6104640336.R

10.10

2021-06-02

```
cat(rep("\n",50))
```

```
library(quantmod)
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 4.0.4
```

```
##
## 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)
```

```
## Warning: package 'sn' was built under R version 4.0.5

## Loading required package: stats4

##
## Attaching package: 'sn'

## The following objects are masked from 'package:fBasics':
##
##     tr, 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)

## Warning: package 'forecast' was built under R version 4.0.4

library(fGarch)

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

require(quantmod)
require(vars)

## Loading required package: 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

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

## Loading required package: urca

## Loading required package: lmtest
```

```
#Question1
getSymbols("IPDCONGD",src = "FRED")
```

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.

## [1] "IPDCONGD"
```

```
dim(IPDCONGD)

## [1] 892   1
```

```
tail(IPDCONGD)

##            IPDCONGD
## 2020-11-01 104.8970
## 2020-12-01 105.3158
## 2021-01-01 107.6347
## 2021-02-01 100.0964
## 2021-03-01 102.5666
## 2021-04-01 100.7979
```

```
getSymbols("IPNCONGD",src = "FRED")

## [1] "IPNCONGD"
```

```
dim(IPNCONGD)

## [1] 892   1
```

```
getSymbols("IPBUSEQ", src = "FRED")

## [1] "IPBUSEQ"
```

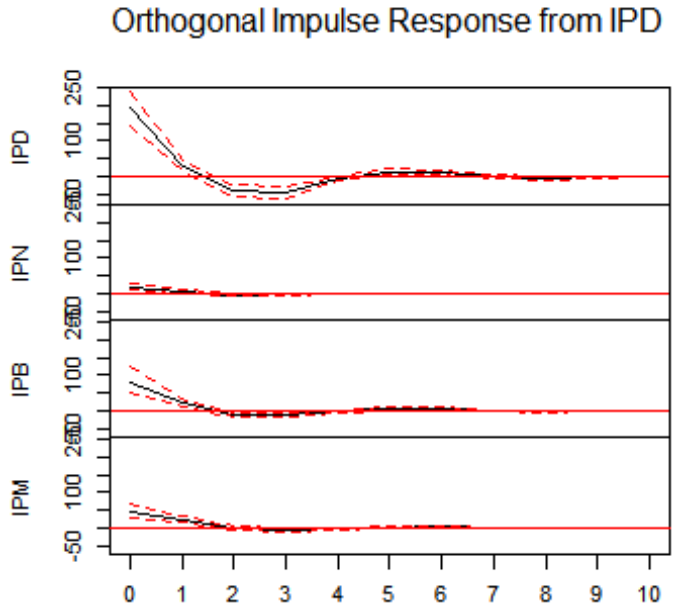
```
dim(IPBUSEQ)

## [1] 892   1

getSymbols("IPMAT", src = "FRED")

## [1] "IPMAT"

dim(IPMAT)

## [1] 988   1

IP=cbind(as.numeric(IPDCONGD),as.numeric(IPNCONGD),as.numeric(IPBUSEQ),as.num
eric(IPMAT[-c(1:96)]))
dim(IP)

## [1] 892   4

colnames(IP) <- c("IPD","IPN","IPB","IPM")
#1.1
log_IP=log(IP)
Zt=diff(IP)*100
#1.2
m1= VAR(Zt,p=3)
summary(m1)

