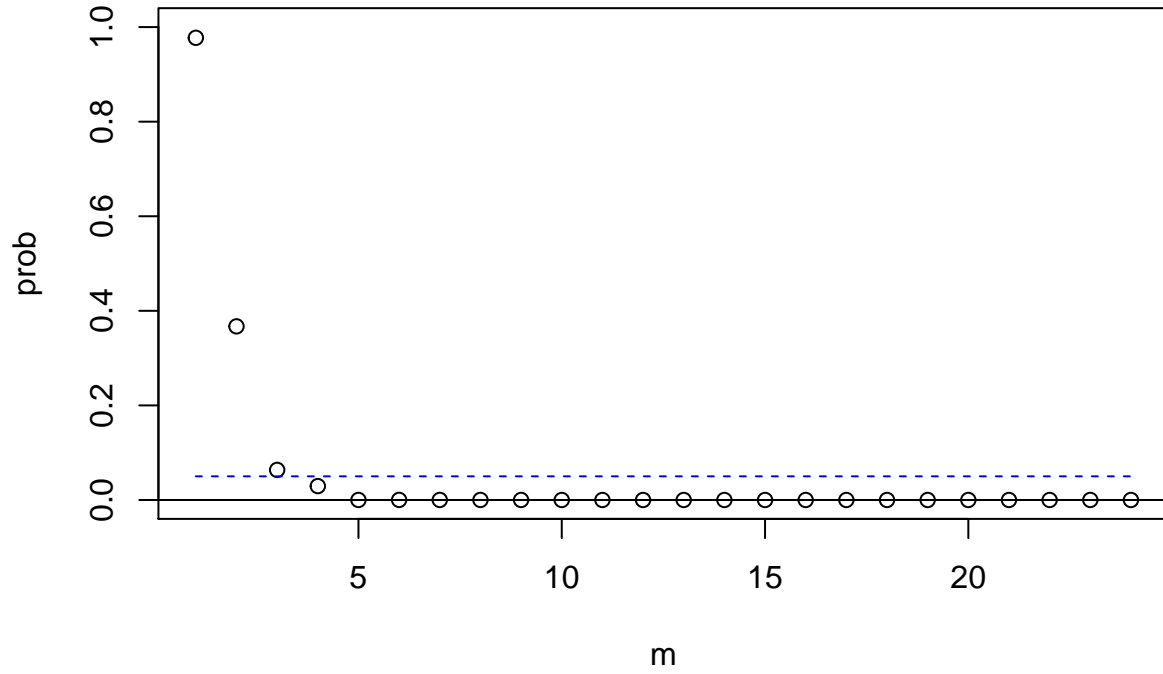
##

Ljung-Box Statistics:

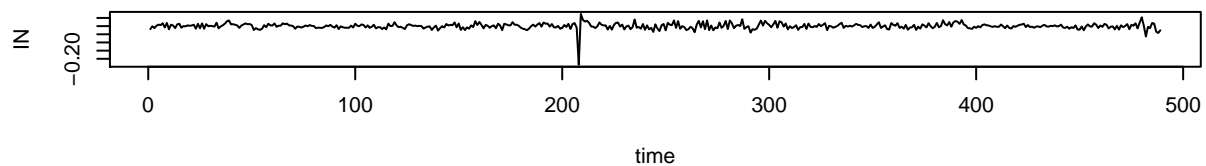
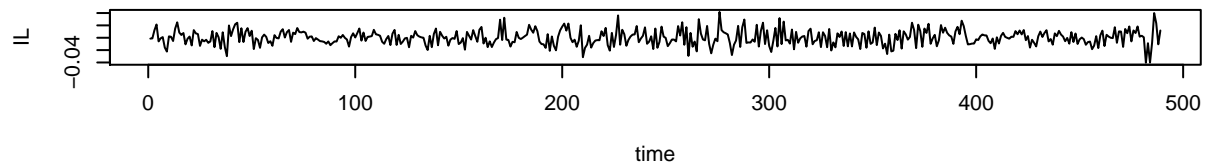
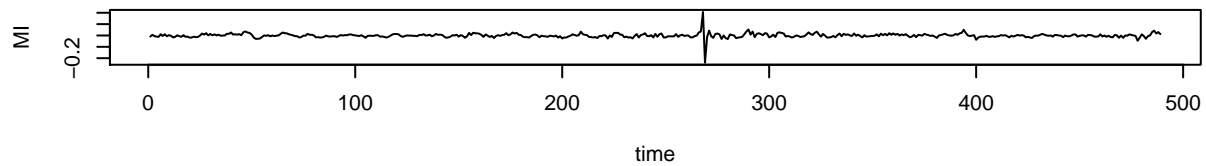
##	m	Q(m)	df	p-value	
##	[1,]	1.00	2.62	9.00	0.98
##	[2,]	2.00	19.41	18.00	0.37
##	[3,]	3.00	38.98	27.00	0.06
##	[4,]	4.00	53.66	36.00	0.03
##	[5,]	5.00	92.77	45.00	0.00
##	[6,]	6.00	99.71	54.00	0.00
##	[7,]	7.00	114.95	63.00	0.00
##	[8,]	8.00	127.87	72.00	0.00
##	[9,]	9.00	147.00	81.00	0.00
##	[10,]	10.00	161.17	90.00	0.00
##	[11,]	11.00	174.49	99.00	0.00
##	[12,]	12.00	187.54	108.00	0.00
##	[13,]	13.00	202.61	117.00	0.00
##	[14,]	14.00	210.24	126.00	0.00
##	[15,]	15.00	224.58	135.00	0.00
##	[16,]	16.00	237.39	144.00	0.00
##	[17,]	17.00	241.92	153.00	0.00
##	[18,]	18.00	255.42	162.00	0.00
##	[19,]	19.00	279.58	171.00	0.00
##	[20,]	20.00	284.39	180.00	0.00
##	[21,]	21.00	291.74	189.00	0.00
##	[22,]	22.00	295.21	198.00	0.00

```
## [23,] 23.00 303.22 207.00 0.00
## [24,] 24.00 319.17 216.00 0.00
```

