

## Assignment 6 Spring 2020

**DUE DATE:** Wednesday 19<sup>th</sup>, May 2021.

I pledge to the Honor Code and to obey all rules for taking and performing homework assignments as specified by the course instructor.

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**There are two questions.**

**Question1.**

Consider the monthly unemployment rates of Michigan, Illinois, and Indiana from 1976.1 to 2017.2. Build a VAR model for this 3-dimensional time series. Simplify (or refine) the model by removing insignificant parameters with threshold of t-ratio 1.645, and perform model checking. The data are in m-unrate-MIILIN.txt.

1.1 Write down the final fitted model.

$$\begin{bmatrix} yt \\ xt \\ zt \end{bmatrix} = \begin{bmatrix} -0.431 \\ 0.021 \\ -0.017 \end{bmatrix} + \begin{bmatrix} 0.199 & 0.276 & 0.131 \\ 0.106 & 0.528 & 0.101 \\ 0.151 & 0.274 & 0.568 \end{bmatrix} \begin{bmatrix} yt - 1 \\ xt - 1 \\ zt - 1 \end{bmatrix} + \begin{bmatrix} 0.309 & -0.106 & 0.006 \\ 0.05 & 0.183 & -0.085 \\ -0.006 & -0.17 & 0.014 \end{bmatrix} \begin{bmatrix} yt - 2 \\ xt - 2 \\ zt - 2 \end{bmatrix}$$

Constant term:

```
## Estimates: -0.04308488 0.02069438 -0.01722694
```

```
## Std.Error: 0.08968027 0.05526058 0.08400675
```

```
## 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,] 3.8551679 0.3071579 0.7144333
## [2,] 0.3071579 1.4637954 0.4019971
## [3,] 0.7144333 0.4019971 3.3828113
##
## det(SSE) = 17.57694
## AIC = 2.939907
## BIC = 3.093748
## HQ = 3.000321

```

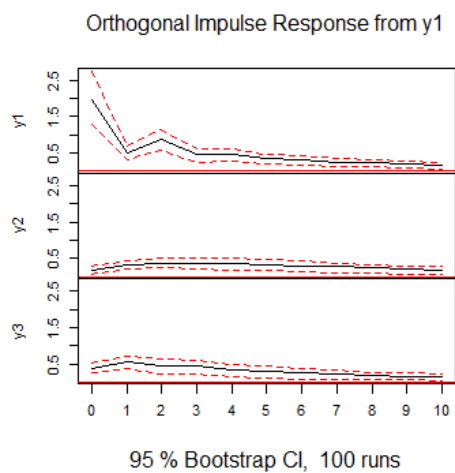
```
MTSdiag(m.MTS)
```

```

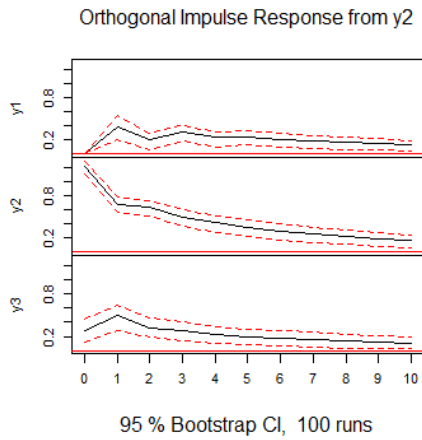
## [1] "Covariance matrix:"
##      [,1] [,2] [,3]
## [1,] 3.863 0.308 0.716
## [2,] 0.308 1.467 0.403
## [3,] 0.716 0.403 3.390
## CCM at lag: 0
##      [,1] [,2] [,3]
## [1,] 1.000 0.129 0.198
## [2,] 0.129 1.000 0.181
## [3,] 0.198 0.181 1.000
## Simplified matrix:
## CCM at lag: 1

```

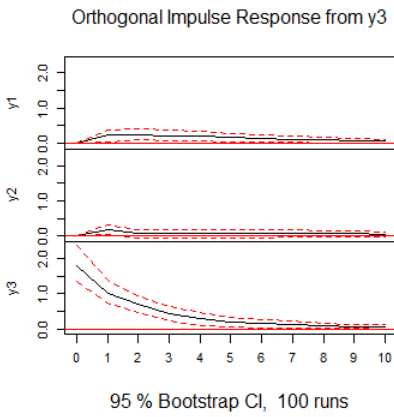
1.2 Obtain the plots of impulse response function of the fitted model and explain the relationship among the monthly unemployment rates of Michigan, Illinois, and Indiana from 1976.1 to 2017.2.