##
## VAR Estimation Results:
## ========================
## Endogenous variables: IPD, IPN, IPB, IPM
## Deterministic variables: const
## Sample size: 888
## Log Likelihood: -20358.954
## Roots of the characteristic polynomial:
## 0.6866 0.6521 0.6521 0.6283 0.6283 0.5705 0.5705 0.5148 0.4082 0.3261
0.3261 0.03523
## Call:
## VAR(y = Zt, p = 3)
##
##
## Estimation results for equation IPD:
## ====================================
## IPD = IPD.l1 + IPN.l1 + IPB.l1 + IPM.l1 + IPD.l2 + IPN.l2 + IPB.l2 +
IPM.l2 + IPD.l3 + IPN.l3 + IPB.l3 + IPM.l3 + const
##
##        Estimate Std. Error t value Pr(>|t|)
## IPD.l1  0.15653    0.05476   2.858  0.00436 **
## IPN.l1  0.08917    0.11855   0.752  0.45213
## IPB.l1  0.07629    0.10513   0.726  0.46823
## IPM.l1 -0.16784    0.13912  -1.206  0.22799
## IPD.l2 -0.21923    0.05372  -4.081  4.9e-05 ***
## IPN.l2  0.02163    0.12243   0.177  0.85981
```

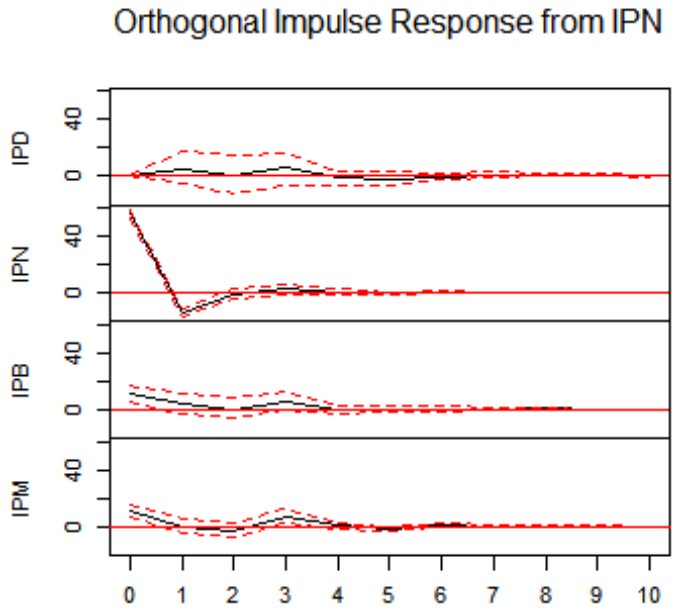
```
## IPB.l2  0.14077    0.10388   1.355  0.17572
## IPM.l2 -0.24366    0.13953  -1.746  0.08112 .
## IPD.l3 -0.17652    0.05430  -3.251  0.00119 **
## IPN.l3  0.11960    0.11878   1.007  0.31429
## IPB.l3  0.09700    0.10554   0.919  0.35831
## IPM.l3 -0.08901    0.13798  -0.645  0.51903
## const  12.15593    6.76687   1.796  0.07278 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 192 on 875 degrees of freedom
## Multiple R-Squared: 0.1226,  Adjusted R-squared: 0.1106
## F-statistic: 10.19 on 12 and 875 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation IPN:
## ====================================
## IPN = IPD.l1 + IPN.l1 + IPB.l1 + IPM.l1 + IPD.l2 + IPN.l2 + IPB.l2 +
IPM.l2 + IPD.l3 + IPN.l3 + IPB.l3 + IPM.l3 + const
##
##         Estimate Std. Error t value Pr(>|t|)
## IPD.l1  0.046301   0.016989   2.725  0.00655 **
## IPN.l1 -0.261433   0.036777  -7.109 2.43e-12 ***
## IPB.l1 -0.019290   0.032613  -0.591  0.55436
## IPM.l1  0.056677   0.043161   1.313  0.18947
## IPD.l2 -0.018761   0.016666  -1.126  0.26061
## IPN.l2 -0.097276   0.037982  -2.561  0.01060 *
## IPB.l2  0.058199   0.032226   1.806  0.07127 .
## IPM.l2 -0.074456   0.043287  -1.720  0.08578 .
## IPD.l3 -0.002635   0.016845  -0.156  0.87575
## IPN.l3  0.007021   0.036850   0.191  0.84894
## IPB.l3 -0.003110   0.032741  -0.095  0.92435
## IPM.l3  0.015960   0.042805   0.373  0.70936
## const  10.837543   2.099282   5.162 3.02e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 59.58 on 875 degrees of freedom
## Multiple R-Squared: 0.07441, Adjusted R-squared: 0.06172
## F-statistic: 5.862 on 12 and 875 DF,  p-value: 7.431e-10
##
##
## Estimation results for equation IPB:
## ====================================
## IPB = IPD.l1 + IPN.l1 + IPB.l1 + IPM.l1 + IPD.l2 + IPN.l2 + IPB.l2 +
IPM.l2 + IPD.l3 + IPN.l3 + IPB.l3 + IPM.l3 + const
##
##        Estimate Std. Error t value Pr(>|t|)
```

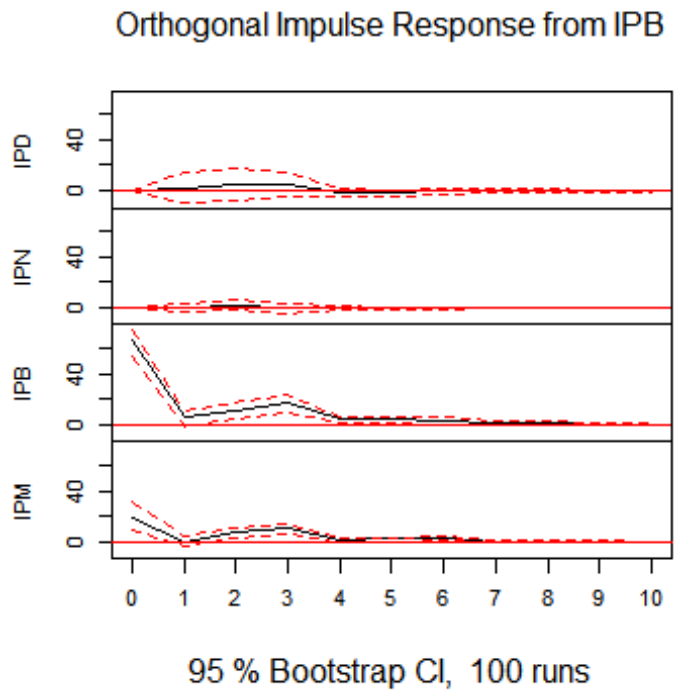
```
## IPD.l1  0.07486    0.03016   2.482  0.01325 *
## IPN.l1  0.06210    0.06528   0.951  0.34172
## IPB.l1  0.13357    0.05789   2.307  0.02128 *
## IPM.l1 -0.11307    0.07662  -1.476  0.14034
## IPD.l2 -0.15513    0.02958  -5.243 1.98e-07 ***
## IPN.l2 -0.03545    0.06742  -0.526  0.59914
## IPB.l2  0.15661    0.05721   2.738  0.00631 **
## IPM.l2  0.04526    0.07684   0.589  0.55602
## IPD.l3 -0.12628    0.02990  -4.223 2.66e-05 ***
## IPN.l3  0.07284    0.06541   1.114  0.26577
## IPB.l3  0.28938    0.05812   4.979 7.70e-07 ***
## IPM.l3 -0.17262    0.07599  -2.272  0.02335 *
## const   7.90970    3.72655   2.123  0.03407 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 105.8 on 875 degrees of freedom
## Multiple R-Squared: 0.1205,  Adjusted R-squared: 0.1084
## F-statistic:  9.99 on 12 and 875 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation IPM:
## ====================================
## IPM = IPD.l1 + IPN.l1 + IPB.l1 + IPM.l1 + IPD.l2 + IPN.l2 + IPB.l2 +
IPM.l2 + IPD.l3 + IPN.l3 + IPB.l3 + IPM.l3 + const
##
##         Estimate Std. Error t value Pr(>|t|)
## IPD.l1  0.125062   0.019407   6.444 1.92e-10 ***
## IPN.l1  0.007548   0.042009   0.180 0.857444
## IPB.l1  0.023126   0.037254   0.621 0.534924
## IPM.l1 -0.024062   0.049302  -0.488 0.625630
## IPD.l2 -0.041265   0.019038  -2.168 0.030459 *
## IPN.l2 -0.063918   0.043386  -1.473 0.141044
## IPB.l2  0.150896   0.036812   4.099 4.53e-05 ***
## IPM.l2 -0.137071   0.049447  -2.772 0.005688 **
## IPD.l3 -0.074706   0.019242  -3.882 0.000111 ***
## IPN.l3  0.059990   0.042093   1.425 0.154465
## IPB.l3  0.107740   0.037400   2.881 0.004064 **
## IPM.l3  0.122299   0.048896   2.501 0.012559 *
## const   7.236032   2.397992   3.018 0.002622 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 68.05 on 875 degrees of freedom
## Multiple R-Squared: 0.1786,  Adjusted R-squared: 0.1673
## F-statistic: 15.86 on 12 and 875 DF,  p-value: < 2.2e-16
##
##
```

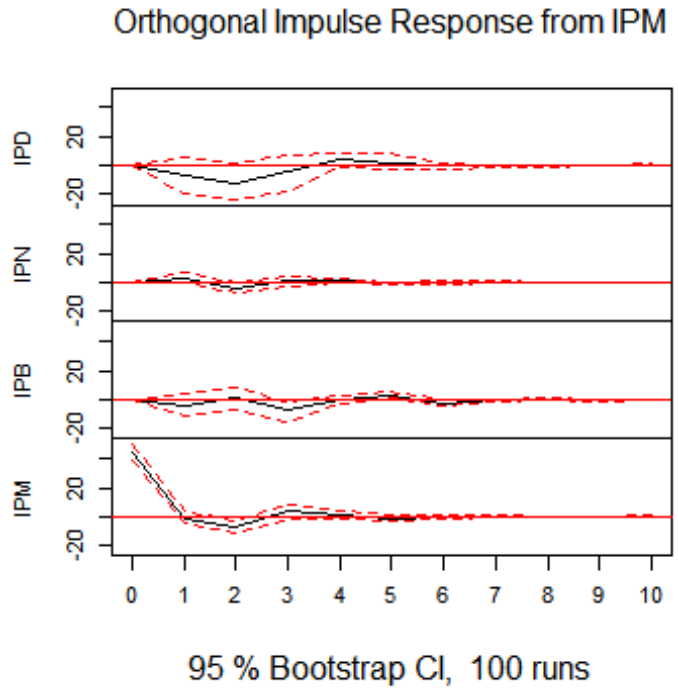
```
##
## Covariance matrix of residuals:
##       IPD  IPN   IPB  IPM
## IPD 36880 3731 15822 8794
## IPN  3731 3549  2242 1520
## IPB 15822 2242 11185 5142
## IPM  8794 1520  5142 4631
##
## Correlation matrix of residuals:
##        IPD    IPN    IPB    IPM
## IPD 1.0000 0.3261 0.7790 0.6729
## IPN 0.3261 1.0000 0.3558 0.3749
## IPB 0.7790 0.3558 1.0000 0.7144
## IPM 0.6729 0.3749 0.7144 1.0000
```

```
#1.3
m1.impresp = irf(m1)
plot(m1.impresp)
```


Orthogonal Impulse Response from IPD
IPD
IPN
IPB
IPM
250
100
-50
0 1 2 3 4 5 6 7 8 9 10
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from IPN
IPD
IPN
IPB
IPM
40
0
0 1 2 3 4 5 6 7 8 9 10
95 % Bootstrap CI, 100 runs






