

## Assignment 14

### ARIMA & GARCH Models

From the data set `assign_timeseries.dta`:

#### Part I

1. Estimate Autoregressive Integrated Moving Average (ARIMA(p,d,q)) model for spot and future – determine the most appropriated order for p, d, and q using SBIC given the maximum lag equals 4.
2. Make dynamic forecast for period time = 796 to 800.

#### Part II

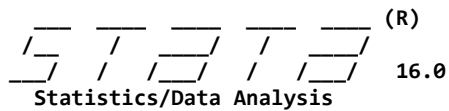
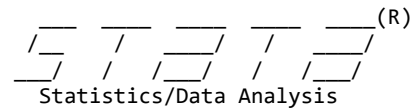
The following GARCH model:

Mean Equation: 
$$rfuture_t = \alpha + \beta rspot_t + \varepsilon_t \quad (1)$$

Variance Equation: 
$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^p \delta_j \sigma_{t-j}^2 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 \quad (2)$$

3. Estimate model (1) using OLS by employing future return (rfuture) as dependent variable and spot return (rspot) as explanatory variable, and determine whether ARCH-effect significantly occurs.
4. Estimate GARCH(p,q) for future return (rfuture) using spot return (rspot) as explanatory variable for mean equation (model (1) and (2)) – determine the most appropriated order p and q for variance equation using SBIC given the maximum lag equals to 2.
5. From (6), predict the variance of future return (rfuture).

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*MP - Parallel Edition*

16.0

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Notes:

1. Unicode is supported; see [help unicode advice](#).
2. More than 2 billion observations are allowed; see [help obs advice](#).
3. Maximum number of variables is set to 5000; see [help set maxvar](#).

```
1 . log using "C:\Users\A\Desktop\426\426.a14.smcl"
```

---

```
name: <unnamed>  
log: C:\Users\A\Desktop\426\426.a14.smcl  
log type: smcl  
opened on: 4 May 2021, 02:13:02
```

```
2 . use "C:\Users\A\Downloads\assign_timeseries (1).dta"
```

```
3 . tsset time  
time variable: time, 1 to 795  
delta: 1 unit
```

```
4 . qui arima y, arima(1,1,1) nolog  
variable y not found  
r(111);
```

```
5 . gen y = spot
```

```
6 . qui arima y, arima(1,1,1) nolog
```

```
7 . est store arima111
```

```
8 . qui arima y, arima(1,1,2) nolog
```

```
9 . est store arima112
```

```
10 . qui arima y, arima(1,1,3) nolog
```

```
11 . est store arima113
```

```
12 . qui arima y, arima(1,1,4) nolog
```

```

13 . est store arima114
14 . qui arima y, arima(2,1,1) nolog
15 . est store arima211
16 . qui arima y, arima(2,1,2) nolog
17 . est store arima212
18 . qui arima y, arima(2,1,3) nolog
19 . est store arima213
20 . qui arima y, arima(2,1,4) nolog
21 . est store arima214
22 . qui arima y, arima(3,1,1) nolog
23 . est store arima311
24 . qui arima y, arima(3,1,2) nolog
25 . est store arima312
26 . qui arima y, arima(3,1,3) nolog
27 . est store arima313
28 . qui arima y, arima(3,1,4) nolog
29 . est store arima314
30 . qui arima y, arima(4,1,1) nolog
31 . est store arima411
32 . qui arima y, arima(4,1,2) nolog
33 . est store arima412
34 . qui arima y, arima(4,1,3) nolog
35 . est store arima413
36 . qui arima y, arima(4,1,4) nolog
37 . est store arima414
38 . est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

```

Variable	arima111	arima112	arima113	arima114
<b>y</b>				
_cons	<b>-.10471744</b>	<b>-.10468155</b>	<b>-.10474014</b>	<b>-.10717398</b>
<b>ARMA</b>				
ar				
L1.	<b>.43536547*</b>	<b>.32884791</b>	<b>-.21609401</b>	<b>.59490084</b>
ma				
L1.	<b>-.35351081</b>	<b>-.25287121</b>	<b>.29330109</b>	<b>-.52209152</b>
L2.		<b>.02661686</b>	<b>.06275321</b>	<b>-.00167449</b>

L3.			.07084457**	.03360908
L4.				-.07201064*
sigma				
_cons	8.1399985***	8.1383248***	8.1283318***	8.1204174***
Statistics				
N	794	794	794	794
ll	-2791.4965	-2791.3458	-2790.3816	-2789.5823
chi2	18.312657	16.97941	13.218602	28.319443
bic	5609.7013	5616.077	5620.8258	5625.9042
aic	5590.993	5592.6915	5592.7633	5593.1646

