

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.

1. *Spot

```
. tsset time
```

```
    time variable:  time, 1 to 795
```

```
        delta: 1 unit
```

```
. do "C:\Users\user\AppData\Local\Temp\STD03000000.tmp"
```

```
. qui arima spot, arima(1,1,1)
```

```
. est store arima111
```

```
. qui arima spot, arima(1,1,2)
```

```
. est store arima112
```

```
. qui arima spot, arima(1,1,3)
```

```
. est store arima113
```

```
. qui arima spot, arima(1,1,4)
```

```
. est store arima114
```

```
. qui arima spot, arima(2,1,1)
```

```
. est store arima211
```

```
. qui arima spot, arima(2,1,2)
```

```
. est store arima212
```

```
. qui arima spot, arima(2,1,3)
```

```
. est store arima213
```

```
. qui arima spot, arima(2,1,4)
```

```
. est store arima214
```

```
. qui arima spot, arima(3,1,1)
```

```
. est store arima311
```

```
. qui arima spot, arima(3,1,2)
```

```
. est store arima312
```

```
. qui arima spot, arima(3,1,3)
. est store arima313
. qui arima spot, arima(3,1,4)
. est store arima314
. qui arima spot, arima(4,1,1)
. est store arima411
. qui arima spot, arima(4,1,2)
. est store arima412
. qui arima spot, arima(4,1,3)
. est store arima413
. qui arima spot, arima(4,1,4)
. est store arima414
. est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

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

aic	5590.993	5592.6915	5592.7633	5593.1646
bic	5609.7013	5616.077	5620.8258	5625.9042

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

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

Variable	arima211	arima212	arima213	arima214
-----+-----				
spot				
_cons	-.10453586	-.10767542	-.10609456	-.10747347
-----+-----				
ARMA				
ar				
L1.	.30210361	1.3247307***	.46523894***	1.3085163***
L2.	.02452891	-.92390998***	-.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	3656.4671	241.72156	4791.7034
aic	5592.7671	5583.0504	5592.2113	5585.0358
bic	5616.1525	5611.1129	5624.9509	5622.4524

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

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

Variable	arima311	arima312	arima313	arima314
spot				
_cons	-.10486338	-.10606433	-.10806841	-.10765208
ARMA				
ar				
L1.	-.56058829	.56814277***	.66749387**	.58444954
L2.	.08569307*	-.89762847***	-.06995188	.02671133
L3.	.06374492**	.09752317***	-.59846871*	-.67269654
ma				
L1.	.63856195	-.49161073***	-.61040004*	-.51894361
L2.		.88783708***	.0556601	-.03501301
L3.			.65798111**	.71899187
L4.				.02307553
sigma				
_cons	8.1302906***	8.1136284***	8.0655263***	8.0640794***
Statistics				
N	794	794	794	794
ll	-2790.5308	-2788.9397	-2784.4054	-2784.2793
chi2	21.334447	289.47751	1722.9017	1770.3817
aic	5593.0617	5591.8793	5584.8108	5586.5587
bic	5621.1242	5624.6189	5622.2274	5628.6524

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

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

Variable	arima411	arima412	arima413	arima414
spot				

```

_cons | -.10781888      -.10743716      -.10771017      -.10767653
-----+-----
ARMA      |
      ar |
L1. | .6019371*      1.3677396***      .61533738      .83865029
L2. | -.00196743     -1.0093746***      .0094391      -.13015924
L3. | .02357655      .05751154      -.67660585     -.67766115
L4. | -.074501**      -.001562      .02303694      .17029235
      |
      ma |
L1. | -.52565375     -1.302657***     -.54898831     -.77133898
L2. |      .96445922***     -.01948257      .10786573
L3. |      .72230601      .72482037
L4. |      -.15743316
-----+-----
sigma      |
      _cons | 8.1178063***      8.066311***      8.0639684***      8.0633837***
-----+-----
Statistics  |
      N |      794      794      794      794
      ll | -2789.3297     -2784.5185     -2784.2686     -2784.2263
      chi2 | 30.742143     5310.9545     1882.2706     2721.9204
      aic | 5592.6594     5585.037      5586.5371     5588.4525
      bic | 5625.399      5622.4537     5628.6309     5635.2234
-----+-----
                                legend: * p<.1; ** p<.05; *** p<.01
.
end of do-file
*Future
. do "C:\Users\user\AppData\Local\Temp\STD030000000.tmp"
. qui arima future, arima(1,1,1)
. est store arima111
. qui arima future, arima(1,1,2)
. est store arima112
. qui arima future, arima(1,1,3)
. est store arima113
. qui arima future, arima(1,1,4)

```

