1. Estimate ARIMA(p,d,q)

For Spot Series,

Variable	arimars101	arimars102	arimars103	arimars104	arimars105
rspot					
_cons	.00002358	.00002358	.00002358	.00002357	.0000236
ARMA					
ar					
L1.	-.39222121***	.42866768***	.65121793**	-.4419119	.19422255
ma					
L1.	.44515732***	-.38284317***	-.60570251**	.48782136	-.14853288
L2.		-.06805288***	-.0785457***	-.02952572	-.0578027**
L3.			.01541405	-.04117649	-.00879285
L4.				-.00216661	.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	133.22283	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<.1; ** p<.05; *** p<.01

Variable	arimars201	arimars202	arimars203	arimars204	arimars205
rspot					
_cons	.00002357	.00002358	.00002357	.00002358	.00002356
ARMA					
ar					
L1.	.38018903***	.4428634***	-.29668626	.20852054	.63265257***
L2.	-.06525664***	.06485063	.18525538	.37775134	-.9173871***
ma					
L1.	-.33467542**	-.39715673***	.3426502	-.16262337	-.58712918***
L2.		-.13338401	-.22062902	-.43686733	.83973716***
L3.			-.0455461	-.02892213	.05477111***
L4.				.02144947	-.0340934***
L5.					-.03011077***
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	104.89138	709.67885
aic	-75428.017	-75426.777	-75424.788	-75423.974	-75429.446
bic	**-75393.283**	-75385.096	-75376.161	-75368.4	-75366.925

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

Variable	arimars301	arimars302	arimars303	arimars304	arimars305
rspot					
_cons	.00002358	.00002358	.00002358	.00002358	.00002358
ARMA					

ar					
L1.	.77437319***	.75391093	-.00931271	.11656704	.17034276
L2.	-.08500113***	-.07142142	.14076076	-.77534242***	-.75360361***
L3.	.02486609	.02349348	.27348399*	.50688547***	.56054909*
ma					
L1.	-.72875825***	-.70829213	.05444554	-.07069015	-.12455802
L2.		-.0126675	-.19087608	.72188937***	.69747322***
L3.			-.29968133**	-.48361496***	-.53438921*
L4.				-.06737523***	-.06848303***
L5.					.00394329
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	10209.973	10000.556
aic	-75427.175	-75425.178	-75425.675	-75427.585	-75425.609
bic	**-75385.495**	-75376.55	-75370.101	-75365.064	-75356.141

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

Variable	arimars401	arimars402	arimars403	arimars404	arimars405
rspot					
_cons	.00002358	.00002358	.00002358	.00002358	.00002358
ARMA					
ar					
L1.	.7666053*	.19158964	.11523364	.1151415	-.5504427
L2.	-.0847024***	.40155116	-.84406727***	-.75782372***	-.78379155***
L3.	.02504525	-.03039789	.47709053***	.51318794***	-.04809472
L4.	-.00097078	.02217215	-.06670122***	.01762523	.25343204
ma					
L1.	-.72097599*	-.14607877	-.06957553	-.06931375	.59650556
L2.		-.45952184	.79160824***	.70434889***	.76129286***
L3.			-.45340835***	-.49005879***	.03653616
L4.				-.08488067	-.30545878
L5.					-.04497466
sigma					
_cons	.00178484***	.0017848***	.00178413***	.00178409***	.00178406***
Statistics					
N	7683	7683	7683	7683	7683
ll	37719.59	37719.787	37722.647	37722.799	37722.91
chi2	116.13751	103.18568	9964.4835	10386.995	10614.78
aic	-75425.181	-75423.574	-75427.294	-75425.598	-75423.821
bic	**-75376.553**	-75368	-75364.773	-75356.131	-75347.406

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

Variable	arimars501	arimars502	arimars503	arimars504	arimars505
rspot					
_cons	.00002358	.00002357	.00002356	.00002359	.00002357
ARMA					
ar					
L1.	.16545423	.27864543	.40276891	.4522115	.65322307
L2.	-.05696613**	-.38380203	-.8125169**	-.79741755***	-.84851364
L3.	-.00729372	.0132755	-.23274748	.79847751	.135421
L4.	.00131373	-.01409715	-.01688907	-.14253218	-.03798813
L5.	-.02387488**	-.027723**	-.03803901	.02403776	.2119602

```
          ma |
         L1. | -.11967988      -.23291974      -.35713416      -.40636659      -.60798872
         L2. |                  .32183897       .74598779**      .7276743***     .77021616
         L3. |                                  .27304521      -.75638256      -.08258281
         L4. |                                                  .06689307       .00478413
         L5. |                                                                  -.24346584
-------------+------------------------------------------------------------------------------
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       754.49844       7095.4758       2756.6385
         aic | -75426.156      -75424.789      -75426.981       -75423.79      -75424.907
         bic | -75370.582      -75362.269      -75357.513      -75347.376      -75341.546
------------------------------------------------------------------------------------------
                                                    legend: * p<.1; ** p<.05; *** p<.01
```