p-values of Ljung-Box statistics



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



```
library(vars)

## Warning: package 'vars' was built under R version 4.0.5
##
## Attaching package: 'vars'
##
## The following object is masked from 'package:MTS':
##
##   VAR

require(vars)

varfit1=VAR(zt1,p=2)

summary(varfit1)

##
## VAR Estimation Results:
## =====
## Endogenous variables: MI, IL, IN
## Deterministic variables: const
## Sample size: 489
## Log Likelihood: 3973.321
## Roots of the characteristic polynomial:
## 0.8686 0.6789 0.4943 0.4486 0.3738 0.0756
## Call:
```

```

## VAR(y = zt1, p = 2)
##
##
## Estimation results for equation MI:
## =====
## MI = MI.l1 + IL.l1 + IN.l1 + MI.l2 + IL.l2 + IN.l2 + const
##
##      Estimate Std. Error t value Pr(>|t|)
## MI.l1  0.1989672  0.0445223   4.469 9.81e-06 ***
## IL.l1  0.2756040  0.0735116   3.749 0.000199 ***
## IN.l1  0.1309946  0.0497042   2.635 0.008673 **
## MI.l2  0.3090974  0.0453597   6.814 2.84e-11 ***
## IL.l2 -0.1060266  0.0720163  -1.472 0.141604
## IN.l2  0.0056175  0.0501371   0.112 0.910836
## const -0.0004308  0.0008968  -0.480 0.631141
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.01978 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
