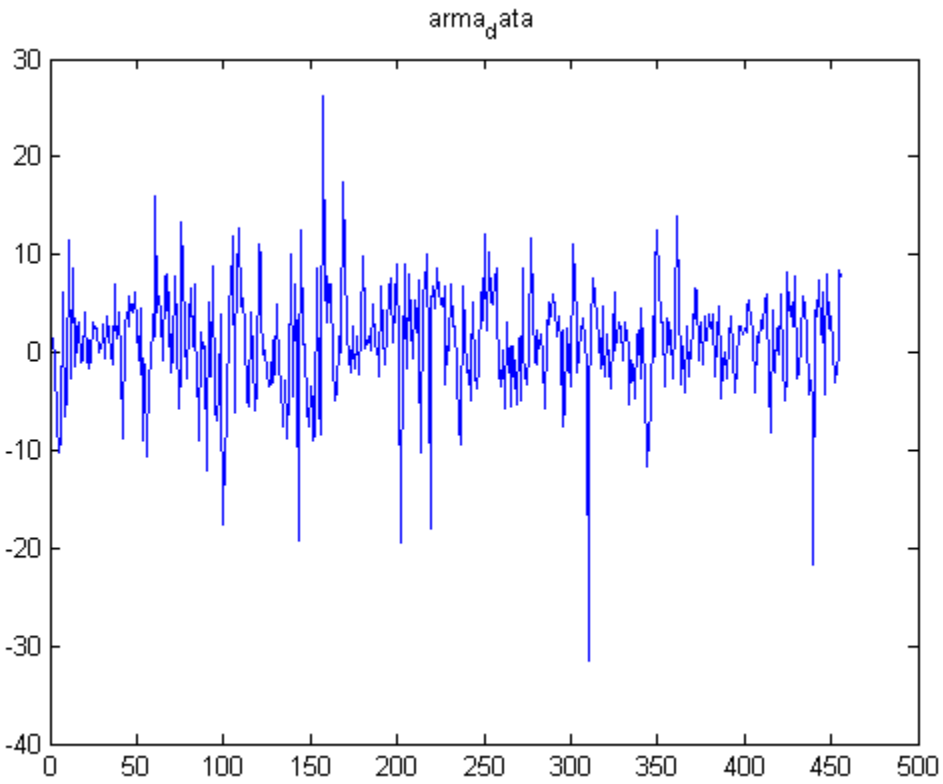
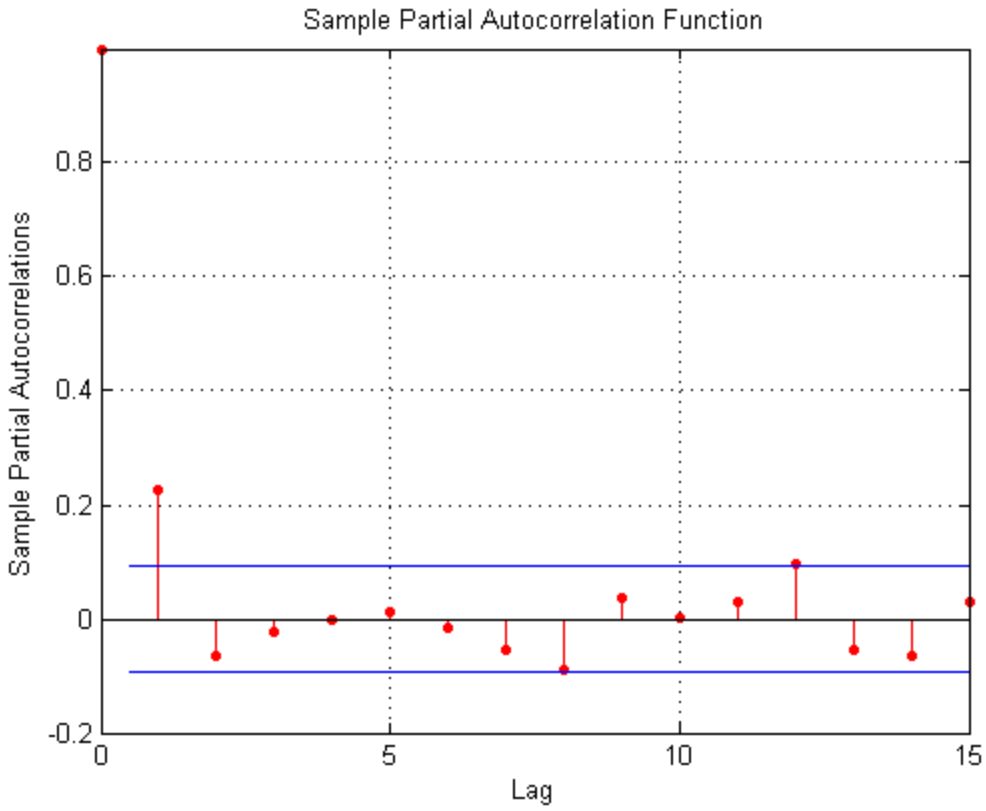
Table of Contents

