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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.

At the first place, we generate return for spot and future. Then, we test the unit root test.

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

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

dfuller rspot, trend lags(1) regress

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

For spot series,

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

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

        estimate store arimars10`i'

}

forvalue i=1(1)5{

        qui arima rspot, arima (2,0,`i') nolog

        estimate store arimars20`i'

}

forvalue i=1(1)5{

        qui arima rspot, arima (3,0,`i') nolog

        estimate store arimars30`i'

}

forvalue i=1(1)5{

        qui arima rspot, arima (4,0,`i') nolog
```

```
        estimate store arimars40`i'
}
forvalue i=1(1)5{
        qui arima rspot, arima (5,0,`i') nolog
        estimate store arimars50`i'
}
est table arimars10*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimars10*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimars10*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimars10*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
```

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 most appropriated model for the spot return is ARIMA (1,0,2) since it has the lowest value of BIC which is -75393.85.

For future series,

```
forvalue i=1(1)5{
        qui arima rfuture, arima (1,0,`i') nolog
        estimate store arimarf10`i'
}

forvalue i=1(1)5{
        qui arima rfuture, arima (2,0,`i') nolog
        estimate store arimarf20`i'
}

forvalue i=1(1)5{
        qui arima rfuture, arima (3,0,`i') nolog
```

```
        estimate store arimarf30`i'
}

forvalue i=1(1)5{
        qui arima rfuture, arima (4,0,`i') nolog
        estimate store arimarf40`i'
}

forvalue i=1(1)5{
        qui arima rfuture, arima (5,0,`i') nolog
        estimate store arimarf50`i'
}

est table arimarf10*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimarf20*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimarf30*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimarf40*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
est table arimarf50*, star (0.1 0.5 0.01) stat (N ll chi2 bic)
```

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
```

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

The most appropriated model for future return is ARIMA (1,0,1) since it has the lowest value of BIC which is -73204.987.

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.
   Static forecast

For spot series with static forecast, RMSE = sqrt(.0244773/7684) = 0.001785

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

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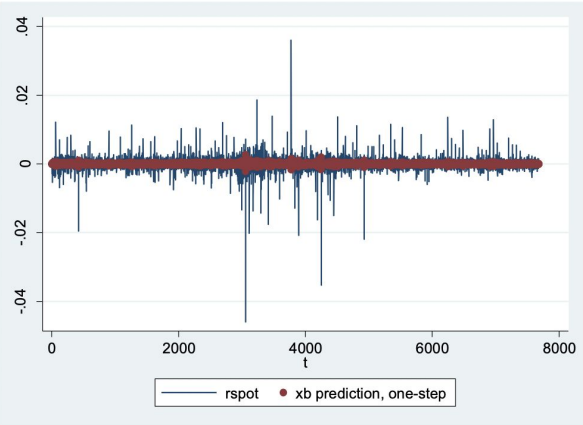
g sfe=fe^2

sum sfe

dis r(sum)



For spot series with dynamic forecast, RMSE = sqrt(.02459747/7684) = 0.001789

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

predict rspothat_d, y dynamic(.)

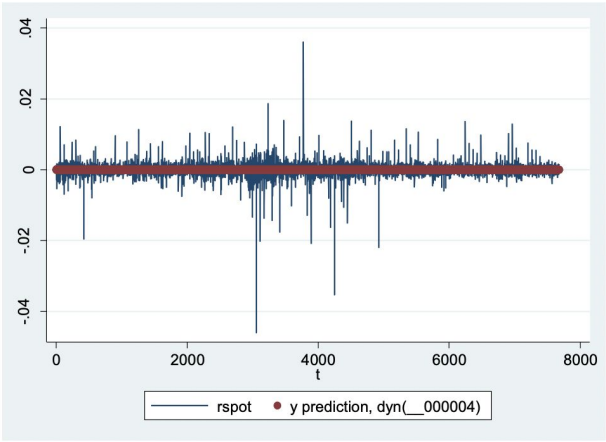
twoway (line rspot t, sort) (scatter rspothat_d t, sort)

g dfe=rspot-rspothat_d if t<7685

g sdfe=dfe^2

sum sdfe

dis r(sum)



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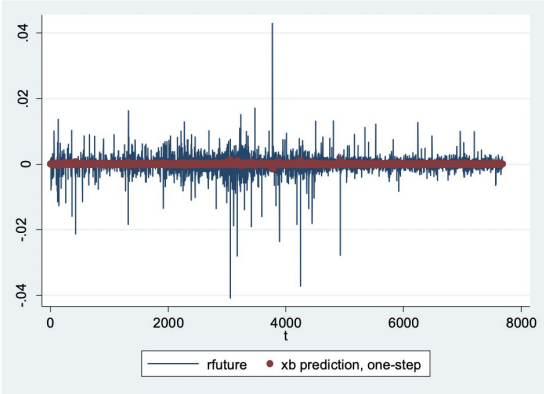
For future series with static forecast, RMSE = sqrt(.03258357/7684) = 0.002059

```
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)
```



For future series with dynamic forecast, RMSE = sqrt(.03263977/7684) = 0.002061

```
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)
```

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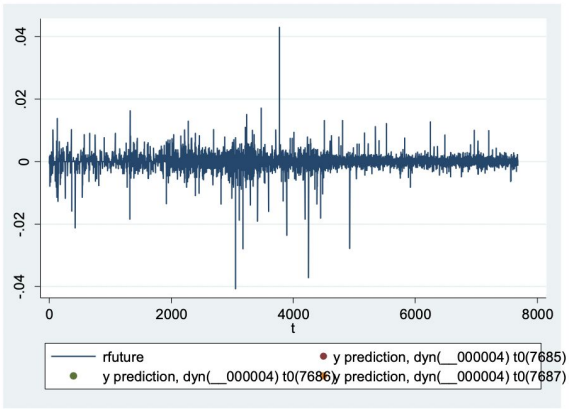


3. Perform out-sample three-period ahead (dynamic) forecast of the two series (sport return (*rspot*) and future return (*rfuture*).

For a three-period ahead dynamic forecast of spot return,

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

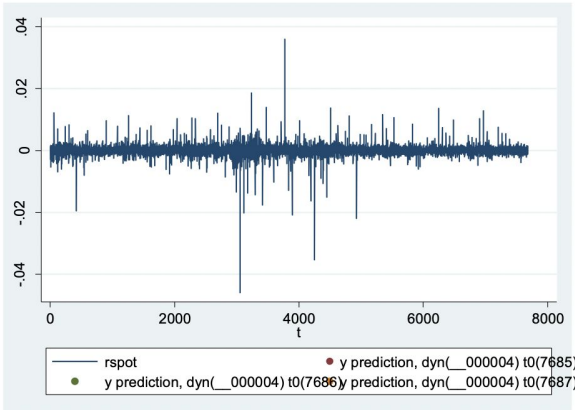
predict rspothat, rspot dynamic(.) t0(7684)

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

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

predict rspothat4, rspot dynamic(.) t0(7687)

twoway (line rspot t, sort) (scatter rspothat3 t, sort)



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For a three-period dynamic forecast of future return,

```
arima rfuture, arima(1,0,1) nolog
predict rfuturehat, rfuture dynamic(.) t0(7684)
predict rfuturehat2, rfuture dynamic(.) t0(7685)
predict rfuturehat3, rfuture dynamic(.) t0(7686)
predict rfuturehat4, rspot dynamic(.) t0(7687)
twoway (line rspot t, sort) (scatter rfuturehat3 t, sort)
```