##
##
## Estimation results for equation IL:
## =====
## IL = MI.l1 + IL.l1 + IN.l1 + MI.l2 + IL.l2 + IN.l2 + const
##
##      Estimate Std. Error t value Pr(>|t|)
## MI.l1  0.1057980  0.0274344   3.856 0.000131 ***
## IL.l1  0.5279993  0.0452975  11.656 < 2e-16 ***
## IN.l1  0.1008975  0.0306275   3.294 0.001059 **
## MI.l2  0.0495593  0.0279504   1.773 0.076841 .
## IL.l2  0.1830327  0.0443761   4.125 4.37e-05 ***
## IN.l2 -0.0848406  0.0308943  -2.746 0.006255 **
## const  0.0002069  0.0005526   0.374 0.708207
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.01219 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
##
##
## 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  0.1514488  0.0417056   3.631 0.000312 ***
## IL.l1  0.2738007  0.0688610   3.976 8.08e-05 ***
## IN.l1  0.5680942  0.0465597  12.201 < 2e-16 ***
## MI.l2 -0.0061173  0.0424900  -0.144 0.885584

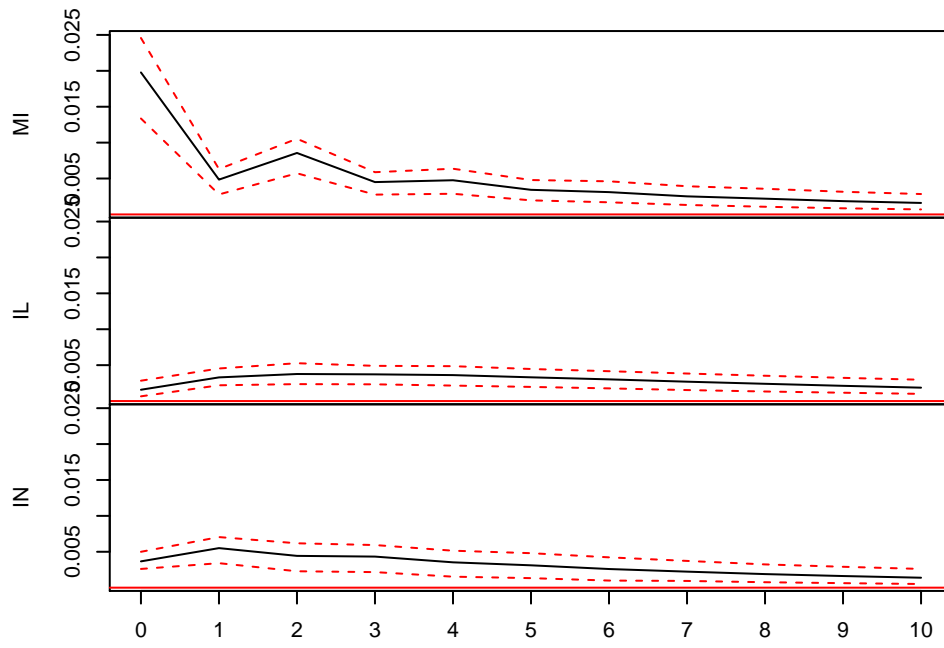
```

```

## IL.12 -0.1699765  0.0674603  -2.520 0.012069 *
## IN.12  0.0138803  0.0469652   0.296 0.767705
## const -0.0001723  0.0008401  -0.205 0.837607
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.01853 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 3.911e-04 3.116e-05 7.248e-05
## IL 3.116e-05 1.485e-04 4.078e-05
## IN 7.248e-05 4.078e-05 3.432e-04
##
## 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
impresp1=irf(varfit1)
plot(impresp1)

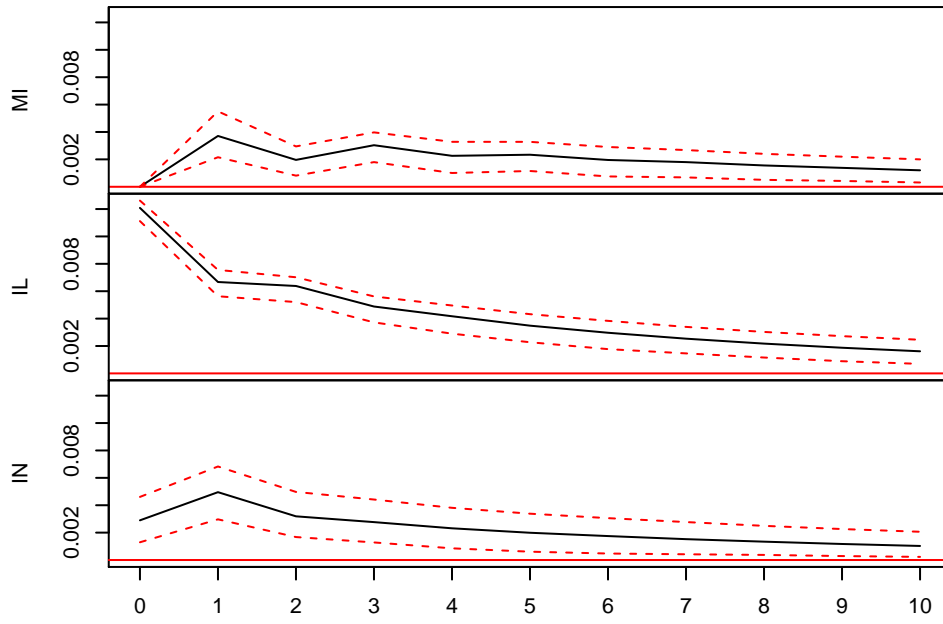
```