```
#1.4
fevd(m1, n.ahead = 20)
```

```
## $IPD
##             IPD          IPN          IPB         IPM
##  [1,] 1.0000000 0.0000000000 0.000000e+00 0.000000000
##  [2,] 0.9979670 0.0004250436 8.491884e-05 0.001522999
##  [3,] 0.9936178 0.0004100185 7.531241e-04 0.005219014
##  [4,] 0.9918724 0.0013662524 1.463226e-03 0.005298160
##  [5,] 0.9914744 0.0013822920 1.470936e-03 0.005672384
##  [6,] 0.9912531 0.0015051074 1.523454e-03 0.005718372
##  [7,] 0.9912299 0.0015270251 1.521433e-03 0.005721625
##  [8,] 0.9912048 0.0015371771 1.524872e-03 0.005733157
##  [9,] 0.9911955 0.0015443110 1.526934e-03 0.005733294
## [10,] 0.9911963 0.0015441492 1.527079e-03 0.005732502
## [11,] 0.9911939 0.0015446167 1.527208e-03 0.005734310
## [12,] 0.9911928 0.0015449778 1.527563e-03 0.005734640
## [13,] 0.9911926 0.0015450057 1.527571e-03 0.005734794
## [14,] 0.9911923 0.0015450843 1.527630e-03 0.005734969
## [15,] 0.9911923 0.0015451324 1.527641e-03 0.005734948
## [16,] 0.9911923 0.0015451331 1.527642e-03 0.005734957
## [17,] 0.9911923 0.0015451422 1.527644e-03 0.005734960
## [18,] 0.9911923 0.0015451430 1.527645e-03 0.005734959
## [19,] 0.9911923 0.0015451431 1.527645e-03 0.005734960
## [20,] 0.9911923 0.0015451435 1.527645e-03 0.005734961
##
## $IPN
##             IPD       IPN          IPB         IPM
##  [1,] 0.1063210 0.8936790 0.000000e+00 0.000000000
##  [2,] 0.1058671 0.8923855 8.840260e-06 0.001738537
##  [3,] 0.1071358 0.8845990 1.580340e-03 0.006684881
##  [4,] 0.1081787 0.8834937 1.584939e-03 0.006742582
##  [5,] 0.1083886 0.8828072 1.602995e-03 0.007201205
##  [6,] 0.1085024 0.8824725 1.605243e-03 0.007419876
##  [7,] 0.1086375 0.8823305 1.613333e-03 0.007418696
##  [8,] 0.1086437 0.8822965 1.617338e-03 0.007442509
##  [9,] 0.1086584 0.8822685 1.617297e-03 0.007455751
## [10,] 0.1086686 0.8822539 1.620517e-03 0.007456980
## [11,] 0.1086683 0.8822516 1.621029e-03 0.007459121
## [12,] 0.1086698 0.8822499 1.621125e-03 0.007459106
## [13,] 0.1086704 0.8822490 1.621290e-03 0.007459366
## [14,] 0.1086704 0.8822489 1.621391e-03 0.007459368
## [15,] 0.1086705 0.8822487 1.621392e-03 0.007459370
## [16,] 0.1086705 0.8822487 1.621403e-03 0.007459382
## [17,] 0.1086705 0.8822487 1.621409e-03 0.007459382
## [18,] 0.1086706 0.8822487 1.621409e-03 0.007459384
## [19,] 0.1086706 0.8822487 1.621410e-03 0.007459385
## [20,] 0.1086706 0.8822486 1.621411e-03 0.007459386
##
## $IPB
##             IPD        IPN       IPB         IPM
##  [1,] 0.6068593 0.01159095 0.3815498 0.000000000
##  [2,] 0.6179030 0.01225658 0.3676075 0.002232922
```

```
##  [3,] 0.6157601 0.01194222 0.3700258 0.002271899
##  [4,] 0.6001250 0.01443847 0.3784401 0.006996476
##  [5,] 0.5993374 0.01441286 0.3792660 0.006983788
##  [6,] 0.5989509 0.01437936 0.3792067 0.007463045
##  [7,] 0.5988685 0.01432999 0.3788978 0.007903719
##  [8,] 0.5986028 0.01433067 0.3791060 0.007960548
##  [9,] 0.5984452 0.01438173 0.3792127 0.007960383
## [10,] 0.5984010 0.01438011 0.3792368 0.007982087
## [11,] 0.5983741 0.01437939 0.3792629 0.007983564
## [12,] 0.5983702 0.01438034 0.3792659 0.007983608
## [13,] 0.5983678 0.01438015 0.3792674 0.007984677
## [14,] 0.5983635 0.01438017 0.3792706 0.007985700
## [15,] 0.5983618 0.01438047 0.3792720 0.007985718
## [16,] 0.5983613 0.01438048 0.3792725 0.007985718
## [17,] 0.5983611 0.01438047 0.3792727 0.007985741
## [18,] 0.5983610 0.01438047 0.3792728 0.007985749
## [19,] 0.5983609 0.01438047 0.3792729 0.007985751
## [20,] 0.5983609 0.01438047 0.3792729 0.007985756
##
## $IPM
##             IPD        IPN        IPB       IPM
##  [1,] 0.4527700 0.02703994 0.07800096 0.4421891
##  [2,] 0.5174437 0.02385445 0.06892657 0.3897753
##  [3,] 0.5060686 0.02493902 0.07814715 0.3908452
##  [4,] 0.4921051 0.03337200 0.09638066 0.3781422
##  [5,] 0.4922373 0.03336890 0.09683090 0.3775629
##  [6,] 0.4915248 0.03347238 0.09808955 0.3769132
##  [7,] 0.4916632 0.03348738 0.09938660 0.3754629
##  [8,] 0.4916658 0.03349706 0.09954050 0.3752966
##  [9,] 0.4915514 0.03348765 0.09974164 0.3752194
## [10,] 0.4914662 0.03348856 0.09989794 0.3751473
## [11,] 0.4914426 0.03349083 0.09993459 0.3751319
## [12,] 0.4914403 0.03348978 0.09995000 0.3751199
## [13,] 0.4914368 0.03348892 0.09996031 0.3751140
## [14,] 0.4914334 0.03348922 0.09996604 0.3751113
## [15,] 0.4914322 0.03348934 0.09996835 0.3751101
## [16,] 0.4914316 0.03348929 0.09996947 0.3751097
## [17,] 0.4914312 0.03348928 0.09997009 0.3751094
## [18,] 0.4914312 0.03348928 0.09997029 0.3751093
## [19,] 0.4914311 0.03348927 0.09997039 0.3751092
## [20,] 0.4914311 0.03348927 0.09997046 0.3751092
```