```
. est store arima114
. qui arima future, arima(2,1,1)
. est store arima211
. qui arima future, arima(2,1,2)
. est store arima212
. qui arima future, arima(2,1,3)
. est store arima213
. qui arima future, arima(2,1,4)
. est store arima214
. qui arima future, arima(3,1,1)
. est store arima311
. qui arima future, arima(3,1,2)
. est store arima312
. qui arima future, arima(3,1,3)
. est store arima313
. qui arima future, arima(3,1,4)
. est store arima314
. qui arima future, arima(4,1,1)
. est store arima411
. qui arima future, arima(4,1,2)
. est store arima412
. qui arima future, arima(4,1,3)
. est store arima413
. qui arima future, arima(4,1,4)
. est store arima414
. est table arima11*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	arima111	arima112	arima113	arima114
-----+-----				
future				
_cons	-.11424575	-.11408115	-.1139183	-.11370744
-----+-----				
ARMA				
ar				
L1.	-.36850497	.30224152	.07471074	-.26441554

ma					
L1.		.33119538	-.33885872	-.11128313	.23060131
L2.			.04456173	.0345267	.02935071
L3.				.03319847	.04074154
L4.					.03843721
-----+-----					
sigma					
_cons		9.5427695***	9.5390832***	9.5360585***	9.532552***
-----+-----					
Statistics					
N		794	794	794	794
ll		-2917.724	-2917.4236	-2917.166	-2916.8767
chi2		3.3320137	3.4714053	5.5726249	7.6343946
aic		5843.4479	5844.8473	5846.3321	5847.7535
bic		5862.1563	5868.2327	5874.3946	5880.493

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

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

-----+-----					
Variable		arima211	arima212	arima213	arima214
-----+-----					
future					
_cons		-.11399264	-.11299023	-.11518755	-.114745
-----+-----					
ARMA					
ar					
L1.		.26006773	1.1957056***	.39680958***	.29779715***
L2.		.03927244	-.91443628***	-.83492246***	-.89274399***
ma					
L1.		-.29537225	-1.2256874***	-.43709178***	-.33588403***
L2.			.97207404***	.86844397***	.9442071***
L3.				.02125732	.00060118
L4.					.05136959*
-----+-----					

```
sigma      |
      _cons |  9.5398841***    9.450655***    9.4808276***    9.473342***
-----+-----
Statistics  |
      N     |      794          794          794          794
      ll     | -2917.4896    -2910.3454    -2912.6217    -2912.0146
     chi2    |  2.8388146     6763.0586     566.77521     690.44183
      aic    |  5844.9792     5832.6907     5839.2433     5840.0292
      bic    |  5868.3646     5860.7532     5871.9829     5877.4458
-----+-----
                                legend: * p<.1; ** p<.05; *** p<.01
```

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

```
-----+-----
      Variable |  arima311      arima312      arima313      arima314
-----+-----
future        |
      _cons    | - .11395314    - .11434855    - .11482471    - .11489771
-----+-----
ARMA          |
      ar       |
      L1.      | .06416111      1.3204613***    - .5619286***    .01972589
      L2.      | .02920804      -.90163025***    -.42025289***    -.77499053***
      L3.      | .02294871      -.05791248**     -.83389309***    -.25249026
      |
      ma       |
      L1.      | -.10003354     -1.3735497      .51793334      -.05826621
      L2.      |                1.0000008      .40777623      .81652449***
      L3.      |                .88983828      .26256084
      L4.      |                .05469308*
-----+-----
sigma         |
      _cons    |  9.5380895***    9.4185571      9.4577901      9.4722994***
-----+-----
Statistics    |
      N        |      794          794          794          794
```

ll		-2917.3418	-2909.7635	-2911.5297	-2911.9403
chi2		3.8262796	32923.58	7392.6354	480.87614
aic		5846.6836	5833.5271	5839.0595	5841.8806
bic		5874.7461	5866.2666	5876.4761	5883.9743