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

39 . est table arima21\*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

Variable	arima211	arima212	arima213	arima214
y				
_cons	-.10453586	-.10767543	-.10609456	-.10747347
ARMA				
ar				
L1.	.30210361	1.3247307***	.46523894***	1.3085163***
L2.	.02452891	-.92390999***	-.83397031***	-.92906275***
ma				
L1.	-.22494448	-1.3022249***	-.39216993***	-1.2433923***
L2.		.94779741***	.82697929***	.88679293***
L3.			.09595475***	.05677728
L4.				.00003472
sigma				
_cons	8.1387104***	8.077039***	8.1149358***	8.0663508***
Statistics				
N	794	794	794	794
ll	-2791.3835	-2785.5252	-2789.1057	-2784.5179
chi2	16.085901	3656.4673	241.72156	4791.7037
bic	5616.1525	5611.1129	5624.9509	5622.4524
aic	5592.7671	5583.0504	5592.2113	5585.0358

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

40 . est table arima31\*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

Variable	arima311	arima312	arima313	arima314
y				
_cons	-.10486338	-.10606429	-.10806841	-.10765207
ARMA				
ar				
L1.	-.56058829	.56814277***	.66749387**	.58444954
L2.	.08569307*	-.89762851***	-.06995188	.02671133
L3.	.06374492**	.09752318***	-.59846871*	-.67269654
ma				
L1.	.63856195	-.49161072***	-.61040004*	-.51894361
L2.		.88783712***	.0556601	-.035013
L3.			.65798111**	.71899187
L4.				.02307553

arima (1,1,1)  
has lowest  
bic  
so it's most  
appropriated

<b>sigma</b>				
_cons	<b>8.1302906***</b>	<b>8.1136284***</b>	<b>8.0655263***</b>	<b>8.0640794***</b>
<b>Statistics</b>				
N	794	794	794	794
ll	-2790.5308	-2788.9397	-2784.4054	-2784.2793
chi2	21.334447	289.47777	1722.9017	1770.3818
bic	5621.1242	5624.6189	5622.2274	5628.6524
aic	5593.0617	5591.8793	5584.8108	5586.5587

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

41 . est table arima41\*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

Variable	arima411	arima412	arima413	arima414
<b>y</b>				
_cons	<b>-.10781888</b>	<b>-.10736741</b>	<b>-.10798992</b>	<b>-.10783286</b>
<b>ARMA</b>				
ar				
L1.	<b>.6019371*</b>	<b>1.3677375***</b>	<b>.61532081</b>	<b>.8379873</b>
L2.	<b>-.00196743</b>	<b>-1.0093777***</b>	<b>.00952804</b>	<b>-.12990838</b>
L3.	<b>.02357655</b>	<b>.05752757</b>	<b>-.6765738</b>	<b>-.67732522</b>
L4.	<b>-.074501**</b>	<b>-.00157964</b>	<b>.02303935</b>	<b>.1696285</b>
ma				
L1.	<b>-.52565375</b>	<b>-1.3026568***</b>	<b>-.54893042</b>	<b>-.77060667</b>
L2.		<b>.96445075***</b>	<b>-.01956286</b>	<b>.10759475</b>
L3.			<b>.72228244</b>	<b>.72452578</b>
L4.				<b>-.15673595</b>
<b>sigma</b>				
_cons	<b>8.1178063***</b>	<b>8.0663819***</b>	<b>8.0637584***</b>	<b>8.0632846***</b>
<b>Statistics</b>				
N	794	794	794	794
ll	-2789.3297	-2784.5185	-2784.2686	-2784.2263
chi2	30.742143	5309.2623	1879.1703	2712.7298
bic	5625.399	5622.4537	5628.6309	5635.2234
aic	5592.6594	5585.037	5586.5371	5588.4525

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

42 . drop y

43 . gen y = future

44 . qui arima y, arima(1,1,1) nolog

45 . est store arima111

```
46 . qui arima y, arima(1,1,2) nolog
47 . est store arima112
48 . qui arima y, arima(1,1,3) nolog
49 . est store arima113
50 . qui arima y, arima(1,1,4) nolog
51 . est store arima114
52 . qui arima y, arima(2,1,1) nolog
53 . est store arima211
54 . qui arima y, arima(2,1,2) nolog
55 . est store arima212
56 . qui arima y, arima(2,1,3) nolog
57 . est store arima213
58 . qui arima y, arima(2,1,4) nolog
59 . est store arima214
60 . qui arima y, arima(3,1,1) nolog
61 . est store arima311
62 . qui arima y, arima(3,1,2) nolog
63 . est store arima312
64 . qui arima y, arima(3,1,3) nolog
65 . est store arima313
66 . qui arima y, arima(3,1,4) nolog
67 . est store arima314
68 . qui arima y, arima(4,1,1) nolog
69 . est store arima411
70 . qui arima y, arima(4,1,2) nolog
71 . est store arima412
72 . qui arima y, arima(4,1,3) nolog
```

```
73 . est store arima413
74 . qui arima y, arima(4,1,4) nolog
75 . est store arima414
76 . est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)
```