```
#1.5
predict(m1, n.ahead = 6, ci =0.95)
```

```
## $IPD
##             fcst     lower    upper       CI
## [1,] 28.43139444 -347.9652 404.8280 376.3966
## [2,]  6.43027854 -375.0385 387.8991 381.4688
## [3,] 66.47727431 -323.2906 456.2452 389.7679
```

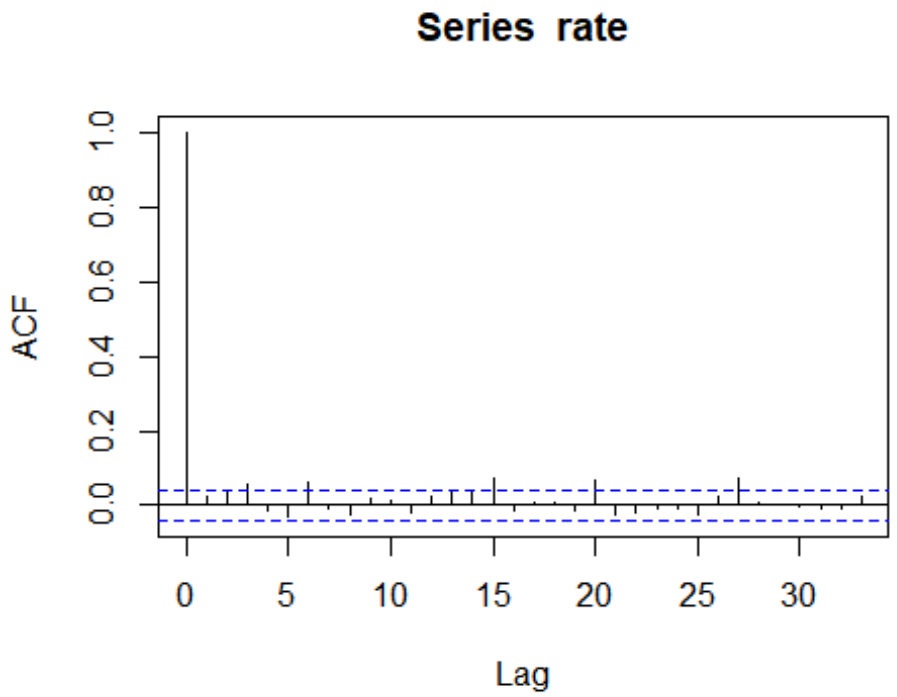
```
## [4,] 16.65753976 -383.2485 416.5636 399.9061
## [5,] -7.52832606 -407.6725 392.6158 400.1441
## [6,]  0.02109574 -401.0963 401.1385 401.1174
##
## $IPN
##            fcst      lower     upper       CI
## [1,] -39.192404 -155.96167  77.57686 116.7693
## [2,]   6.141801 -114.42467 126.70827 120.5665
## [3,]  27.675478  -93.47669 148.82765 121.1522
## [4,]   6.739005 -114.58541 128.06342 121.3244
## [5,]   3.738534 -117.63437 125.11143 121.3729
## [6,]  11.920676 -109.48308 133.32443 121.4038
##
## $IPB
##            fcst      lower    upper       CI
## [1,] 112.208449  -95.07482 319.4917 207.2833
## [2,]  52.013612 -160.23137 264.2586 212.2450
## [3,]  35.928136 -179.11104 250.9673 215.0392
## [4,]  56.117462 -163.87413 276.1091 219.9916
## [5,]  18.543060 -201.64964 238.7358 220.1927
## [6,]   8.129404 -212.52746 228.7863 220.6569
##
## $IPM
##           fcst      lower     upper       CI
## [1,] -50.89055 -184.27506  82.49396 133.3845
## [2,]  49.55739  -92.55370 191.66848 142.1111
## [3,]  64.29124  -79.42182 208.00430 143.7131
## [4,]  16.83084 -129.75184 163.41352 146.5827
## [5,]  13.91250 -132.83552 160.66051 146.7480
## [6,]  19.88719 -127.03735 166.81174 146.9245
```

```
#Question2
getSymbols("DOGE-USD",from="2015-01-01",to="2021-05-24" )
```

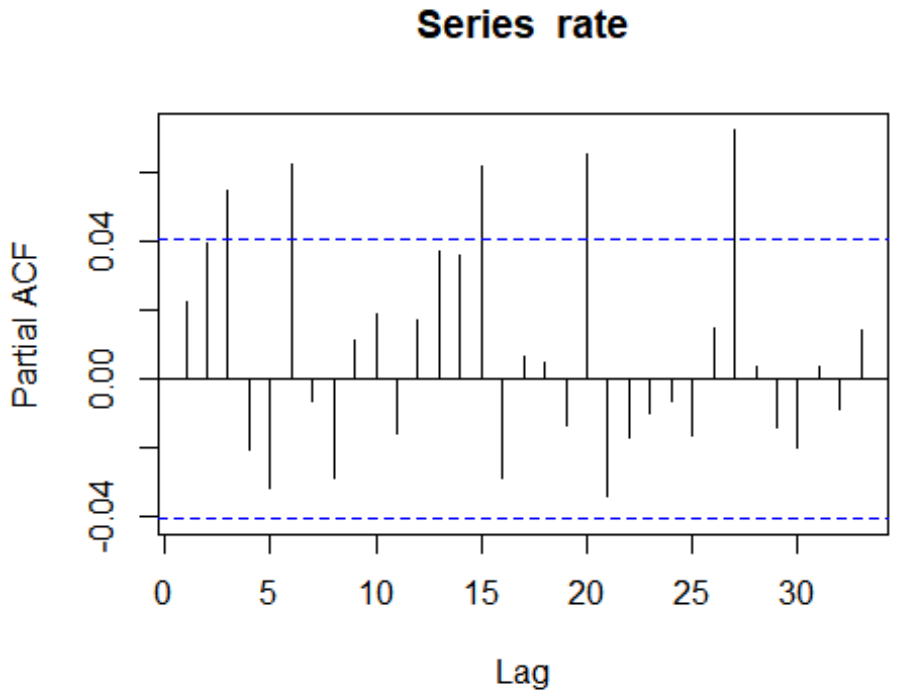
```
## Warning: DOGE-USD contains missing values. Some functions will not work if
## objects contain missing values in the middle of the series. Consider using
## na.omit(), na.approx(), na.fill(), etc to remove or replace them.
```

```
## [1] "DOGE-USD"
```

```
rate=diff(log(as.numeric(`DOGE-USD`[,6])))
rate=na.omit(rate)
#2.1
acf(rate)
```


Series rate
ACF
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
Lag

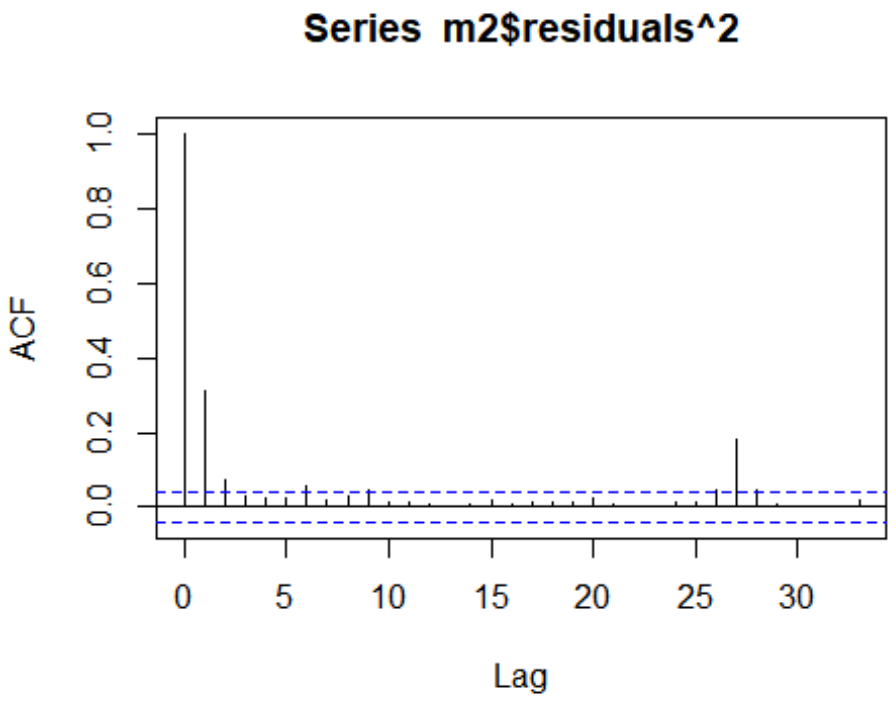
```
pacf(rate)
```


Series rate
Partial ACF
-0.04
0.00
0.04
0
5
10
15
20
25
30
Lag

