Instruction:

• Exam time: 120 minutes.
• You may use a calculator, turn off cell phones. Phone communication are strictly prohibited during the exam.
• The exam has pages including the R output. Please check that you have all pages.
• For each question, write your answer in the blank space provided.
• Manage your time carefully and answer as many questions as you can.
• For simplicity, if not specifically given, use 5 % level of significance.
• Round your answer to 3 significant digits.

Question 1 (80 points)

Your score.....................

Consider the daily log returns of the NASDAQ starting from January 3, 2008 for 2787 observations. Let r_t be the log return series. Based on the below R output, answer the following questions.

Toolbox 1

```
> #question1
> getSymbols("^IXIC",from="2008-01-03",to="2019-01-30")
[1] "IXIC"
> dim(IXIC)
[1] 2787    6
> head(IXIC)
            IXIC.Open IXIC.High IXIC.Low IXIC.Close IXIC.Volume IXIC.Adjusted
2008-01-03   2611.96   2624.27  2592.18    2602.68  1970200000       2602.68
2008-01-04   2571.08   2571.08  2502.68    2504.65  2516310000       2504.65
2008-01-07   2514.15   2521.62  2471.23    2499.46  2600100000       2499.46
2008-01-08   2506.97   2527.42  2440.51    2440.51  2566480000       2440.51
2008-01-09   2443.85   2474.55  2407.39    2474.55  2821160000       2474.55
2008-01-10   2452.12   2503.55  2446.80    2488.52  2640400000       2488.52
> tail(IXIC)
           IXIC.Open IXIC.High IXIC.Low IXIC.Close IXIC.Volume IXIC.Adjusted
2019-01-22   7109.57   7110.16  6979.81    7020.36  2380950000       7020.36
2019-01-23   7061.65   7084.85  6953.23    7025.77  2274420000       7025.77
2019-01-24   7042.25   7078.96  7029.95    7073.46  2400290000       7073.46
2019-01-25   7128.18   7174.56  7111.09    7164.86  2440840000       7164.86
2019-01-28   7075.01   7086.30  7034.25    7085.68  2435480000       7085.68
2019-01-29   7087.49   7092.29  7011.47    7028.29  2089690000       7028.29
> rtn=diff(log(as.numeric(IXIC[,6]))) * 100
> basicStats(rtn)
rtn
nobs         2786.000000
NAs             0.000000
Minimum        -9.587695
Maximum        11.159441
1. Quartile    -0.490151
3. Quartile     0.680110
Mean            0.035657
Median          0.087823
Sum            99.340178
```

```
SE Mean        0.025908
LCL Mean      -0.015144
UCL Mean       0.086458
Variance       1.870054
Stdev          1.367499
Skewness      -0.283525
Kurtosis       7.229479
> t.test(rtn)

One Sample t-test

data:  rtn
t = 1.3763, df = 2785, p-value = 0.1688
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
-0.01514422  0.08645806
sample estimates:
mean of x
0.03565692

> plot(rtn,type='l')
> m1=arima(rtn,order=c(0,0,1),include.mean=F)
> m1

Call:
arima(x = rtn, order = c(0, 0, 1), include.mean = F)

Coefficients:
ma1
-0.0777
s.e.   0.0197

sigma^2 estimated as 1.86:  log likelihood = -4817.89,  aic = 9639.77
> Box.test(m1$residuals,lag=10,type='Ljung')

Box-Ljung test

data:  m1$residuals
X-squared = 15.168, df = 10, p-value = 0.126

> Box.test(m1$residuals^2,lag=10,type='Ljung')
```

```
Box-Ljung test

data:  m1$residuals^2
X-squared = 2247.8, df = 10, p-value < 2.2e-16

> m2=garchFit(~arma(0,1)+garch(1,1),data=rtn,trace=F,include.mean=F)
> summary(m2)

Title:
GARCH Modelling

Call:
garchFit(formula = ~arma(0, 1) + garch(1, 1), data = rtn, include.mean = F,
trace = F)

Mean and Variance Equation:
data ~ arma(0, 1) + garch(1, 1)
<environment: 0x11bdb3748>
[data = rtn]

Conditional Distribution:
norm

Coefficient(s):
ma1        omega      alpha1      beta1
-0.029344   0.032817   0.109038   0.869583

Std. Errors:
based on Hessian

Error Analysis:
Estimate  Std. Error  t value Pr(>|t|)
ma1     -0.029344    0.020465   -1.434    0.152
omega    0.032817    0.005978    5.489 4.03e-08 ***
alpha1   0.109038    0.012288    8.874  < 2e-16 ***
beta1    0.869583    0.013618   63.854  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log Likelihood:
-4200.004    normalized:  -1.507539
```

```
Description:
Sun May 26 16:42:03 2019 by user:

Standardised Residuals Tests:
Statistic p-Value
Jarque-Bera Test   R    Chi^2  328.5828  0
Shapiro-Wilk Test  R    W      0.9795447 0
Ljung-Box Test     R    Q(10)  8.922562  0.5394682
Ljung-Box Test     R    Q(15)  14.74016  0.4702906
Ljung-Box Test     R    Q(20)  21.93287  0.3441646
Ljung-Box Test     R^2  Q(10)  11.81068  0.2979267
Ljung-Box Test     R^2  Q(15)  20.81972  0.1426889
Ljung-Box Test     R^2  Q(20)  25.45612  0.1845349
LM Arch Test       R    TR^2   12.53407  0.4037952

Information Criterion Statistics:
AIC      BIC      SIC      HQIC
3.017950 3.026467 3.017946 3.021025

> m3=garchFit(~garch(1,1),data=rtn,trace=F,cond.dist="std",include.mean=F)
> summary(m3)

Title:
GARCH Modelling

Call:
garchFit(formula = ~garch(1, 1), data = rtn, cond.dist = "std",
include.mean = F, trace = F)

Mean and Variance Equation:
data ~ garch(1, 1)
<environment: 0x11c282518>
[data = rtn]

Conditional Distribution:
std

Coefficient(s):
omega     alpha1     beta1     shape
0.021197  0.106503  0.885072  6.248983

Std. Errors:
```

```
based on Hessian

Error Analysis:
Estimate  Std. Error  t value Pr(>|t|)
omega    0.021197    0.006222    3.407 0.000658 ***
alpha1   0.106503    0.014708    7.241 4.45e-13 ***
beta1    0.885072    0.014888   59.449  < 2e-16 ***
shape    6.248983    0.774776    8.066 6.66e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1

Log Likelihood:
-4153.563    normalized:  -1.49087

Description:
Sun May 26 16:42:05 2019 by user:


Standardised Residuals Tests:
Statistic p-Value
Jarque-Bera Test   R    Chi^2  381.1543  0
Shapiro-Wilk Test  R    W      0.9788346 0
Ljung-Box Test     R    Q(10)  12.05337  0.2815005
Ljung-Box Test     R    Q(15)  17.80505  0.2730533
Ljung-Box Test     R    Q(20)  25.24494  0.1922204
Ljung-Box Test     R^2  Q(10)  8.997072  0.5323815
Ljung-Box Test     R^2  Q(15)  20.50156  0.1535246
Ljung-Box Test     R^2  Q(20)  26.65738  0.1451813
LM Arch Test       R    TR^2   11.23462  0.508926

Information Criterion Statistics:
AIC      BIC      SIC      HQIC
2.984611 2.993129 2.984607 2.987686

> predict(m3,5)
meanForecast meanError standardDeviation
1            0   1.374799         1.374799
2            0   1.376715         1.376715
3            0   1.378612         1.378612
4            0   1.380490         1.380490
5            0   1.382351         1.382351
```

