Assignment 6

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.

```
. g rspot = (spot/l.spot)-1
(1 missing value generated)

. g rfuture = (future/l.future)-1
(1 missing value generated)

. dfuller rspot, trend lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                                 ------------ Interpolated Dickey-Fuller ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)           -63.787            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.rspot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       rspot |
         L1. |  -1.005168   .0157581   -63.79   0.000    -1.036058   -.9742776
         LD. |   .0517018   .0113974     4.54   0.000     .0293598    .0740439
      _trend |   9.56e-10   9.19e-09     0.10   0.917    -1.71e-08    1.90e-08
       _cons |   .0000199   .0000408     0.49   0.626      -.00006    .0000998
------------------------------------------------------------------------------
```

The first step is to identify the order of ARIMA(p,d,q). To find the value of p, d, and q, we should firstly identify value of d by performing unit root test to find which order the series is integrated.

From the result, p-value = 0.0000, which is lower than 0.05, the null hypothesis of unit root is rejected. It means that return on spot is stationary.

```
. dfuller rfuture, trend lags(1) regress

Augmented Dickey-Fuller test for unit root         Number of obs   =      7681

                                 ------------ Interpolated Dickey-Fuller ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)           -65.070            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.rfuture |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      rfuture |
         L1. |  -1.063572   .0163449   -65.07   0.000    -1.095612   -1.031531
         LD. |     .03575   .0114053     3.13   0.002     .0133924    .0581076
      _trend |   1.17e-09   1.06e-08     0.11   0.912    -1.96e-08    2.19e-08
       _cons |   .0000231    .000047     0.49   0.624    -.0000691    .0001152
------------------------------------------------------------------------------
```

From the result, p-value = 0.0000, which is lower than 0.05, the null hypothesis of unit root is rejected. It means that return on future is stationary.

Next, we have to perform ARIMA. From the given maximum lag equals 5,we have to run

ARIMA (1,0,1) (2,0,1) (3,0,1) (4,0,1) (5,0,1)

(1,0,2) (2,0,2) (3,0,2) (4,0,2) (5,0,2)

(1,0,3) (2,0,3) (3,0,3) (4,0,3) (5,0,3)

(1,0,4) (2,0,4) (3,0,4) (4,0,4) (5,0,4)

(1,0,5) (2,0,5) (3,0,5) (4,0,5) (5,0,5)