```
m2=auto.arima(rate)
summary(m2)
```

```
## Series: rate
## ARIMA(3,0,3) with non-zero mean
##
## Coefficients:
##           ar1      ar2     ar3     ma1     ma2      ma3    mean
##       -0.1365  -0.6177  0.2899  0.1575  0.6680  -0.2124  0.0032
## s.e.   0.2863   0.1375  0.2476  0.2920  0.1342   0.2587  0.0017
##
## sigma^2 estimated as 0.005466:  log likelihood=2763.68
## AIC=-5511.36   AICc=-5511.3   BIC=-5465.34
##
## Training set error measures:
##                       ME       RMSE        MAE MPE MAPE      MASE
ACF1
## Training set 7.095178e-06 0.07382195 0.03969358 NaN  Inf 0.6871478
0.000674244
```

```
acf(m2$residuals^2)
```




```
Box.test(m2$residuals^2,lag = 10,type = 'Ljung')
```

```
##
##  Box-Ljung test
##
```

```
## data:  m2$residuals^2
## X-squared = 261.5, df = 10, p-value < 2.2e-16

m3= garchFit(~arma(3,3)+garch(1,1),data = rate,trace = F)

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean):
## possible convergence problem: optim gave code = 1

## Warning: Using formula(x) is deprecated when x is a character vector of
length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

summary(m3)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(3, 3) + garch(1, 1), data = rate, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(3, 3) + garch(1, 1)
## <environment: 0x00000000137eb290>
##  [data = rate]
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ar1          ar2          ar3          ma1
ma2
## -0.00099345  -0.05263201  -0.50537351   0.42283458   0.01227320
0.52563486
##         ma3        omega       alpha1        beta1
## -0.44071728   0.00012893   0.29654730   0.73900398
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu     -9.935e-04   1.098e-03   -0.905  0.36546
## ar1    -5.263e-02   3.151e-01   -0.167  0.86736
## ar2    -5.054e-01   1.748e-01   -2.891  0.00384 **
## ar3     4.228e-01   2.851e-01    1.483  0.13802
## ma1     1.227e-02   3.090e-01    0.040  0.96832
## ma2     5.256e-01   1.640e-01    3.205  0.00135 **
## ma3    -4.407e-01   2.833e-01   -1.556  0.11976
## omega   1.289e-04   1.795e-05    7.182 6.85e-13 ***
```

```
## alpha1  2.965e-01   2.719e-02   10.906  < 2e-16 ***
## beta1   7.390e-01   1.904e-02   38.813  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  3673.958    normalized:  1.578161
##
## Description:
##  Wed Jun 02 17:27:19 2021 by user: 10.10
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  9736.563  0
##  Shapiro-Wilk Test  R    W      0.8764044 0
##  Ljung-Box Test     R    Q(10)  25.55084  0.004393644
##  Ljung-Box Test     R    Q(15)  44.71646  8.487242e-05
##  Ljung-Box Test     R    Q(20)  47.38148  0.0005191375
##  Ljung-Box Test     R^2  Q(10)  16.1789   0.09462443
##  Ljung-Box Test     R^2  Q(15)  16.74733  0.3341923
##  Ljung-Box Test     R^2  Q(20)  19.19326  0.509298
##  LM Arch Test       R    TR^2   15.82561  0.1993548
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.147730 -3.123019 -3.147767 -3.138726
```

```
m4= garchFit(~arma(3,3)+garch(1,0),data = rate,trace = F)
```

```
## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): possible convergence problem: optim gave code = 1

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): Using formula(x) is deprecated when x is a character vector of
length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.
```

```
summary(m4)
```

```
##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(3, 3) + garch(1, 0), data = rate, trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(3, 3) + garch(1, 0)
## <environment: 0x0000000020f3c360>
##  [data = rate]
```

```
##
## Conditional Distribution:
##  norm
##
## Coefficient(s):
##          mu          ar1          ar2          ar3          ma1
ma2
## -6.2596e-06  -1.9619e-01   2.5383e-01   2.7780e-01   8.4942e-02  -2.5553e-
01
##         ma3        omega       alpha1
## -3.3379e-01   1.6543e-03   1.0000e+00
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu     -6.260e-06   4.549e-04   -0.014   0.9890
## ar1    -1.962e-01   3.089e-01   -0.635   0.5253
## ar2     2.538e-01   1.232e-01    2.060   0.0394 *
## ar3     2.778e-01   1.524e-01    1.823   0.0683 .
## ma1     8.494e-02   2.889e-01    0.294   0.7687
## ma2    -2.555e-01   1.452e-01   -1.760   0.0784 .
## ma3    -3.338e-01   1.379e-01   -2.420   0.0155 *
## omega   1.654e-03   7.841e-05   21.098   <2e-16 ***
## alpha1  1.000e+00   8.502e-02   11.762   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  3435.069    normalized:  1.475545
##
## Description:
##  Wed Jun 02 17:27:20 2021 by user: 10.10
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  14587.88  0
##  Shapiro-Wilk Test  R    W      0.854688  0
##  Ljung-Box Test     R    Q(10)  92.80669  1.44329e-15
##  Ljung-Box Test     R    Q(15)  125.0957  0
##  Ljung-Box Test     R    Q(20)  130.7534  0
##  Ljung-Box Test     R^2  Q(10)  42.00527  7.482514e-06
##  Ljung-Box Test     R^2  Q(15)  60.86605  1.788975e-07
##  Ljung-Box Test     R^2  Q(20)  75.41615  2.3218e-08
##  LM Arch Test       R    TR^2   40.50904  5.91752e-05
##
## Information Criterion Statistics:
```

```
##       AIC       BIC       SIC      HQIC
## -2.943358 -2.921118 -2.943388 -2.935255

m5= garchFit(~arma(3,3)+garch(1,1),data = rate,cond.dist = 'std',trace = F)

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): possible convergence problem: optim gave code = 1

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): Using formula(x) is deprecated when x is a character vector of
length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

summary(m5)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(3, 3) + garch(1, 1), data = rate, cond.dist =
"std",
##     trace = F)
##
## Mean and Variance Equation:
##  data ~ arma(3, 3) + garch(1, 1)
## <environment: 0x00000000200b85d8>
##  [data = rate]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##          mu          ar1          ar2          ar3          ma1
ma2
## -0.00142845   0.38830308  -0.50602012   0.10205168  -0.53308519
0.57494661
##         ma3        omega       alpha1        beta1        shape
## -0.18459409   0.00017662   0.66916538   0.71102963   2.39292439
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##         Estimate  Std. Error  t value Pr(>|t|)
## mu     -0.0014284   0.0006017   -2.374 0.017586 *
## ar1     0.3883031   0.2913734    1.333 0.182642
## ar2    -0.5060201   0.1501570   -3.370 0.000752 ***
## ar3     0.1020517   0.1807280    0.565 0.572298
## ma1    -0.5330852   0.2890136   -1.844 0.065111 .
## ma2     0.5749466   0.1390096    4.136 3.53e-05 ***
```

```
## ma3    -0.1845941   0.1827987   -1.010 0.312581
## omega   0.0001766   0.0000624    2.830 0.004651 **
## alpha1  0.6691654   0.2075135    3.225 0.001261 **
## beta1   0.7110296   0.0293852   24.197  < 2e-16 ***
## shape   2.3929244   0.1501627   15.936  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  4104.081    normalized:  1.762922
##
## Description:
##  Wed Jun 02 17:27:22 2021 by user: 10.10
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  11703.26  0
##  Shapiro-Wilk Test  R    W      0.8658672 0
##  Ljung-Box Test     R    Q(10)  56.74168  1.49041e-08
##  Ljung-Box Test     R    Q(15)  81.0624   4.463296e-11
##  Ljung-Box Test     R    Q(20)  85.27692  4.90407e-10
##  Ljung-Box Test     R^2  Q(10)  11.10941  0.3490581
##  Ljung-Box Test     R^2  Q(15)  11.69615  0.7018674
##  Ljung-Box Test     R^2  Q(20)  14.32062  0.8138748
##  LM Arch Test       R    TR^2   11.58158  0.4798406
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.516393 -3.489211 -3.516437 -3.506489

m6= garchFit(~arma(3,3)+garch(1,0),data = rate,cond.dist = 'std',trace = F)