Question 1.1 (10 points)

Your score.....................

Does the mean for $r_t = 0$? Why? Write down Null Hypothesis: (H_0) and Alternative Hypothesis: (H_1) to test this. Obtain the test statistic and draw your conclusion.

Question 1.2 (10 points)

Your score.....................

An MA(1) model is fitted. Write down the fitted model, including σ^2 of the residuals.

Question 1.3 (10 points)

Your score.....................

Is there any ARCH effect in the residuals of the fitted MA(1) model? Why? Write down Null Hypothesis: (H_0) and Alternative Hypothesis: (H_1) to test this. Obtain the test statistic and draw your conclusion.

Question 1.4 (10 points)

Your score.....................

An ARMA(0,1)+GARCH(1,1) model with Gaussian innovations was entertained for rt. See m2. Write down the fitted model.

Question 1.5 (10 points)

Your score.....................

Is the fitted ARMA(0,1)+GARCH(1,1) model adequate? Why?

Question 1.6 (10 points)

Your score.....................

A GARCH(1,1) model with standardized Student-t innovations was fitted. See m3. Write down the fitted model.

Question 1.7 (10 points)

Your score.....................

Compare the three models m1, m2, m3. Which model is preferred? Why?

Question 1.8 (10 points)

Your score.....................

Based on the output provided in model m3, Compute the 1-step ahead forecast of its volatility at the forecast origin t = 2786?. We have $r_{2786} = -0.0955$ and $\sigma_{2786} = 0.745$.