The model ARIMA(1,0,2) has the lowst BIC(-75393.85). Therefore, the most appropriated model for spot return is ARIMA(1,0,2).

For Future Series,

```
------------------------------------------------------------------------------------------
    Variable |   arimaf101       arimaf102       arimaf103       arimaf104       arimaf105
-------------+----------------------------------------------------------------------------
rfuture      |
       _cons |  .00002616       .00002615       .00002616       .00002616       .00002616
-------------+----------------------------------------------------------------------------
ARMA         |
          ar |
         L1. |  .57862596***     .1646139      -.99197396***     .7969672      -.18361821
             |
          ma |
         L1. | -.61250239***   -.19269514       .96410749***   -.82504953       .15556594
         L2. |                 -.03060977**    -.06340384***   -.01284081      -.04031228
         L3. |                                 -.03781399***    .02240475      -.01199443
         L4. |                                                  .00290008      -.00091534
         L5. |                                                                 -.00688194
-------------+----------------------------------------------------------------------------
sigma        |
       _cons |  .00205937***    .00205903***    .00205869***    .00205901***    .00205897***
-------------+----------------------------------------------------------------------------
Statistics   |
           N |       7683            7683            7683            7683            7683
          ll |  36620.387       36621.683       36622.888       36621.711        36621.87
        chi2 |  81.753207       31.061825       22845.807       196.93459       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<.1; ** p<.05; *** p<.01

------------------------------------------------------------------------
    Variable |   arimaf201       arimaf202       arimaf203       arimaf204
-------------+----------------------------------------------------------
rfuture      |
       _cons |  .00002615       .00002616       .00002615       .00002616
-------------+----------------------------------------------------------
ARMA         |
          ar |
         L1. |   .1969293       .15226368      -.89486565***   -.21249116
         L2. | -.02961053**     .01296947       .09649512       .77335544
             |
          ma |
         L1. | -.22502128      -.18034762       .86712136***    .18471269
         L2. |                 -.04390959      -.15696342       -.814853
         L3. |                                 -.03516964***    .00871263
         L4. |                                                  .0264409
```

sigma				
_cons	.00205903***	.00205902***	.00205869***	.00205868***
Statistics				
N	7683	7683	7683	7683
ll	36621.673	36621.684	36622.933	36622.979
chi2	31.861358	30.829039	19166.908	7241.8566
aic	-73233.346	-73231.368	-73231.866	-73229.957
bic	**-73198.612**	-73189.687	-73183.239	-73174.383

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

Variable	arimaf301	arimaf302	arimaf303	arimaf304
rfuture				
_cons	.00002615	.00002616	.00002616	.00002616
ARMA				
ar				
L1.	.43723766	-.85962639***	-.52740176***	-.83422394***
L2.	-.02300598	.09722315	-.40401367**	-.75316796***
L3.	.00949808	-.03403703***	.51718986***	.2296664
ma				
L1.	-.46532123	.83183829***	.49699427***	.80715267***
L2.		-.15647239	.36085732**	.6960639***
L3.			-.55339935***	-.2860842
L4.				-.02533183*
sigma				
_cons	.00205901***	.00205869***	.00205829***	.00205707***
Statistics				
N	7683	7683	7683	7683
ll	36621.693	36622.898	36624.395	36628.568
chi2	52.844319	16992.278	3952.7769	1327865.3
aic	-73231.387	-73231.797	-73232.791	-73239.135
bic	**-73189.706**	-73183.17	-73177.217	-73176.615

