

# VAR\_USD/EUR\_RATE

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```
library(xts)
```

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

```
##  
## Attaching package: 'zoo'
```

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

```
## Registered S3 method overwritten by 'xts':  
##   method      from  
##   as.zoo.xts  zoo
```

```
library(data.table)
```

```
##  
## Attaching package: 'data.table'
```

```
## The following objects are masked from 'package:xts':  
##  
##   first, last
```

```
library(quantmod)
```

```
## Loading required package: TTR
```

```
## Registered S3 method overwritten by 'quantmod':  
##   method      from  
##   as.zoo.data.frame zoo
```

```
## Version 0.4-0 included new data defaults. See ?getSymbols.
```

```
library(MTS)
```

```
##  
## Attaching package: 'MTS'
```

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

```
library(Metrics)
```

## 1.Data preparation:

```
data <- read.csv("/Users/yijingtang/Desktop/time series/project/code/sample/code.csv", header=TRUE, stringsAsFactors=FALSE)
setDT(data)
head(data)
```

```
##           DATE      XAU    WTI    RATE
## 1: 2015-01-01 1181.97 58.33 0.8261
## 2: 2015-01-02 1189.18 57.59 0.8332
## 3: 2015-01-05 1204.45 57.98 0.8380
## 4: 2015-01-06 1219.20 60.30 0.8411
## 5: 2015-01-07 1210.80 60.21 0.8447
## 6: 2015-01-08 1208.98 61.05 0.8480
```

```
d=as.Date(data$DATE, format='%Y-%m-%d')
d1=d[1:980]

us=data[,c(2,3,4)]
usdt=xts(us,order.by = d)
```

## 2.Data processing:

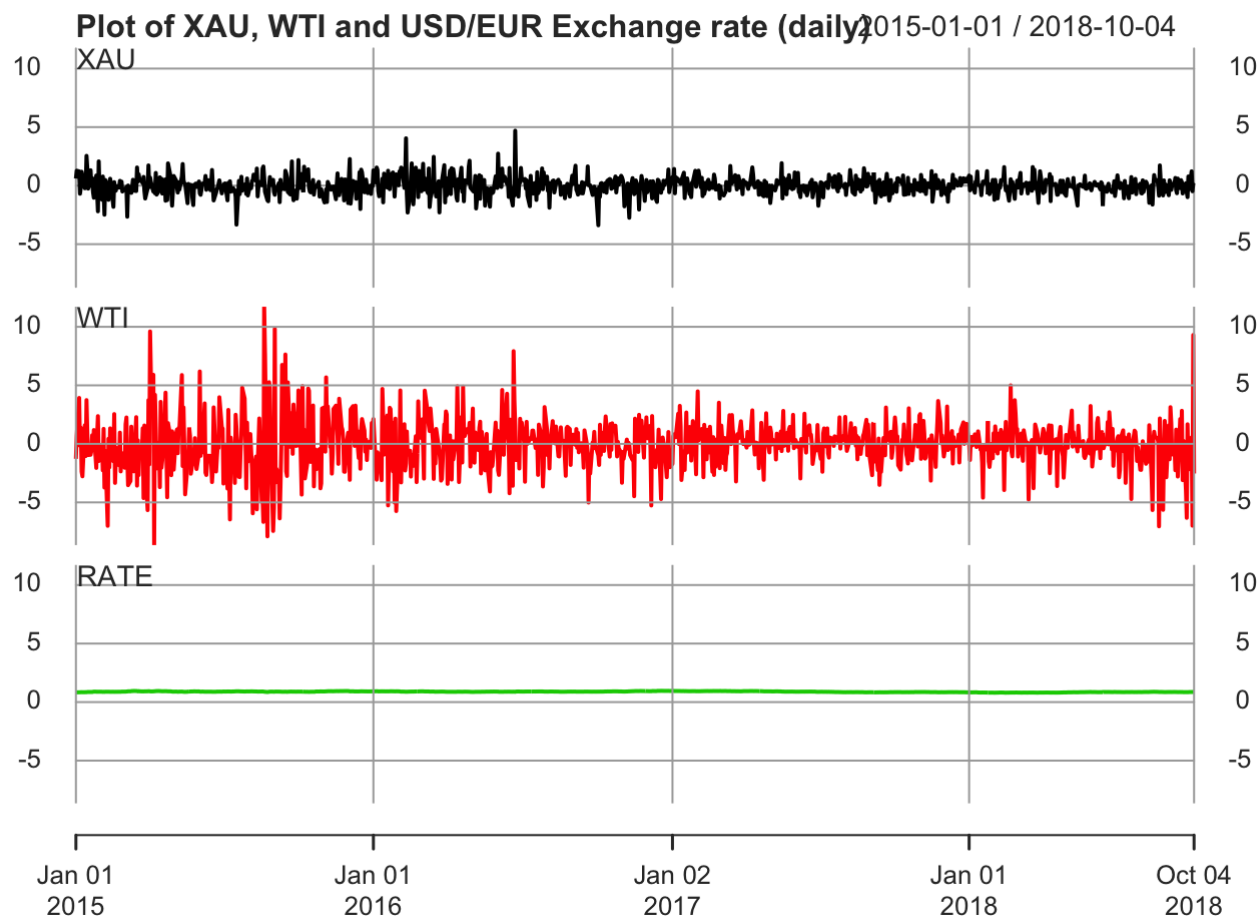
```
us= ts( as.matrix(usdt[,c("XAU","WTI","RATE")]), start=c(2015,01) )
z=diff(log(us[,1:2]))*100
RATE=us[1:1343,3]
dt=data.frame(z,RATE)

tst=dt[979:1343,3]      #test data
z=xts(dt[1:980,],order.by = d1)  #training data
head(z)
```

```
##           XAU      WTI    RATE
## 2015-01-01 0.6081456 -1.2767599 0.8261
## 2015-01-02 1.2759037 0.6749182 0.8332
## 2015-01-05 1.2171875 3.9233980 0.8380
## 2015-01-06 -0.6913608 -0.1493652 0.8411
## 2015-01-07 -0.1504269 1.3854749 0.8447
## 2015-01-08 1.1856839 -2.3702112 0.8480
```

The data has been stationary after log transformation and differencing.

```
plot(as.xts(z), type="l",
     multi.panel=TRUE, theme="white",
     plot.type="single",
     main="Plot of XAU, WTI and USD/EUR Exchange rate (daily)",
     major.ticks="years",
     grid.ticks.on = "years")
```



### 3. Build VAR model:

```
z=coredat(as.xts(z))
vaor=VARorder(z/100)    #select VAR model order
```

```
## selected order: aic = 3
## selected order: bic = 1
## selected order: hq = 1
## Summary table:
```

| ## |       | p  | AIC      | BIC      | HQ       | M(p)      | p-value |
|----|-------|----|----------|----------|----------|-----------|---------|
| ## | [1,]  | 0  | -33.0961 | -33.0961 | -33.0961 | 0.0000    | 0.0000  |
| ## | [2,]  | 1  | -37.2159 | -37.1711 | -37.1989 | 3983.0008 | 0.0000  |
| ## | [3,]  | 2  | -37.2138 | -37.1241 | -37.1797 | 15.5949   | 0.0758  |
| ## | [4,]  | 3  | -37.2255 | -37.0908 | -37.1743 | 28.7280   | 0.0007  |
| ## | [5,]  | 4  | -37.2118 | -37.0323 | -37.1435 | 4.4831    | 0.8768  |
| ## | [6,]  | 5  | -37.2160 | -36.9916 | -37.1306 | 21.4357   | 0.0109  |
| ## | [7,]  | 6  | -37.2071 | -36.9377 | -37.1046 | 8.9083    | 0.4458  |
| ## | [8,]  | 7  | -37.1922 | -36.8780 | -37.0727 | 3.3154    | 0.9505  |
| ## | [9,]  | 8  | -37.1831 | -36.8241 | -37.0465 | 8.7632    | 0.4594  |
| ## | [10,] | 9  | -37.1759 | -36.7720 | -37.0222 | 10.4681   | 0.3139  |
| ## | [11,] | 10 | -37.1646 | -36.7158 | -36.9939 | 6.6136    | 0.6773  |
| ## | [12,] | 11 | -37.1616 | -36.6679 | -36.9738 | 14.3037   | 0.1119  |
| ## | [13,] | 12 | -37.1468 | -36.6082 | -36.9419 | 3.2990    | 0.9512  |
| ## | [14,] | 13 | -37.1332 | -36.5497 | -36.9112 | 4.4197    | 0.8817  |

```
#recommend p=3
vamd=VAR(Z, 3)
```

```

## Constant term:
## Estimates:  -0.3761896 -0.4797572 0.008158511
## Std.Error:  0.6010232 1.666652 0.003589223
## AR coefficient matrix
## AR( 1 )-matrix
##           [,1]      [,2]      [,3]
## [1,] -0.01562  2.33e-03 -2.119
## [2,] -0.04583 -2.70e-02 -26.877
## [3,] -0.00217  3.44e-05  0.954
## standard error
##           [,1]      [,2]      [,3]
## [1,] 0.032022 1.16e-02  5.3352
## [2,] 0.088798 3.21e-02 14.7946
## [3,] 0.000191 6.91e-05  0.0319
## AR( 2 )-matrix
##           [,1]      [,2]      [,3]
## [1,] -0.018152  1.40e-02 14.32030
## [2,]  0.056608 -3.11e-02  1.91254
## [3,] -0.000447 -6.24e-05  0.00588
## standard error
##           [,1]      [,2]      [,3]
## [1,] 0.033886 1.16e-02  7.3780
## [2,] 0.093967 3.23e-02 20.4594
## [3,] 0.000202 6.95e-05  0.0441
## AR( 3 )-matrix
##           [,1]      [,2]      [,3]
## [1,]  0.077592  0.004744 -11.778
## [2,]  0.049482 -0.018688  25.473
## [3,] -0.000374  0.000269  0.031
## standard error
##           [,1]      [,2]      [,3]
## [1,] 0.033906 1.17e-02  5.3168
## [2,] 0.094021 3.25e-02 14.7436
## [3,] 0.000202 6.99e-05  0.0318
##
## Residuals cov-mtx:
##           [,1]      [,2]      [,3]
## [1,] 0.6213102753 0.0582599808 -1.135385e-04
## [2,] 0.0582599808 4.7776671462  1.607742e-04
## [3,] -0.0001135385 0.0001607742  2.215782e-05
##
## det(SSE) = 6.561859e-05
## AIC = -9.576549
## BIC = -9.441892
## HQ  = -9.52532

```

From the perspective of AIC, we should take  $p = 3$ . P-values are not significant any more since  $i = 3$ .

#### 4. Model test:

```

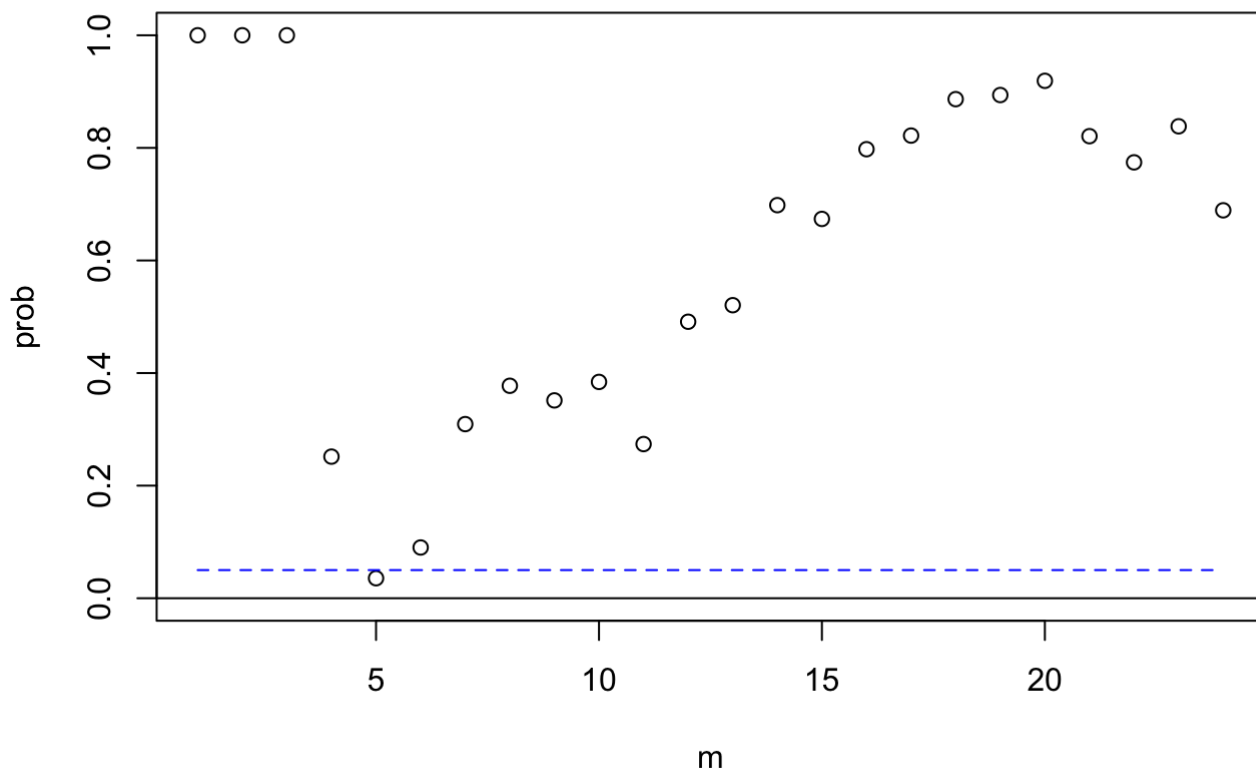
res= vamd$residuals
mq(res, adj=3^2*3)

```

## ## Ljung-Box Statistics:

| ## |       | m       | Q(m)     | df       | p-value |
|----|-------|---------|----------|----------|---------|
| ## | [1,]  | 1.0000  | 0.0426   | -18.0000 | 1.00    |
| ## | [2,]  | 2.0000  | 0.3623   | -9.0000  | 1.00    |
| ## | [3,]  | 3.0000  | 0.6880   | 0.0000   | 1.00    |
| ## | [4,]  | 4.0000  | 11.3649  | 9.0000   | 0.25    |
| ## | [5,]  | 5.0000  | 30.2003  | 18.0000  | 0.04    |
| ## | [6,]  | 6.0000  | 37.2699  | 27.0000  | 0.09    |
| ## | [7,]  | 7.0000  | 39.6808  | 36.0000  | 0.31    |
| ## | [8,]  | 8.0000  | 47.3379  | 45.0000  | 0.38    |
| ## | [9,]  | 9.0000  | 57.3686  | 54.0000  | 0.35    |
| ## | [10,] | 10.0000 | 65.6763  | 63.0000  | 0.38    |
| ## | [11,] | 11.0000 | 78.7534  | 72.0000  | 0.27    |
| ## | [12,] | 12.0000 | 80.6152  | 81.0000  | 0.49    |
| ## | [13,] | 13.0000 | 88.6471  | 90.0000  | 0.52    |
| ## | [14,] | 14.0000 | 91.2327  | 99.0000  | 0.70    |
| ## | [15,] | 15.0000 | 100.8724 | 108.0000 | 0.67    |
| ## | [16,] | 16.0000 | 104.0892 | 117.0000 | 0.80    |
| ## | [17,] | 17.0000 | 111.2980 | 126.0000 | 0.82    |
| ## | [18,] | 18.0000 | 115.4954 | 135.0000 | 0.89    |
| ## | [19,] | 19.0000 | 123.2466 | 144.0000 | 0.89    |
| ## | [20,] | 20.0000 | 129.2074 | 153.0000 | 0.92    |
| ## | [21,] | 21.0000 | 145.4004 | 162.0000 | 0.82    |
| ## | [22,] | 22.0000 | 156.8140 | 171.0000 | 0.77    |
| ## | [23,] | 23.0000 | 161.2802 | 180.0000 | 0.84    |
| ## | [24,] | 24.0000 | 178.9238 | 189.0000 | 0.69    |

## p-values of Ljung-Box statistics



The

test result is only significant at lag 5; thus, the model can be considered sufficient.

5. Model simplification:

```
VARchi(Z, 3, thres=1.96)
```

```
## Number of targeted parameters: 23
## Chi-square test and p-value: 25.28634 0.3356928
```

```
#compare restrictd model with normal VAR model
```

When significance level is 0.05, there are 23 parameters are insignificant.  $H_0$  is that all the 23 parameters equals to 0 at the same time. P-value is 0.3356928 which means that we can simultaneously set the 23 parameters to be zero.

```
vamd
```

```
## $data
##           XAU           WTI    RATE
## [1,] 0.6081456020 -1.27675992 0.8261
## [2,] 1.2759037239  0.67491820 0.8332
## [3,] 1.2171874739  3.92339802 0.8380
## [4,] -0.6913607785 -0.14936523 0.8411
## [5,] -0.1504269267  1.38547491 0.8447
## [6,] 1.1856838928 -2.37021123 0.8480
## [7,] 0.8335280896 -2.77205064 0.8445
## [8,] -0.2239787994  1.59100097 0.8451
## [9,] -0.0755842577 -1.04069864 0.8495
## [10,] 2.5438943783  3.73655047 0.8482
## [11,] 1.4681963535  0.95364090 0.8598
## [12,] -0.2518203553 -0.95364090 0.8643
## [13,] 1.3115605235 -0.92946727 0.8617
## [14,] -0.0386491359 -0.60210919 0.8658
## [15,] 0.6388813217  0.73542033 0.8613
## [16,] -0.5531004594 -0.41718876 0.8798
## [17,] -1.0334785419  1.18029797 0.8922
## [18,] 0.8633907511 -2.05366596 0.8898
## [19,] -0.5625730176  0.67249749 0.8786
## [20,] -2.1909740261  2.36785630 0.8859
## [21,] 2.0702880480 -1.46709959 0.8834
## [22,] -0.6338459433 -0.95103745 0.8859
## [23,] -1.2020778591 -0.11742013 0.8817
## [24,] 0.7785831248 -2.25758548 0.8710
## [25,] -0.4221329870  1.27933515 0.8813
## [26,] -2.4800944543 -3.72971407 0.8714
## [27,] 0.4819286436 -0.59996651 0.8837
## [28,] -0.4592356313 -7.00047613 0.8831
## [29,] -1.2098828470  0.43564800 0.8833
## [30,] 0.2735845354 -2.00445768 0.8823
## [31,] 0.5872294829  1.32173172 0.8770
## [32,] 0.1438340550  0.49354694 0.8783
## [33,] -1.8084208889 -1.48800914 0.8807
## [34,] 0.2964017048  2.54283150 0.8762
## [35,] -0.4577688085 -3.33395961 0.8774
## [36,] -0.4199455098 -1.24757953 0.8798
## [37,] -0.0390964564 -0.35370444 0.8787
## [38,] -0.1690392232 -1.82762338 0.8824
## [39,] 0.4083692138  0.95770884 0.8818
## [40,] 0.3521349207 -2.35068584 0.8801
## [41,] 0.3385355392 -0.77551409 0.8931
## [42,] -0.4999493938 -1.73593944 0.8932
## [43,] -0.2737568593 -2.04282138 0.8941
## [44,] -0.3286671151  1.68780378 0.8947
## [45,] -0.1042339939  2.25472371 0.9026
## [46,] -2.6537923340 -0.90405383 0.9066
## [47,] 0.0077103975 -3.52903666 0.9222
## [48,] -0.4610974025 -3.17142131 0.9214
## [49,] -0.6155246845  1.46787607 0.9347
## [50,] -0.0952999856 -1.79947801 0.9482
## [51,] 0.4997459799 -0.73341811 0.9403
```



```
## [52,] -0.4226326151 -2.34720774 0.9528
## [53,] -0.4592241206 2.28026586 0.9462
## [54,] 1.5497493476 -3.56734407 0.9435
## [55,] 0.3463688225 0.30026585 0.9203
## [56,] 0.9668806579 -2.66433147 0.9381
## [57,] 0.5581849078 -0.14221382 0.9241
## [58,] 0.3215207414 -0.71411872 0.9135
## [59,] 0.1942577372 1.32892321 0.9152
## [60,] 0.7442228172 -4.63179750 0.9114
## [61,] -0.4226858453 1.56789101 0.9188
## [62,] -1.0983132833 -1.93894895 0.9184
## [63,] -0.2278770451 -5.65900208 0.9231
## [64,] 1.7256249944 3.73225663 0.9319
## [65,] -0.1254835644 -1.75867920 0.9290
## [66,] 0.6886320506 9.60345720 0.9188
## [67,] 0.3133247946 5.87403849 0.9109
## [68,] -0.5034467779 5.90166960 0.9154
## [69,] -0.4810492813 -8.64829754 0.9246
## [70,] -0.6497618583 4.18990688 0.9276
## [71,] 1.0852935835 1.31566656 0.9382
## [72,] -0.7644725419 -2.10032621 0.9430
## [73,] -0.4405569671 0.10934938 0.9463
## [74,] 0.7071238291 -3.69587924 0.9386
## [75,] -0.3667129167 3.58652985 0.9358
## [76,] 0.5827764902 -2.03366867 0.9293
## [77,] -0.6788439954 -1.39422092 0.9254
## [78,] 0.5151771579 2.23923373 0.9311
## [79,] -1.2870578256 4.37583347 0.9315
## [80,] 0.5627193281 -0.68056409 0.9323
## [81,] -1.2320138305 -4.56261608 0.9237
## [82,] 1.8997959448 1.77113330 0.9196
## [83,] 0.8367556381 0.56892932 0.9184
## [84,] -0.6040814431 -2.67567095 0.9106
## [85,] -1.7102590420 1.07000575 0.8983
## [86,] -0.4968544250 0.75105279 0.8909
## [87,] 0.8239193118 -2.20278125 0.8927
## [88,] 0.4266081933 0.91815671 0.8972
## [89,] -0.1282949114 1.21858160 0.8940
## [90,] -0.5890785359 -0.79593611 0.8808
## [91,] 0.2823491625 1.34496570 0.8876
## [92,] -0.3330034481 1.28388229 0.8925
## [93,] 0.7822725681 5.87787221 0.8964
## [94,] 1.8454552619 -1.89345027 0.8917
## [95,] 0.4751265477 3.10927072 0.8805
## [96,] 0.1905642668 -0.24198439 0.8764
## [97,] 0.1543115685 -4.31127919 0.8732
## [98,] -1.4984355162 -1.78652136 0.8838
## [99,] 0.1464753095 -0.64585800 0.8969
## [100,] -0.2342978143 1.39412446 0.9014
## [101,] -0.0058023151 0.67926392 0.8999
## [102,] 0.0654637383 -2.54968284 0.9077
## [103,] -1.6596955578 -1.15683927 0.9109
## [104,] 0.0715653907 -0.77135369 0.9196
## [105,] 0.0252461501 0.48554498 0.9170
```