Orthogonal Impulse Response from MI



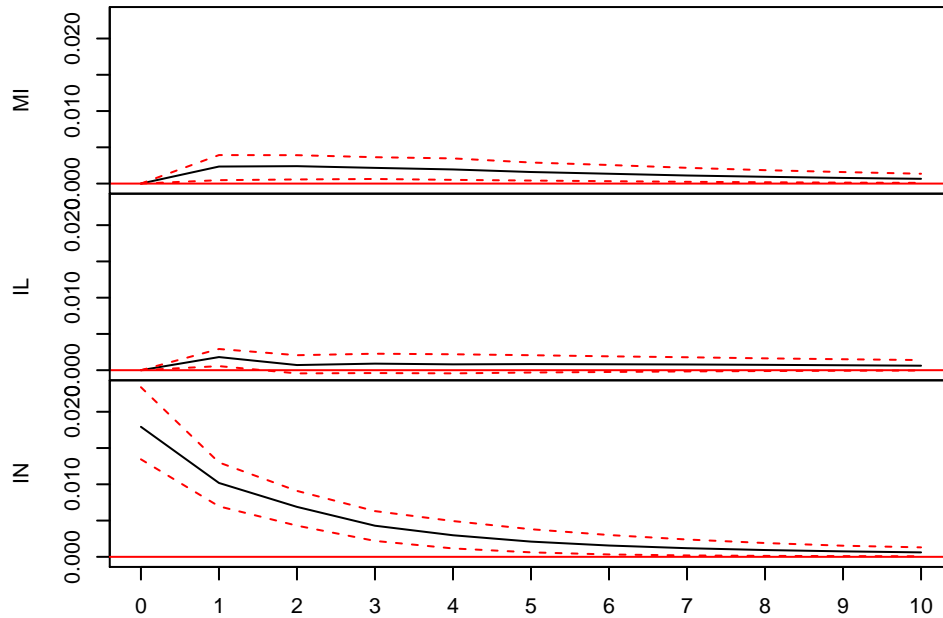
95 % Bootstrap CI, 100 runs

Orthogonal Impulse Response from IL



95 % Bootstrap CI, 100 runs

Orthogonal Impulse Response from IN



95 % Bootstrap CI, 100 runs

```
#cannot compile the plot function
```

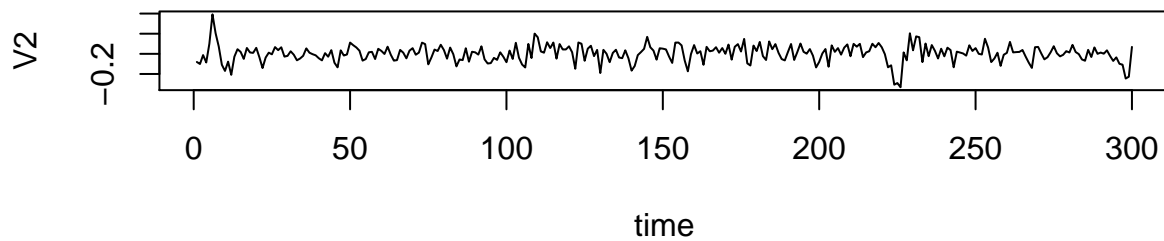
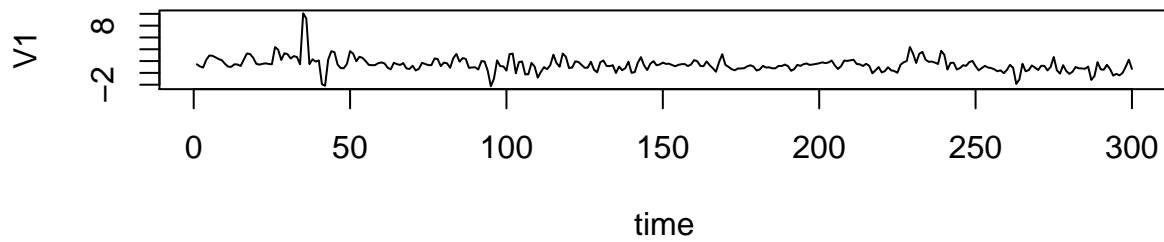
```
#1.2
```

```
#The shock rate from unemployment from each current month of each state has a positively significant i  
#However, the shock will drydown after 5 month and change into long run growth.
```

```
detach("package:vars", unload = TRUE)  
#question2
```

```
da2=read.table("m-m1cnwti.txt")
```

```
zt2= cbind(da2$V1,da2$V2)  
MTSplot(da2)
```



#2.1

```
colnames(zt2)<-c("M1","OIL")
```

```
VARorder(zt2)
```

```
## 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
```

#BIC has the least value, the optimal lag is 3 periods

#2.2

```
m2=VAR(zt2,3)
```

```
## 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]
## [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
```

```
m2a<-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,] 3.874526e-04 3.062712e-05 7.153133e-05
## [2,] 3.062712e-05 1.464221e-04 4.016425e-05
## [3,] 7.153133e-05 4.016425e-05 3.383777e-04
##
## det(SSE) = 1.768107e-11
## AIC = -24.7015
## BIC = -24.58185
## HQ = -24.65451

```

```

sig2=m2a$Sigma
sig2

```

```

##      [,1] [,2] [,3]
## [1,] 3.874526e-04 3.062712e-05 7.153133e-05
## [2,] 3.062712e-05 1.464221e-04 4.016425e-05
## [3,] 7.153133e-05 4.016425e-05 3.383777e-04

```

```

U2=chol(sig2)
U2

```

```

##      [,1] [,2] [,3]
## [1,] 0.01968382 0.001555955 0.003634018
## [2,] 0.00000000 0.012000047 0.002875813
## [3,] 0.00000000 0.000000000 0.017801722

```

```

MTSdiag(m2a)