*most  
lowest ; appropriate*

Variable	arima111	arima112	arima113	arima114
<b>y</b>				
_cons	-.11424575	-.11408115	-.1139183	-.11370744
<b>ARMA</b>				
ar				
L1.	-.36850497	.30224152	.07471074	-.26441554
ma				
L1.	.33119538	-.33885872	-.11128313	.23060131
L2.		.04456173	.0345267	.02935071
L3.			.03319847	.04074154
L4.				.03843721
<b>sigma</b>				
_cons	9.5427695***	9.5390832***	9.5360585***	9.532552***
<b>Statistics</b>				
N	794	794	794	794
ll	-2917.724	-2917.4236	-2917.166	-2916.8767
chi2	3.3320137	3.4714053	5.5726249	7.6343946
bic	5862.1563	5868.2327	5874.3946	5880.493
aic	5843.4479	5844.8473	5846.3321	5847.7535

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

```
77 . est table arima21*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)
```

Variable	arima211	arima212	arima213	arima214
<b>y</b>				
_cons	-.11399264	-.11488781	-.11518755	-.114745
<b>ARMA</b>				
ar				
L1.	.26006773	1.2835738***	.39680958***	.29779715***
L2.	.03927244	-.90739116***	-.83492246***	-.89274399***
ma				
L1.	-.29537225	-1.2846762***	-.43709178***	-.33588403***
L2.		.95025686***	.86844397***	.9442071***
L3.			.02125732	.00060118
L4.				.05136959*
<b>sigma</b>				
_cons	9.5398841***	9.4620541***	9.4808276***	9.473342***
<b>Statistics</b>				
N	794	794	794	794
ll	-2917.4896	-2911.1516	-2912.6217	-2912.0146
chi2	2.8388146	3447.4967	566.77521	690.44183
bic	5868.3646	5862.3657	5871.9829	5877.4458
aic	5844.9792	5834.3032	5839.2433	5840.0292

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

78 . est table arima31\*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

Variable	arima311	arima312	arima313	arima314
<b>y</b>				
_cons	-.11395314	-.11434855	-.11487997	-.11489771
<b>ARMA</b>				
ar				
L1.	.06416111	1.3204613***	-.56194538***	.01972589
L2.	.02920804	-.90163025***	-.42027467***	-.77499053***
L3.	.02294871	-.05791248**	-.83389917***	-.25249026
ma				
L1.	-.10003354	-1.3735497	.51794954	-.05826621
L2.		1.0000008	.40778767	.81652449***
L3.			.88983994	.26256083
L4.				.05469308*
<b>sigma</b>				
_cons	9.5380895***	9.4185571	9.4578166	9.4722994***
<b>Statistics</b>				
N	794	794	794	794
ll	-2917.3418	-2909.7635	-2911.5297	-2911.9403
chi2	3.8262796	32923.58	7410.3936	480.87615
bic	5874.7461	5866.2666	5876.4761	5883.9743
aic	5846.6836	5833.5271	5839.0595	5841.8806

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

79 . est table arima41\*, star(0.1 0.05 0.01) stat(N ll chi2 bic aic)

Variable	arima411	arima412	arima413	arima414
<b>y</b>				
_cons	-.11336618	-.11461152	-.11590868	-.11376705
<b>ARMA</b>				
ar				
L1.	-.26142231	.3181852***	1.7676398***	-.41944632***
L2.	.01694481	-.85050807***	-1.50548*	.36718541***
L3.	.03124469	.00130972	.41843717	-.35522863***
L4.	.0307881	.04773204	.00058669	-.86090936***
ma				
L1.	.22521179	-.35750674***	-1.8167691***	.38743681***
L2.		.90090477***	1.6207448*	-.30501342***
L3.			-.49952541	.42560261***
L4.				.8658178***
<b>sigma</b>				
_cons	9.5350812***	9.4739792***	9.4436415***	9.4058783***
<b>Statistics</b>				
N	794	794	794	794
ll	-2917.0927	-2912.0811	-2909.6096	-2906.4848
chi2	5.4882963	661.06102	4207.3323	932.73412
bic	5880.9249	5877.5789	5879.313	5879.7404
aic	5848.1853	5840.1622	5837.2193	5832.9696

```

13 . set obs 800
    number of observations (_N) was 800, now 800

14 . replace time=_n
    (0 real changes made)

15 . clear

16 . use "C:\Users\A\Downloads\assign_timeseries.dta", clear

17 . tsset t
    time variable:  time, 1 to 795
                   delta: 1 unit

18 . arima spot, arima(1,1,1) nolog