rspot

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

. est store arima101

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

. est store arima102

. qui arima rspot, arima(1,0,3) nolog

. est store arima103

. qui arima rspot, arima(1,0,4) nolog

. est store arima104

. qui arima rspot, arima(1,0,5) nolog

. est store arima105

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

. est store arima201

. qui arima rspot, arima(2,0,2) nolog

. est store arima202

. qui arima rspot, arima(2,0,3) nolog

. est store arima203

. qui arima rspot, arima(2,0,4) nolog

. est store arima204

. qui arima rspot, arima(2,0,5) nolog

. est store arima205
```

```
. qui arima rspot, arima(3,0,1) nolog

. est store arima301

. qui arima rspot, arima(3,0,2) nolog

. est store arima302

. qui arima rspot, arima(3,0,3) nolog

. est store arima303

. qui arima rspot, arima(3,0,4) nolog

. est store arima304

. qui arima rspot, arima(3,0,5) nolog

. est store arima305

. qui arima rspot, arima(4,0,1) nolog

. est store arima401

. qui arima rspot, arima(4,0,2) nolog

. est store arima402

. qui arima rspot, arima(4,0,3) nolog

. est store arima403

. qui arima rspot, arima(4,0,4) nolog

. est store arima404

. qui arima rspot, arima(4,0,5) nolog

. est store arima405

. qui arima rspot, arima(5,0,1) nolog

. est store arima501

. qui arima rspot, arima(5,0,2) nolog

. est store arima502

. qui arima rspot, arima(5,0,3) nolog

. est store arima503

. qui arima rspot, arima(5,0,4) nolog

. est store arima504

. qui arima rspot, arima(5,0,5) nolog

. est store arima505
```

```
. est table arima10*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima101	arima102	arima103	arima104	arima105
rspot					
_cons	.00002358*	.00002358*	.00002358*	.00002357*	.0000236*
ARMA					
ar					
L1.	-.39222121***	.42866768***	.65121793**	-.44187083	.19422255
ma					
L1.	.44515732***	-.38284317***	-.60570251**	.48778128	-.14853288
L2.		-.06805288***	-.0785457***	-.02952615	-.0578027**
L3.			.01541405*	-.04117544	-.00879285
L4.				-.00216734	.00427518
L5.					-.02212732**
sigma					
_cons	.00178634***	.00178491***	.00178487***	.00178491***	.00178452***
Statistics					
N	7683	7683	7683	7683	7683
ll	37713.142	37719.292	37719.478	37719.305	37720.958
chi2	119.51861	100.14226	108.29283	133.21806	101.26927
aic	-75418.284	-75428.583	-75426.956	-75424.609	-75425.916
bic	-75390.497	-75393.85	-75385.276	-75375.982	-75370.342

legend: * p<.5; ** p<.1; *** p<.01

```
. . est table arima20*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima201	arima202	arima203	arima204	arima205
rspot					
_cons	.00002357*	.00002358*	.00002357*	.00002358*	.00002356*
ARMA					
ar					
L1.	.38018903***	.4428634***	-.29668626	.20849639	.63271495***
L2.	-.06525664***	.06485063	.18525538	.3777193*	-.9174531***
ma					
L1.	-.33467542**	-.39715673***	.3426502	-.16259964	-.58719207***
L2.		-.13338401*	-.22062902	-.4368354*	.83979784***
L3.			-.0455461	-.02891993	.05477838***
L4.				.02145033*	-.0341015***
L5.					-.03010547***
sigma					
_cons	.00178498***	.00178489***	.00178489***	.00178475***	.00178388***
Statistics					
N	7683	7683	7683	7683	7683
ll	37719.008	37719.388	37719.394	37719.987	37723.723
chi2	97.508642	100.31373	120.1281	104.88266	710.97147
aic	-75428.017	-75426.777	-75424.788	-75423.974	-75429.446
bic	-75393.283	-75385.096	-75376.161	-75368.4	-75366.925

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima30*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima301	arima302	arima303	arima304	arima305
rspot					
_cons	.00002358*	.00002358*	.00002358*	.00002358*	.00002358*
ARMA					
ar					
L1.	.77437319***	.75391093*	-.00931271	.11658227*	.1701239
L2.	-.08500113***	-.07142142	.14076076	-.77533773***	-.75368747***
L3.	.02486609*	.02349348	.27348399**	.50689845***	.56032548**
ma					
L1.	-.72875825***	-.70829213*	.05444554	-.07070647	-.12433777
L2.		-.0126675	-.19087608*	.72188531***	.69756857***
L3.			-.29968133**	-.48362803***	-.53417632**
L4.				-.06737448***	-.06847815***
L5.					.00392646
sigma					
_cons	.00178484***	.00178484***	.00178455***	.00178409***	.00178409***
Statistics					
N	7683	7683	7683	7683	7683
ll	37719.588	37719.589	37720.837	37722.792	37722.804
chi2	116.99403	115.5826	113.25114	10208.991	9995.0318
aic	-75427.175	-75425.178	-75425.675	-75427.585	-75425.609
bic	-75385.495	-75376.55	-75370.101	-75365.064	-75356.141

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima40*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima401	arima402	arima403	arima404	arima405
rspot					
_cons	.00002358*	.00002358*	.00002358*	.00002358*	.00002358*
ARMA					
ar					
L1.	.7666053**	.19158964	.11455665*	.11554831*	-.54927322
L2.	-.0847024***	.40155116	-.84432053***	-.7579017***	-.78567965***
L3.	.02504525*	-.03039789	.4764288***	.51349215***	-.04793383
L4.	-.00097078	.02217215*	-.06669135***	.01738201	.25111025
ma					
L1.	-.72097599**	-.14607877	-.0688967	-.0697206	.59533818
L2.		-.45952184	.79187066***	.70442344***	.76310459***
L3.			-.45274427***	-.49036213***	.03649951
L4.				-.08464192	-.30317115
L5.					-.04483284
sigma					
_cons	.00178484***	.0017848***	.00178412***	.00178409***	.00178407***
Statistics					
N	7683	7683	7683	7683	7683
ll	37719.59	37719.787	37722.647	37722.799	37722.91
chi2	116.13751	103.18568	9970.8895	10384.247	10621.886
aic	-75425.181	-75423.574	-75427.294	-75425.598	-75423.821
bic	-75376.553	-75368	-75364.773	-75356.131	-75347.407

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima50*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima501	arima502	arima503	arima504	arima505
rspot					
_cons	.00002358*	.00002357*	.00002356*	.00002358*	.00002357*
ARMA					
ar					
L1.	.16545423	.27864545	.40295474*	.45006125	.64948609*
L2.	-.05696613**	-.38380205*	-.81262761**	-.79649687***	-.844491*
L3.	-.00729372	.0132755	-.23254742	.79695972	.13043438
L4.	.00131372	-.01409715	-.01690687	-.14085523	-.03624586
L5.	-.02387488**	-.027723**	-.03802772*	.02389748	.21166048*
ma					
L1.	-.11967988	-.23291976	-.35731992*	-.40421962	-.60425085*
L2.		.32183899	.7460888**	.72684872***	.76637039*
L3.			.27286254	-.75498242	-.07798537
L4.				.06527172	.00341651
L5.					-.24345546*
sigma					
_cons	.0017845***	.00178443***	.00178393***	.00178407***	.00178371***
Statistics					
N	7683	7683	7683	7683	7683
ll	37721.078	37721.395	37723.49	37722.895	37724.453
chi2	102.58864	114.46132	754.18517	7125.4394	2753.0424
aic	-75426.156	-75424.789	-75426.981	-75423.79	-75424.907
bic	-75370.582	-75362.269	-75357.513	-75347.376	-75341.546

legend: * p<.5; ** p<.1; *** p<.01

From the result of SBIC , ARIMA(1,0,2) has the lowest value. So, ARIMA(1,0,2) is the most appropriated.

rfuture