Question2(40 points)

Your score.....................

Suppose the daily log return r_t of Stock A follows the model:

$$r_t = 0.002 + a_t$$

$$a_t = \sigma_t \epsilon_t$$

where ϵ_t is an independent and identically distributed (iid) sequence of standardized Student-t distribution with 5 degrees of freedom. In addition,

$$\sigma_t^2 = 0.01 + 0.1 a_{t-1}^2 + 0.9 \sigma_{t-1}^2$$

.

Question2.1 (10 points)

Your score.....................

From the above model, Find out the unconditional Expectation of a_t :$E(a_t)$ and the unconditional expectation of r_t :$E(r_t)$

Question2.2 (10 points) | Your score......................

Find out the unconditional variance of a_t :$Var(a_t)$ and the conditional variance of a_t :$Var(a_t|F_{t-1})$

Question2.3 (10 points) | Your score......................

Let h = 100 be the forecast origin with $a_h = 0.015$ and $\sigma_h = 0.2$. Calculate the 1-step ahead prediction $r_h(1)$ and 1-step ahead volatility forecast.

Question2.4 (10 points)

Your score.....................

Calculate the 5-step ahead prediction $r_h(5)$ and the 5-step ahead volatility forecast at the forecast origin h.

Question3 (30 points) Your score.....................

Consider a bivariate time series $\mathbf{z_t}$, where z_{1t} is the change (first difference) in monthly U.S. treasury bills with maturity 3 months and z_{2t} is the inflation rate, in percentage, of the U.S. monthly consumer price index (CPI). The CPI used is the consumer price index for all urban consumers: all items (CPIAUCSL). The original data are downloaded from the Federal Reserve Bank of St. Louis. The CPI rate is 100 times the first difference of the log CPI index. The sample period is from January 1947 to December 2012. The original data are in the file m-cpitb3m.txt.