```
## [106,] 0.1723449848 -1.55317078 0.9133
## [107,] -0.1134620759 -2.14721776 0.9101
## [108,] 0.3550850940 -0.80284868 0.9151
## [109,] -0.6624990602 6.18431600 0.8965
## [110,] -0.7824713048 -1.02274855 0.8871
## [111,] -0.3628222321 1.51945619 0.8898
## [112,] 0.1662439906 -0.73513845 0.8999
## [113,] 0.2339779427 3.45523815 0.8857
## [114,] 0.8277029964 -2.46192400 0.8862
## [115,] -0.3529246565 -2.65637217 0.8829
## [116,] -0.1269519023 -1.71362822 0.8882
## [117,] 0.4731336978 -1.01523715 0.8873
## [118,] -0.3834043189 -1.02565002 0.8862
## [119,] 0.3032980684 -1.52357518 0.8891
## [120,] 1.3381741203 -3.26270075 0.8821
## [121,] -0.0757724033 -2.08846833 0.8802
## [122,] -1.2624017170 3.11657063 0.8808
## [123,] -0.5930919415 -2.35871344 0.8818
## [124,] -0.2753184044 -1.15126807 0.8952
## [125,] -0.1592485849 -0.14792902 0.8924
## [126,] 0.1481860261 -0.34602111 0.8925
## [127,] 0.4491756405 3.98014194 0.8956
## [128,] -0.6595971146 1.44091308 0.8900
## [129,] -0.3245924094 1.30477154 0.8979
## [130,] -0.2269856860 -3.39015517 0.9047
## [131,] 0.1533788629 -0.16776517 0.9022
## [132,] 0.1890432497 -0.07198561 0.8998
## [133,] -1.2555524613 -3.81651015 0.9044
## [134,] 0.2359725016 2.90017869 0.9081
## [135,] 0.1182089329 -2.77556808 0.9026
## [136,] 0.3709749005 -6.45551257 0.9059
## [137,] -0.5133605307 0.52994295 0.8957
## [138,] -0.2135265969 -1.62518563 0.9088
## [139,] -0.5101564956 -1.81601413 0.9081
## [140,] -0.3921915433 -3.33735088 0.9133
## [141,] -0.9696247954 2.48581435 0.9195
## [142,] -3.3305783436 1.34266985 0.9234
## [143,] 0.4057575756 -2.81553238 0.9236
## [144,] -0.7253341806 -2.83948662 0.9143
## [145,] -0.2426463363 -0.66464628 0.9146
## [146,] 0.7580291103 0.72223339 0.9105
## [147,] -0.4267120520 4.80496976 0.9104
## [148,] 0.0849404326 3.87457666 0.9014
## [149,] 0.1222605579 0.57894899 0.9042
## [150,] -0.7045891306 -3.79724765 0.9103
## [151,] 0.6097133287 1.80963750 0.9146
## [152,] -0.8386273745 -1.51027682 0.9101
## [153,] 0.0873985198 0.83886299 0.9132
## [154,] -0.2209437032 -0.59459635 0.9189
## [155,] 0.4010196410 -2.10937831 0.9169
## [156,] 0.4387237357 -5.93104248 0.9153
## [157,] 0.9378295060 -2.28802137 0.9117
## [158,] 0.4065927753 -1.08795271 0.9074
## [159,] 1.4581941314 -5.59258636 0.9058
```

```
## [160,] -0.9150419818 -1.78315634 0.8963
## [161,] -0.0843367058 -0.06544503 0.8970
## [162,] 0.3181334093 2.16942295 0.9003
## [163,] 0.0313105246 -4.95752256 0.9026
## [164,] 1.4606447557 -4.57990177 0.9073
## [165,] 1.6349233296 -6.66549240 0.8993
## [166,] 0.6818768021 11.71550922 0.8895
## [167,] -0.5181135031 7.73332034 0.8780
## [168,] -1.2545357723 -7.90096497 0.8605
## [169,] -1.3326470279 2.38738129 0.8682
## [170,] 0.0142142623 5.26521348 0.8838
## [171,] 0.7301983614 4.79460761 0.8892
## [172,] 0.0476093923 0.00000000 0.8945
## [173,] 0.4932723742 -7.44043124 0.8917
## [174,] -0.5329452935 -5.47767683 0.8838
## [175,] -0.7790062853 9.81871750 0.8907
## [176,] -0.2001557435 -3.29324573 0.8990
## [177,] -0.3148316736 -2.13894827 0.8971
## [178,] 0.2079179072 -2.71480287 0.8954
## [179,] -1.4094223166 -6.36547385 0.8929
## [180,] 0.4915122740 -3.59751025 0.8924
## [181,] -0.3289106121 -0.29347050 0.8865
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## [863,] -0.5538802635 -0.08797655 0.8190
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## [865,] 0.4181697558 -1.03904750 0.8223
## [866,] -0.5647912214 -2.89129351 0.8263
## [867,] -0.8689332806 0.76499761 0.8244
## [868,] 0.0666970789 0.71380059 0.8279
## [869,] 0.5540857836 -0.33348523 0.8338
## [870,] 0.2253401990 0.68094384 0.8367
## [871,] -0.0570483215 0.85592534 0.8341
## [872,] 0.0129338056 2.84491144 0.8361
## [873,] -0.1286516497 -0.23279510 0.8387
## [874,] 0.6544754549 1.00008080 0.8428
## [875,] -0.2409438888 0.05767013 0.8438
## [876,] -0.4104846435 0.41711675 0.8393
## [877,] -1.7031527851 -0.64799708 0.8373
## [878,] 0.0294381955 1.54819606 0.8385
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## [880,] 0.1161215536 -0.21257005 0.8469
## [881,] 0.0139255294 -0.07095722 0.8478
## [882,] -0.1052631676 0.24104939 0.8491
## [883,] 0.1880027013 -1.06785381 0.8481
## [884,] 0.8566104492 -1.20969217 0.8489
## [885,] -0.2509122779 -1.00474089 0.8550
## [886,] -0.2700302828 -0.23443234 0.8532
## [887,] 0.0577600663 0.36605942 0.8582
## [888,] 0.2022820870 -0.82184202 0.8603
## [889,] -0.2430957425 3.23333712 0.8666
## [890,] -0.3990018684 0.42710771 0.8575
## [891,] -0.0905176977 -1.93651608 0.8552
## [892,] 0.3214691423 0.18811958 0.8576
## [893,] 0.0663288547 -0.40562130 0.8548
## [894,] 0.0100226280 -0.40727329 0.8534
## [895,] 0.1248131817 1.80549427 0.8494
## [896,] 0.1077378995 2.20847028 0.8476
## [897,] -0.3220192913 -1.22562639 0.8498
## [898,] 0.2881713145 0.76250016 0.8487
## [899,] 0.1929337667 1.00770622 0.8515
## [900,] -1.7335430208 0.95628197 0.8481
## [901,] -0.1196177067 -0.37310898 0.8643
## [902,] -0.2773122870 0.26270323 0.8614
## [903,] -0.5246052922 0.00000000 0.8603
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## [908,] -0.5543622321 1.27793057 0.8545
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## [910,] 0.3774072157 -0.62889081 0.8656
## [911,] -0.8841847284 -0.60585847 0.8643
## [912,] 0.8785979801 0.49841822 0.8558
## [913,] 0.3203343138 0.65626700 0.8591
## [914,] 0.0644209494 -2.85714378 0.8579
## [915,] -0.2212724862 -2.22231368 0.8579
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## [916,] 0.2220675472 0.50434402 0.8554
## [917,] -0.1686944882 1.15319097 0.8512
## [918,] -1.0801567101 -0.65137781 0.8509
## [919,] 0.4009148466 0.55463259 0.8515
## [920,] -0.4524512775 -3.33200150 0.8567
## [921,] -0.0563983998 -1.61410047 0.8567
## [922,] -1.0776577551 0.81030685 0.8558
## [923,] -0.0277019597 -0.07208247 0.8539
## [924,] -0.3575543201 0.18730644 0.8576
## [925,] 0.7308848337 -4.71576986 0.8592
## [926,] -0.5886896100 -0.31738861 0.8589
## [927,] 0.0008166299 1.12893500 0.8532
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## [930,] 0.0572349018 -1.46053267 0.8527
## [931,] -0.1292338576 -0.31576599 0.8589
## [932,] 0.1660104322 -2.20793134 0.8579
## [933,] -0.6369161123 -2.22629262 0.8542
## [934,] -0.6683138050 -1.18775646 0.8554
## [935,] 0.4518073755 0.22278813 0.8577
## [936,] -0.5362829282 -0.17500601 0.8632
## [937,] 0.3374748856 -1.70230544 0.8645
## [938,] 0.2128169341 -0.19455259 0.8656
## [939,] -0.1038772693 -1.53723387 0.8621
## [940,] -0.0858213319 -1.46084935 0.8612
## [941,] -1.4686701070 1.59260168 0.8676
## [942,] 0.0326678313 -3.04117004 0.8763
## [943,] -1.6168125562 -5.65398304 0.8765
## [944,] -0.0613016400 0.34053263 0.8815
## [945,] 0.8995664601 1.03240504 0.8814
## [946,] 0.4849923202 0.60028429 0.8790
## [947,] 0.4692759150 0.49166034 0.8743
## [948,] -0.0518472691 0.17500880 0.8710
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## [951,] 0.4451254609 -1.16334061 0.8666
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## [955,] 0.1007926049 0.92861956 0.8541
## [956,] 0.0049953377 -2.85175575 0.8569
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## [958,] 0.4522431392 -1.31542095 0.8603
## [959,] 0.2836999692 3.13224711 0.8634
## [960,] -0.3589319379 1.80321864 0.8599
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## [963,] 0.6571090985 -2.24987858 0.8626
## [964,] -0.3945794132 1.21775932 0.8616
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## [966,] 0.6030152239 -2.79033798 0.8555
## [967,] -0.2150646023 2.11925886 0.8598
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## [969,] 0.2985621485 2.82466661 0.8570
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## [970,] -0.6671870474 -3.09789083 0.8567
## [971,] -0.0583722498 0.25373294 0.8491
## [972,] 0.2049864060 -3.93610739 0.8510
## [973,] -0.5718427617 -6.31877172 0.8512
## [974,] -0.9809691412 1.67063213 0.8495
## [975,] 0.7823560152 -2.19033880 0.8518
## [976,] -0.3049717766 -2.15062052 0.8590
## [977,] 1.2243207674 0.55303758 0.8614
## [978,] -0.4774074146 -6.98914504 0.8638
## [979,] 0.1910698403 9.30063042 0.8659
## [980,] 0.2655557625 -2.53233353 0.8712
##
## $cnst
## [1] TRUE
##
## $order
## [1] 3
##
## $coef
##           [,1]           [,2]           [,3]
## [1,] -0.376189609 -0.47975724 8.158511e-03
## [2,] -0.015615355 -0.04583267 -2.168778e-03
## [3,] 0.002331963 -0.02703073 3.439252e-05
## [4,] -2.118536595 -26.87732397 9.539734e-01
## [5,] -0.018151902 0.05660769 -4.472130e-04
## [6,] 0.013955212 -0.03111959 -6.242724e-05
## [7,] 14.320300756 1.91253974 5.881862e-03
## [8,] 0.077592334 0.04948218 -3.735543e-04
## [9,] 0.004744356 -0.01868789 2.691037e-04
## [10,] -11.778379496 25.47294108 3.097939e-02
##
## $aic
## [1] -9.576549
##
## $bic
## [1] -9.441892
##
## $hq
## [1] -9.52532
##
## $residuals
##           [,1]           [,2]           [,3]
## [1,] -7.589238e-01 0.2735289306 6.707317e-03
## [2,] -3.243099e-01 1.6119328343 3.003442e-03
## [3,] 1.047775e+00 -2.0640052134 1.818691e-03
## [4,] 8.730036e-01 -2.4678117774 -1.198958e-03
## [5,] -1.739248e-01 1.4855597427 2.011191e-03
## [6,] -4.859539e-02 -1.2667820372 4.640812e-03
## [7,] 2.487991e+00 3.8579549210 -5.633970e-04
## [8,] 1.484134e+00 1.3091624184 1.608199e-02
## [9,] -1.693218e-01 -0.5766036509 9.383328e-03
## [10,] 9.931479e-01 -0.6169919229 -2.164101e-03
## [11,] -1.739618e-01 -0.5520665670 6.878975e-03
## [12,] 7.511927e-01 0.6946893715 -4.024584e-03
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## [13,] -6.826970e-01 -0.4435602473 2.024225e-02
## [14,] -9.302290e-01 1.5457356555 1.214172e-02
## [15,] 5.992866e-01 -1.2314624499 -3.865599e-03
## [16,] -6.873276e-01 1.0491009412 -9.447206e-03
## [17,] -2.078403e+00 1.9861006084 5.017989e-03
## [18,] 2.105295e+00 -1.5876420591 -6.784406e-03
## [19,] -7.206153e-01 -0.5093495672 5.889486e-03
## [20,] -9.560217e-01 -0.1480011422 -6.187547e-03
## [21,] 5.709438e-01 -2.4590499025 -1.263245e-02
## [22,] -3.415061e-01 0.9691210966 1.084045e-02
## [23,] -2.194931e+00 -3.7300934277 -1.110258e-02
## [24,] 2.374513e-01 -0.8032555099 7.621298e-03
## [25,] -2.666797e-01 -6.8101258906 -1.290480e-03
## [26,] -1.117578e+00 0.5603302274 -5.563305e-06
## [27,] 3.182748e-01 -2.2539530120 -4.013827e-03
## [28,] 6.347203e-01 1.2631541384 -3.541867e-03
## [29,] 2.778586e-01 0.4098203880 1.609309e-03
## [30,] -1.756769e+00 -1.5771448939 3.456862e-03
## [31,] 2.096240e-01 2.5536480924 -8.369908e-03
## [32,] -5.191197e-01 -3.2210591065 5.553046e-04
## [33,] -2.412804e-01 -1.2825147979 1.326053e-03
## [34,] -4.392827e-02 -0.3226858042 -2.923456e-03
## [35,] -1.346034e-01 -1.8294306135 4.016763e-03
## [36,] 4.776777e-01 0.9938962037 -7.331452e-04
## [37,] 3.411704e-01 -2.2485798820 -9.403725e-04
## [38,] 3.716652e-01 -0.8713295874 1.434231e-02
## [39,] -4.387554e-01 -1.4981519350 1.220046e-03
## [40,] -4.315609e-01 -1.8575519515 1.176939e-03
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## [42,] -5.442323e-02 2.2939713466 7.251319e-03
## [43,] -2.652207e+00 -0.5486614707 4.526181e-03
## [44,] -1.380164e-01 -3.2213927056 9.935768e-03
## [45,] -5.126273e-01 -2.5568350953 -1.558104e-03
## [46,] -5.554310e-01 1.7521898305 1.218439e-02
## [47,] -3.261964e-02 -1.5783032602 1.353677e-02
## [48,] 3.740204e-01 -0.0359380907 -6.105494e-03
## [49,] -5.499488e-01 -2.2073664200 1.341586e-02
## [50,] -3.274999e-01 2.2540904630 -6.019239e-03
## [51,] 1.338625e+00 -3.4777019170 -3.068153e-03
## [52,] 4.302596e-01 0.1071210836 -1.912048e-02
## [53,] 1.033695e+00 -3.4657649243 1.756361e-02
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## [55,] 9.669832e-02 -0.7613621919 -8.723292e-03
## [56,] 2.780591e-01 0.5593476016 3.130390e-03
## [57,] 8.352030e-01 -4.8664396685 -3.114499e-03
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## [59,] -1.001049e+00 -1.9682683325 -1.194335e-03
## [60,] -4.066536e-01 -5.6218052608 4.291440e-03
## [61,] 1.769765e+00 3.7500953376 7.771261e-03
## [62,] 1.066309e-02 -1.3568768187 1.223125e-03
## [63,] 5.863865e-01 9.6265747750 -7.447376e-03
## [64,] 1.677592e-01 5.7615823810 -7.465653e-03
## [65,] -5.251033e-01 5.8487345322 5.894410e-03
## [66,] -5.848429e-01 -8.2648020892 6.237503e-03
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## [67,] -8.256727e-01  4.6170052425  1.728058e-03
## [68,]  1.071120e+00  1.6173419286  7.254338e-03
## [69,] -7.719232e-01 -1.6159568296  1.015119e-02
## [70,] -5.514305e-01  0.5095262084  1.901257e-03
## [71,]  5.523636e-01 -3.5527866629 -8.295849e-03
## [72,] -3.669340e-01  3.4219495387 -7.873565e-04
## [73,]  7.303263e-01 -2.3533261811 -7.450471e-03
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## [77,]  4.854942e-01 -0.4106556250 -1.079698e-03
## [78,] -1.377875e+00 -4.2917351537 -7.640498e-03
## [79,]  1.943841e+00  1.4790003326 -8.048902e-03
## [80,]  9.408837e-01  0.2721773242  2.269272e-03
## [81,] -4.327379e-01 -2.8229063343 -4.189345e-03
## [82,] -1.877053e+00  0.6522798058 -1.301254e-02
## [83,] -5.108377e-01  0.1094971403 -1.204398e-02
## [84,]  9.530592e-01 -2.5841807585 -1.539819e-04
## [85,]  6.427069e-01  0.9394177880  5.121040e-03
## [86,] -5.652311e-02  1.3793087180 -2.176826e-03
## [87,] -7.159251e-01 -0.7939286418 -1.231472e-02
## [88,]  2.256245e-01  0.9268559970  4.809412e-03
## [89,] -1.539899e-01  1.2495723704  4.595510e-03
## [90,]  7.405999e-01  6.2710923235  3.750860e-03
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## [94,]  1.155068e-01 -4.7290933001 -1.796973e-03
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## [96,]  2.432078e-01 -0.6802575710  1.008128e-02
## [97,] -3.193875e-01  1.9771569002  6.149232e-03
## [98,] -2.460456e-02  1.1972135456 -1.435034e-03
## [99,] -2.985016e-02 -2.3982408763  8.148340e-03
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## [101,] -1.086513e-02 -0.6455622573  5.375236e-03
## [102,] -7.534167e-03  0.8072617360 -1.832349e-03
## [103,]  1.968035e-01 -1.3422482008 -3.566961e-03
## [104,] -1.046288e-01 -2.3374757720 -2.501612e-03
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## [109,]  2.962105e-01 -0.6877810326  6.740530e-03
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## [113,] -1.233293e-01 -1.9186125114  3.827435e-03
## [114,]  5.057484e-01 -1.1275333369 -3.930534e-04
## [115,] -3.762448e-01 -0.9704977913  4.852231e-04
## [116,]  3.492301e-01 -1.6766117447  2.561096e-03
## [117,]  1.342008e+00 -3.2632290127 -6.012126e-03
## [118,] -3.511406e-02 -2.2664217899  1.045795e-03
## [119,] -1.124052e+00  2.6380144074  1.047511e-03
## [120,] -6.534791e-01 -2.5200158536 -7.538363e-04
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## [121,] -3.313750e-01 -1.0347066767 1.233750e-02
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## [123,] 4.773634e-02 -0.1013561461 3.104758e-04
## [124,] 5.098473e-01 3.9317418469 3.498315e-03
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## [134,] -4.178885e-01 0.2915930337 -9.890475e-03
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## [136,] -3.797161e-01 -1.8463052857 9.099507e-04
## [137,] -5.041626e-01 -3.0801773715 4.169299e-03
## [138,] -9.166301e-01 2.4704187844 5.862475e-03
## [139,] -3.322462e+00 1.5898292734 2.284670e-03
## [140,] 2.667161e-01 -2.5673433123 -5.955704e-03
## [141,] -7.884599e-01 -2.4569969852 -1.032516e-02
## [142,] 1.445622e-02 -0.9297759220 -2.890439e-03
## [143,] 8.633872e-01 0.3594623524 -4.248703e-03
## [144,] -3.651942e-01 4.7475558233 1.907032e-03
## [145,] 1.315111e-01 3.8740059593 -9.563459e-03
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## [151,] -2.211388e-01 -0.5778184820 5.318313e-03
## [152,] 4.261898e-01 -1.8532709886 -1.704438e-03
## [153,] 3.591982e-01 -5.8600722809 -6.386794e-04
## [154,] 1.023347e+00 -2.5968780629 -2.209779e-03
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## [156,] 1.533613e+00 -6.0510020668 1.243866e-03
## [157,] -8.793125e-01 -2.1474138451 -5.113909e-03
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## [952,] 2.596091e-01 0.7421736731 -1.339063e-03
## [953,] -3.629611e-02 -2.7795007858 2.854607e-03
## [954,] -7.581149e-01 1.6816379835 4.243906e-03
## [955,] 4.544488e-01 -1.1370913861 -3.806691e-03
## [956,] 2.191468e-01 3.2853307806 4.449518e-03
## [957,] -2.417707e-01 1.9894326066 -3.781983e-03
## [958,] -1.080011e-01 -0.8143798561 2.946807e-04
## [959,] 1.895403e-01 -0.1046968003 3.993739e-03
## [960,] 7.082548e-01 -2.0273365100 -3.250722e-03
## [961,] -4.256401e-01 1.2424449881 6.218303e-04
## [962,] -5.817645e-01 0.3690897943 -2.514437e-03
## [963,] 5.472179e-01 -2.8436075906 -5.629515e-03
## [964,] -1.735473e-01 2.0478346933 4.439929e-03
## [965,] 6.351105e-01 -1.2854862270 -4.991457e-03
## [966,] 1.951312e-01 2.8547778023 2.848999e-03
## [967,] -5.737857e-01 -3.0494667133 -6.557115e-04
## [968,] -1.260221e-01 0.2272037259 -8.389896e-03
## [969,] 1.989455e-01 -4.1200380691 -4.132882e-05
## [970,] -3.873627e-01 -6.5236974893 8.299086e-04
## [971,] -9.192539e-01 1.4482480803 -3.257735e-03
## [972,] 8.535581e-01 -2.4314911715 1.716319e-04
## [973,] -2.129984e-01 -2.0896463827 9.805132e-03
## [974,] 1.341245e+00 0.7472520483 1.260864e-03
## [975,] -5.526331e-01 -6.7562290620 5.695349e-03
## [976,] 2.365886e-01 9.1803038472 2.273205e-03
## [977,] 2.247488e-01 -2.3545060019 4.982764e-03
##
## $secoef
##          [,1]          [,2]          [,3]
## [1,] 0.60102318 1.66665188 3.589223e-03
## [2,] 0.03202197 0.08879770 1.912306e-04
## [3,] 0.01156463 0.03206900 6.906229e-05
## [4,] 5.33517553 14.79457144 3.186089e-02

```