```
. qui arima rfuture, arima(1,0,1) nolog

. est store arima101

. qui arima rfuture, arima(1,0,2) nolog

. est store arima102

. qui arima rfuture, arima(1,0,3) nolog

. est store arima103

. qui arima rfuture, arima(1,0,4) nolog

. est store arima104

. qui arima rfuture, arima(1,0,5) nolog

. est store arima105
```

```
. qui arima rfuture, arima(2,0,1) nolog

. est store arima201

. qui arima rfuture, arima(2,0,2) nolog

. est store arima202

. qui arima rfuture, arima(2,0,3) nolog

. est store arima203

. qui arima rfuture, arima(2,0,4) nolog

. est store arima204

. qui arima rfuture, arima(2,0,5) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
. est store arima205

. qui arima rfuture, arima(3,0,1) nolog

. est store arima301

. qui arima rfuture, arima(3,0,2) nolog

. est store arima302

. qui arima rfuture, arima(3,0,3) nolog

. est store arima303

. qui arima rfuture, arima(3,0,4) nolog

. est store arima304

. qui arima rfuture, arima(3,0,5) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
.
. est store arima305

. qui arima rfuture, arima(4,0,1) nolog

. est store arima401

. qui arima rfuture, arima(4,0,2) nolog

. est store arima402

. qui arima rfuture, arima(4,0,3) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
.
. est store arima403

. qui arima rfuture, arima(4,0,4) nolog

. est store arima404

. qui arima rfuture, arima(4,0,5) nolog

. est store arima405
```

```
. qui arima rfuture, arima(5,0,1) nolog

. est store arima501

. qui arima rfuture, arima(5,0,2) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
.
. est store arima502

. qui arima rfuture, arima(5,0,3) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
.
. est store arima503

. qui arima rfuture, arima(5,0,4) nolog

. est store arima504

. qui arima rfuture, arima(5,0,5) nolog

. est store arima505

. est table arima10*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima101	arima102	arima103	arima104	arima105
rfuture					
_cons	.00002616*	.00002615*	.00002616*	.00002616*	.00002616*
ARMA					
ar					
L1.	.57862596***	.1646139*	-.99197447***	.79841544	-.18361821
ma					
L1.	-.61250239***	-.19269514*	.96410656***	-.82650053	.15556594
L2.		-.03060977**	-.06340407***	-.01279972	-.04031228*
L3.			-.03781316***	.02245519	-.01199443
L4.				.00291512	-.00091534
L5.					-.00688194
sigma					
_cons	.00205937***	.00205903***	.00205869***	.00205902***	.00205897***
Statistics					
N	7683	7683	7683	7683	7683
ll	36620.387	36621.683	36622.888	36621.711	36621.87
chi2	81.753207	31.061825	22854.409	198.49394	20.219307
aic	-73232.774	-73233.366	-73233.777	-73229.421	-73227.74
bic	-73204.987	-73198.632	-73192.096	-73180.794	-73172.166