Toolbox 3

```
mt <- read.table("m-cpitb3m.txt",header=T)
> inflation=diff(log(mt$cpiaucsl))*100
> diffinterest=diff((mt$tb3m))
> zt=cbind(diffinterest,inflation)
> colnames(zt) <- c("z1t","z2t")
> ccm(zt,lag=2,level=T)
[1] "Covariance␣matrix:"
z1t    z2t
z1t 0.1689 0.0106
z2t 0.0106 0.1231
CCM at lag:  0
[,1]   [,2]
[1,] 1.0000 0.0736
[2,] 0.0736 1.0000
Simplified matrix:
CCM at lag:  1
+ .
+ +
Correlations:
[,1]   [,2]
[1,] 0.336 0.0281
[2,] 0.114 0.5714
CCM at lag:  2
- .
+ +
Correlations:
[,1]    [,2]
[1,] -0.0714 -0.0552
[2,]  0.1427  0.4097
Hit Enter for p-value plot of individual ccm:
VARorder(zt)
```

```
>
> VARorder(zt)
selected order: aic =
selected order: bic =
selected order: hq =
Summary table:
p      AIC      BIC       HQ      M(p) p-value
[1,]  0 -3.9368 -3.9368 -3.9368   0.0000  0.0000
[2,]  1 -4.4945 -4.4709 -4.4854 439.7991  0.0000
[3,]  2 -4.5665 -4.5192 -4.5483  63.4139  0.0000
[4,]  3 -4.5725 -4.5016 -4.5453  12.4585  0.0142
[5,]  4 -4.5863 -4.4918 -4.5500  18.3614  0.0010
[6,]  5 -4.6055 -4.4873 -4.5600  22.4288  0.0002
[7,]  6 -4.6634 -4.5216 -4.6089  52.0039  0.0000
[8,]  7 -4.6812 -4.5158 -4.6176  21.3291  0.0003
[9,]  8 -4.6979 -4.5088 -4.6252  20.3814  0.0004
[10,]  9 -4.7069 -4.4942 -4.6252  14.5220  0.0058
[11,] 10 -4.7143 -4.4780 -4.6235  13.2318  0.0102
[12,] 11 -4.7077 -4.4477 -4.6078   2.6230  0.6228
[13,] 12 -4.7542 -4.4706 -4.6452  42.6086  0.0000
[14,] 13 -4.7629 -4.4557 -4.6449  14.1646  0.0068


> model_1=VAR(zt,p=2)
> summary(model_1)

VAR Estimation Results:
=========================
Endogenous variables: z1t, z2t
Deterministic variables: const
Sample size: 789
Log Likelihood: -463.147
Roots of the characteristic polynomial:
0.6618 0.4346 0.4346 0.1701
Call:
VAR(y = zt, p = 2)


Estimation results for equation z1t:
====================================
z1t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + const
```

```
Estimate Std. Error t value Pr(>|t|)
z1t.l1  0.403556   0.034830  11.587  < 2e-16 ***
z2t.l1  0.089951   0.047099   1.910   0.0565 .
z1t.l2 -0.208945   0.034959  -5.977 3.45e-09 ***
z2t.l2 -0.111813   0.046949  -2.382   0.0175 *
const   0.006382   0.018817   0.339   0.7346
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1


Residual standard error: 0.3786 on 784 degrees of freedom
Multiple R-Squared: 0.1581,     Adjusted R-squared: 0.1538
F-statistic:  36.8 on 4 and 784 DF,  p-value: < 2.2e-16


Estimation results for equation z2t:
====================================
z2t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + const

Estimate Std. Error t value Pr(>|t|)
z1t.l1  0.04636    0.02582   1.795  0.07298 .
z2t.l1  0.48359    0.03492  13.849  < 2e-16 ***
z1t.l2  0.05135    0.02592   1.981  0.04790 *
z2t.l2  0.12922    0.03481   3.712  0.00022 ***
const   0.11390    0.01395   8.164 1.29e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1


Residual standard error: 0.2807 on 784 degrees of freedom
Multiple R-Squared: 0.3499,     Adjusted R-squared: 0.3466
F-statistic: 105.5 on 4 and 784 DF,  p-value: < 2.2e-16



Covariance matrix of residuals:
z1t      z2t
z1t 0.143322 0.007726
z2t 0.007726 0.078782

Correlation matrix of residuals:
z1t     z2t
```

```
z1t 1.00000 0.07271
z2t 0.07271 1.00000

##############################################
> model_2=VAR(zt,p=4)
> summary(model_2)

VAR Estimation Results:
=========================
Endogenous variables: z1t, z2t
Deterministic variables: const
Sample size: 787
Log Likelihood: -436.404
Roots of the characteristic polynomial:
0.8272 0.559 0.559 0.459 0.459 0.3213 0.319 0.319
Call:
VAR(y = zt, p = 4)


Estimation results for equation z1t:
====================================
z1t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + z1t.l3 + z2t.l3 + z1t.l4 + z2t.l4 + const

Estimate Std. Error t value Pr(>|t|)
z1t.l1   0.409569   0.035881   11.415  < 2e-16 ***
z2t.l1   0.103747   0.049459    2.098   0.0363 *
z1t.l2  -0.227252   0.038791   -5.858  6.9e-09 ***
z2t.l2  -0.117128   0.054031   -2.168   0.0305 *
z1t.l3   0.030040   0.038699    0.776   0.4378
z2t.l3   0.044169   0.052965    0.834   0.4046
z1t.l4  -0.007184   0.035948   -0.200   0.8417
z2t.l4  -0.076537   0.048358   -1.583   0.1139
const    0.013486   0.020220    0.667   0.5050
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1


Residual standard error: 0.3792 on 778 degrees of freedom
Multiple R-Squared: 0.1618,     Adjusted R-squared: 0.1532
F-statistic: 18.78 on 8 and 778 DF,  p-value: < 2.2e-16
```

```
Estimation results for equation z2t:
====================================
z2t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + z1t.l3 + z2t.l3 + z1t.l4 + z2t.l4 + const

Estimate Std. Error t value Pr(>|t|)
z1t.l1  0.056844   0.025819   2.202  0.02798 *