1 ARMA model

1.a

```
the result of 1.a

Data_mean =

   1.059510964912281


Data_variance =

  31.360269533945456


Data_median =

   1.494500000000000


Data_kurtosis =

   7.154228266875846


Data_skewness =

  -0.675491315279429


h_adf =

     1
```


arma_data
30
20
10
0
-10
-20
-30
-40
0
50
100
150
200
250
300
350
400
450
500



1.b

the result of 1.b

Mean: ARMAX(1,0,0); Variance: GARCH(0,0)

Conditional Probability Distribution: Gaussian
Number of Model Parameters Estimated: 3

Parameter	Value	Standard Error	T Statistic
C	0.82229	0.26496	3.1035
AR(1)	0.22709	0.047546	4.7762
K	29.681	1.1017	26.9414

h_LB =

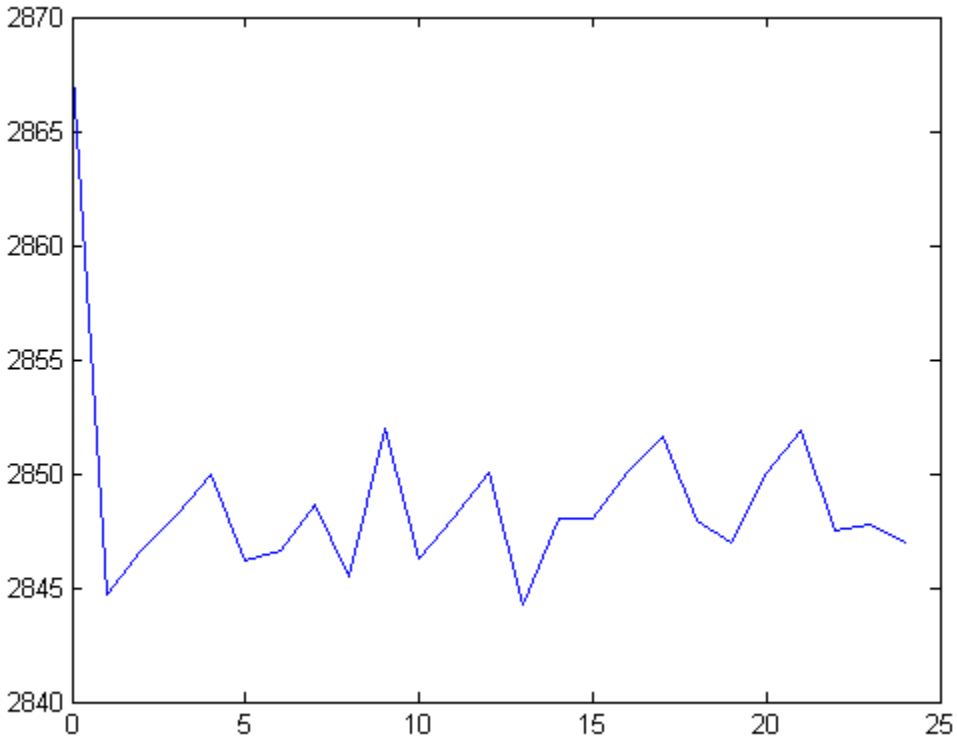
0

we fail to reject the null autocorrelation of the series

1.c

the result of 1.c

```
  Mean: ARMAX(2,3,0); Variance: GARCH(0,0)

  Conditional Probability Distribution: Gaussian
  Number of Model Parameters Estimated: 7

                                 Standard          T
  Parameter       Value          Error       Statistic
 -----------   -----------   ------------   -----------
           C    1.7635         0.39383          4.4778
      AR(1)    0.76564        0.0080525       95.0808
      AR(2)    -0.99708       0.0068798      -144.9293
      MA(1)    -0.53168       0.04944         -10.7540
      MA(2)    0.82849        0.037218         22.2604
      MA(3)    0.22339        0.048923         4.5663
          K    29.041         1.1733           24.7517

h_arch =

     0

fail to reject null of no arch effect
```



