Assignment 6
Guideline Solution

From the data set `Assignment 5-8.dta`:

Requirements:

1. Estimate Autoregressive Integrated Moving Average (ARIMA(p,d,q)) model for spot return (*rspot*) and future return (*rfuture*) – determine the most appropriated order for p, d, and q using SBIC given the maximum lag equals 5.

```
. *Define Variable y
.         g y = rspot
(1 missing value generated)

. *Specify order p d q
. forvalue d = 0(1)0 {
  2.  forvalue p = 1(1)5 {
  3.  forvalue q = 1(1)5 {
  4.          display "estimate arima`p'`d'`q'"
  5.          capture: quietly arima y, arima(`p',`d',`q') nolog
  6.          if _rc~=0 {
  7.          display "flatlog when pdq =" `p'`d'`q'
  8.          continue
  9.          }
 10.          estimates store arima`p'`d'`q'
 11.          display "arima`p'`d'`q' already estimated"
 12.  }
 13.  }
 14.  estimates table arima1`d'1 arima1`d'2 arima1`d'3 arima1`d'4 arima1`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 15.  estimates table arima2`d'1 arima2`d'2 arima2`d'3 arima2`d'4 arima2`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 16.  estimates table arima3`d'1 arima3`d'2 arima3`d'3 arima3`d'4 arima3`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 17.  estimates table arima4`d'1 arima4`d'2 arima4`d'3 arima4`d'4 arima4`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 18.  estimates table arima5`d'1 arima5`d'2 arima5`d'3 arima5`d'4 arima5`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 19.  }
estimate arima101
arima101 already estimated
estimate arima102
arima102 already estimated
estimate arima103
arima103 already estimated
estimate arima104
arima104 already estimated
estimate arima105
arima105 already estimated
estimate arima201
arima201 already estimated
estimate arima202
arima202 already estimated
estimate arima203
arima203 already estimated
estimate arima204
arima204 already estimated
estimate arima205
arima205 already estimated
estimate arima301
arima301 already estimated
estimate arima302
arima302 already estimated
estimate arima303
arima303 already estimated
estimate arima304
arima304 already estimated
estimate arima305
arima305 already estimated
```

```
estimate arima401
arima401 already estimated
estimate arima402
arima402 already estimated
estimate arima403
arima403 already estimated
estimate arima404
arima404 already estimated
estimate arima405
arima405 already estimated
estimate arima501
arima501 already estimated
estimate arima502
arima502 already estimated
estimate arima503
arima503 already estimated
estimate arima504
arima504 already estimated
estimate arima505
arima505 already estimated
```

Variable	arima101	arima102	arima103	arima104	arima105
y					
_cons	.00002358	.00002358	.00002358	.00002357	.0000236
ARMA					
ar					
L1.	-.39222121***	.42866768***	.65121793**	-.4418708	.19422255
ma					
L1.	.44515732***	-.38284317***	-.60570251**	.48778125	-.14853288
L2.		-.06805288***	-.0785457***	-.02952616	-.0578027**
L3.			.01541405	-.04117543	-.00879285
L4.				-.00216733	.00427518
L5.					-.02212732*
sigma					
_cons	.00178634***	.00178491***	.00178487***	.00178491***	.00178452***
Statistics					
aic	-75418.284	-75428.583	-75426.956	-75424.609	-75425.916
bic	-75390.497	-75393.85	-75385.276	-75375.982	-75370.342
ll	37713.142	37719.292	37719.478	37719.305	37720.958

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima201	arima202	arima203	arima204	arima205
y					
_cons	.00002357	.00002358	.00002357	.00002358	.00002357
ARMA					
ar					
L1.	.38018903***	.4428634***	-.29668626	.20849565	.63263472***
L2.	-.06525664***	.06485063	.18525538	.37776554	-.91731069***
ma					
L1.	-.33467542**	-.39715673***	.3426502	-.16260084	-.58710754***
L2.		-.13338401	-.22062902	-.43688009	.83965418***
L3.			-.0455461	-.02892354	.05476885***
L4.				.02145155	-.03409321***
L5.					-.03012065***
sigma					
_cons	.00178498***	.00178489***	.00178489***	.00178475***	.00178388***
Statistics					
aic	-75428.017	-75426.777	-75424.788	-75423.974	-75429.446
bic	-75393.283	-75385.096	-75376.161	-75368.4	-75366.925
ll	37719.008	37719.388	37719.394	37719.987	37723.723