z2t.l1  0.454665   0.035589  12.775  < 2e-16 ***
z1t.l2  0.064485   0.027913   2.310  0.02114 *
z2t.l2  0.047248   0.038879   1.215  0.22463
z1t.l3 -0.009805   0.027847  -0.352  0.72485
z2t.l3  0.099027   0.038111   2.598  0.00954 **
z1t.l4  0.033906   0.025867   1.311  0.19032
z2t.l4  0.113370   0.034797   3.258  0.00117 **
const   0.085132   0.014550   5.851 7.19e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1


Residual standard error: 0.2729 on 778 degrees of freedom
Multiple R-Squared: 0.388,      Adjusted R-squared: 0.3817
F-statistic: 61.66 on 8 and 778 DF,  p-value: < 2.2e-16



Covariance matrix of residuals:
z1t       z2t
z1t 0.143786 0.008417
z2t 0.008417 0.074448

Correlation matrix of residuals:
z1t      z2t
z1t 1.00000 0.08135
z2t 0.08135 1.00000


##############################################
> model_3=VAR(zt,p=6)
> summary(model_3)

VAR Estimation Results:
=========================
Endogenous variables: z1t, z2t
```

```
Deterministic variables: const
Sample size: 785
Log Likelihood: -396.324
Roots of the characteristic polynomial:
0.9103 0.8084 0.8084 0.7899 0.7899 0.7822 0.7822 0.6926 0.6926 0.6423 0.6423 0.6164
Call:
VAR(y = zt, p = 6)


Estimation results for equation z1t:
====================================
z1t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + z1t.l3 + z2t.l3 + z1t.l4 + z2t.l4 + z1t.l5 +
    z2t.l5 + z1t.l6 + z2t.l6 + const

Estimate Std. Error t value Pr(>|t|)
z1t.l1   0.429039   0.034965  12.271  < 2e-16 ***
z2t.l1   0.084630   0.048623   1.741 0.082163 .
z1t.l2 -0.238675   0.037729  -6.326 4.26e-10 ***
z2t.l2 -0.114167   0.053009  -2.154 0.031571 *
z1t.l3   0.063236   0.038510   1.642 0.100981
z2t.l3   0.034541   0.052956   0.652 0.514431
z1t.l4 -0.082077   0.038524  -2.131 0.033443 *
z2t.l4 -0.130934   0.052617  -2.488 0.013041 *
z1t.l5   0.141563   0.037450   3.780 0.000169 ***
z2t.l5   0.170047   0.051868   3.278 0.001090 **
z1t.l6 -0.243548   0.034806  -6.997 5.67e-12 ***
z2t.l6 -0.020680   0.047760  -0.433 0.665138
const  -0.007827   0.020332  -0.385 0.700353
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


Residual standard error: 0.3663 on 772 degrees of freedom
Multiple R-Squared: 0.2233,     Adjusted R-squared: 0.2112
F-statistic: 18.49 on 12 and 772 DF,  p-value: < 2.2e-16


Estimation results for equation z2t:
====================================
z2t = z1t.l1 + z2t.l1 + z1t.l2 + z2t.l2 + z1t.l3 + z2t.l3 + z1t.l4 + z2t.l4 + z1t.l5 +
    z2t.l5 + z1t.l6 + z2t.l6 + const
```

```
Estimate Std. Error t value Pr(>|t|)
z1t.l1  0.054422   0.025750   2.114  0.03488 *
z2t.l1  0.431232   0.035808  12.043  < 2e-16 ***
z1t.l2  0.071858   0.027785   2.586  0.00989 **
z2t.l2  0.036356   0.039038   0.931  0.35199
z1t.l3  0.001092   0.028360   0.039  0.96929
z2t.l3  0.070906   0.038999   1.818  0.06943 .
z1t.l4  0.034776   0.028371   1.226  0.22065
z2t.l4  0.058616   0.038750   1.513  0.13077
z1t.l5  0.021306   0.027580   0.773  0.44004
z2t.l5  0.061985   0.038198   1.623  0.10505
z1t.l6 -0.027493   0.025633  -1.073  0.28379
z2t.l6  0.111394   0.035172   3.167  0.00160 **
const   0.067396   0.014973   4.501  7.8e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1


Residual standard error: 0.2698 on 772 degrees of freedom
Multiple R-Squared: 0.4049,     Adjusted R-squared: 0.3956
F-statistic: 43.77 on 12 and 772 DF,  p-value: < 2.2e-16



Covariance matrix of residuals:
z1t      z2t
z1t 0.134204 0.006223
z2t 0.006223 0.072785

Correlation matrix of residuals:
z1t     z2t
z1t 1.00000 0.06296
z2t 0.06296 1.00000


> fevd(model_X, n.ahead = 20)
$z1t
             z1t         z2t
[1,] 1.0000000 0.000000000
[2,] 0.9962227 0.003777297
[3,] 0.9957532 0.004246838
[4,] 0.9945115 0.005488455
```

```
[5,] 0.9939951 0.006004927
[6,] 0.9938876 0.006112423
[7,] 0.9938607 0.006139276
[8,] 0.9938473 0.006152714
[9,] 0.9938393 0.006160720
[10,] 0.9938353 0.006164678
[11,] 0.9938337 0.006166334
[12,] 0.9938330 0.006167003
[13,] 0.9938327 0.006167288
[14,] 0.9938326 0.006167415
[15,] 0.9938325 0.006167472
[16,] 0.9938325 0.006167497
[17,] 0.9938325 0.006167508
[18,] 0.9938325 0.006167513
[19,] 0.9938325 0.006167515
[20,] 0.9938325 0.006167516

$z2t
                 z1t          z2t
[1,] 0.005286047 0.9947140
[2,] 0.011938419 0.9880616
[3,] 0.026988642 0.9730114
[4,] 0.034122822 0.9658772
[5,] 0.036182754 0.9638172
[6,] 0.036751348 0.9632487
[7,] 0.036980291 0.9630197
[8,] 0.037098701 0.9629013
[9,] 0.037157121 0.9628429
[10,] 0.037182806 0.9628172
[11,] 0.037193522 0.9628065
[12,] 0.037198069 0.9628019
[13,] 0.037200064 0.9627999
[14,] 0.037200951 0.9627990
[15,] 0.037201343 0.9627987
[16,] 0.037201514 0.9627985
[17,] 0.037201589 0.9627984
[18,] 0.037201621 0.9627984
[19,] 0.037201636 0.9627984
[20,] 0.037201642 0.9627984
```