```

ARIMA regression

```

Sample: 2 - 795
Log likelihood = -2791.496
Number of obs = 794
Wald chi2(2) = 18.31
Prob > chi2 = 0.0001

```

D.spot	Coef.	OPG Std. Err.	z	P> z	[95% Conf. Interval]	
<b>spot</b>						
_cons	<b>-0.1047174</b>	<b>.3525647</b>	<b>-0.30</b>	<b>0.766</b>	<b>-.7957316</b>	<b>.5862967</b>
<b>ARMA</b>						
ar L1.	<b>.4353655</b>	<b>.2343856</b>	<b>1.86</b>	<b>0.063</b>	<b>-.0240219</b>	<b>.8947528</b>
ma L1.	<b>-.3535108</b>	<b>.242659</b>	<b>-1.46</b>	<b>0.145</b>	<b>-.8291138</b>	<b>.1220922</b>
/sigma	<b>8.139999</b>	<b>.1507405</b>	<b>54.00</b>	<b>0.000</b>	<b>7.844553</b>	<b>8.435444</b>

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

```

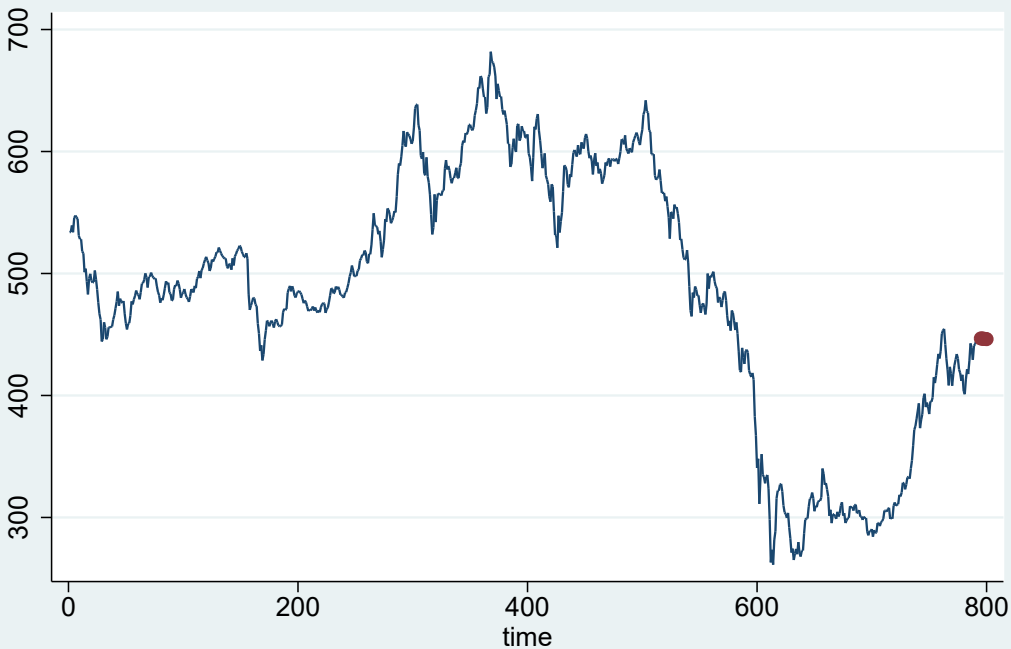
19 . set obs 800
    number of observations (_N) was 795, now 800

20 . replace time=_n
    (5 real changes made)

21 . predict yhat, y dynamic(.) t0(795)
    Note: beginning dynamic predictions in period 4.
    (794 missing values generated)

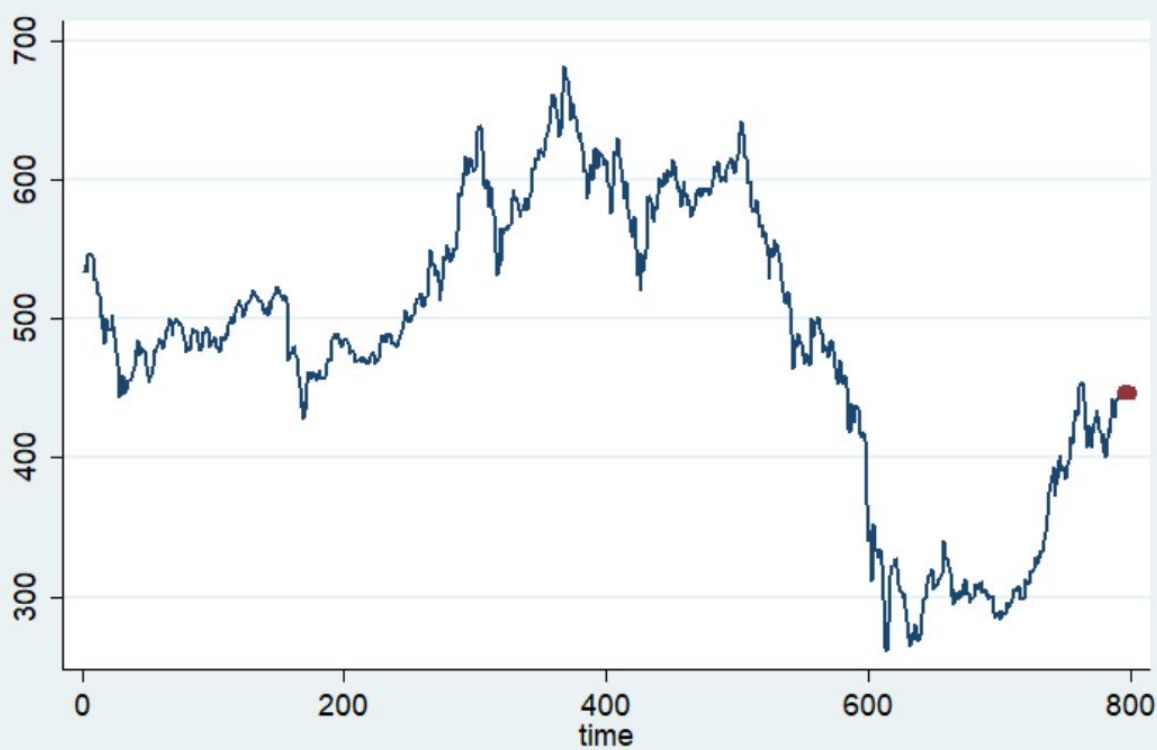
22 . twoway (line spot time, sort) (scatter yhat time, sort)