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): possible convergence problem: optim gave code = 1

## Warning in arima(.series$x, order = c(u, 0, v), include.mean =
include.mean): Using formula(x) is deprecated when x is a character vector of
length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

summary(m6)

##
## Title:
##  GARCH Modelling
##
## Call:
##  garchFit(formula = ~arma(3, 3) + garch(1, 0), data = rate, cond.dist =
"std",
##     trace = F)
```

```
##
## Mean and Variance Equation:
##  data ~ arma(3, 3) + garch(1, 0)
## <environment: 0x000000002131d5f0>
##  [data = rate]
##
## Conditional Distribution:
##  std
##
## Coefficient(s):
##         mu         ar1         ar2         ar3         ma1         ma2
## -0.0013427   0.3423265  -0.4494836   0.2165952  -0.4823234   0.5045966
##        ma3       omega      alpha1       shape
## -0.2639528   0.0016711   1.0000000   2.6372226
##
## Std. Errors:
##  based on Hessian
##
## Error Analysis:
##          Estimate  Std. Error  t value Pr(>|t|)
## mu     -0.0013427   0.0005965   -2.251  0.02440 *
## ar1     0.3423265   0.2245698    1.524  0.12742
## ar2    -0.4494836   0.1510429   -2.976  0.00292 **
## ar3     0.2165952   0.1056803    2.050  0.04041 *
## ma1    -0.4823234   0.2218631   -2.174  0.02971 *
## ma2     0.5045966   0.1686922    2.991  0.00278 **
## ma3    -0.2639528   0.1025971   -2.573  0.01009 *
## omega   0.0016711   0.0001946    8.588  < 2e-16 ***
## alpha1  1.0000000   0.1135881    8.804  < 2e-16 ***
## shape   2.6372226   0.0956395   27.575  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Log Likelihood:
##  3966.142    normalized:  1.703669
##
## Description:
##  Wed Jun 02 17:27:24 2021 by user: 10.10
##
##
## Standardised Residuals Tests:
##                                 Statistic p-Value
##  Jarque-Bera Test   R    Chi^2  23197.99  0
##  Shapiro-Wilk Test  R    W      0.8353825 0
##  Ljung-Box Test     R    Q(10)  54.36079  4.156337e-08
##  Ljung-Box Test     R    Q(15)  77.58016  1.929145e-10
##  Ljung-Box Test     R    Q(20)  81.49889  2.182092e-09
##  Ljung-Box Test     R^2  Q(10)  40.80123  1.223601e-05
##  Ljung-Box Test     R^2  Q(15)  60.96747  1.718316e-07
##  Ljung-Box Test     R^2  Q(20)  71.93533  8.771372e-08
```

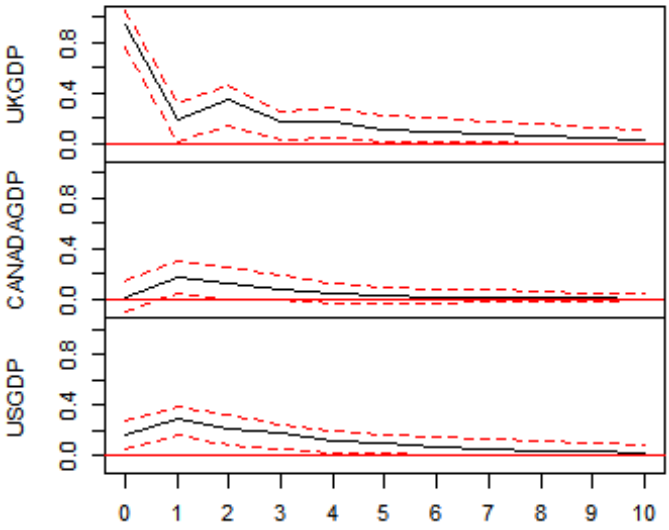
```
##  LM Arch Test       R    TR^2   45.90772  7.196928e-06
##
## Information Criterion Statistics:
##       AIC       BIC       SIC      HQIC
## -3.398747 -3.374036 -3.398784 -3.389743

#Question3
getSymbols("UKNGDP",from="1980-01-01", to="2011-04-1",src = "FRED")

## [1] "UKNGDP"

getSymbols("NAEXKP01CAQ189S",from="1980-01-01", to="2011-06-31",src = "FRED")

## [1] "NAEXKP01CAQ189S"

getSymbols("GDP",from="1980-01-01", to="2011-06-31",src = "FRED")

## [1] "GDP"

zt=cbind(UKNGDP$UKNGDP,NAEXKP01CAQ189S$NAEXKP01CAQ189S,GDP$GDP)
zt=zt[132:258,]
colnames(zt) <- c("UKGDP","CANADAGDP","USGDP")
log_zt=log(zt)
diff_log_zt=diff(log_zt)*100
diff_log_zt=diff_log_zt[2:127,]
#3.1
varfit= VAR(diff_log_zt,p=2)
summary(varfit)

##
## VAR Estimation Results:
## ========================
## Endogenous variables: UKGDP, CANADAGDP, USGDP
## Deterministic variables: const
## Sample size: 124
## Log Likelihood: -387.34
## Roots of the characteristic polynomial:
## 0.7642 0.5113 0.4815 0.3415 0.3165 0.3165
## Call:
## VAR(y = diff_log_zt, p = 2)
##
##
## Estimation results for equation UKGDP:
## ======================================
## UKGDP = UKGDP.l1 + CANADAGDP.l1 + USGDP.l1 + UKGDP.l2 + CANADAGDP.l2 +
USGDP.l2 + const
##
##              Estimate Std. Error t value Pr(>|t|)
## UKGDP.l1      0.13130    0.09349   1.404  0.16282
## CANADAGDP.l1 -0.31837    0.14219  -2.239  0.02704 *
## USGDP.l1      0.40317    0.13747   2.933  0.00404 **
## UKGDP.l2      0.27087    0.09313   2.908  0.00435 **
```