Question3.1 (10 points)

Your score.....................

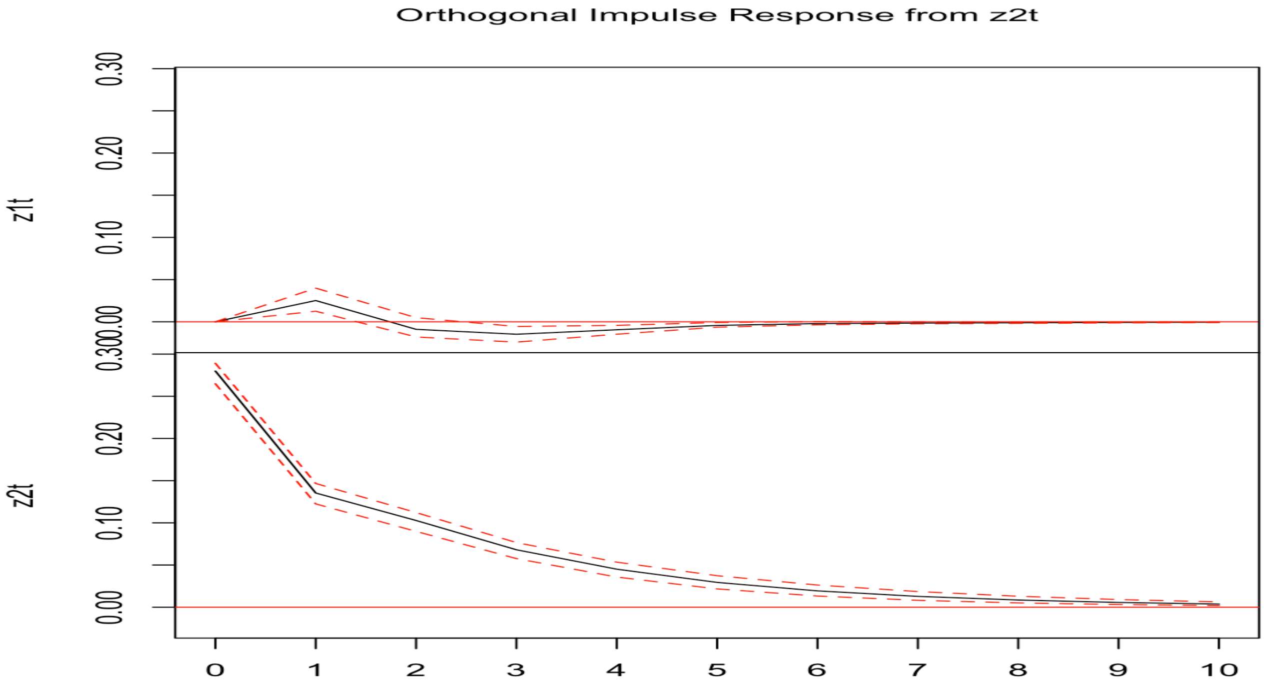
From the toolbox 3, Let $\boldsymbol{\rho}_l$ is cross-correlation matrix (CCM) at lag l of $\mathbf{z_t}$. Write down the meanings of $\boldsymbol{\rho}_1$.

Question3.2 (10 points)

Your score.....................

Select a VAR order for $\mathbf{z_t}$ using the BIC criterion. Write down the fitted model you selected.