A unit change in MI generate significant impact on MI the most



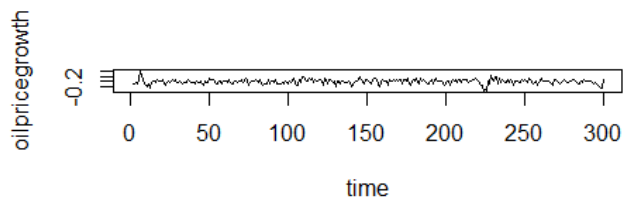
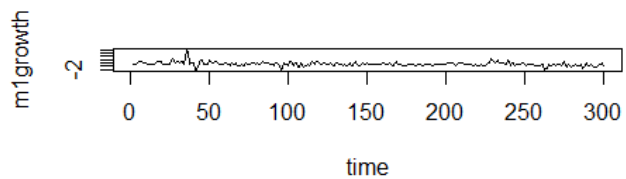
and a unit change in IL significantly impact IL



Lastly, a unit change in IN significantly impact IN

Consider the monthly growth rate of M1 money supply of China and the growth rate of monthly crude oil price. The original data are from FRED. The crude oil prices are MCOILWTICO, Western Texas Intermediate. The data are in m-m1cnwti.txt with first column containing M1 series.

2.1 Obtain the time series plots of the bivariate time series, say  $z_t$ .



2.2 Build a VAR model for  $z_t$ , including simplification and model checking. Write down the fitted model.

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} 0.4891 & 0 \\ 0.0103 & 0 \end{bmatrix} + \begin{bmatrix} 0.675 & 0 \\ 0 & 0.303 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} -0.405 & -0.932 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} y_{t-2} \\ x_{t-2} \end{bmatrix} + \begin{bmatrix} 0.381 & 0 \\ -0.008 & 0 \end{bmatrix} \begin{bmatrix} y_{t-3} \\ x_{t-3} \end{bmatrix}$$

```
VARorder(xt)

## 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

#choosing the optimal model with Lowest BIC
#model 4 contain the Lowest BIC
m3.MTS=VAR(xt,4)

## Constant term:
## Estimates:  0.5496963 -0.004820463
## Std.Error:  0.1068995 0.008959398
## AR coefficient matrix
## AR( 1 )-matrix
##      [,1] [,2]
## [1,] 0.71043 0.487
## [2,] 0.00133 0.300
## standard error
##      [,1] [,2]
## [1,] 0.05897 0.7064
## [2,] 0.00494 0.0592
## AR( 2 )-matrix
##      [,1] [,2]
## [1,] -0.45332 -0.8657
```

```

## [2,] 0.00909 0.0263
## standard error
##      [,1] [,2]
## [1,] 0.06731 0.7367
## [2,] 0.00564 0.0617
## AR( 3 )-matrix
##      [,1] [,2]
## [1,] 0.45754 -0.0948
## [2,] -0.00981 -0.0393
## standard error
##      [,1] [,2]
## [1,] 0.06749 0.7428
## [2,] 0.00566 0.0623
## AR( 4 )-matrix
##      [,1] [,2]
## [1,] -0.10907 -0.6965
## [2,] 0.00519 -0.0934
## standard error
##      [,1] [,2]
## [1,] 0.05932 0.7140
## [2,] 0.00497 0.0598
##
## Residuals cov-mtx:
##      [,1] [,2]
## [1,] 0.89234706 0.008260130
## [2,] 0.00826013 0.006268155
##
## det(SSE) = 0.00552514
## AIC = -5.09178
## BIC = -4.894245
## HQ = -5.012726

MTSdiag(m3.MTS)

## [1] "Covariance matrix:"
##      m1growth oilpricegrowth
## m1growth      0.89537      0.00829
## oilpricegrowth 0.00829      0.00629
## CCM at lag: 0
##      [,1] [,2]
## [1,] 1.00 0.11
## [2,] 0.11 1.00
m4.MTS=refVAR(m3.MTS)

## Constant term:
## Estimates: 0.5463485 0
## Std.Error: 0.1064132 0
## AR coefficient matrix
## AR( 1 )-matrix
##      [,1] [,2]

```

```

## [1,] 0.715 0.000
## [2,] 0.000 0.307
## standard error
##      [,1] [,2]
## [1,] 0.0582 0.0000
## [2,] 0.0000 0.0555
## AR( 2 )-matrix
##      [,1] [,2]
## [1,] -0.45547 -0.736
## [2,] 0.00902 0.000
## standard error
##      [,1] [,2]
## [1,] 0.0668 0.678
## [2,] 0.0041 0.000
## AR( 3 )-matrix
##      [,1] [,2]
## [1,] 0.4631 0
## [2,] -0.0106 0
## standard error
##      [,1] [,2]
## [1,] 0.06684 0
## [2,] 0.00523 0
## AR( 4 )-matrix
##      [,1] [,2]
## [1,] -0.11449 -0.739
## [2,] 0.00478 -0.102
## standard error
##      [,1] [,2]
## [1,] 0.05858 0.6860
## [2,] 0.00411 0.0569
##
## Residuals cov-mtx:
##      [,1] [,2]
## [1,] 0.893853212 0.008254988
## [2,] 0.008254988 0.006285750
##
## det(SSE) = 0.005550393
## AIC = -5.120553
## BIC = -4.984748
## HQ = -5.066204