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

Variable	arimaf401	arimaf402	arimaf403	arimaf404
rfuture				
_cons	.00002616	.00002616	.00002619	.00002616
ARMA				
ar				
L1.	.76071201	-.25409204	-.18936941**	-1.0431113
L2.	-.01390611	.71291982	-.93574833***	-.7992043**
L3.	.02102091	.0057631	.21211369**	.17869513
L4.	.00316275	.0246218	-.02826146**	.13931101
ma				
L1.	-.78880185	.2263405	.16146457	1.015465
L2.		-.75552764	.8962194	.73534439*
L3.			-.25137844	-.24363018
L4.				-.16703558
sigma				
_cons	.00205902***	.00205867***	.00205766**	.00205817***
Statistics				
N	7683	7683	7683	7683
ll	36621.713	36622.973	36624.996	36624.797
chi2	166.90558	7243.9202	5.226e+08	6824.9136
aic	-73229.427	-73229.946	-73231.992	-73229.594

```
        bic | -73180.799      -73174.372      -73169.471      -73160.126
------------------------------------------------------------------------------
                                     legend: * p<.1; ** p<.05; *** p<.01
```

Variable	arima501	arima504	arima505
y			
_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***
Statistics			
N	7683	7683	7683
ll	36621.909	36626.203	36626.651
chi2	20.150745	1.266e+08	200769.26
aic	-73227.818	-73230.405	-73229.302
bic	**-73172.244**	-73153.991	-73145.941

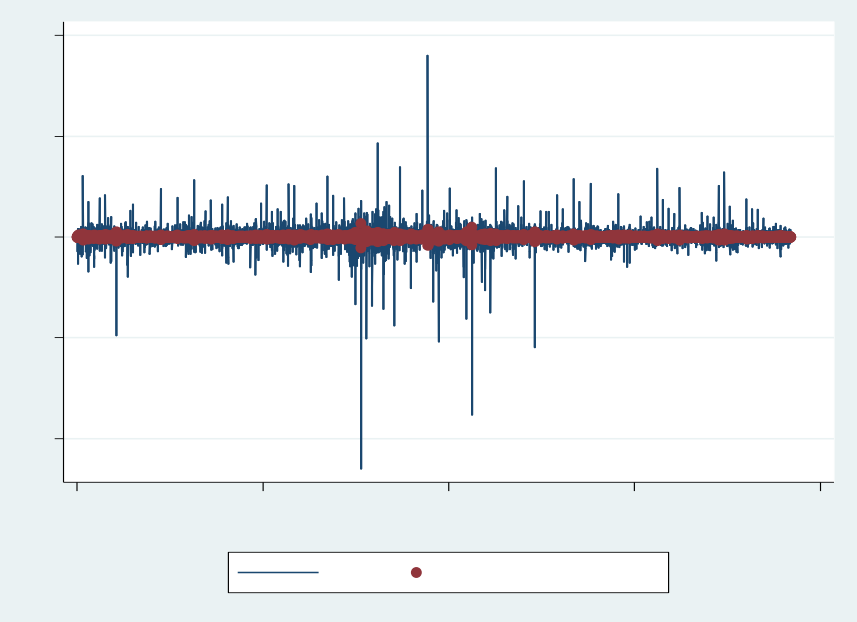
legend: * p<.1; ** p<.05; *** p<.01

The model ARIMA(1,0,1) has the lowest BIC(-73204.987). Therefore, the most appropriated model for future return is ARIMA(1,0,1).