Figure 3.1 Orthogonal Impulse Response from z_{2t}



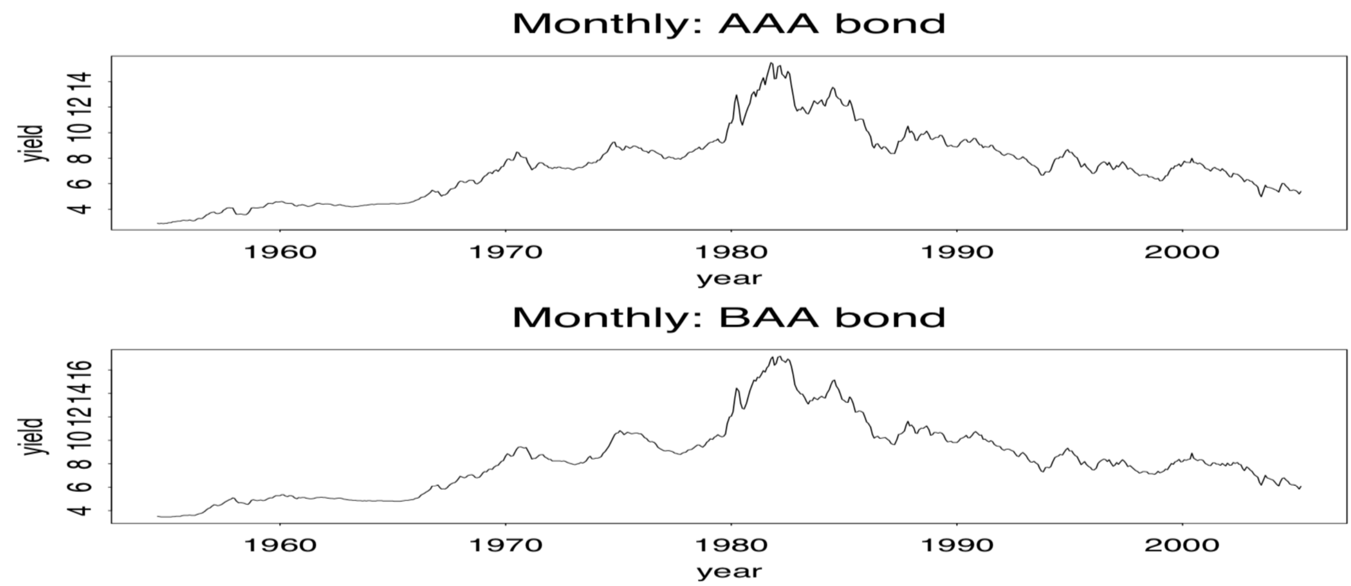
Question3.3 (10 points) Your score.....................

Briefly explain the concept of the impulse response functions. Based on the plots on the figure 3.1, what is the impact of inflation rate on the 3-month treasury bills?.

Question4 (30 points) Your score.....................

Consider the monthly yields of Moody's seasoned corporate Aaa and Baa bonds from 1954.7 to 2005.2. The data are obtained from Federal Reserve Bank of St Louis. Figure 4.1 shows the time plots of the yield data. The two series move in a parallel manner.

Figure 4.1 Time plots of Monthly Moody's Seasoned Corporate Aaa and Baa Bond Yields from July 1954 to February 2005.