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima20*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima201	arima202	arima203	arima204	arima205
rfuture					
_cons	.00002615*	.00002616*	.00002616*	.00002616*	
ARMA					
ar					
L1.	.1969293*	.15226368	-.89465216***	-.21191276	
L2.	-.02961053**	.01296947	.09670737	.7739461*	
ma					
L1.	-.22502128*	-.18034761	.86690892***	.18414572	
L2.		-.04390959	-.15716989*	-.81541951*	
L3.			-.03516526***	.0087431	
L4.				.02645814*	
sigma					
_cons	.00205903***	.00205902***	.00205868***	.00205865***	
_					
__000001					
L1.					-.20330359*
L2.					-.26517311*
__000002					
L1.					.1763371*
L2.					.22465735*
L3.					-.01997915*
L4.					-.01071388*
L5.					-.00857039*
Statistics					
N	7683	7683	7683	7683	7647
ll	36621.673	36621.684	36622.933	36622.979	36449.918
chi2	31.861358	30.829039	19162.658	7252.7011	
aic	-73233.346	-73231.368	-73231.866	-73229.957	-72885.836
bic	-73198.612	-73189.687	-73183.239	-73174.383	-72837.241

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima30*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima301	arima302	arima303	arima304	arima305
rfuture					
_cons	.00002616*	.00002616*	.00002616*	.00002616*	
ARMA					
ar					
L1.	.43719971	-.85909988***	-.52747572***	-.82736723***	
L2.	-.02300883*	.09775979	-.40407854**	-.74587198***	
L3.	.00949671	-.03402297**	.51713482***	.23650853*	
ma					
L1.	-.46528441	.83132969***	.4970627***	.80029577***	
L2.		-.15697594*	.36091826**	.68901778***	
L3.			-.55335106***	-.29264193*	
L4.				-.025065*	
sigma					
_cons	.00205902***	.00205869***	.00205828***	.00205707***	
_					
__000001					
L1.					-.18924579*
L2.					-.24847615*
L3.					.11181123
__000002					
L1.					.16231046
L2.					.20835636*
L3.					-.13083923
L4.					-.00698344
L5.					-.00455255
Statistics					
N	7683	7683	7683	7683	7647
ll	36621.693	36622.898	36624.395	36628.568	36450.025
chi2	52.845219	16988.837	3955.2326	1315798.4	
aic	-73231.387	-73231.797	-73232.791	-73239.136	-72884.051
bic	-73189.706	-73183.17	-73177.217	-73176.615	-72828.514

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima40*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima401	arima402	arima403	arima404	arima405
rfuture					
_cons	.00002615*	.00002616*		.00002616*	.00002616*
ARMA					
ar					
L1.	.76058435*	-.25527038		-1.0425111*	-1.8573076***
L2.	-.01390815	.71171913*		-.79921724**	-1.6443249***
L3.	.02101897	.00567706		.17857969	-.58098208*
L4.	.00315781	.02457106*		.1386749	.19738539*
ma					
L1.	-.78867414*	.22752078		1.014861*	1.8305835***
L2.		-.75436369*		.73536519**	1.5600418***
L3.				-.24349783*	.46380195*
L4.				-.16638352	-.28342558*
L5.					-.02886948**
sigma					
_cons	.00205902***	.00205868***		.00205819***	.00205674***
_					
__000001					
L1.			-.18517822*		
L2.			-.23095887*		
L3.			.15772674*		
L4.			-.00484301		
__000002					
L1.			.15784926		
L2.			.19096724*		
L3.			-.17612485*		
Statistics					
N	7683	7683	7649	7683	7683
ll	36621.713	36622.973	36459.436	36624.797	36629.763
chi2	166.77546	7255.7719		6825.9109	1522945.7
aic	-73229.427	-73229.946	-72904.872	-73229.594	-73237.526
bic	-73180.799	-73174.372	-72856.276	-73160.126	-73161.112

legend: * p<.5; ** p<.1; *** p<.01

```
. est table arima50*,star(0.1 0.5 0.01) stat(N ll chi2 aic bic)
```