2. Perform in-sample forecast and compute RMSE of each forecast

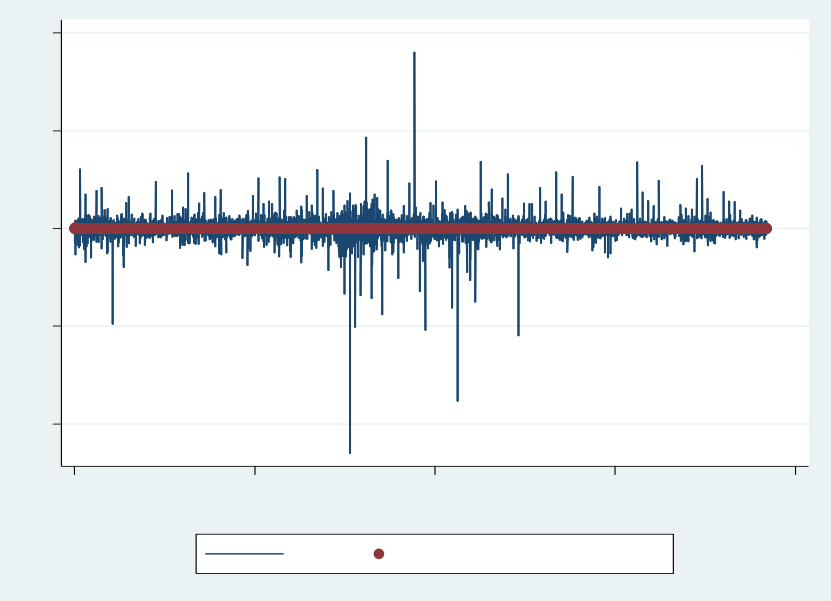
For Spot Series static,

RMSE = sqrt(.0244773/7684) = 0.001785



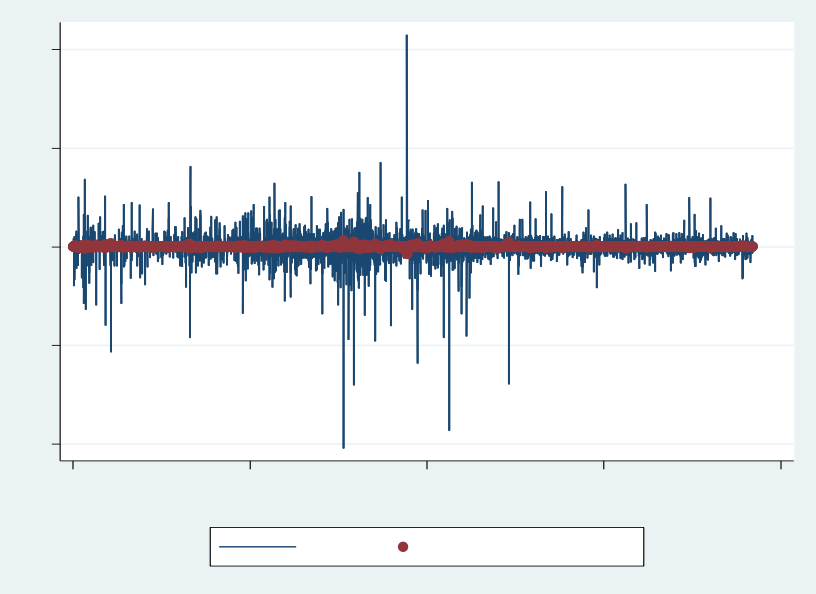
For Spot Series dynamic,

RMSE = sqrt(.02459747/7684) = 0.001789



For Future Series static,

RMSE = sqrt(.03258357/7684) = 0.002059

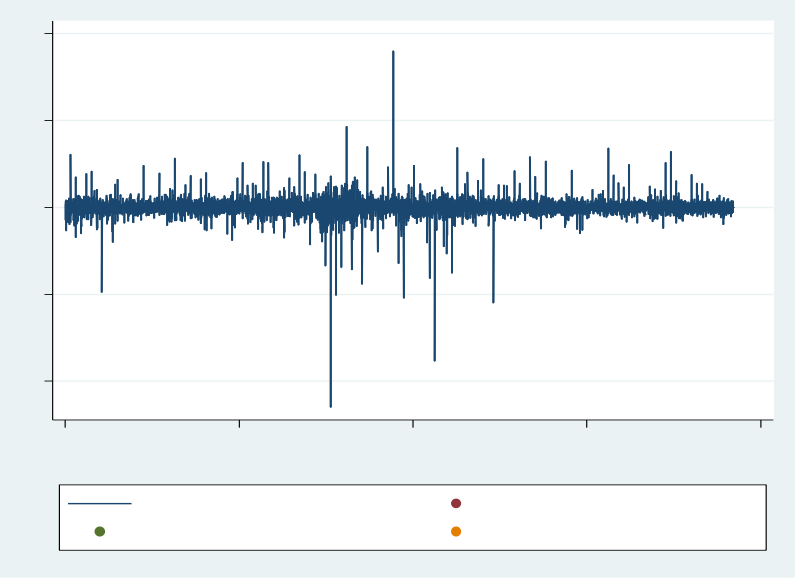


For Future Series dynamic,

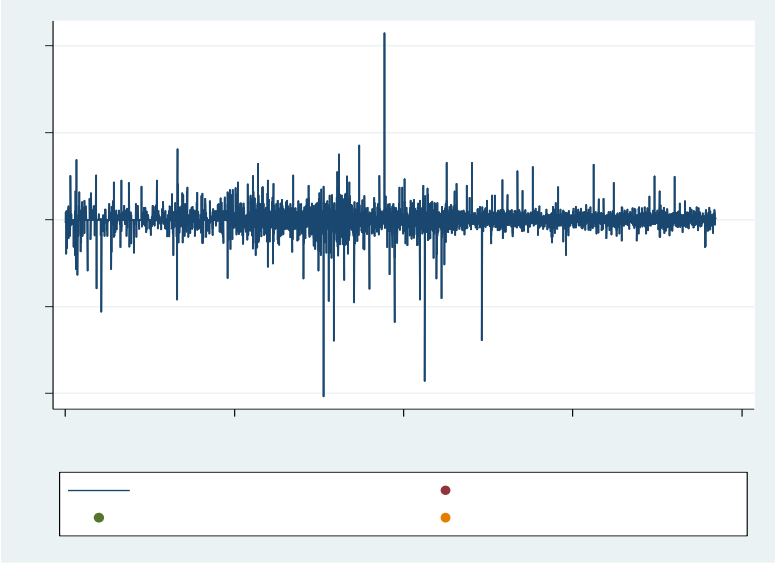
RMSE = sqrt(.03263977/7684) = 0.002061

3. Perform 3 out-sample dynamic forecast

For Spot Series dynamic,



For Future Series dynamic,



Code

```
tsset t

g rspot = (spot/l.spot) - 1

g rfuture = (future/l.future) - 1

*==================================================

dfuller rspot, trend lag(1) regress

dfuller rfuture, trend lag(1) regress

*================================================== 1st question rspot

forvalue i=1(1)5 {

      qui arima rspot, arima(1,0,`i') nolog

      est store arimars10`i'

}

forvalue i=1(1)5 {
```

```
	qui arima rspot, arima(2,0,`i') nolog
	est store arimars20`i'
}
forvalue i=1(1)5 {
	qui arima rspot, arima(3,0,`i') nolog
	est store arimars30`i'
}
forvalue i=1(1)5 {
	qui arima rspot, arima(4,0,`i') nolog
	est store arimars40`i'
}
forvalue i=1(1)5 {
	qui arima rspot, arima(5,0,`i') nolog
	est store arimars50`i'
}
forvalue j=1(1)5 {
	est table arimars`j'0*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
}
*================================================ 1st question rfuture
forvalue i=1(1)5 {
	qui arima rfuture, arima(1,0,`i') nolog
	est store arimaf10`i'
}
forvalue i=1(1)5 {
	qui arima rfuture, arima(2,0,`i') nolog
	est store arimaf20`i'
}
forvalue i=1(1)5 {
```

```
	qui arima rfuture, arima(3,0,`i') nolog
	est store arimaf30`i'
}
forvalue i=1(1)4 {
	qui arima rfuture, arima(4,0,`i') nolog
	est store arimaf40`i'
}
forvalue i=1(1)4 {
	qui arima rfuture, arima(5,0,`i') nolog
	est store arimaf50`i'
}
forvalue j=1(1)5 {
	est table arimaf`j'0*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