Toolbox 4

```
> da=read.table("m-bnd.txt",header=T)
> head(da)
year mon day  Aaa  Baa
1 1954   7   1 2.89 3.50
2 1954   8   1 2.87 3.49
3 1954   9   1 2.89 3.47
4 1954  10   1 2.87 3.46
5 1954  11   1 2.89 3.45
6 1954  12   1 2.90 3.45
> Aaa=da$Aaa
> Baa=da$Baa
> m1=adfTest(Aaa, lags = 3, type = c("ct"), title = NULL,description = NULL)
> m1@test$p.value

0.9374049
> m1@test$parameter
Lag Order
3
> m1@test$lm

Call:
lm(formula = y.diff ~ y.lag.1 + 1 + tt + y.diff.lag)

Coefficients:
(Intercept)      y.lag.1           tt   y.diff.lag1  y.diff.lag2  y.diff.lag3
4.718e-02   -3.442e-03   -5.941e-05    4.582e-01   -2.798e-01    5.022e-02

> m2=adfTest(Baa, lags = 3, type = c("ct"), title = NULL,description = NULL)
> m2@test$p.value

0.9320769
> m2@test$parameter
Lag Order
3
> m2@test$lm

Call:
lm(formula = y.diff ~ y.lag.1 + 1 + tt + y.diff.lag)
```

```
Coefficients:
(Intercept)      y.lag.1           tt   y.diff.lag1  y.diff.lag2  y.diff.lag3
4.187e-02   -2.810e-03   -5.051e-05    5.178e-01   -1.835e-01    5.811e-02

> m3=adfTest(diff(Aaa), lags = 3, type = c("c"), title = NULL,description = NULL)
Warning message:
In adfTest(diff(Aaa), lags = 3, type = c("c"), title = NULL, description = NULL) :
p-value smaller than printed p-value
> m3@test$p.value

0.01
> m3@test$parameter
Lag Order
3
> m3@test$lm

Call:
lm(formula = y.diff ~ y.lag.1 + 1 + y.diff.lag)

Coefficients:
(Intercept)      y.lag.1  y.diff.lag1  y.diff.lag2  y.diff.lag3
0.003136    -0.729407     0.188799    -0.078179    -0.046852

> m4=adfTest(diff(Baa), lags = 3, type = c("c"), title = NULL,description = NULL)
Warning message:
In adfTest(diff(Baa), lags = 3, type = c("c"), title = NULL, description = NULL) :
p-value smaller than printed p-value
> m4@test$p.value

0.01
> m4@test$parameter
Lag Order
3
> m4@test$lm

Call:
lm(formula = y.diff ~ y.lag.1 + 1 + y.diff.lag)

Coefficients:
(Intercept)      y.lag.1  y.diff.lag1  y.diff.lag2  y.diff.lag3
0.002613    -0.561875     0.079686    -0.091754    -0.065853
```

```
> fit <- lm(Baa~Aaa)
> summary(fit)

Call:
lm(formula = Baa ~ Aaa)

Residuals:
Min        1Q    Median       3Q       Max
-0.45999 -0.21169 -0.04535  0.14767  1.17675

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.100177   0.033594    2.982   0.00298 **
Aaa         1.114989   0.004254  262.080   < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2828 on 607 degrees of freedom
Multiple R-squared:  0.9912,    Adjusted R-squared:  0.9912
F-statistic: 6.869e+04 on 1 and 607 DF,  p-value: < 2.2e-16

> error=residuals(fit)
> m5=adfTest(error, lags = 3, type = c("nc"), title = NULL,description = NULL)
Warning message:
In adfTest(error, lags = 3, type = c("nc"), title = NULL, description = NULL) :
p-value smaller than printed p-value
> m5@test$p.value

0.01
> m5@test$parameter
Lag Order
3
> m5@test$lm

Call:
lm(formula = y.diff ~ y.lag.1 - 1 + y.diff.lag)

Coefficients:
y.lag.1  y.diff.lag1  y.diff.lag2  y.diff.lag3
-0.07415       0.23717      -0.20281      -0.03096

> diff.Aaa =diff(Aaa)
```

```
> diff.Baa=diff(Baa)
> diff.Aaa.L.1=Lag(diff(Aaa),k=1)
> diff.Baa.L.1=Lag(diff(Baa),k=1)
> error.L.1 =Lag(error,k=1)
> error.L.1=error.L.1[2:609]
> fit <- lm(diff.Baa~diff.Baa.L.1+diff.Aaa.L.1+error.L.1)
> summary(fit)

Call:
lm(formula = diff.Baa ~ diff.Baa.L.1 + diff.Aaa.L.1 + error.L.1)

Residuals:
Min       1Q    Median      3Q      Max
-0.71830 -0.07404 -0.00321  0.07837  0.99170

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.002563   0.007242   0.354    0.724
diff.Baa.L.1   0.101000   0.079795   1.266    0.206
diff.Aaa.L.1   0.335635   0.073882   4.543 6.71e-06 ***
error.L.1     -0.041930   0.026888  -1.559    0.119
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '␣' 1

Residual standard error: 0.1784 on 603 degrees of freedom
(1 observation deleted due to missingness)
Multiple R-squared:  0.2305,    Adjusted R-squared:  0.2267
F-statistic: 60.21 on 3 and 603 DF,  p-value: < 2.2e-16
```

Question4.1 (10 points) Your score......................

From the toolbox 4, perform augmented Dickey–Fuller tests on the monthly yields of Moody's seasoned corporate Aaa and Baa bonds. Write down Null Hypothesis: (H_0) and Alternative Hypothesis: (H_1) to test this. Obtain the test statistic and draw your conclusion by setting $\alpha = 0.05$. Also find out the intregated order I(p) of these two series.

Question4.2 (10 points)

Your score......................

Based on the estimation result of the cointegrating relationships using the Engle–Granger procedure in toolbox 4, are the two series co-integrated? Why? Write down Null Hypothesis: (H_0) and Alternative Hypothesis: (H_1) to test this. Obtain the test statistic and draw your conclusion by setting $\alpha = 0.05$.

Question4.3 (10 points)

Your score.....................

Based on the toolbox 4, write down the error-correcting model (ECM) using 1 lagged changes of each variable. Discuss the nature of the adjustment. In response to a deviation from the long-run relationship, how are the monthly yields of Moody's seasoned corporate Baa bonds predicted to change?