```
## CANADAGDP.l2  0.12100    0.13823   0.875  0.38316
## USGDP.l2      0.00351    0.14283   0.025  0.98044
## const         0.44760    0.19167   2.335  0.02123 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.9323 on 117 degrees of freedom
## Multiple R-Squared: 0.2855,  Adjusted R-squared: 0.2488
## F-statistic: 7.791 on 6 and 117 DF,  p-value: 4.599e-07
##
##
## Estimation results for equation CANADAGDP:
## ==========================================
## CANADAGDP = UKGDP.l1 + CANADAGDP.l1 + USGDP.l1 + UKGDP.l2 + CANADAGDP.l2 +
USGDP.l2 + const
##
##              Estimate Std. Error t value Pr(>|t|)
## UKGDP.l1      0.11947    0.06266   1.907 0.059002 .
## CANADAGDP.l1  0.47321    0.09530   4.966 2.35e-06 ***
## USGDP.l1      0.31920    0.09213   3.465 0.000743 ***
## UKGDP.l2     -0.02657    0.06242  -0.426 0.671114
## CANADAGDP.l2  0.02889    0.09264   0.312 0.755747
## USGDP.l2     -0.27868    0.09573  -2.911 0.004313 **
## const         0.11003    0.12846   0.857 0.393463
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.6248 on 117 degrees of freedom
## Multiple R-Squared: 0.4148,  Adjusted R-squared: 0.3847
## F-statistic: 13.82 on 6 and 117 DF,  p-value: 7.957e-12
##
##
## Estimation results for equation USGDP:
## ======================================
## USGDP = UKGDP.l1 + CANADAGDP.l1 + USGDP.l1 + UKGDP.l2 + CANADAGDP.l2 +
USGDP.l2 + const
##
##              Estimate Std. Error t value Pr(>|t|)
## UKGDP.l1      0.26552    0.06779   3.917 0.000151 ***
## CANADAGDP.l1  0.18335    0.10310   1.778 0.077936 .
## USGDP.l1      0.26106    0.09968   2.619 0.009986 **
## UKGDP.l2      0.05442    0.06753   0.806 0.421998
## CANADAGDP.l2 -0.06486    0.10023  -0.647 0.518799
## USGDP.l2      0.02657    0.10357   0.257 0.797946
## const         0.42320    0.13898   3.045 0.002874 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
##
## Residual standard error: 0.676 on 117 degrees of freedom
## Multiple R-Squared: 0.388,   Adjusted R-squared: 0.3566
## F-statistic: 12.36 on 6 and 117 DF,  p-value: 9.544e-11
##
##
##
## Covariance matrix of residuals:
##            UKGDP CANADAGDP  USGDP
## UKGDP     0.8692    0.0107 0.1552
## CANADAGDP 0.0107    0.3904 0.1617
## USGDP     0.1552    0.1617 0.4570
##
## Correlation matrix of residuals:
##             UKGDP CANADAGDP  USGDP
## UKGDP     1.00000   0.01837 0.2462
## CANADAGDP 0.01837   1.00000 0.3827
## USGDP     0.24625   0.38272 1.0000
```

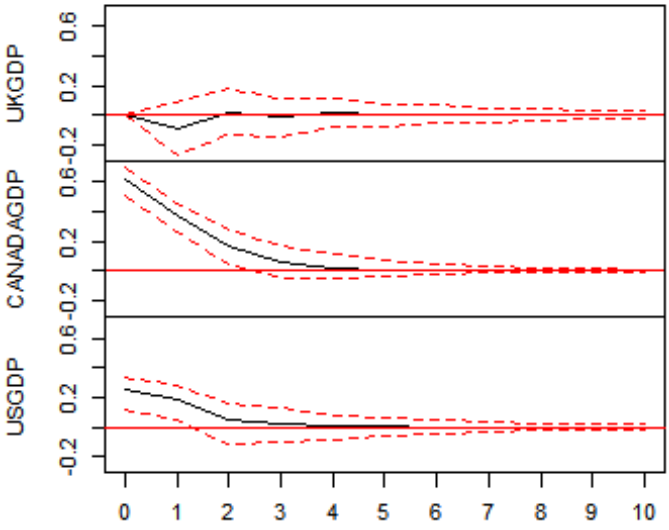
```
#3.2
impresp_3 = irf(varfit)
plot(impresp_3)
```

Orthogonal Impulse Response from UKGDP

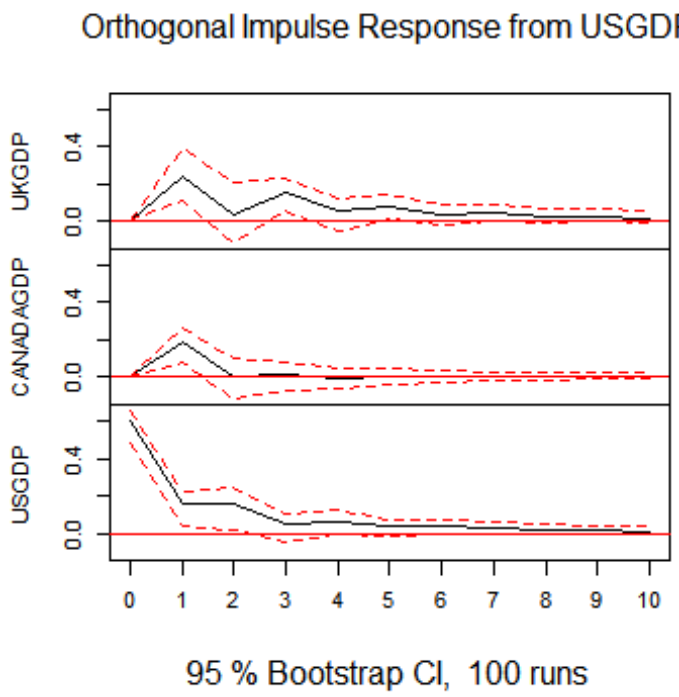


95 % Bootstrap CI, 100 runs

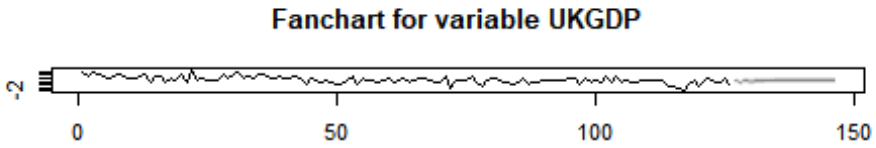
Orthogonal Impulse Response from CANADAGDP

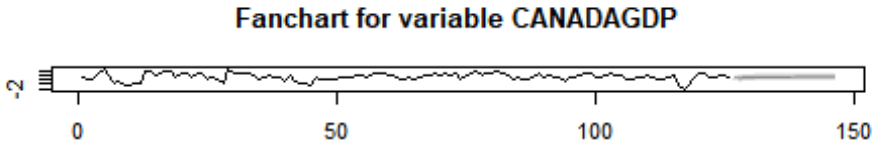


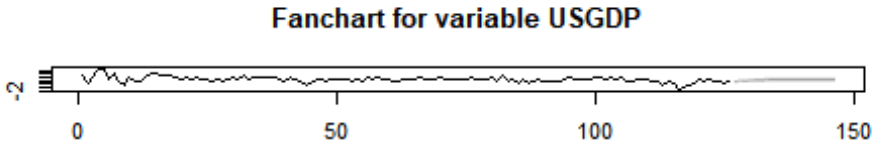
95 % Bootstrap CI, 100 runs




```r
#3.3
varfit.prd= predict(varfit, n.ahead = 20, ci= 0.95)
fanchart(varfit.prd)
```







```
fevd(varfit,n.ahead = 20)
```

```
## $UKGDP
##            UKGDP   CANADAGDP      USGDP
##  [1,] 1.0000000 0.000000000 0.00000000
##  [2,] 0.9297076 0.009441237 0.06085112
##  [3,] 0.9359223 0.008671549 0.05540613
##  [4,] 0.9171259 0.008354668 0.07451939
##  [5,] 0.9171105 0.008295939 0.07459352
##  [6,] 0.9133324 0.008173334 0.07849425
##  [7,] 0.9128934 0.008134848 0.07897178
##  [8,] 0.9120215 0.008097890 0.07988060
##  [9,] 0.9117790 0.008081759 0.08013920
## [10,] 0.9115388 0.008070197 0.08039100
## [11,] 0.9114390 0.008064331 0.08049666
## [12,] 0.9113653 0.008060576 0.08057408
## [13,] 0.9113285 0.008058521 0.08061296
## [14,] 0.9113046 0.008057269 0.08063809
## [15,] 0.9112916 0.008056559 0.08065180
## [16,] 0.9112837 0.008056137 0.08066018
## [17,] 0.9112792 0.008055894 0.08066492
## [18,] 0.9112765 0.008055750 0.08066775
## [19,] 0.9112750 0.008055667 0.08066938
## [20,] 0.9112740 0.008055618 0.08067034
##
## $CANADAGDP
##               UKGDP CANADAGDP      USGDP
##  [1,] 0.0003373506 0.9996626 0.00000000
##  [2,] 0.0484624625 0.8896079 0.06192963
##  [3,] 0.0694636089 0.8729466 0.05758981
##  [4,] 0.0795270108 0.8637328 0.05674023
##  [5,] 0.0832090324 0.8603302 0.05646073
##  [6,] 0.0847049460 0.8588925 0.05640257
##  [7,] 0.0853874952 0.8582191 0.05639341
##  [8,] 0.0857234666 0.8578577 0.05641885
##  [9,] 0.0859041554 0.8576590 0.05643684
## [10,] 0.0860025114 0.8575461 0.05645139
## [11,] 0.0860581801 0.8574817 0.05646014
## [12,] 0.0860896845 0.8574445 0.05646579
## [13,] 0.0861078461 0.8574230 0.05646912
## [14,] 0.0861183097 0.8574105 0.05647115
## [15,] 0.0861243897 0.8574033 0.05647233
## [16,] 0.0861279206 0.8573990 0.05647304
## [17,] 0.0861299788 0.8573966 0.05647345
## [18,] 0.0861311780 0.8573951 0.05647369
## [19,] 0.0861318779 0.8573943 0.05647383
## [20,] 0.0861322862 0.8573938 0.05647392
##
## $USGDP
##             UKGDP CANADAGDP     USGDP
```