```

```

## [1] "Covariance matrix:"
##      MI      IL      IN
## MI 3.88e-04 3.08e-05 7.16e-05
## IL 3.08e-05 1.47e-04 4.03e-05
## IN 7.16e-05 4.03e-05 3.39e-04
## CCM at lag: 0

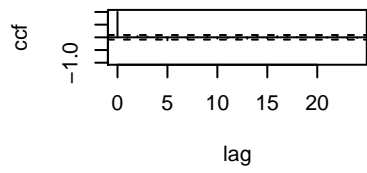
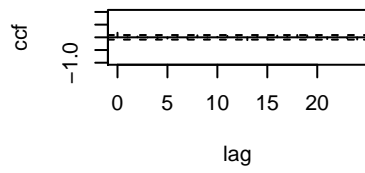
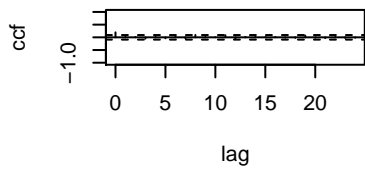
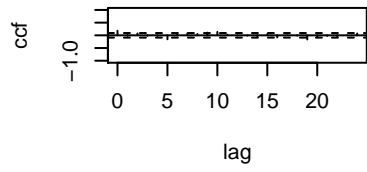
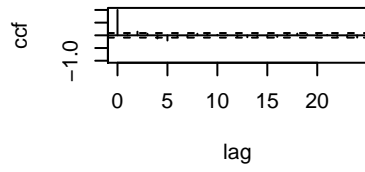
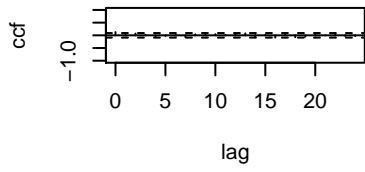
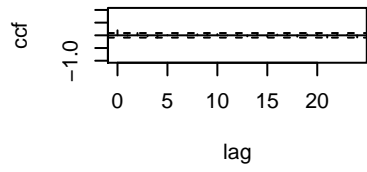
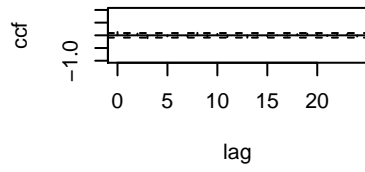
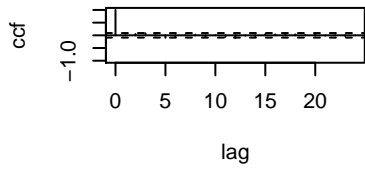
```

```

##      [,1] [,2] [,3]
## [1,] 1.000 0.129 0.197
## [2,] 0.129 1.000 0.181
## [3,] 0.197 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 at lag: 13

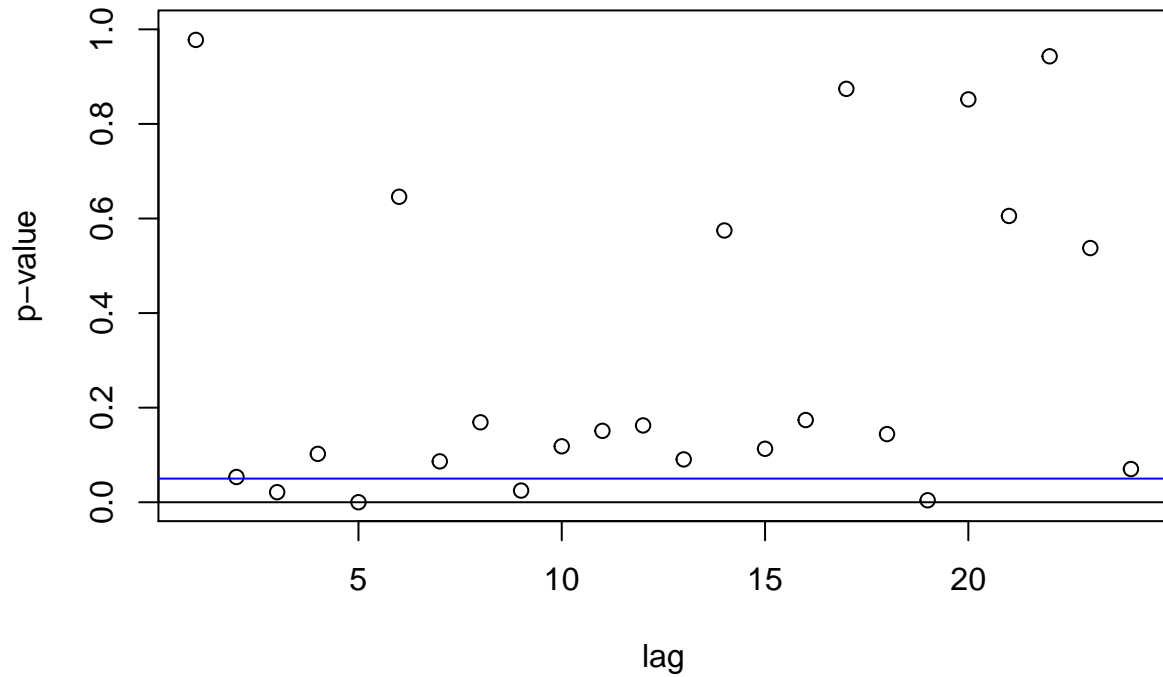
```

```
## . - .
## . . .
## . - .
## 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:

Significance plot of CCM



Hit Enter to compute MQ-statistics:

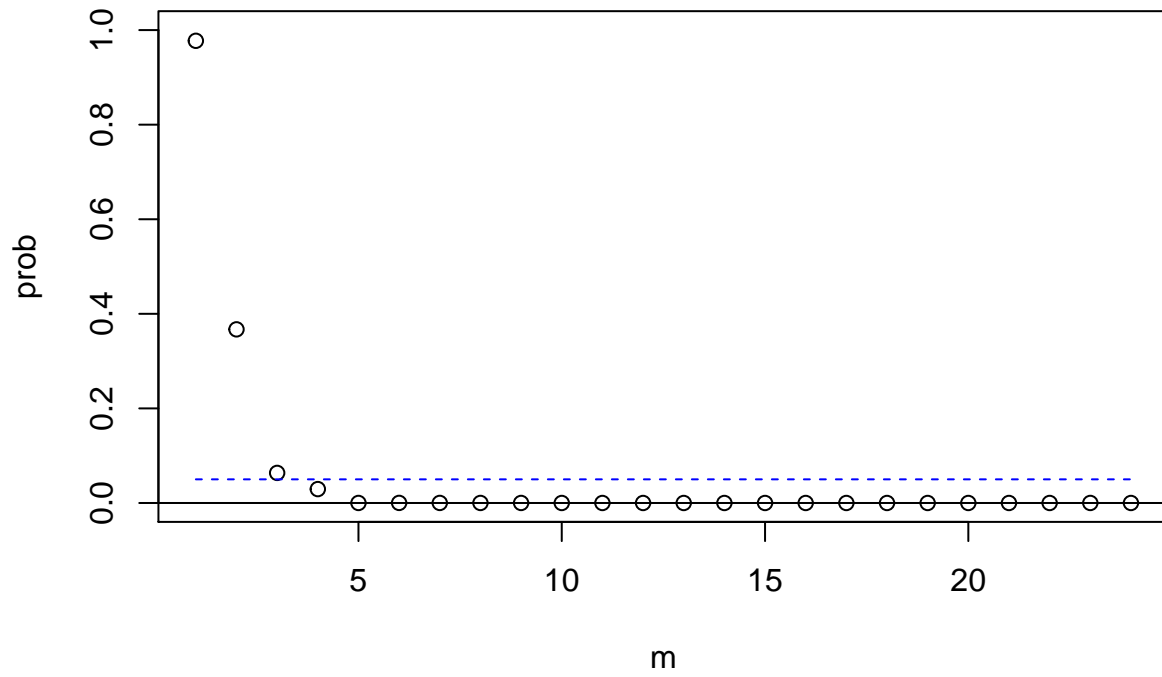
##

Ljung-Box Statistics:

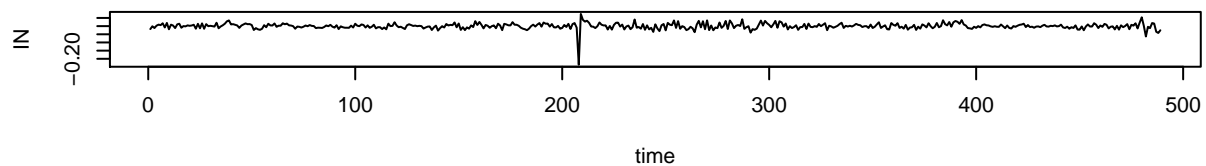
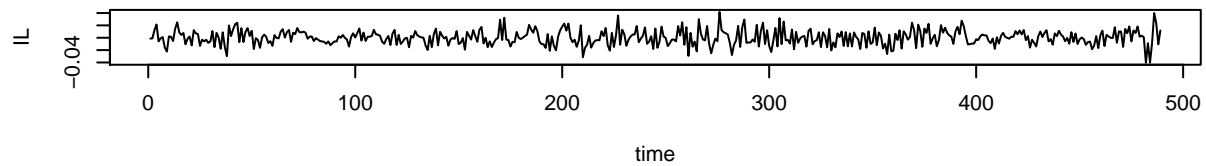
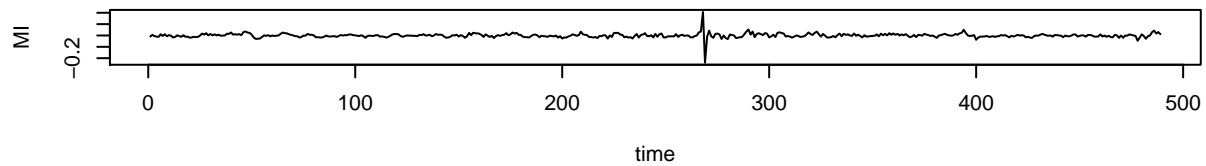
##	m	Q(m)	df	p-value	
##	[1,]	1.00	2.62	9.00	0.98
##	[2,]	2.00	19.41	18.00	0.37
##	[3,]	3.00	38.98	27.00	0.06
##	[4,]	4.00	53.66	36.00	0.03
##	[5,]	5.00	92.77	45.00	0.00
##	[6,]	6.00	99.71	54.00	0.00
##	[7,]	7.00	114.95	63.00	0.00
##	[8,]	8.00	127.87	72.00	0.00
##	[9,]	9.00	147.00	81.00	0.00
##	[10,]	10.00	161.17	90.00	0.00
##	[11,]	11.00	174.49	99.00	0.00
##	[12,]	12.00	187.54	108.00	0.00
##	[13,]	13.00	202.61	117.00	0.00
##	[14,]	14.00	210.24	126.00	0.00
##	[15,]	15.00	224.58	135.00	0.00
##	[16,]	16.00	237.39	144.00	0.00
##	[17,]	17.00	241.92	153.00	0.00
##	[18,]	18.00	255.42	162.00	0.00
##	[19,]	19.00	279.58	171.00	0.00
##	[20,]	20.00	284.39	180.00	0.00
##	[21,]	21.00	291.74	189.00	0.00
##	[22,]	22.00	295.21	198.00	0.00