```

## [5,] 0.03388623 0.09396734 2.023636e-04
## [6,] 0.01163502 0.03226419 6.948264e-05
## [7,] 7.37802592 20.45944522 4.406050e-02
## [8,] 0.03390571 0.09402137 2.024800e-04
## [9,] 0.01171033 0.03247304 6.993241e-05
## [10,] 5.31679513 14.74360215 3.175113e-02
##
## $Sigma
##           [,1]           [,2]           [,3]
## [1,] 0.6213102753 0.0582599808 -1.135385e-04
## [2,] 0.0582599808 4.7776671462 1.607742e-04
## [3,] -0.0001135385 0.0001607742 2.215782e-05
##
## $Phi
##           [,1]           [,2]           [,3]           [,4]           [,5]
## [1,] -0.015615355 2.331963e-03 -2.1185366 -0.018151902 1.395521e-02
## [2,] -0.045832667 -2.703073e-02 -26.8773240 0.056607690 -3.111959e-02
## [3,] -0.002168778 3.439252e-05 0.9539734 -0.000447213 -6.242724e-05
##           [,6]           [,7]           [,8]           [,9]
## [1,] 14.320300756 0.0775923341 0.0047443561 -11.77837950
## [2,] 1.912539742 0.0494821804 -0.0186878895 25.47294108
## [3,] 0.005881862 -0.0003735543 0.0002691037 0.03097939
##
## $Ph0
## [1] -0.376189609 -0.479757239 0.008158511
##
## $fixed
## NULL

```