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima301	arima302	arima303	arima304	arima305
y					
_cons	.00002358	.00002358	.00002358	.00002358	.00002358
ARMA					
ar					
L1.	.77437319***	.75391093	-.00931271	.11659349	.17008802
L2.	-.08500113***	-.07142142	.14076076	-.77533292***	-.75369599***
L3.	.02486609	.02349348	.27348399*	.50690923***	.56028712*
ma					
L1.	-.72875825***	-.70829213	.05444554	-.07071828	-.12430409
L2.		-.0126675	-.19087608	.72187978***	.69757843***
L3.			-.29968133**	-.48363964***	-.53414149*
L4.				-.06737484***	-.06847599***
L5.					.00392386
sigma					
_cons	.00178484***	.00178484***	.00178455***	.00178409***	.00178409***
Statistics					
aic	-75427.175	-75425.178	-75425.675	-75427.585	-75425.609
bic	-75385.495	-75376.55	-75370.101	-75365.064	-75356.141
ll	37719.588	37719.589	37720.837	37722.792	37722.804

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima401	arima402	arima403	arima404	arima405
y					
_cons	.00002358	.00002358	.00002358	.00002358	.00002358
ARMA					
ar					
L1.	.7666053*	.19158964	.11479526	.11582617	-.55025558
L2.	-.0847024***	.40155116	-.84422456***	-.75582354***	-.78564519***
L3.	.02504525	-.03039789	.47666348***	.51458285***	-.04871012
L4.	-.00097078	.02217215	-.06669164***	.01927272	.25153939
ma					
L1.	-.72097599*	-.14607877	-.06913672	-.07000046	.59631735
L2.		-.45952184	.79177357***	.70233001***	.76311658***
L3.			-.45297968***	-.49146562***	.03723265
L4.				-.08652975	-.30357175
L5.					-.04488519
sigma					
_cons	.00178484***	.0017848***	.00178412***	.00178409***	.00178406***
Statistics					
aic	-75425.181	-75423.574	-75427.294	-75425.598	-75423.821
bic	-75376.553	-75368	-75364.773	-75356.13	-75347.407
ll	37719.59	37719.787	37722.647	37722.799	37722.91