Variable	arima501	arima502	arima503	arima504	arima505
rfuture					
_cons	.00002616*			.00002615*	.00002616*
ARMA					
ar					
L1.	-.17881777			-1.2088095***	-.79758143***
L2.	-.04028792*			-1.1649322***	-1.5288687***
L3.	-.01301738			-.75929455**	-.09243149
L4.	-.00282876			.15079556	-.23653186*
L5.	-.00826276*			-.03135393**	.52788065***
ma					
L1.	.15074717			1.1813416***	.76659346***
L2.				1.0976641***	1.4784826***
L3.				.6778281**	.01626756
L4.				-.21960633*	.1865648*
L5.					-.56308807***
sigma					
_cons	.00205896***			.00205707***	.00205767***
_					
__000001					
L1.		-.20262924*	-.19167923*		
L2.		-.25266835*	-.24450765*		
L3.		-.01930101*	.11301221		
L4.		-.01061853*	-.00665161		
L5.		-.00920511*	-.00441732		
__000002					
L1.		.17526386*	.16433907*		
L2.		.21217017*	.20433355*		
L3.			-.13201063		
Statistics					
N	7683	7650	7649	7683	7683
ll	36621.909	36462.282	36459.482	36626.203	36626.651
chi2	20.150745			1.266e+08	200769.26
aic	-73227.818	-72910.563	-72902.965	-73230.405	-73229.302
bic	-73172.244	-72861.966	-72847.426	-73153.991	-73145.941

legend: * p<.5; ** p<.1; *** p<.01

From the result of SBIC, ARIMA(1,0,1) has the lowest value. So, ARIMA(1,0,1) is the most appropriated.

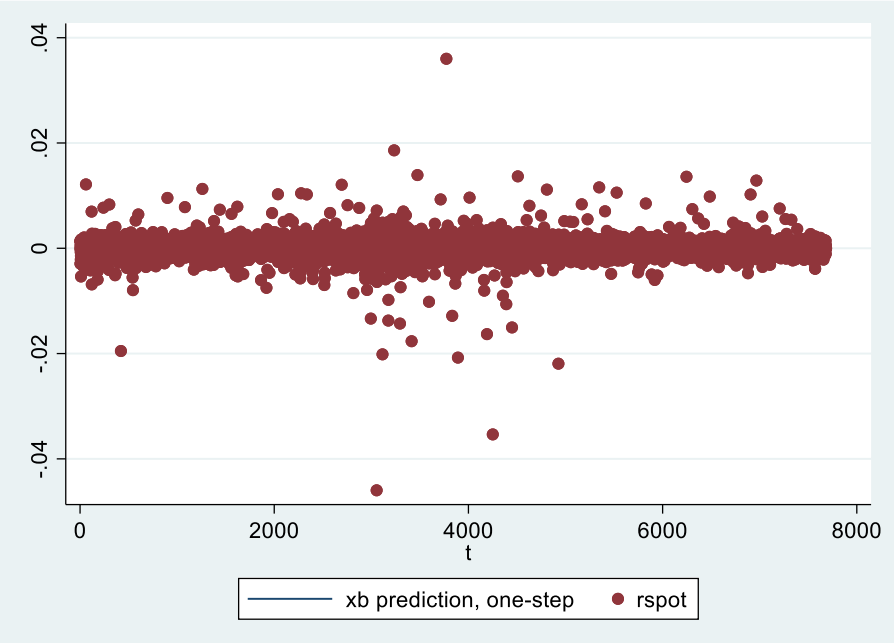
2. Perform in-sample (both static and dynamic) forecast of the two series (sport return(rspot) and future return (rfuture), then, compute RMSE of each forecast.

rspot

```
. 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
```

rspot	Coef.	OPG 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_s, xb
.  twoway (line rspothat_s t, sort) (scatter rspot t, sort)
```



```
. g fe_spot=rspot-rspothat_s

. g sfe=fe^2

. sum sfe if t>=2
```

RMSE of static forecast

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