```
rvamd=refVAR(vamd, thres=1.96)
```

```

## Constant term:
## Estimates:  0 0 0.008107189
## Std.Error:  0 0 0.00358173
## AR coefficient matrix
## AR( 1 )-matrix
##           [,1] [,2] [,3]
## [1,]  0.00000  0  0.000
## [2,]  0.00000  0 -28.857
## [3,] -0.00215  0  0.991
## standard error
##           [,1] [,2] [,3]
## [1,] 0.000000  0 0.00000
## [2,] 0.000000  0 9.81936
## [3,] 0.000191  0 0.00404
## AR( 2 )-matrix
##           [,1] [,2] [,3]
## [1,]    0    0 12.2
## [2,]    0    0  0.0
## [3,]    0    0  0.0
## standard error
##           [,1] [,2] [,3]
## [1,]    0    0 5.28
## [2,]    0    0 0.00
## [3,]    0    0 0.00
## AR( 3 )-matrix
##           [,1] [,2] [,3]
## [1,] 0.0792 0.000000 -12.2
## [2,] 0.0000 0.000000  28.8
## [3,] 0.0000 0.000266  0.0
## standard error
##           [,1] [,2] [,3]
## [1,] 0.0337 0.00e+00 5.28
## [2,] 0.0000 0.00e+00 9.82
## [3,] 0.0000 6.99e-05 0.00
##
## Residuals cov-mtx:
##           [,1] [,2] [,3]
## [1,] 0.6229454564 0.0558471257 -0.0001124053
## [2,] 0.0558471257 4.7920023826  0.0001429938
## [3,] -0.0001124053 0.0001429938  0.0000223731
##
## det(SSE) =  6.664232e-05
## AIC =  -9.599844
## BIC =  -9.559946
## HQ  =  -9.584665

```

The AIC of the unconstrained VAR (3) is -9.576549 and the AIC of the VAR (3) with 23 parameters of zero constraints is -9.599844, so the constrained model is better.

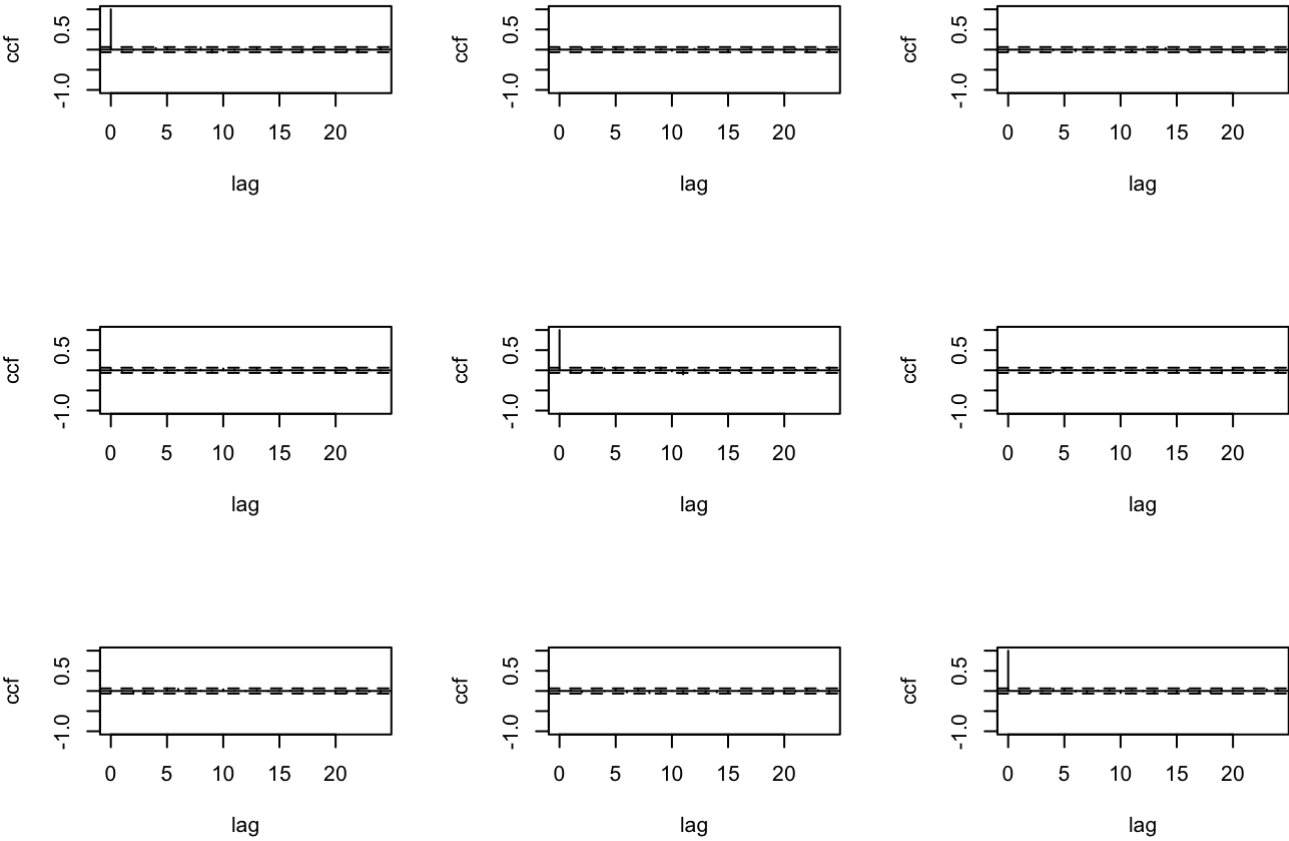
## 6.Simplified Model test

```
MTSdiag(rvamd, adj=8)
```

```
## [1] "Covariance matrix:"
##           XAU      WTI      RATE
## XAU    0.623583 0.055904 -1.13e-04
## WTI    0.055904 4.796912  1.43e-04
## RATE -0.000113 0.000143  2.24e-05
## CCM at lag:  0
##           [,1]  [,2]  [,3]
## [1,]  1.0000 0.0323 -0.0301
## [2,]  0.0323 1.0000  0.0138
## [3,] -0.0301 0.0138  1.0000
## 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
## . . .
```

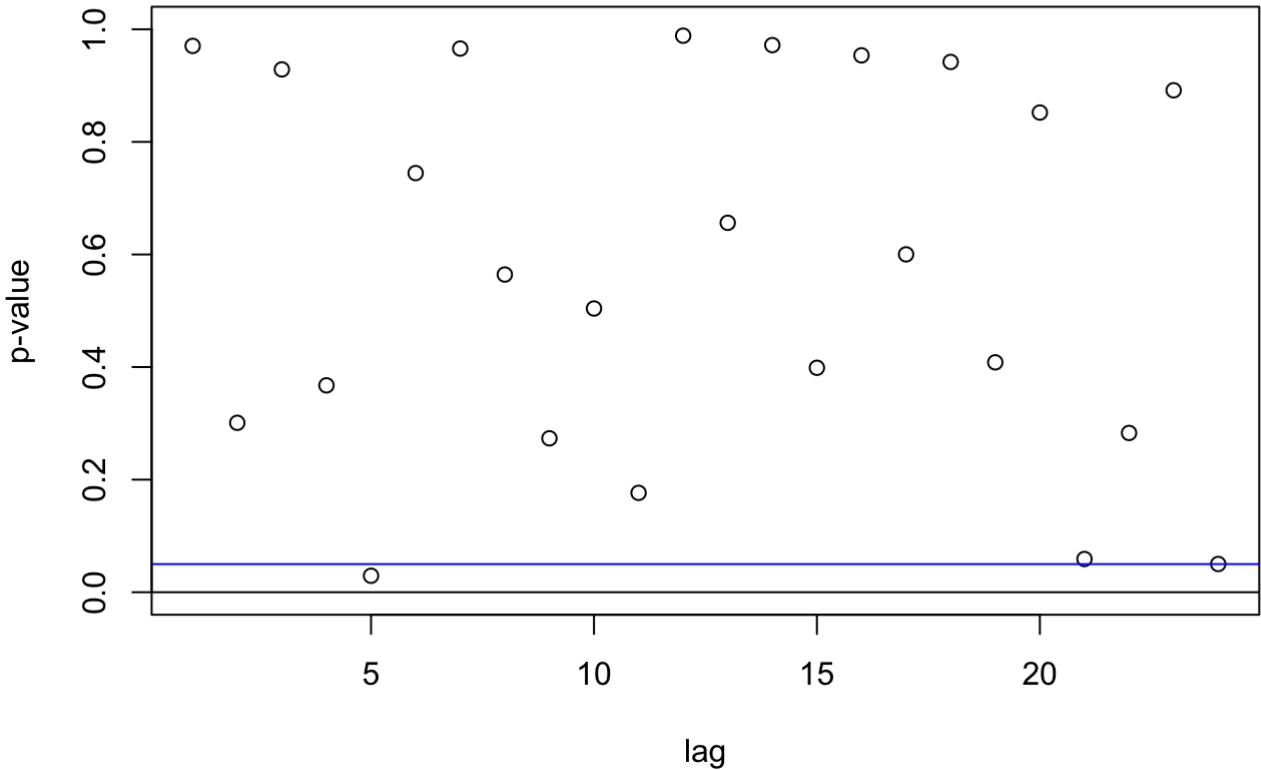
```
## . - .
## . . .
## CCM at lag: 12
## . . .
## . . .
## . . .
## CCM at lag: 13
## . . .
## . . .
## . . .
## CCM at lag: 14
## . . .
## . . .
## . . .
## CCM at lag: 15
## . . .
## . . .
## . . .
## CCM at lag: 16
## . . .
## . . .
## . . .
## CCM at lag: 17
## . . .
## . . .
## . . .
## CCM at 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



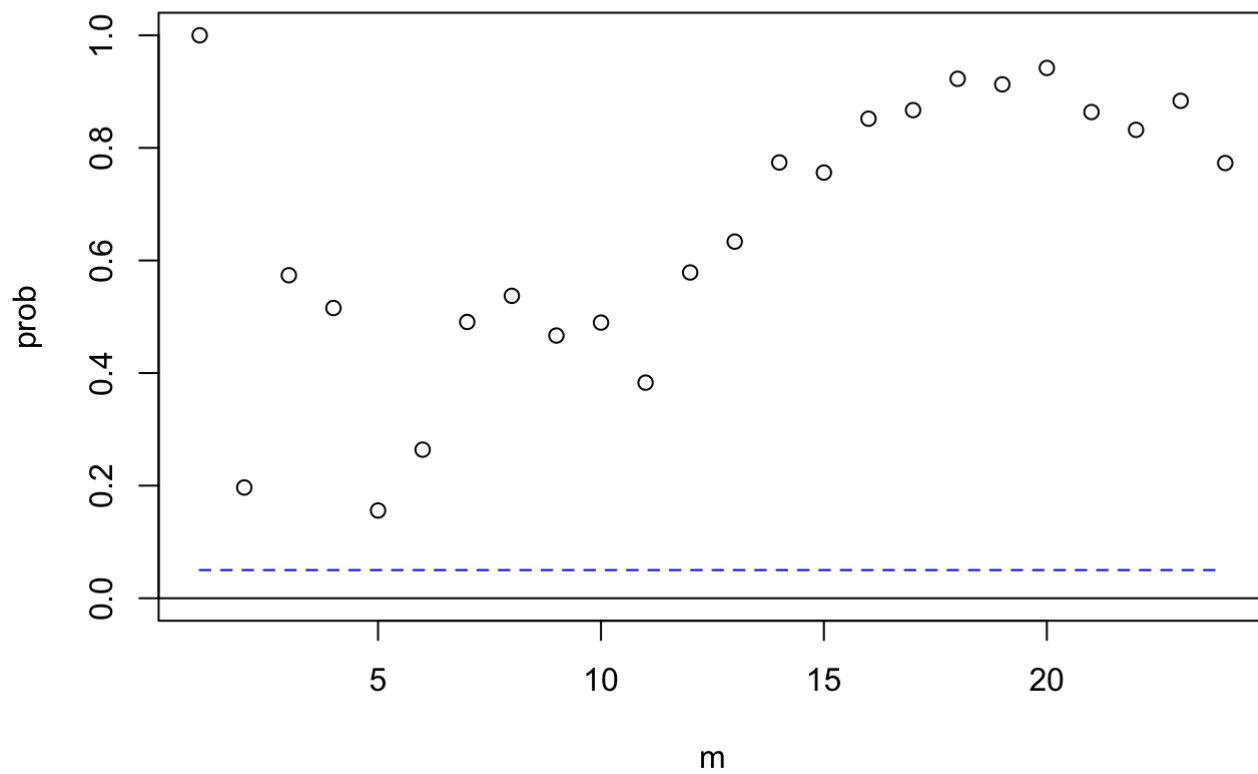
```
## Hit Enter to compute MQ-statistics:
```

```
##
```