legend: * p<.1; ** p<.05; *** p<.01

Variable	arima501	arima502	arima503	arima504	arima505
y					
_cons	.00002358	.00002357	.00002357	.00002358	.00002357
ARMA					
ar					
L1.	.16545423	.27864543	.40337768	.45212007	.65262081
L2.	-.05696613**	-.38380203	-.81291959**	-.79726544***	-.84750045
L3.	-.00729372	.0132755	-.23210031	.79847234	.13436587
L4.	.00131373	-.01409715	-.01694377	-.14234401	-.03733553
L5.	-.02387488**	-.027723**	-.03800524	.02403092	.21196901
ma					
L1.	-.11967988	-.23291974	-.35773961	-.40627736	-.6073824
L2.		.32183897	.74635725**	.72752725***	.76923758
L3.			.27245433	-.75638633	-.08161162
L4.				.06670883	.00421319

```
         L5. |                                                                    -.24353795
-------------+----------------------------------------------------------------------------
sigma        |
       _cons |   .0017845***    .00178443***    .00178393***    .00178407***    .00178371***
-------------+----------------------------------------------------------------------------
Statistics   |
         aic | -75426.156      -75424.789      -75426.981       -75423.79      -75424.907
         bic | -75370.582      -75362.269      -75357.513      -75347.376      -75341.546
          ll |  37721.078       37721.395        37723.49       37722.895       37724.453
-------------------------------------------------------------------------------------------
                                                        legend: * p<.1; ** p<.05; *** p<.01

. drop y

. *Define variable y
.    g y = rfuture
(1 missing value generated)

. *Specify order p d q
. forvalue d = 0(1)0 {
  2.  forvalue p = 1(1)3 {
  3.  forvalue q = 1(1)3 {
  4.          display "estimate arima`p'`d'`q'"
  5.          capture: quietly arima y, arima(`p',`d',`q') nolog
  6.          if _rc~=0 {
  7.          display "flatlog when pdq =" `p'`d'`q'
  8.          continue
  9.          }
 10.          estimates store arima`p'`d'`q'
 11.          display "arima`p'`d'`q' already estimated"
 12.  }
 13.  }
 14.  estimates table arima1`d'1 arima1`d'2 arima1`d'3 arima1`d'4 arima1`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 15.  estimates table arima2`d'1 arima2`d'2 arima2`d'3 arima2`d'4 arima2`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 16.  estimates table arima3`d'1 arima3`d'2 arima3`d'3 arima3`d'4 arima3`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 17.  estimates table arima4`d'1 arima4`d'2 arima4`d'3 arima4`d'4 arima4`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 18.  estimates table arima5`d'1 arima5`d'2 arima5`d'3 arima5`d'4 arima5`d'5, star(0.1 0.05
0.01) stat(aic bic ll)
 19.  }
estimate arima101
arima101 already estimated
estimate arima102
arima102 already estimated
estimate arima103
arima103 already estimated
estimate arima201
arima201 already estimated
estimate arima202
arima202 already estimated
estimate arima203
arima203 already estimated
estimate arima301
arima301 already estimated
estimate arima302
arima302 already estimated
estimate arima303
arima303 already estimated

-------------------------------------------------------------------------------------------
    Variable |   arima101        arima102        arima103        arima104        arima105
-------------+-----------------------------------------------------------------------------
y            |
       _cons |  .00002616       .00002615       .00002616       .00002357        .0000236
-------------+-----------------------------------------------------------------------------
ARMA         |
          ar |
          L1. |  .57862596***     .1646139      -.99197304***    -.4418708       .19422255
             |
          ma |
          L1. | -.61250239***   -.19269514       .96410702***    .48778125      -.14853288
          L2. |                 -.03060977**    -.06339899***   -.02952616       -.0578027**
          L3. |                                 -.03780979***   -.04117543      -.00879285
          L4. |                                                 -.00216733       .00427518
```

```
         L5. |                                                                -.02212732*
-------------+------------------------------------------------------------------------------
sigma        |
       _cons |  .00205937***    .00205903***    .00205869***    .00178491***    .00178452***
-------------+------------------------------------------------------------------------------
Statistics   |
         aic | -73232.774      -73233.366      -73233.777      -75424.609      -75425.916
         bic | -73204.987      -73198.632      -73192.096      -75375.982      -75370.342
          ll |  36620.387       36621.683       36622.888       37719.305       37720.958
-------------------------------------------------------------------------------------------
                                                      legend: * p<.1; ** p<.05; *** p<.01

-------------------------------------------------------------------------------------------
    Variable |   arima201        arima202        arima203        arima204        arima205
-------------+-----------------------------------------------------------------------------
y            |
       _cons |  .00002615       .00002616       .00002616       .00002358       .00002357
-------------+-----------------------------------------------------------------------------
ARMA         |
          ar |
         L1. |   .1969293       .15226369      -.89430512***    .20849565       .63263472***
         L2. | -.02961053**     .01296948       .09704817       .37776554      -.91731069***
             |
          ma |
         L1. | -.22502128      -.18034762        .8665611***   -.16260084      -.58710754***
         L2. |                  -.0439096      -.15750986      -.43688009       .83965418***
         L3. |                                 -.03516485***   -.02892354       .05476885***
         L4. |                                                  .02145155      -.03409321***
         L5. |                                                                 -.03012065***
-------------+-----------------------------------------------------------------------------
sigma        |
       _cons |  .00205903***    .00205902***    .00205869***    .00178475***    .00178388***
-------------+-----------------------------------------------------------------------------
Statistics   |
         aic | -73233.346      -73231.368      -73231.866      -75423.974      -75429.446
         bic | -73198.612      -73189.687      -73183.239       -75368.4       -75366.925