```
## [23,] 23.00 303.22 207.00 0.00
## [24,] 24.00 319.17 216.00 0.00
```

p-values of Ljung-Box statistics



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



#2.3

```
require(vars)

## Loading required package: vars
## Warning: package 'vars' was built under R version 4.0.5
##
## Attaching package: 'vars'
##
## The following object is masked from 'package:MTS':
##
##   VAR

library(vars)
varfit2=VAR(zt2,p=3)

summary(varfit2)

##
## VAR Estimation Results:
## =====
## Endogenous variables: M1, OIL
## 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
```

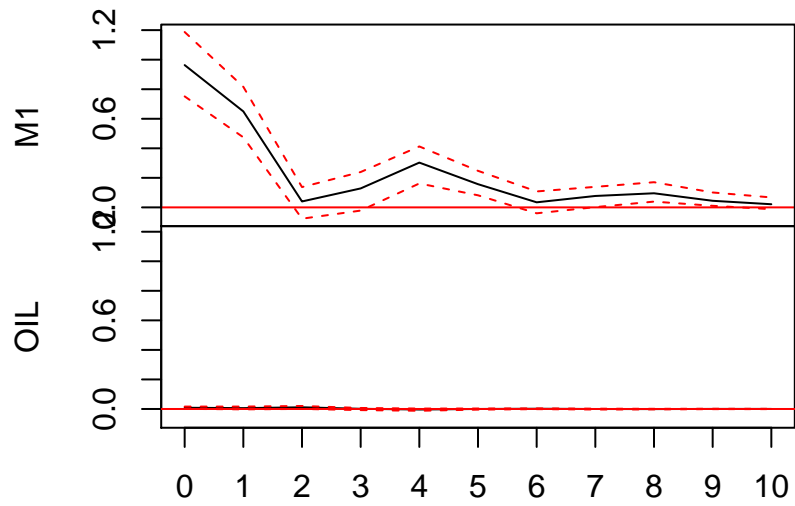
```