```
. 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
```

rspot	Coef.	OPG 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_d, y dynamic(.)
Note: beginning dynamic predictions in period        5.

. g dfe=rspot-rspothat_d if t<7685
(1 missing value generated)

. g sdfe=dfe^2
(1 missing value generated)
```

RMSE of dynamic forecast

```
. sum sdfe
```

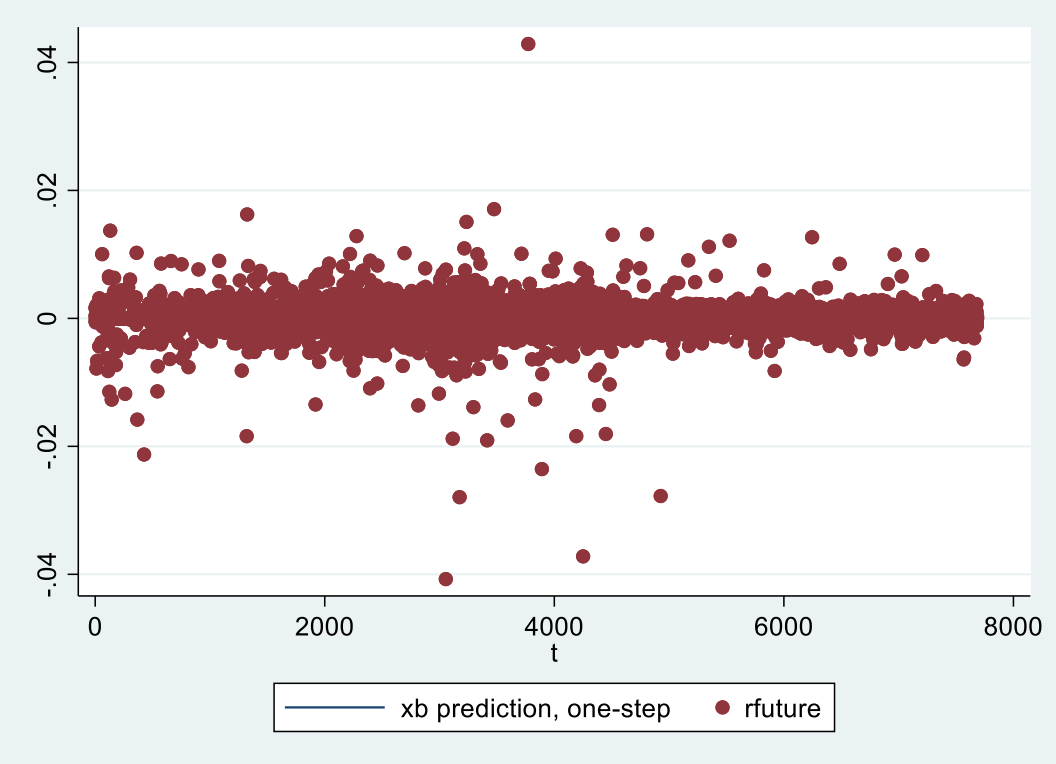
Variable	Obs	Mean	Std. Dev.	Min	Max
sdfe	7,683	3.20e-06	.000035	8.09e-12	.0021155

rfuture

```
. arima rfuture, arima(1,0,1) nolog

ARIMA regression

Sample:  2 - 7684                               Number of obs     =       7683
                                                Wald chi2(2)      =      81.75
Log likelihood =  36620.39                      Prob > chi2       =     0.0000
```

rfuture	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
rfuture						
_cons	.0000262	.0000221	1.18	0.237	-.0000172	.0000695
ARMA						
ar L1.	.578626	.142571	4.06	0.000	.299192	.8580599
ma L1.	-.6125024	.1373304	-4.46	0.000	-.881665	-.3433398
/sigma	.0020594	2.64e-06	779.58	0.000	.0020542	.0020645

```
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

. predict rfuturehat_s, xb

. twoway (line rfuturehat_s t, sort) (scatter rfuture t,sort)
```



```
. g fe_future=rfuture-rfuturehat_s
(1 missing value generated)

. g sfe_future=fe_future^2
(1 missing value generated)

. sum sfe_future if t>=2 // static forecast
```