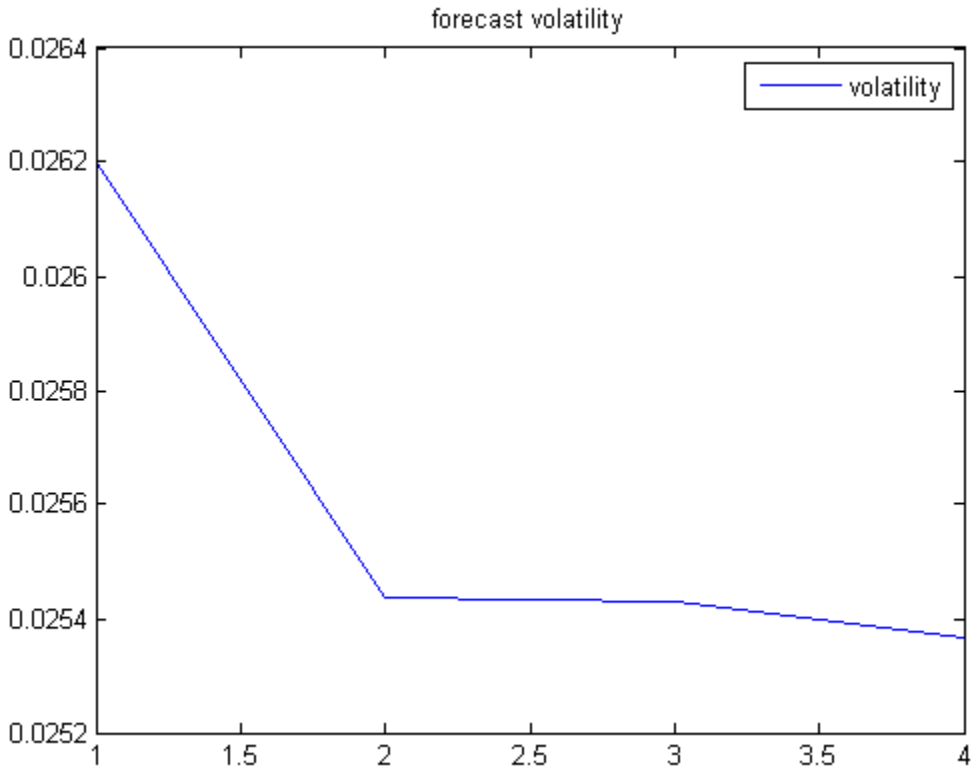
GARCH model

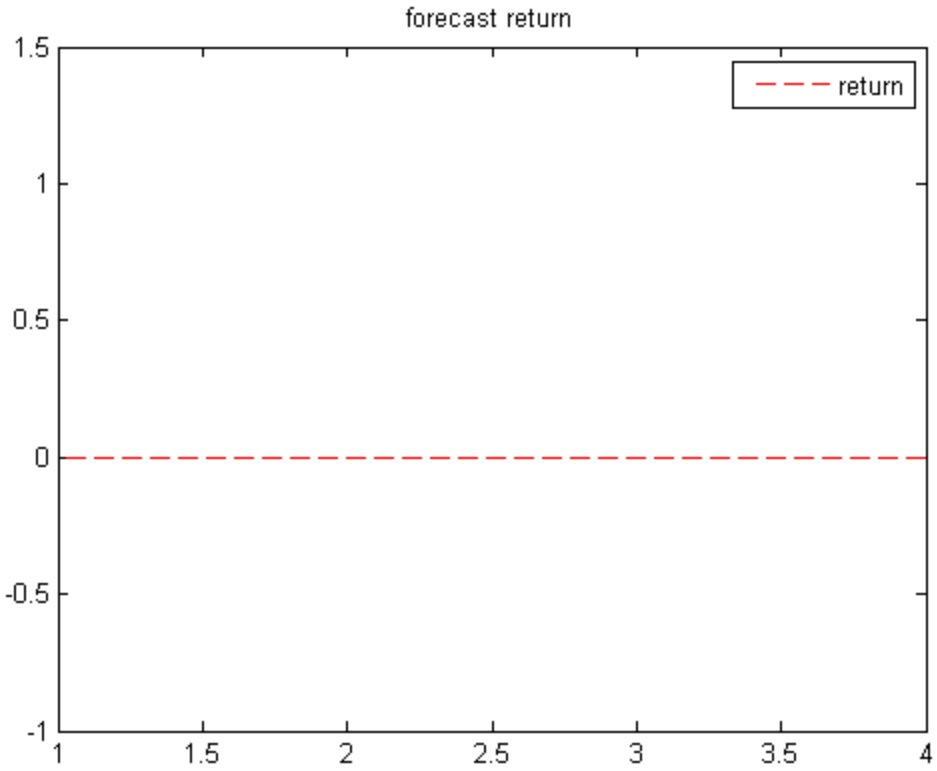
2.a

Mean: ARMAX(0,0,0); Variance: GARCH(1,2)

Conditional Probability Distribution: Gaussian
Number of Model Parameters Estimated: 5

Parameter	Value	Standard Error	T Statistic
C	0.00032358	0.00018583	1.7412
K	1.2906e-06	2.3361e-07	5.5248
GARCH(1)	0.90767	0.0093076	97.5194
ARCH(1)	0.012487	0.013844	0.9020
ARCH(2)	0.072915	0.015283	4.7709





2.b

ar5 garch(1,1)

2.b

Mean: ARMAX(5,0,0); Variance: GARCH(1,1)

Conditional Probability Distribution: T
Number of Model Parameters Estimated: 6

Parameter	Value	Standard Error	T Statistic
C	0	Fixed	Fixed
AR(1)	0	Fixed	Fixed
AR(2)	0	Fixed	Fixed
AR(3)	-0.010767	0.020159	-0.5341
AR(4)	0	Fixed	Fixed
AR(5)	-0.042019	0.020268	-2.0731
K	6.1291e-07	2.794e-07	2.1937
GARCH(1)	0.92806	0.0098329	94.3835
ARCH(1)	0.070814	0.0098912	7.1594
DoF	10.109	1.5831	6.3853