## Call:
## VAR(y = zt2, p = 3)
##
##
## Estimation results for equation M1:
## =====
## M1 = M1.l1 + OIL.l1 + M1.l2 + OIL.l2 + M1.l3 + OIL.l3 + const
##
##      Estimate Std. Error t value Pr(>|t|)
## M1.l1  0.66841    0.05465  12.230 < 2e-16 ***
## OIL.l1  0.70145    0.70262   0.998  0.319
## M1.l2 -0.40451    0.06295  -6.426 5.37e-10 ***
## OIL.l2 -1.01842    0.73654  -1.383  0.168
## M1.l3  0.37999    0.05474   6.942 2.53e-11 ***
## OIL.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 OIL:
## =====
## OIL = M1.l1 + OIL.l1 + M1.l2 + OIL.l2 + M1.l3 + OIL.l3 + const
##
##      Estimate Std. Error t value Pr(>|t|)
## M1.l1  0.003467   0.004573   0.758  0.449
## OIL.l1  0.296716   0.058787   5.047 7.93e-07 ***
## M1.l2  0.007504   0.005267   1.425  0.155
## OIL.l2  0.029814   0.061626   0.484  0.629
## M1.l3 -0.007121   0.004580  -1.555  0.121
## OIL.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:
##      M1      OIL
## M1  0.927944 0.008104
## OIL 0.008104 0.006496
##
## Correlation matrix of residuals:
##      M1      OIL

```

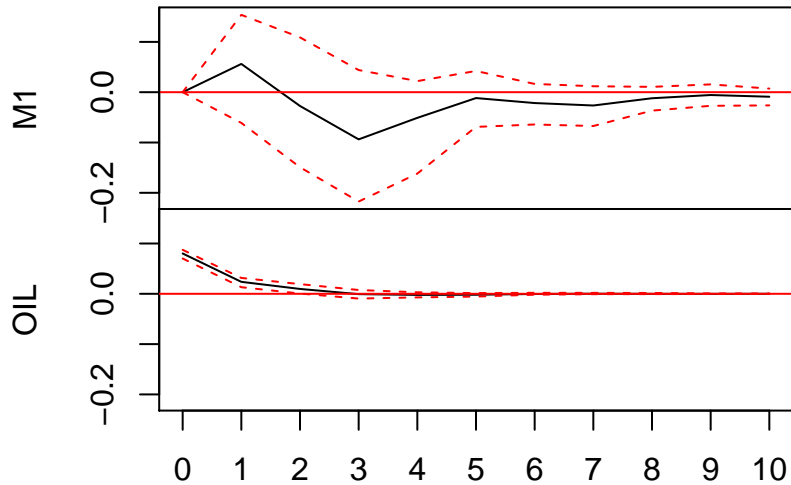
```
## M1 1.0000 0.1044
## OIL 0.1044 1.0000
impresp2=irf(varfit2)
plot(impresp2)
```

Orthogonal Impulse Response from M1



95 % Bootstrap CI, 100 runs

Orthogonal Impulse Response from OIL



95 % Bootstrap CI, 100 runs

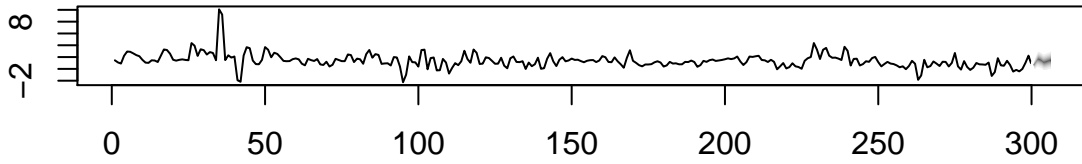
#2.4

```
varfit.prd<-predict(varfit2, n.ahead = 6, ci=0.95)
varfit.prd
```

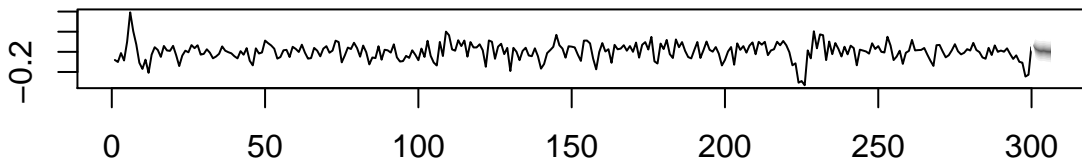
```
## $M1
##          fcst      lower      upper      CI
## [1,] 0.8091018 -1.0789282 2.697132 1.888030
## [2,] 1.6764551 -0.6036171 3.956527 2.280072
## [3,] 1.4855759 -0.7964864 3.767638 2.282062
## [4,] 1.0923405 -1.2109109 3.395592 2.303251
## [5,] 1.2573493 -1.1234082 3.638107 2.380758
## [6,] 1.4498503 -0.9508618 3.850562 2.400712
##
## $OIL
##          fcst      lower      upper      CI
## [1,] 3.680456e-02 -0.1211647 0.1947738 0.1579692
## [2,] 1.511540e-02 -0.1499850 0.1802158 0.1651004
## [3,] 6.096637e-03 -0.1615940 0.1737873 0.1676906
## [4,] 9.409539e-03 -0.1583044 0.1771235 0.1677139
## [5,] 2.392189e-03 -0.1655178 0.1703022 0.1679100
## [6,] -9.518535e-05 -0.1680471 0.1678567 0.1679519
```

```
fanchart(varfit.prd)
```

Fanchart for variable M1



Fanchart for variable OIL



```
fevd(varfit2,n.ahead = 6)
```

```
## $M1
##           M1           OIL
## [1,] 1.0000000 0.000000000
## [2,] 0.9976640 0.002336045
## [3,] 0.9971155 0.002884469
## [4,] 0.9908030 0.009196979
## [5,] 0.9896296 0.010370432
## [6,] 0.9897108 0.010289214
##
## $OIL
##           M1           OIL
## [1,] 0.01089392 0.9891061
## [2,] 0.01477258 0.9852274
## [3,] 0.03227375 0.9677262
## [4,] 0.03247842 0.9675216
## [5,] 0.03407249 0.9659275
## [6,] 0.03405620 0.9659438
```