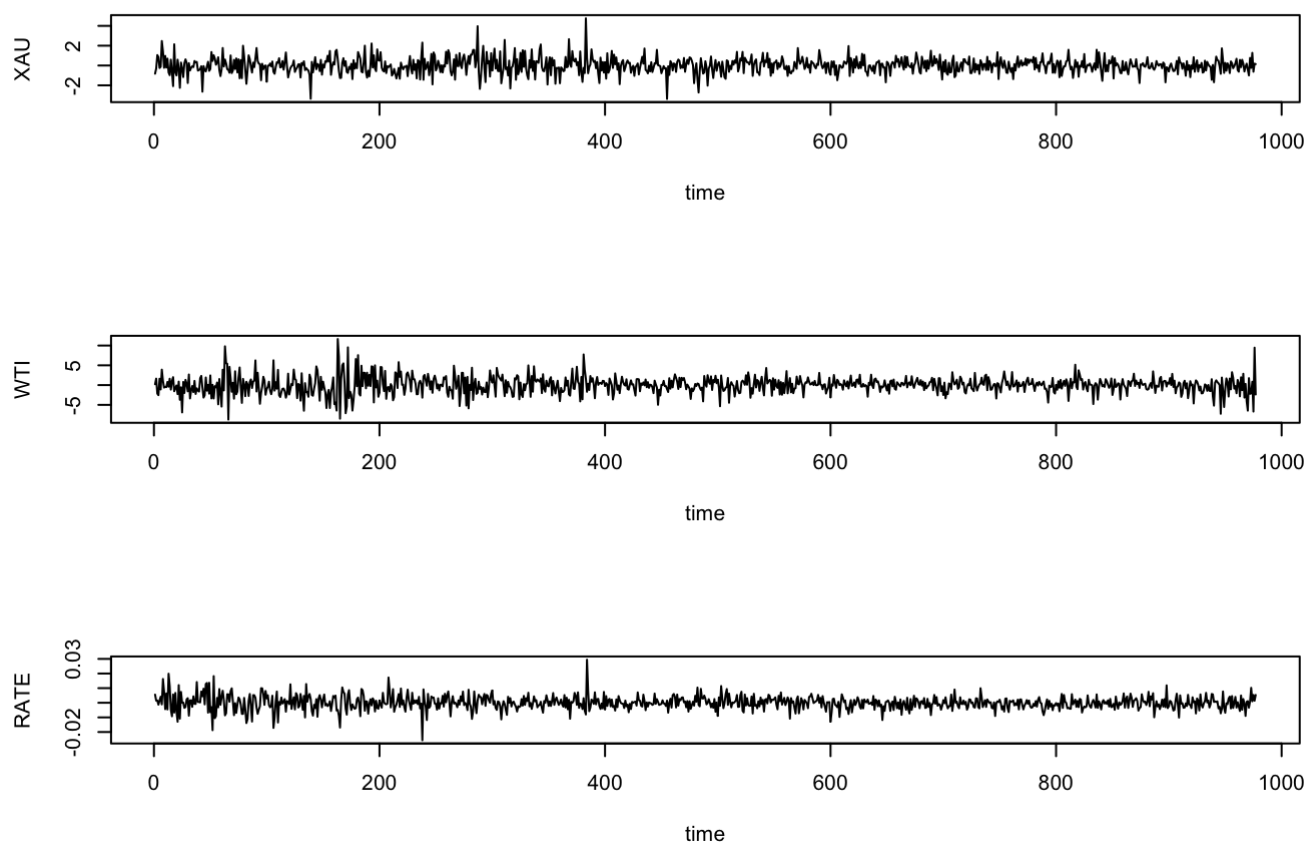
```
## Ljung-Box Statistics:
```

| ## |       | m     | Q(m)   | df     | p-value |
|----|-------|-------|--------|--------|---------|
| ## | [1,]  | 1.00  | 2.84   | 1.00   | 1.00    |
| ## | [2,]  | 2.00  | 13.51  | 10.00  | 0.20    |
| ## | [3,]  | 3.00  | 17.24  | 19.00  | 0.57    |
| ## | [4,]  | 4.00  | 27.05  | 28.00  | 0.52    |
| ## | [5,]  | 5.00  | 45.64  | 37.00  | 0.16    |
| ## | [6,]  | 6.00  | 51.61  | 46.00  | 0.26    |
| ## | [7,]  | 7.00  | 54.58  | 55.00  | 0.49    |
| ## | [8,]  | 8.00  | 62.29  | 64.00  | 0.54    |
| ## | [9,]  | 9.00  | 73.35  | 73.00  | 0.47    |
| ## | [10,] | 10.00 | 81.67  | 82.00  | 0.49    |
| ## | [11,] | 11.00 | 94.39  | 91.00  | 0.38    |
| ## | [12,] | 12.00 | 96.56  | 100.00 | 0.58    |
| ## | [13,] | 13.00 | 103.39 | 109.00 | 0.63    |
| ## | [14,] | 14.00 | 106.19 | 118.00 | 0.77    |
| ## | [15,] | 15.00 | 115.63 | 127.00 | 0.76    |
| ## | [16,] | 16.00 | 118.88 | 136.00 | 0.85    |
| ## | [17,] | 17.00 | 126.25 | 145.00 | 0.87    |
| ## | [18,] | 18.00 | 129.75 | 154.00 | 0.92    |
| ## | [19,] | 19.00 | 139.08 | 163.00 | 0.91    |
| ## | [20,] | 20.00 | 143.87 | 172.00 | 0.94    |
| ## | [21,] | 21.00 | 160.30 | 181.00 | 0.86    |
| ## | [22,] | 22.00 | 171.22 | 190.00 | 0.83    |
| ## | [23,] | 23.00 | 175.52 | 199.00 | 0.88    |
| ## | [24,] | 24.00 | 192.46 | 208.00 | 0.77    |

### p-values of Ljung-Box statistics



## Hit Enter to obtain residual plots:



The

number of degrees of freedom has been reduced from the original 27 to 5. From the CCM of residuals and the results of multivariate portmanteau test, the constrained model is sufficient.

Correlation matrix of residuals:

```
cor(rvamd$residuals)
```

```
##           [,1]      [,2]      [,3]
## [1,]  1.00000000 0.03232313 -0.03010918
## [2,]  0.03232313 1.00000000  0.01381007
## [3,] -0.03010918 0.01381007  1.00000000
```

## 7.Granger causality test

```
GrangerTest(Z, p=3, locInput=3)
```

```
## Number of targeted zero parameters:  6
## Chi-square test for Granger Causality and p-value:  147.0674  0
```

The p-value is less than 0.05, indicating that XAU and WIT are Granger causes of the USD/EUR exchange rate.

```
GrangerTest(Z, p=3, locInput=2)
```

```
## Number of targeted zero parameters: 6
## Chi-square test for Granger Causality and p-value: 9.729048 0.136536
## Constant term:
## Estimates: -0.001474547 -0.4797572 0.008158511
## Std.Error: 0.02536656 1.666652 0.003589223
## AR coefficient matrix
## AR( 1 )-matrix
##      [,1]      [,2]      [,3]
## [1,] -0.01522 0.00e+00 0.000
## [2,] -0.04583 -2.70e-02 -26.877
## [3,] -0.00217 3.44e-05 0.954
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031974 0.00e+00 0.0000
## [2,] 0.088798 3.21e-02 14.7946
## [3,] 0.000191 6.91e-05 0.0319
## AR( 2 )-matrix
##      [,1]      [,2]      [,3]
## [1,] -0.014238 0.00e+00 0.00000
## [2,] 0.056608 -3.11e-02 1.91254
## [3,] -0.000447 -6.24e-05 0.00588
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031932 0.00e+00 0.0000
## [2,] 0.093967 3.23e-02 20.4594
## [3,] 0.000202 6.95e-05 0.0441
## AR( 3 )-matrix
##      [,1]      [,2]      [,3]
## [1,] 0.053176 0.000000 0.000
## [2,] 0.049482 -0.018688 25.473
## [3,] -0.000374 0.000269 0.031
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031929 0.00e+00 0.0000
## [2,] 0.094021 3.25e-02 14.7436
## [3,] 0.000202 6.99e-05 0.0318
##
## Residuals cov-mtx:
##      [,1]      [,2]      [,3]
## [1,] 0.6260849242 0.0582599808 -1.135385e-04
## [2,] 0.0582599808 4.7776671462 1.607742e-04
## [3,] -0.0001135385 0.0001607742 2.215782e-05
##
## det(SSE) = 6.612392e-05
## AIC = -9.581123
## BIC = -9.47639
## HQ = -9.541278
```

```
GrangerTest(Z, p=3, locInput=1)
```

```

## Number of targeted zero parameters: 6
## Chi-square test for Granger Causality and p-value: 7.431207 0.2828019
## Constant term:
## Estimates: -0.001474547 -0.4797572 0.008158511
## Std.Error: 0.02536656 1.666652 0.003589223
## AR coefficient matrix
## AR( 1 )-matrix
##      [,1]      [,2]      [,3]
## [1,] -0.01522 0.00e+00 0.000
## [2,] -0.04583 -2.70e-02 -26.877
## [3,] -0.00217 3.44e-05 0.954
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031974 0.00e+00 0.0000
## [2,] 0.088798 3.21e-02 14.7946
## [3,] 0.000191 6.91e-05 0.0319
## AR( 2 )-matrix
##      [,1]      [,2]      [,3]
## [1,] -0.014238 0.00e+00 0.00000
## [2,] 0.056608 -3.11e-02 1.91254
## [3,] -0.000447 -6.24e-05 0.00588
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031932 0.00e+00 0.0000
## [2,] 0.093967 3.23e-02 20.4594
## [3,] 0.000202 6.95e-05 0.0441
## AR( 3 )-matrix
##      [,1]      [,2]      [,3]
## [1,] 0.053176 0.000000 0.000
## [2,] 0.049482 -0.018688 25.473
## [3,] -0.000374 0.000269 0.031
## standard error
##      [,1]      [,2]      [,3]
## [1,] 0.031929 0.00e+00 0.0000
## [2,] 0.094021 3.25e-02 14.7436
## [3,] 0.000202 6.99e-05 0.0318
##
## Residuals cov-mtx:
##      [,1]      [,2]      [,3]
## [1,] 0.6260849242 0.0582599808 -1.135385e-04
## [2,] 0.0582599808 4.7776671462 1.607742e-04
## [3,] -0.0001135385 0.0001607742 2.215782e-05
##
## det(SSE) = 6.612392e-05
## AIC = -9.581123
## BIC = -9.47639
## HQ = -9.541278

```

Both the test results show that under significance level of 0.05, the USD/EUR exchange rate are not Granger causes of XAU and WTI.