```
##  [1,] 0.06063856 0.1430828 0.7962787
##  [2,] 0.18918578 0.1636079 0.6472063
##  [3,] 0.23517742 0.1508355 0.6139871
##  [4,] 0.26741869 0.1443755 0.5882058
##  [5,] 0.28063551 0.1407135 0.5786510
##  [6,] 0.28887541 0.1387469 0.5723777
##  [7,] 0.29296398 0.1376151 0.5694209
##  [8,] 0.29547802 0.1369707 0.5675512
##  [9,] 0.29685250 0.1365947 0.5665528
## [10,] 0.29767814 0.1363771 0.5659447
## [11,] 0.29814676 0.1362500 0.5656032
## [12,] 0.29842405 0.1361761 0.5653999
## [13,] 0.29858396 0.1361329 0.5652832
## [14,] 0.29867792 0.1361077 0.5652144
## [15,] 0.29873248 0.1360930 0.5651746
## [16,] 0.29876444 0.1360844 0.5651512
## [17,] 0.29878305 0.1360793 0.5651376
## [18,] 0.29879394 0.1360764 0.5651296
## [19,] 0.29880029 0.1360747 0.5651250
## [20,] 0.29880400 0.1360737 0.5651223
```

```
#3.4
UK=zt$UKGDP
CANADA=zt$CANADAGDP
US=zt$USGDP
fit <-lm(UK~CANADA+US)
summary(fit)
```

```
##
## Call:
## lm(formula = UK ~ CANADA + US)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11745.9  -6772.7   -669.4   6486.1  12835.5
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.387e+04  1.326e+04   1.046    0.298
## CANADA      -1.324e-07  8.545e-08  -1.550    0.124
## US           3.013e+01  1.659e+00  18.165   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7111 on 124 degrees of freedom
## Multiple R-squared:  0.9958, Adjusted R-squared:  0.9957
## F-statistic: 1.461e+04 on 2 and 124 DF,  p-value: < 2.2e-16
```

```
fit2 <-lm(CANADA~UK+US)
summary(fit2)
```

```
##
## Call:
## lm(formula = CANADA ~ UK + US)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.317e+10 -5.414e+09 -9.450e+08  5.901e+09  1.584e+10
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.533e+11  1.670e+09  91.771  < 2e-16 ***
## UK          -1.435e+05  9.258e+04  -1.550    0.124
## US           2.328e+07  2.558e+06   9.098  1.9e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7.402e+09 on 124 degrees of freedom
## Multiple R-squared:  0.9907, Adjusted R-squared:  0.9906
## F-statistic:  6623 on 2 and 124 DF,  p-value: < 2.2e-16
```

```
fit3 <-lm(US~UK+CANADA)
summary(fit3)
```

```
##
## Call:
## lm(formula = US ~ UK + CANADA)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -379.53 -142.12  -50.88  176.28  403.55
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.473e+03  3.046e+02  -8.118 3.98e-13 ***
## UK           2.412e-02  1.328e-03  18.165  < 2e-16 ***
## CANADA       1.720e-08  1.890e-09   9.098 1.90e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 201.2 on 124 degrees of freedom
## Multiple R-squared:  0.9974, Adjusted R-squared:  0.9974
## F-statistic: 2.395e+04 on 2 and 124 DF,  p-value: < 2.2e-16
```

```
#3.5
diff.UK=diff(UK)
diff.CANADA=diff(CANADA)
diff.US=diff(US)
diff.UK.L1=Lag(diff(UK),k=1)
diff.CANADA.L1=Lag(diff(CANADA),k=1)
diff.US.L1=Lag(diff(US),k=1)
```

```r
error=residuals(fit)
error.L1= Lag(error,k=1)
error2=residuals(fit2)
error2.L1= Lag(error2,k=1)
error3=residuals(fit3)
error3.L1=Lag(error3,k=1)
VECM<-lm(diff.UK~diff.UK.L1+diff.CANADA.L1+diff.US.L1+error.L1)
summary(VECM)
```

```
##
## Call:
## lm(formula = diff.UK ~ diff.UK.L1 + diff.CANADA.L1 + diff.US.L1 +
##     error.L1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6024.8 -1070.3   168.1  1310.2  4773.9
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     1.134e+03  3.423e+02   3.312  0.00123 **
## diff.UK.L1     -4.232e-02  9.151e-02  -0.462  0.64461
## diff.CANADA.L1 -1.802e-07  9.775e-08  -1.844  0.06768 .
## diff.US.L1      2.116e+01  3.539e+00   5.980 2.36e-08 ***
## error.L1       -1.726e-02  2.690e-02  -0.642  0.52233
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2061 on 120 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.2744, Adjusted R-squared:  0.2503
## F-statistic: 11.35 on 4 and 120 DF,  p-value: 7.632e-08
```

```r
VECM2<-lm(diff.CANADA~diff.UK.L1+diff.CANADA.L1+diff.US.L1+error2.L1)
summary(VECM2)
```

```
##
## Call:
## lm(formula = diff.CANADA ~ diff.UK.L1 + diff.CANADA.L1 + diff.US.L1 +
##     error2.L1)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -6.364e+09 -1.278e+09 -1.858e+08  1.301e+09  5.505e+09
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -2.780e+08  3.139e+08  -0.886 0.377585
## diff.UK.L1      9.858e+04  8.273e+04   1.192 0.235756
## diff.CANADA.L1  3.338e-01  8.864e-02   3.766 0.000259 ***
```

```
## diff.US.L1      1.248e+07  3.200e+06   3.900 0.000159 ***
## error2.L1      -5.261e-02  2.365e-02  -2.225 0.027984 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.864e+09 on 120 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.4371, Adjusted R-squared:  0.4183
## F-statistic:  23.3 on 4 and 120 DF,  p-value: 2.889e-14
```

```
VECM3<-lm(diff.US~diff.UK.L1+diff.CANADA.L1+diff.US.L1+error3.L1)
summary(VECM3)
```

```
##
## Call:
## lm(formula = diff.US ~ diff.UK.L1 + diff.CANADA.L1 + diff.US.L1 +
##     error3.L1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -306.873  -21.905   -1.991   32.717  136.470
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     3.496e+01  9.532e+00   3.668 0.000366 ***
## diff.UK.L1      1.073e-02  2.557e-03   4.196 5.24e-05 ***
## diff.CANADA.L1  2.670e-09  2.693e-09   0.991 0.323595
## diff.US.L1      3.098e-01  9.779e-02   3.168 0.001947 **
## error3.L1      -2.078e-02  2.673e-02  -0.777 0.438401
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 56.94 on 120 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.3965, Adjusted R-squared:  0.3763
## F-statistic: 19.71 on 4 and 120 DF,  p-value: 1.726e-12
```