2.c

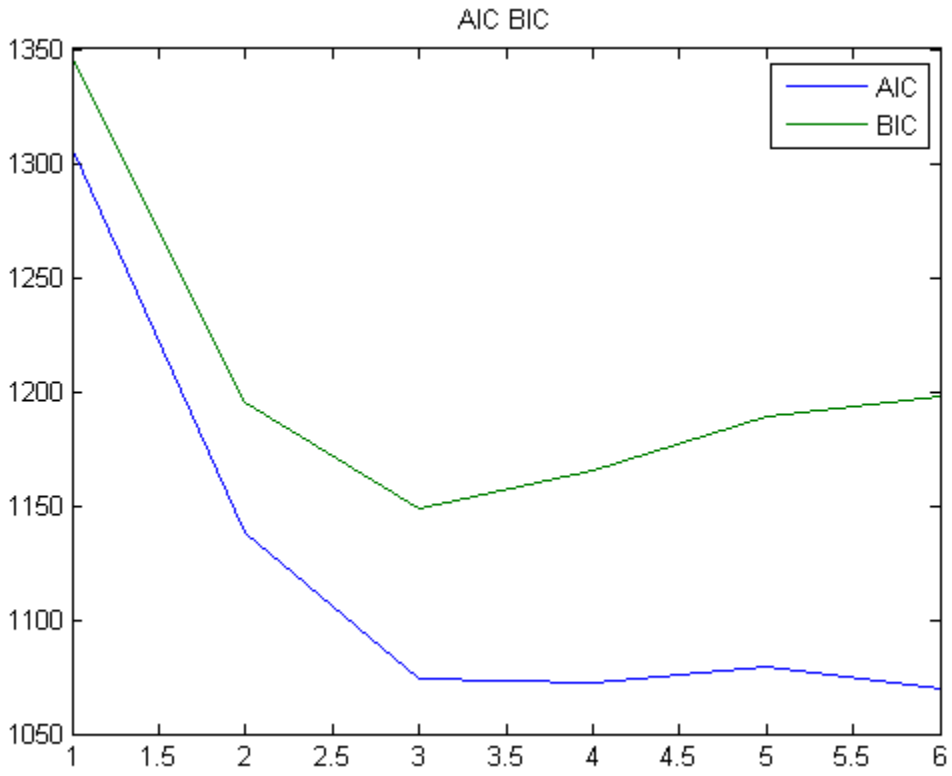
```
 Mean: ARMAX(2,0,0); Variance: EGARCH(0,2)

 Conditional Probability Distribution: Gaussian
 Number of Model Parameters Estimated: 8

                            Standard          T
 Parameter       Value        Error       Statistic
-----------   -----------   ------------   -----------
          C    -0.00060919    0.00052954      -1.1504
      AR(1)    0.046761       0.014681         3.1851
      AR(2)    -0.097694      0.012614        -7.7448
          K    -6.8778        0.027816      -247.2602
    ARCH(1)    0.5302         0.030395         17.4433
    ARCH(2)    0.6282         0.022719         27.6507
Leverage(1)    -0.023715      0.018974        -1.2499
Leverage(2)    -0.053014      0.01562         -3.3939

 Mean: ARMAX(2,0,0); Variance: EGARCH(0,2)

 Conditional Probability Distribution: Gaussian
 Number of Model Parameters Estimated: 6

                            Standard          T
 Parameter       Value        Error       Statistic
-----------   -----------   ------------   -----------
          C    -0.00026344    0.00049541      -0.5318
      AR(1)    0.045298       0.014269         3.1747
      AR(2)    -0.086127      0.012662        -6.8021
          K    -6.8767        0.027685      -248.3885
    ARCH(1)    0.53183        0.030605         17.3775
    ARCH(2)    0.62898        0.023389         26.8927
Leverage(1)    0              Fixed             Fixed
Leverage(2)    0              Fixed             Fixed

H_LR_2C =

     0
```