## 8.Predication

```
p=VARpred(rvamd, 244)$pred[,3] #predication of USD/EUR exchange rate
```



```
## orig 980
## Forecasts at origin: 980
##          XAU      WTI    RATE
## [1,] -1.346e-02 -0.23947 0.8689
## [2,]  7.851e-02 -0.11378 0.8716
## [3,] -7.801e-03 -0.03871 0.8710
## [4,]  3.051e-02 -0.08432 0.8711
## [5,] -3.307e-03 -0.01031 0.8712
## [6,] -3.679e-04 -0.03197 0.8713
## [7,]  2.056e-03 -0.03318 0.8715
## [8,]  4.988e-04 -0.03526 0.8716
## [9,]  4.878e-04 -0.03506 0.8718
## [10,] 8.397e-04 -0.03533 0.8720
## [11,] 6.688e-04 -0.03518 0.8721
## [12,] 6.466e-04 -0.03505 0.8723
## [13,] 6.411e-04 -0.03495 0.8724
## [14,] 6.154e-04 -0.03489 0.8726
## [15,] 5.963e-04 -0.03481 0.8727
## [16,] 5.796e-04 -0.03474 0.8728
## [17,] 5.619e-04 -0.03467 0.8730
## [18,] 5.446e-04 -0.03461 0.8731
## [19,] 5.275e-04 -0.03454 0.8733
## [20,] 5.104e-04 -0.03447 0.8734
## [21,] 4.935e-04 -0.03440 0.8736
## [22,] 4.768e-04 -0.03433 0.8737
## [23,] 4.602e-04 -0.03427 0.8738
## [24,] 4.438e-04 -0.03420 0.8740
## [25,] 4.275e-04 -0.03414 0.8741
## [26,] 4.113e-04 -0.03407 0.8742
## [27,] 3.953e-04 -0.03401 0.8744
## [28,] 3.794e-04 -0.03394 0.8745
## [29,] 3.637e-04 -0.03388 0.8746
## [30,] 3.481e-04 -0.03382 0.8748
## [31,] 3.327e-04 -0.03375 0.8749
## [32,] 3.173e-04 -0.03369 0.8750
## [33,] 3.021e-04 -0.03363 0.8751
## [34,] 2.871e-04 -0.03357 0.8753
## [35,] 2.721e-04 -0.03351 0.8754
## [36,] 2.573e-04 -0.03345 0.8755
## [37,] 2.427e-04 -0.03339 0.8756
## [38,] 2.281e-04 -0.03334 0.8758
## [39,] 2.137e-04 -0.03328 0.8759
## [40,] 1.994e-04 -0.03322 0.8760
## [41,] 1.853e-04 -0.03316 0.8761
## [42,] 1.712e-04 -0.03311 0.8762
## [43,] 1.573e-04 -0.03305 0.8763
## [44,] 1.435e-04 -0.03300 0.8765
## [45,] 1.298e-04 -0.03294 0.8766
## [46,] 1.163e-04 -0.03289 0.8767
## [47,] 1.028e-04 -0.03283 0.8768
## [48,] 8.950e-05 -0.03278 0.8769
## [49,] 7.629e-05 -0.03273 0.8770
## [50,] 6.320e-05 -0.03267 0.8771
```

```
## [51,] 5.023e-05 -0.03262 0.8772
## [52,] 3.736e-05 -0.03257 0.8773
## [53,] 2.461e-05 -0.03252 0.8775
## [54,] 1.197e-05 -0.03247 0.8776
## [55,] -5.625e-07 -0.03242 0.8777
## [56,] -1.298e-05 -0.03237 0.8778
## [57,] -2.530e-05 -0.03232 0.8779
## [58,] -3.750e-05 -0.03227 0.8780
## [59,] -4.960e-05 -0.03222 0.8781
## [60,] -6.160e-05 -0.03217 0.8782
## [61,] -7.348e-05 -0.03213 0.8783
## [62,] -8.527e-05 -0.03208 0.8784
## [63,] -9.695e-05 -0.03203 0.8785
## [64,] -1.085e-04 -0.03198 0.8786
## [65,] -1.200e-04 -0.03194 0.8787
## [66,] -1.314e-04 -0.03189 0.8787
## [67,] -1.427e-04 -0.03185 0.8788
## [68,] -1.539e-04 -0.03180 0.8789
## [69,] -1.649e-04 -0.03176 0.8790
## [70,] -1.759e-04 -0.03171 0.8791
## [71,] -1.868e-04 -0.03167 0.8792
## [72,] -1.976e-04 -0.03163 0.8793
## [73,] -2.083e-04 -0.03158 0.8794
## [74,] -2.189e-04 -0.03154 0.8795
## [75,] -2.294e-04 -0.03150 0.8796
## [76,] -2.399e-04 -0.03146 0.8796
## [77,] -2.502e-04 -0.03142 0.8797
## [78,] -2.605e-04 -0.03138 0.8798
## [79,] -2.706e-04 -0.03133 0.8799
## [80,] -2.807e-04 -0.03129 0.8800
## [81,] -2.907e-04 -0.03125 0.8801
## [82,] -3.005e-04 -0.03121 0.8801
## [83,] -3.103e-04 -0.03117 0.8802
## [84,] -3.201e-04 -0.03114 0.8803
## [85,] -3.297e-04 -0.03110 0.8804
## [86,] -3.393e-04 -0.03106 0.8805
## [87,] -3.487e-04 -0.03102 0.8805
## [88,] -3.581e-04 -0.03098 0.8806
## [89,] -3.674e-04 -0.03095 0.8807
## [90,] -3.766e-04 -0.03091 0.8808
## [91,] -3.858e-04 -0.03087 0.8809
## [92,] -3.948e-04 -0.03084 0.8809
## [93,] -4.038e-04 -0.03080 0.8810
## [94,] -4.127e-04 -0.03076 0.8811
## [95,] -4.216e-04 -0.03073 0.8812
## [96,] -4.303e-04 -0.03069 0.8812
## [97,] -4.390e-04 -0.03066 0.8813
## [98,] -4.476e-04 -0.03062 0.8814
## [99,] -4.561e-04 -0.03059 0.8814
## [100,] -4.645e-04 -0.03056 0.8815
## [101,] -4.729e-04 -0.03052 0.8816
## [102,] -4.812e-04 -0.03049 0.8816
## [103,] -4.895e-04 -0.03046 0.8817
## [104,] -4.976e-04 -0.03042 0.8818
```

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## [105,] -5.057e-04 -0.03039 0.8819
## [106,] -5.137e-04 -0.03036 0.8819
## [107,] -5.217e-04 -0.03033 0.8820
## [108,] -5.295e-04 -0.03030 0.8820
## [109,] -5.373e-04 -0.03026 0.8821
## [110,] -5.451e-04 -0.03023 0.8822
## [111,] -5.528e-04 -0.03020 0.8822
## [112,] -5.604e-04 -0.03017 0.8823
## [113,] -5.679e-04 -0.03014 0.8824
## [114,] -5.754e-04 -0.03011 0.8824
## [115,] -5.828e-04 -0.03008 0.8825
## [116,] -5.901e-04 -0.03005 0.8826
## [117,] -5.974e-04 -0.03002 0.8826
## [118,] -6.046e-04 -0.02999 0.8827
## [119,] -6.118e-04 -0.02997 0.8827
## [120,] -6.189e-04 -0.02994 0.8828
## [121,] -6.259e-04 -0.02991 0.8828
## [122,] -6.329e-04 -0.02988 0.8829
## [123,] -6.398e-04 -0.02985 0.8830
## [124,] -6.466e-04 -0.02983 0.8830
## [125,] -6.534e-04 -0.02980 0.8831
## [126,] -6.601e-04 -0.02977 0.8831
## [127,] -6.668e-04 -0.02974 0.8832
## [128,] -6.734e-04 -0.02972 0.8832
## [129,] -6.800e-04 -0.02969 0.8833
## [130,] -6.865e-04 -0.02967 0.8834
## [131,] -6.929e-04 -0.02964 0.8834
## [132,] -6.993e-04 -0.02961 0.8835
## [133,] -7.056e-04 -0.02959 0.8835
## [134,] -7.119e-04 -0.02956 0.8836
## [135,] -7.181e-04 -0.02954 0.8836
## [136,] -7.243e-04 -0.02951 0.8837
## [137,] -7.304e-04 -0.02949 0.8837
## [138,] -7.364e-04 -0.02947 0.8838
## [139,] -7.424e-04 -0.02944 0.8838
## [140,] -7.484e-04 -0.02942 0.8839
## [141,] -7.543e-04 -0.02939 0.8839
## [142,] -7.601e-04 -0.02937 0.8840
## [143,] -7.659e-04 -0.02935 0.8840
## [144,] -7.717e-04 -0.02932 0.8841
## [145,] -7.774e-04 -0.02930 0.8841
## [146,] -7.830e-04 -0.02928 0.8842
## [147,] -7.886e-04 -0.02926 0.8842
## [148,] -7.942e-04 -0.02923 0.8842
## [149,] -7.997e-04 -0.02921 0.8843
## [150,] -8.051e-04 -0.02919 0.8843
## [151,] -8.105e-04 -0.02917 0.8844
## [152,] -8.159e-04 -0.02915 0.8844
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## [155,] -8.317e-04 -0.02908 0.8846
## [156,] -8.369e-04 -0.02906 0.8846
## [157,] -8.420e-04 -0.02904 0.8846
## [158,] -8.471e-04 -0.02902 0.8847
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## [159,] -8.521e-04 -0.02900 0.8847
## [160,] -8.571e-04 -0.02898 0.8848
## [161,] -8.621e-04 -0.02896 0.8848
## [162,] -8.670e-04 -0.02894 0.8848
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## [172,] -9.138e-04 -0.02875 0.8852
## [173,] -9.182e-04 -0.02874 0.8853
## [174,] -9.226e-04 -0.02872 0.8853
## [175,] -9.270e-04 -0.02870 0.8853
## [176,] -9.314e-04 -0.02868 0.8854
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## [180,] -9.484e-04 -0.02861 0.8855
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## [182,] -9.566e-04 -0.02858 0.8856
## [183,] -9.607e-04 -0.02857 0.8856
## [184,] -9.648e-04 -0.02855 0.8857
## [185,] -9.688e-04 -0.02853 0.8857
## [186,] -9.728e-04 -0.02852 0.8857
## [187,] -9.767e-04 -0.02850 0.8858
## [188,] -9.806e-04 -0.02849 0.8858
## [189,] -9.845e-04 -0.02847 0.8858
## [190,] -9.883e-04 -0.02845 0.8859
## [191,] -9.921e-04 -0.02844 0.8859
## [192,] -9.959e-04 -0.02842 0.8859
## [193,] -9.997e-04 -0.02841 0.8859
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## [195,] -1.007e-03 -0.02838 0.8860
## [196,] -1.011e-03 -0.02836 0.8860
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## [198,] -1.018e-03 -0.02834 0.8861
## [199,] -1.021e-03 -0.02832 0.8861
## [200,] -1.025e-03 -0.02831 0.8862
## [201,] -1.028e-03 -0.02829 0.8862
## [202,] -1.032e-03 -0.02828 0.8862
## [203,] -1.035e-03 -0.02827 0.8862
## [204,] -1.039e-03 -0.02825 0.8863
## [205,] -1.042e-03 -0.02824 0.8863
## [206,] -1.045e-03 -0.02823 0.8863
## [207,] -1.049e-03 -0.02821 0.8864
## [208,] -1.052e-03 -0.02820 0.8864
## [209,] -1.055e-03 -0.02819 0.8864
## [210,] -1.058e-03 -0.02817 0.8864
## [211,] -1.062e-03 -0.02816 0.8865
## [212,] -1.065e-03 -0.02815 0.8865
```

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## [213,] -1.068e-03 -0.02813 0.8865
## [214,] -1.071e-03 -0.02812 0.8865
## [215,] -1.074e-03 -0.02811 0.8866
## [216,] -1.077e-03 -0.02810 0.8866
## [217,] -1.080e-03 -0.02809 0.8866
## [218,] -1.083e-03 -0.02807 0.8866
## [219,] -1.086e-03 -0.02806 0.8867
## [220,] -1.089e-03 -0.02805 0.8867
## [221,] -1.092e-03 -0.02804 0.8867
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## [224,] -1.101e-03 -0.02800 0.8868
## [225,] -1.104e-03 -0.02799 0.8868
## [226,] -1.106e-03 -0.02798 0.8868
## [227,] -1.109e-03 -0.02797 0.8869
## [228,] -1.112e-03 -0.02796 0.8869
## [229,] -1.115e-03 -0.02795 0.8869
## [230,] -1.117e-03 -0.02794 0.8869
## [231,] -1.120e-03 -0.02793 0.8869
## [232,] -1.123e-03 -0.02792 0.8870
## [233,] -1.125e-03 -0.02790 0.8870
## [234,] -1.128e-03 -0.02789 0.8870
## [235,] -1.131e-03 -0.02788 0.8870
## [236,] -1.133e-03 -0.02787 0.8871
## [237,] -1.136e-03 -0.02786 0.8871
## [238,] -1.138e-03 -0.02785 0.8871
## [239,] -1.141e-03 -0.02784 0.8871
## [240,] -1.143e-03 -0.02783 0.8871
## [241,] -1.146e-03 -0.02782 0.8872
## [242,] -1.148e-03 -0.02781 0.8872
## [243,] -1.150e-03 -0.02780 0.8872
## [244,] -1.153e-03 -0.02779 0.8872
## Standard Errors of predictions:
##           [,1] [,2]      [,3]
## [1,] 0.7893 2.189 0.004730
## [2,] 0.7893 2.193 0.006906
## [3,] 0.7914 2.198 0.008517
## [4,] 0.7925 2.199 0.009806
## [5,] 0.7925 2.199 0.010925
## [6,] 0.7925 2.199 0.011907
## [7,] 0.7925 2.199 0.012794
## [8,] 0.7925 2.199 0.013611
## [9,] 0.7925 2.199 0.014369
## [10,] 0.7925 2.199 0.015076
## [11,] 0.7925 2.199 0.015741
## [12,] 0.7925 2.199 0.016367
## [13,] 0.7925 2.199 0.016961
## [14,] 0.7925 2.199 0.017524
## [15,] 0.7925 2.199 0.018060
## [16,] 0.7925 2.199 0.018573
## [17,] 0.7925 2.199 0.019062
## [18,] 0.7925 2.199 0.019532
## [19,] 0.7925 2.199 0.019982
## [20,] 0.7925 2.199 0.020415
```

```
## [21,] 0.7925 2.199 0.020832
## [22,] 0.7925 2.199 0.021233
## [23,] 0.7925 2.199 0.021620
## [24,] 0.7925 2.199 0.021994
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## [45,] 0.7925 2.199 0.027708
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## [58,] 0.7925 2.199 0.029964
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## [72,] 0.7925 2.199 0.031756
## [73,] 0.7925 2.199 0.031865
## [74,] 0.7925 2.199 0.031971
```