          ll |  36621.673       36621.684       36622.933       37719.987       37723.723
-------------------------------------------------------------------------------------------
                                                      legend: * p<.1; ** p<.05; *** p<.01

-------------------------------------------------------------------------------------------
    Variable |   arima301        arima302        arima303        arima304        arima305
-------------+-----------------------------------------------------------------------------
y            |
       _cons |  .00002616       .00002616       .00002618       .00002358       .00002358
-------------+-----------------------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .43745093       -.8588441***   -.52730643***    .11659349       .17008802
         L2. | -.02300296       .09802834      -.40394239**    -.77533292***   -.75369599***
         L3. |  .00950901      -.03401356**      .5172721***    .50690923***    .56028712*
             |
          ma |
         L1. | -.46553637       .83106571***    .49689489***   -.07071828      -.12430409
         L2. |                 -.15724365        .3607837**     .72187978***    .69757843***
         L3. |                                 -.55348204***   -.48363964***   -.53414149*
         L4. |                                                 -.06737484***   -.06847599***
         L5. |                                                                  .00392386
-------------+-----------------------------------------------------------------------------
sigma        |
       _cons |  .00205902***    .00205869***     .0020583***    .00178409***    .00178409***
-------------+-----------------------------------------------------------------------------
Statistics   |
         aic | -73231.387      -73231.797      -73232.791      -75427.585      -75425.609
         bic | -73189.706       -73183.17      -73177.217      -75365.064      -75356.141
          ll |  36621.693       36622.898       36624.395       37722.792       37722.804
-------------------------------------------------------------------------------------------
                                                      legend: * p<.1; ** p<.05; *** p<.01

-------------------------------------------------------------------------------------------
    Variable |   arima401        arima402        arima403        arima404        arima405
-------------+-----------------------------------------------------------------------------
y            |
       _cons |  .00002358       .00002358       .00002358       .00002358       .00002358
-------------+-----------------------------------------------------------------------------
ARMA         |
          ar |
```

```
         L1. |   .7666053*      .19158964       .11479526       .11582617      -.55025558
         L2. |  -.0847024***     .40155116      -.84422456***   -.75582354***   -.78564519***
         L3. |  .02504525       -.03039789       .47666348***    .51458285***   -.04871012
         L4. | -.00097078        .02217215      -.06669164***    .01927272       .25153939
             |
          ma |
         L1. | -.72097599*      -.14607877      -.06913672      -.07000046       .59631735
         L2. |                  -.45952184       .79177357***    .70233001***    .76311658***
         L3. |                                  -.45297968***   -.49146562***    .03723265
         L4. |                                                  -.08652975      -.30357175
         L5. |                                                                  -.04488519
-------------+----------------------------------------------------------------------------
sigma        |
       _cons |  .00178484***     .0017848***     .00178412***    .00178409***    .00178406***
-------------+----------------------------------------------------------------------------
Statistics   |
         aic | -75425.181       -75423.574      -75427.294      -75425.598      -75423.821
         bic | -75376.553          -75368       -75364.773       -75356.13      -75347.407
          ll |   37719.59        37719.787        37722.647       37722.799        37722.91
------------------------------------------------------------------------------------------
                                                      legend: * p<.1; ** p<.05; *** p<.01

------------------------------------------------------------------------------------------
    Variable |   arima501        arima502        arima503        arima504        arima505
-------------+----------------------------------------------------------------------------
y            |
       _cons |  .00002358        .00002357       .00002357       .00002358       .00002357
-------------+----------------------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .16545423        .27864543       .40337768       .45212007       .65262081
         L2. | -.05696613**     -.38380203      -.81291959**    -.79726544***   -.84750045
         L3. | -.00729372         .0132755      -.23210031       .79847234       .13436587
         L4. |  .00131373       -.01409715      -.01694377      -.14234401      -.03733553
         L5. | -.02387488**       -.027723**    -.03800524       .02403092       .21196901
             |
          ma |
         L1. | -.11967988       -.23291974      -.35773961      -.40627736       -.6073824
         L2. |                   .32183897       .74635725**     .72752725***    .76923758
         L3. |                                   .27245433      -.75638633      -.08161162
         L4. |                                                   .06670883       .00421319
         L5. |                                                                  -.24353795
-------------+----------------------------------------------------------------------------
sigma        |
       _cons |   .0017845***     .00178443***    .00178393***    .00178407***    .00178371***
-------------+----------------------------------------------------------------------------
Statistics   |
         aic | -75426.156       -75424.789      -75426.981       -75423.79      -75424.907
         bic | -75370.582       -75362.269      -75357.513      -75347.376      -75341.546
          ll |  37721.078        37721.395        37723.49       37722.895       37724.453
------------------------------------------------------------------------------------------
                                                      legend: * p<.1; ** p<.05; *** p<.01

.
end of do-file
```