```

2.3 Obtain the impulse response functions of the fitted model. What is the relationship between the M1 money supply of China and crude oil price, which represents commodity prices.

```
VARselect(xt, lag.max=10)
```

```

## $selection
## AIC(n)  HQ(n)  SC(n)  FPE(n)
##      10      3      3      10
##

```

```
## $criteria
##           1           2           3           4           5
## AIC(n) -4.981203511 -4.999832079 -5.138250646 -5.1336059 -5.120954677
## HQ(n) -4.950782762 -4.949130830 -5.067268897 -5.0423436 -5.009411928
## SC(n) -4.905274941 -4.873284461 -4.961083981 -4.9058202 -4.842549917
## FPE(n) 0.006865805 0.006739125 0.005868056 0.0058955 0.005970755
##           6           7           8           9          10
## AIC(n) -5.122862589 -5.137715694 -5.113114433 -5.150621360 -5.153027938
## HQ(n) -4.991039341 -4.985611946 -4.940730185 -4.957956612 -4.940082690
## SC(n) -4.793838782 -4.758072840 -4.682852531 -4.669740411 -4.621527942
## FPE(n) 0.005959657 0.005872171 0.006018933 0.005797982 0.005784808
```

```
m3.var=VAR(xt,p=3)
summary(m3.var)
```

```
##
## VAR Estimation Results:
## =====
## Endogenous variables: m1growth, oilpricegrowth
## 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 = xt, p = 3)
##
##
## Estimation results for equation m1growth:
## =====
## m1growth = m1growth.l1 + oilpricegrowth.l1 + m1growth.l2 + oilpricegrowth.
l2 + m1growth.l3 + oilpricegrowth.l3 + const
##
##           Estimate Std. Error t value Pr(>|t|)
## m1growth.l1      0.66841    0.05465  12.230 < 2e-16 ***
## oilpricegrowth.l1 0.70145    0.70262   0.998  0.319
## m1growth.l2     -0.40451    0.06295  -6.426 5.37e-10 ***
## oilpricegrowth.l2 -1.01842    0.73654  -1.383  0.168
## m1growth.l3      0.37999    0.05474   6.942 2.53e-11 ***
## oilpricegrowth.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
##
##
```

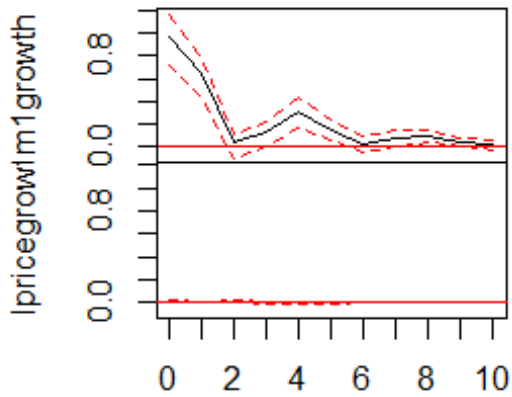
```

## Estimation results for equation oilpricegrowth:
## =====
## oilpricegrowth = m1growth.l1 + oilpricegrowth.l1 + m1growth.l2 + oilpriceg
rowth.l2 + m1growth.l3 + oilpricegrowth.l3 + const
##
##              Estimate Std. Error t value Pr(>|t|)
## m1growth.l1      0.003467   0.004573   0.758   0.449
## oilpricegrowth.l1 0.296716   0.058787   5.047 7.93e-07 ***
## m1growth.l2      0.007504   0.005267   1.425   0.155
## oilpricegrowth.l2 0.029814   0.061626   0.484   0.629
## m1growth.l3     -0.007121   0.004580  -1.555   0.121
## oilpricegrowth.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:
##              m1growth oilpricegrowth
## m1growth      0.927944      0.008104
## oilpricegrowth 0.008104      0.006496
##
## Correlation matrix of residuals:
##              m1growth oilpricegrowth
## m1growth      1.0000      0.1044
## oilpricegrowth 0.1044      1.0000

IRF2=irf(m3.var)
plot(IRF2)

```

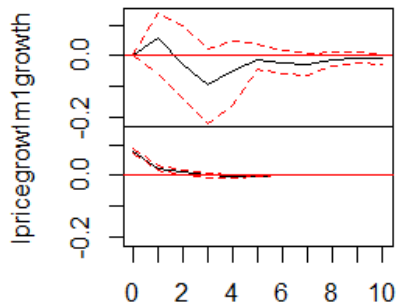
### Orthogonal Impulse Response from m1growth



Unit change from shocks of MI impact on MI significantly

95 % Bootstrap CI, 100 runs

### Orthogonal Impulse Response from oilpricegrowth

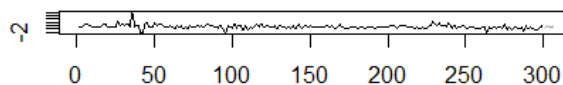


Unit change from shocks o OIL impact on OIL significantly

95 % Bootstrap CI, 100 runs

2.4 Obtain 1-step to 6-step ahead predictions of  $z_t$  at the forecast origin 2015.2.

**Fanchart for variable m1growth**



**Fanchart for variable oilpricegrowth**