RMSE of static forecast

Variable	Obs	Mean	Std. Dev.	Min	Max
sfe_future	7,683	4.24e-06	.0000388	1.12e-17	.0018431

```
. arima rfuture, arima(1,0,1) nolog

ARIMA regression

Sample:  2 - 7684                               Number of obs     =       7683
                                                Wald chi2(2)      =      81.75
Log likelihood =  36620.39                      Prob > chi2       =     0.0000
```

rfuture	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
rfuture						
_cons	.0000262	.0000221	1.18	0.237	-.0000172	.0000695
ARMA						
ar L1.	.578626	.142571	4.06	0.000	.299192	.8580599
ma L1.	-.6125024	.1373304	-4.46	0.000	-.881665	-.3433398
/sigma	.0020594	2.64e-06	779.58	0.000	.0020542	.0020645

```
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

. predict rfuturehat_d, y dynamic(.)
Note: beginning dynamic predictions in period       4.

. g dfe_future=rfuture-rfuturehat_d
(1 missing value generated)

. g sdfe_future=dfe_future^2
(1 missing value generated)

. sum sdfe_future if t<7685 // dynamic forecast
```

RMSE of dynamic forecast

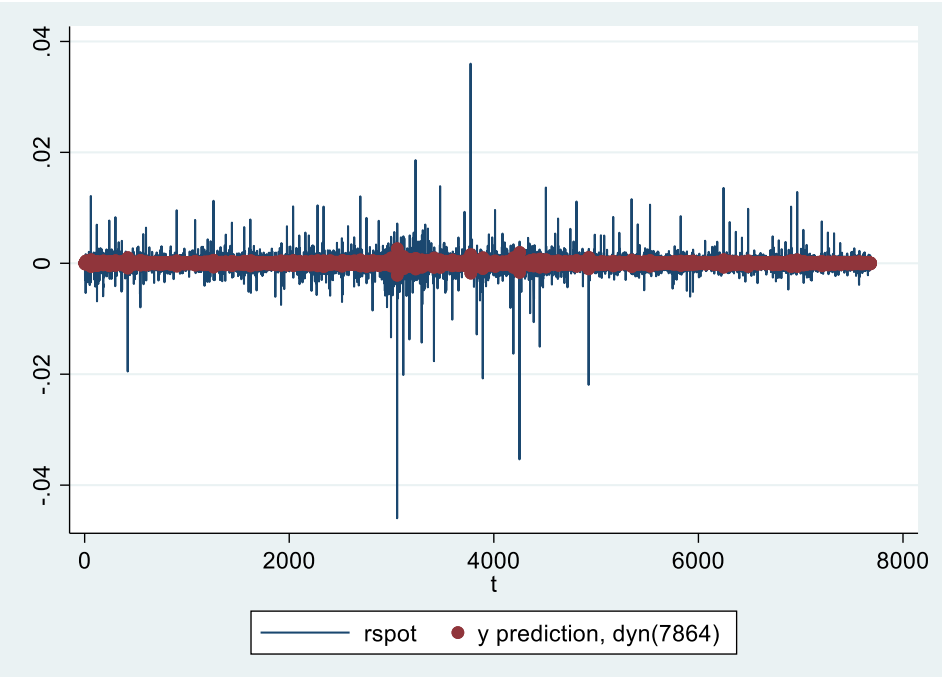
Variable	Obs	Mean	Std. Dev.	Min	Max
sdfe_future	7,683	4.25e-06	.0000388	1.19e-10	.0018373

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

```
. 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
```

rspot	Coef.	OPG 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, y dynamic(7864)

. twoway (line rspot t, sort) (scatter rspothat t,sort)
```



```
. arima rfuture, arima(1,0,1) nolog

ARIMA regression

Sample:  2 - 7684                               Number of obs     =       7683
                                                Wald chi2(2)      =      81.75
Log likelihood =  36620.39                      Prob > chi2       =     0.0000
```

rfuture	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
rfuture						
_cons	.0000262	.0000221	1.18	0.237	-.0000172	.0000695
ARMA						
ar L1.	.578626	.142571	4.06	0.000	.299192	.8580599
ma L1.	-.6125024	.1373304	-4.46	0.000	-.881665	-.3433398
/sigma	.0020594	2.64e-06	779.58	0.000	.0020542	.0020645

```
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

. predict rfuturehat, y dynamic(7864)

. twoway (line rfuture t, sort) (scatter rfuturehat t,sort)
```