VAR model

3.a

```
 Model  : 2-D VAR(3) with Additive Constant
          Conditional mean is AR-stable and is MA-invertible
          Standard errors without DoF adjustment (maximum likelihood)
      Parameter          Value     Std. Error    t-Statistic
 -------------- -------------- -------------- --------------
```

a(1)	0.0637785	0.0450303	1.41635
a(2)	0.0787124	0.0377855	2.08314
AR(1)(1,1)	1.15919	0.109481	10.588
(1,2)	0.357914	0.129991	2.75338
(2,1)	0.01686	0.0918671	0.183526
(2,2)	1.40597	0.109077	12.8897
AR(2)(1,1)	-0.287219	0.162183	-1.77096
(1,2)	-0.506112	0.193168	-2.62007
(2,1)	0.0141312	0.136089	0.103838
(2,2)	-0.699753	0.162089	-4.31708
AR(3)(1,1)	0.110005	0.107288	1.02532
(1,2)	0.15471	0.12862	1.20284
(2,1)	0.00824625	0.0900263	0.0915982
(2,2)	0.244512	0.107927	2.26554
Q(1,1)	0.164541	0.00946044	17.3925
Q(2,1)	0		
Q(2,2)	0.115855	0.00666118	17.3925



3.b

```
Model  : 2-D VAR(3) with Additive Constant
         Conditional mean is AR-stable and is MA-invertible
         Standard errors without DoF adjustment (maximum likelihood)
     Parameter          Value     Std. Error    t-Statistic
-------------- -------------- -------------- --------------
          a(1)      0.0581032      0.0441289        1.31667
```

```
              a(2)      0.0508601       0.033019        1.54033
        AR(1)(1,1)        1.16257       0.108835        10.6819
             (1,2)         0.3542       0.129159        2.74235
             (2,1)              0
             (2,2)        1.42545      0.0391895        36.3733
        AR(2)(1,1)      -0.290487       0.161176       -1.8023
             (1,2)      -0.502106       0.191839       -2.61732
             (2,1)              0
             (2,2)      -0.680464      0.0640382       -10.6259
        AR(3)(1,1)       0.108677        0.10664         1.0191
             (1,2)       0.156257        0.12778        1.22287
             (2,1)              0
             (2,2)       0.246694      0.0392032         6.2927
            Q(1,1)       0.163088     0.00932315        17.4929
            Q(2,1)              0
            Q(2,2)       0.115253     0.00658856        17.4929

H_LR_VAR =

     0

the modified model
  Model  : 2-D VAR(3) with Additive Constant
           Conditional mean is AR-stable and is MA-invertible
           Standard errors without DoF adjustment (maximum likelihood)
       Parameter           Value     Std. Error    t-Statistic
  -------------- -------------- -------------- --------------
              a(1)      0.0581032      0.0441289        1.31667
              a(2)      0.0508601       0.033019        1.54033
        AR(1)(1,1)        1.16257       0.108835        10.6819
             (1,2)         0.3542       0.129159        2.74235
             (2,1)              0
             (2,2)        1.42545      0.0391895        36.3733
        AR(2)(1,1)      -0.290487       0.161176       -1.8023
             (1,2)      -0.502106       0.191839       -2.61732
             (2,1)              0
             (2,2)      -0.680464      0.0640382       -10.6259
        AR(3)(1,1)       0.108677        0.10664         1.0191
             (1,2)       0.156257        0.12778        1.22287
             (2,1)              0
             (2,2)       0.246694      0.0392032         6.2927
            Q(1,1)       0.163088     0.00932315        17.4929
            Q(2,1)              0
            Q(2,2)       0.115253     0.00658856        17.4929
```

3.c

change to MA

```
  Model  : 2-D VMA(6) with Additive Constant
           Conditional mean is AR-stable and is not MA-invertible
  a Constant:
         5.67353
```

```
       6.11358
MA(1) Moving Average Matrix:
       1.16257         0.3542
             0        1.42545
MA(2) Moving Average Matrix:
       1.06108       0.414572
             0        1.35145
MA(3) Moving Average Matrix:
       1.00455       0.298292
             0        1.20315
MA(4) Moving Average Matrix:
      0.985968       0.235174
             0        1.14707
MA(5) Moving Average Matrix:
      0.969763       0.245168
             0        1.14978
MA(6) Moving Average Matrix:
      0.950177       0.268432
             0        1.15523
Q Innovations Covariance:
      0.163088              0
             0       0.115253
```

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