}
*================================================= 2nd question
**================================================= 2nd question rspot static forecast
arima rspot, arima(1,0,2) nolog
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
dis r(sum)
**================================================= 2nd question rspot dynamic forecast
arima rspot, arima(1,0,2) nolog
predict rspothat_d, y dynamic(.)
twoway (line rspot t, sort) (scatter rspothat_d t, sort)
```

```
g dfe=rspot-rspothat_d if t<7685

g sdfe=dfe^2

sum sdfe

dis r(sum)

**================================================== 2nd question rfuture
static forecast

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

predict rfuturehat_s, xb

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

g fe_future=rfuture-rfuturehat_s

g sfe_future=fe_future^2

sum sfe_future if t>=2

dis r(sum)

**================================================== 2nd question rspot
dynamic forecast

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

predict rfuturehat_d, y dynamic(.)

g dfe_future=rfuture-rfuturehat_d

g sdfe_future=dfe_future^2

sum sdfe_future if t<7685

dis r(sum)

*================================================== 3rd question

**================================================== 3rd question rspot
dynamic forecast

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

predict rspothat, y dynamic(.) t0(7684)

predict rspothat2, y dynamic(.) t0(7685)

predict rspothat3, y dynamic(.) t0(7686)

predict rspothat4, y dynamic(.) t0(7687)
```

```
twoway (line rspot t, sort) (scatter rspothat2 rspothat3 rspothat4 t, sort)

**================================================ 3rd question rspot
dynamic forecast

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

predict rfuturehat, y dynamic(.) t0(7684)

predict rfuturehat2, y dynamic(.) t0(7685)

predict rfuturehat3, y dynamic(.) t0(7686)

predict rfuturehat4, y dynamic(.) t0(7687)

twoway (line rfuture t, sort) (scatter rfuturehat2 rfuturehat3 rfuturehat4 t,
sort)

*********
```