```



— spot ● y prediction, dyn(\_\_000004) t0(795)





— spot • y prediction, dyn(\_\_000004) t0(795)

```
31 . estat archlm
LM test for autoregressive conditional heteroskedasticity (ARCH)
```

lags(p)	chi2	df	Prob > chi2
1	<b>43.545</b>	1	0.0000

< 0.05

H0: no ARCH effects vs. H1: ARCH(p) disturbance

; there is ARCH problem

```
32 . qui arch rfuture rspot, arch(1) garch(1) nolog
33 . est store ga11
34 . qui arch rfuture rspot, arch(1) garch(1/2) nolog
35 . est store ga12
36 . qui arch rfuture rspot, arch(1/2) garch(1) nolog
37 . est store ga21
38 . qui arch rfuture rspot, arch(1/2) garch(1/2) nolog
39 . est store ga22
40 . est table ga*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	ga11	ga12	ga21	ga22
<b>rfuture</b>				
rspot	1.066779***	1.0662306***	1.0686232***	1.0681952***
_cons	.00003064	.00002879	.00002254	.00002246
<b>ARCH</b>				
arch				
L1.	.0846231***	.11369071***	.21216553***	.21614027***
L2.			-.14954538***	-.17303686***
garch				
L1.	.89700601***	.54514871	.92239369***	1.1227156***
L2.		.31487285		-.17547448
_cons	9.850e-07***	1.380e-06**	7.744e-07***	5.016e-07**
<b>Statistics</b>				
N	794	794	794	794
ll	2856.1421	2857.27	2860.4654	2860.969
chi2	10757.643	10547.689	10668.211	11008.252
aic	-5702.2841	-5702.54	-5708.9307	-5707.938
bic	-5678.8987	-5674.4775	-5680.8682	-5675.1984

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

garch(1,2) has lowest bic value  
 so it's the most appropriated

```
41 . predict sigmahat, v
42 . line sigmahat time
43 . graph export "C:\Users\A\Desktop\426\signma.pdf", as(pdf) replace
    (file C:\Users\A\Desktop\426\signma.pdf written in PDF format)
44 . log close
    name: <unnamed>
    log: C:\Users\A\Desktop\426\426.A14-2.smcl
    log type: smcl
    closed on: 4 May 2021, 10:43:51
```

---

```
45 .
```