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## [75,] 0.7925 2.199 0.032075
## [76,] 0.7925 2.199 0.032177
## [77,] 0.7925 2.199 0.032277
## [78,] 0.7925 2.199 0.032375
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## [80,] 0.7925 2.199 0.032565
## [81,] 0.7925 2.199 0.032657
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## [98,] 0.7925 2.199 0.033972
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## [128,] 0.7925 2.199 0.035458
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## [242,] 0.7925 2.199 0.037232
## [243,] 0.7925 2.199 0.037237
## [244,] 0.7925 2.199 0.037241
## Root mean square errors of predictions:
##           [,1] [,2]      [,3]
## [1,] 0.7933 2.200 0.004754
## [2,] 0.7893 2.195 0.007746
## [3,] 0.7924 2.200 0.009199
## [4,] 0.7930 2.199 0.010375
## [5,] 0.7925 2.199 0.011430
## [6,] 0.7925 2.199 0.012357
## [7,] 0.7925 2.199 0.013204
## [8,] 0.7925 2.199 0.013991
## [9,] 0.7925 2.199 0.014723
## [10,] 0.7925 2.199 0.015409
## [11,] 0.7925 2.199 0.016054
## [12,] 0.7925 2.199 0.016664
## [13,] 0.7925 2.199 0.017242
## [14,] 0.7925 2.199 0.017791
## [15,] 0.7925 2.199 0.018316
## [16,] 0.7925 2.199 0.018817
## [17,] 0.7925 2.199 0.019296
## [18,] 0.7925 2.199 0.019756
## [19,] 0.7925 2.199 0.020198
## [20,] 0.7925 2.199 0.020622
## [21,] 0.7925 2.199 0.021031
## [22,] 0.7925 2.199 0.021426
## [23,] 0.7925 2.199 0.021806
## [24,] 0.7925 2.199 0.022174
## [25,] 0.7925 2.199 0.022529
## [26,] 0.7925 2.199 0.022873
## [27,] 0.7925 2.199 0.023206
## [28,] 0.7925 2.199 0.023528
## [29,] 0.7925 2.199 0.023841
## [30,] 0.7925 2.199 0.024144
## [31,] 0.7925 2.199 0.024439
## [32,] 0.7925 2.199 0.024724
## [33,] 0.7925 2.199 0.025002
## [34,] 0.7925 2.199 0.025272
## [35,] 0.7925 2.199 0.025534
## [36,] 0.7925 2.199 0.025790
## [37,] 0.7925 2.199 0.026038
## [38,] 0.7925 2.199 0.026280
## [39,] 0.7925 2.199 0.026515
## [40,] 0.7925 2.199 0.026745
## [41,] 0.7925 2.199 0.026968
## [42,] 0.7925 2.199 0.027186
## [43,] 0.7925 2.199 0.027398
## [44,] 0.7925 2.199 0.027605
```

```
## [45,] 0.7925 2.199 0.027807
## [46,] 0.7925 2.199 0.028004
## [47,] 0.7925 2.199 0.028197
## [48,] 0.7925 2.199 0.028384
## [49,] 0.7925 2.199 0.028567
## [50,] 0.7925 2.199 0.028746
## [51,] 0.7925 2.199 0.028921
## [52,] 0.7925 2.199 0.029092
## [53,] 0.7925 2.199 0.029258
## [54,] 0.7925 2.199 0.029421
## [55,] 0.7925 2.199 0.029580
## [56,] 0.7925 2.199 0.029736
## [57,] 0.7925 2.199 0.029888
## [58,] 0.7925 2.199 0.030037
## [59,] 0.7925 2.199 0.030182
## [60,] 0.7925 2.199 0.030324
## [61,] 0.7925 2.199 0.030463
## [62,] 0.7925 2.199 0.030600
## [63,] 0.7925 2.199 0.030733
## [64,] 0.7925 2.199 0.030863
## [65,] 0.7925 2.199 0.030990
## [66,] 0.7925 2.199 0.031115
## [67,] 0.7925 2.199 0.031237
## [68,] 0.7925 2.199 0.031357
## [69,] 0.7925 2.199 0.031474
## [70,] 0.7925 2.199 0.031588
## [71,] 0.7925 2.199 0.031700
## [72,] 0.7925 2.199 0.031810
## [73,] 0.7925 2.199 0.031918
## [74,] 0.7925 2.199 0.032023
## [75,] 0.7925 2.199 0.032126
## [76,] 0.7925 2.199 0.032227
## [77,] 0.7925 2.199 0.032326
## [78,] 0.7925 2.199 0.032423
## [79,] 0.7925 2.199 0.032518
## [80,] 0.7925 2.199 0.032611
## [81,] 0.7925 2.199 0.032702
## [82,] 0.7925 2.199 0.032792
## [83,] 0.7925 2.199 0.032879
## [84,] 0.7925 2.199 0.032965
## [85,] 0.7925 2.199 0.033049
## [86,] 0.7925 2.199 0.033132
## [87,] 0.7925 2.199 0.033212
## [88,] 0.7925 2.199 0.033292
## [89,] 0.7925 2.199 0.033369
## [90,] 0.7925 2.199 0.033445
## [91,] 0.7925 2.199 0.033520
## [92,] 0.7925 2.199 0.033593
## [93,] 0.7925 2.199 0.033665
## [94,] 0.7925 2.199 0.033735
## [95,] 0.7925 2.199 0.033804
## [96,] 0.7925 2.199 0.033872
## [97,] 0.7925 2.199 0.033938
## [98,] 0.7925 2.199 0.034003
```

```
## [99,] 0.7925 2.199 0.034067
## [100,] 0.7925 2.199 0.034130
## [101,] 0.7925 2.199 0.034191
## [102,] 0.7925 2.199 0.034252
## [103,] 0.7925 2.199 0.034311
## [104,] 0.7925 2.199 0.034369
## [105,] 0.7925 2.199 0.034425
## [106,] 0.7925 2.199 0.034481
## [107,] 0.7925 2.199 0.034536
## [108,] 0.7925 2.199 0.034590
## [109,] 0.7925 2.199 0.034642
## [110,] 0.7925 2.199 0.034694
## [111,] 0.7925 2.199 0.034745
## [112,] 0.7925 2.199 0.034795
## [113,] 0.7925 2.199 0.034843
## [114,] 0.7925 2.199 0.034891
## [115,] 0.7925 2.199 0.034938
## [116,] 0.7925 2.199 0.034984
## [117,] 0.7925 2.199 0.035030
## [118,] 0.7925 2.199 0.035074
## [119,] 0.7925 2.199 0.035118
## [120,] 0.7925 2.199 0.035161
## [121,] 0.7925 2.199 0.035203
## [122,] 0.7925 2.199 0.035244
## [123,] 0.7925 2.199 0.035284
## [124,] 0.7925 2.199 0.035324
## [125,] 0.7925 2.199 0.035363
## [126,] 0.7925 2.199 0.035401
## [127,] 0.7925 2.199 0.035439
## [128,] 0.7925 2.199 0.035476
## [129,] 0.7925 2.199 0.035512
## [130,] 0.7925 2.199 0.035547
## [131,] 0.7925 2.199 0.035582
## [132,] 0.7925 2.199 0.035616
## [133,] 0.7925 2.199 0.035650
## [134,] 0.7925 2.199 0.035683
## [135,] 0.7925 2.199 0.035715
## [136,] 0.7925 2.199 0.035747
## [137,] 0.7925 2.199 0.035779
## [138,] 0.7925 2.199 0.035809
## [139,] 0.7925 2.199 0.035839
## [140,] 0.7925 2.199 0.035869
## [141,] 0.7925 2.199 0.035898
## [142,] 0.7925 2.199 0.035926
## [143,] 0.7925 2.199 0.035954
## [144,] 0.7925 2.199 0.035982
## [145,] 0.7925 2.199 0.036009
## [146,] 0.7925 2.199 0.036035
## [147,] 0.7925 2.199 0.036061
## [148,] 0.7925 2.199 0.036087
## [149,] 0.7925 2.199 0.036112
## [150,] 0.7925 2.199 0.036136
## [151,] 0.7925 2.199 0.036161
## [152,] 0.7925 2.199 0.036184
```

```
## [153,] 0.7925 2.199 0.036208
## [154,] 0.7925 2.199 0.036230
## [155,] 0.7925 2.199 0.036253
## [156,] 0.7925 2.199 0.036275
## [157,] 0.7925 2.199 0.036297
## [158,] 0.7925 2.199 0.036318
## [159,] 0.7925 2.199 0.036339
## [160,] 0.7925 2.199 0.036359
## [161,] 0.7925 2.199 0.036380
## [162,] 0.7925 2.199 0.036399
## [163,] 0.7925 2.199 0.036419
## [164,] 0.7925 2.199 0.036438
## [165,] 0.7925 2.199 0.036457
## [166,] 0.7925 2.199 0.036475
## [167,] 0.7925 2.199 0.036493
## [168,] 0.7925 2.199 0.036511
## [169,] 0.7925 2.199 0.036528
## [170,] 0.7925 2.199 0.036546
## [171,] 0.7925 2.199 0.036562
## [172,] 0.7925 2.199 0.036579
## [173,] 0.7925 2.199 0.036595
## [174,] 0.7925 2.199 0.036611
## [175,] 0.7925 2.199 0.036627
## [176,] 0.7925 2.199 0.036642
## [177,] 0.7925 2.199 0.036657
## [178,] 0.7925 2.199 0.036672
## [179,] 0.7925 2.199 0.036687
## [180,] 0.7925 2.199 0.036701
## [181,] 0.7925 2.199 0.036715
## [182,] 0.7925 2.199 0.036729
## [183,] 0.7925 2.199 0.036743
## [184,] 0.7925 2.199 0.036756
## [185,] 0.7925 2.199 0.036769
## [186,] 0.7925 2.199 0.036782
## [187,] 0.7925 2.199 0.036795
## [188,] 0.7925 2.199 0.036807
## [189,] 0.7925 2.199 0.036819
## [190,] 0.7925 2.199 0.036831
## [191,] 0.7925 2.199 0.036843
## [192,] 0.7925 2.199 0.036855
## [193,] 0.7925 2.199 0.036866
## [194,] 0.7925 2.199 0.036877
## [195,] 0.7925 2.199 0.036888
## [196,] 0.7925 2.199 0.036899
## [197,] 0.7925 2.199 0.036909
## [198,] 0.7925 2.199 0.036920
## [199,] 0.7925 2.199 0.036930
## [200,] 0.7925 2.199 0.036940
## [201,] 0.7925 2.199 0.036950
## [202,] 0.7925 2.199 0.036959
## [203,] 0.7925 2.199 0.036969
## [204,] 0.7925 2.199 0.036978
## [205,] 0.7925 2.199 0.036988
## [206,] 0.7925 2.199 0.036997
```

```
## [207,] 0.7925 2.199 0.037005
## [208,] 0.7925 2.199 0.037014
## [209,] 0.7925 2.199 0.037023
## [210,] 0.7925 2.199 0.037031
## [211,] 0.7925 2.199 0.037039
## [212,] 0.7925 2.199 0.037047
## [213,] 0.7925 2.199 0.037055
## [214,] 0.7925 2.199 0.037063
## [215,] 0.7925 2.199 0.037071
## [216,] 0.7925 2.199 0.037078
## [217,] 0.7925 2.199 0.037086
## [218,] 0.7925 2.199 0.037093
## [219,] 0.7925 2.199 0.037100
## [220,] 0.7925 2.199 0.037107
## [221,] 0.7925 2.199 0.037114
## [222,] 0.7925 2.199 0.037121
## [223,] 0.7925 2.199 0.037128
## [224,] 0.7925 2.199 0.037134
## [225,] 0.7925 2.199 0.037141
## [226,] 0.7925 2.199 0.037147
## [227,] 0.7925 2.199 0.037153
## [228,] 0.7925 2.199 0.037159
## [229,] 0.7925 2.199 0.037165
## [230,] 0.7925 2.199 0.037171
## [231,] 0.7925 2.199 0.037177
## [232,] 0.7925 2.199 0.037183
## [233,] 0.7925 2.199 0.037188
## [234,] 0.7925 2.199 0.037194
## [235,] 0.7925 2.199 0.037199
## [236,] 0.7925 2.199 0.037204
## [237,] 0.7925 2.199 0.037210
## [238,] 0.7925 2.199 0.037215
## [239,] 0.7925 2.199 0.037220
## [240,] 0.7925 2.199 0.037225
## [241,] 0.7925 2.199 0.037230
## [242,] 0.7925 2.199 0.037234
## [243,] 0.7925 2.199 0.037239
## [244,] 0.7925 2.199 0.037244
```

```
y_test=tst[1:244]
rmse(y_test,p)
```

```
## [1] 0.00766455
```

The RMSE is around 0.00766, indicating that the model is adequate to predict short term USD/EUR exchange rate.