- ***The most appropriated order for rspot is ARIMA(1,0,2).***
- ***The most appropriated order for rfuture is ARIMA(4,0,1).***

2. Perform in-sample (both static and dynamic) forecast of the two series (sport return (*rspot*) and future return (*rfuture*), then, compute RMSE of each forecast.

```
. arima rspot, arima(1,0,2) nolog

ARIMA regression

Sample:  2 - 7684                               Number of obs     =       7683
                                                Wald chi2(3)      =     100.14
Log likelihood =  37719.29                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
       rspot |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
```

```
-------------+----------------------------------------------------------------
rspot        |
       _cons |   .0000236   .0000205     1.15   0.251    -.0000167    .0000639
-------------+----------------------------------------------------------------
ARMA         |
          ar |
         L1. |   .4286677     .14387     2.98   0.003     .1466877    .7106476
             |
          ma |
         L1. |  -.3828432   .1441239    -2.66   0.008    -.6653209   -.1003655
         L2. |  -.0680529   .0088279    -7.71   0.000    -.0853552   -.0507505
-------------+----------------------------------------------------------------
      /sigma |   .0017849   2.07e-06   861.95   0.000     .0017809     .001789
------------------------------------------------------------------------------
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

. predict rspothat, xb

. g erspot2=(rspot-rspothat)^2
(1 missing value generated)

. sum erspot2

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
     erspot2 |      7,683    3.19e-06    .0000348   1.61e-15   .0020963

. sca mse=r(mean)

. sca rmse_rspot=sqrt(mse)


. est restore arima401
(results arima401 are active now)

. predict rfuturehat, xb

. g erfuture2=(rfuture-rfuturehat)^2
(1 missing value generated)

. sum erfuture2

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
   erfuture2 |      7,683    4.24e-06    .0000388   2.01e-15   .0018415

. sca mse_rfuture=r(mean)

. sca rmse_rfuture=sqrt(mse_rfuture)

. sca list rmse_rspot rmse_rfuture
rmse_rspot =  .00178491
rmse_rfuture =  .00205901
```

- ***RMSE of rspot is* 0.00178.**
- ***RMSE of rfuture is* 0.00206.**

3. Perform out-sample three-period ahead (dynamic) forecast of the two series (sport return (*rspot*) and future return (*rfuture*).

```
. set obs 7687
number of observations (_N) was 7,684, now 7,687

. replace t=_n
(3 real changes made)

. tsset t
        time variable:  t, 1 to 7687
                delta:  1 unit

. est restore arima102
(results arima102 are active now)
```

```
. predict rspothat_d, y dynamic(.) t0(7685)
Note: beginning dynamic predictions in period        5.
(7,683 missing values generated)

. est restore arima401
(results arima401 are active now)

. predict rfuturehat_d, y dynamic(.) t0(7685)
Note: beginning dynamic predictions in period        7.
(7,683 missing values generated)
```