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

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

Variable		arima411	arima412	arima413	arima414
-----+					
future					
_cons		-.11336618	-.11461152	-.11590868	-.11376705
-----+					
ARMA					
ar					
L1.		-.26142231	.3181852***	1.7676402***	-.41944632***
L2.		.01694481	-.85050807***	-1.5054804*	.36718541***
L3.		.03124469	.00130972	.41843748	-.35522863***
L4.		.0307881	.04773204	.0005867	-.86090936***
ma					
L1.		.22521179	-.35750674***	-1.8167695***	.38743681***
L2.			.90090477***	1.6207452*	-.30501342***
L3.				-.49952574	.42560261***
L4.					.8658178***
-----+					
sigma					
_cons		9.5350812***	9.4739792***	9.4436415***	9.4058783***
-----+					
Statistics					
N		794	794	794	794
ll		-2917.0927	-2912.0811	-2909.6096	-2906.4848
chi2		5.4882963	661.06102	4207.3335	932.73412
aic		5848.1853	5840.1622	5837.2193	5832.9696
bic		5880.9249	5877.5789	5879.313	5879.7404

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

.

end of do-file

From the above estimation, the most appropriated order for spot is ARIMA(1,1,1) and future is ARIMA(2,1,2).

2. Make dynamic forecast for period time = 796 to 800.

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

ARIMA regression

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

		OPG				
D.spot	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
-----+-----						
spot						
_cons	-.1047174	.3525647	-0.30	0.766	-.7957316	.5862967
-----+-----						
ARMA						
ar						
L1.	.4353655	.2343856	1.86	0.063	-.0240219	.8947528
ma						
L1.	-.3535108	.242659	-1.46	0.145	-.8291138	.1220922
-----+-----						
/sigma	8.139999	.1507405	54.00	0.000	7.844553	8.435444

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

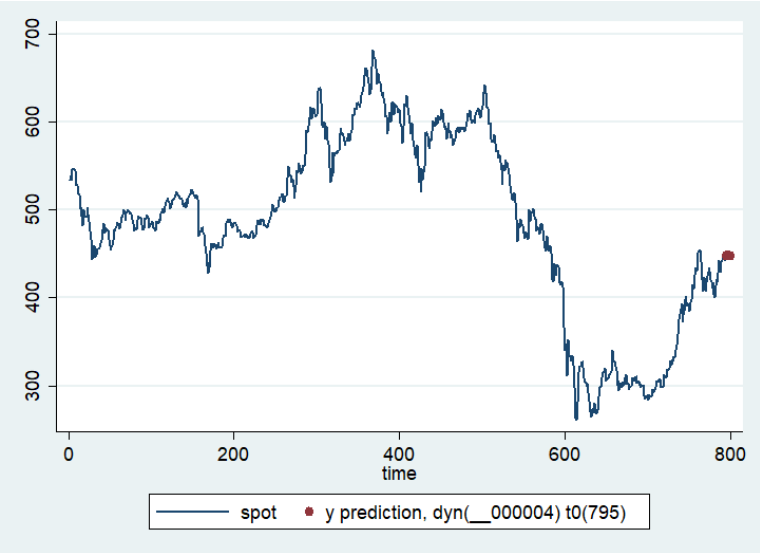
. set obs 800

number of observations (_N) was 795, now 800

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

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

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



```
. graph save Graph "C:\Users\user\Documents\BE TU\Year2\EE426\HW14\Graph.gph"
(file C:\Users\user\Documents\BE TU\Year2\EE426\HW14\Graph.gph saved)
```

```
. arima future, arima(1,1,1) nolog
```

ARIMA regression

Sample: 2 - 795	Number of obs	=	794
	Wald chi2(2)	=	3.33
Log likelihood = -2917.724	Prob > chi2	=	0.1890

		OPG			
D.future		Coef.	Std. Err.	z	P> z [95% Conf. Interval]
-----+-----					

```

future      |
      _cons |  -.1142458   .3326737   -0.34   0.731   -.7662743   .5377828
-----+-----
ARMA        |
      ar    |
      L1.   |  -.368505   .5847749   -0.63   0.529   -1.514643   .7776328
      |
      ma    |
      L1.   |  .3311954   .5949511    0.56   0.578   -.8348873   1.497278
-----+-----
      /sigma |    9.54277   .1687756   56.54   0.000    9.211975   9.873564
-----+-----

```

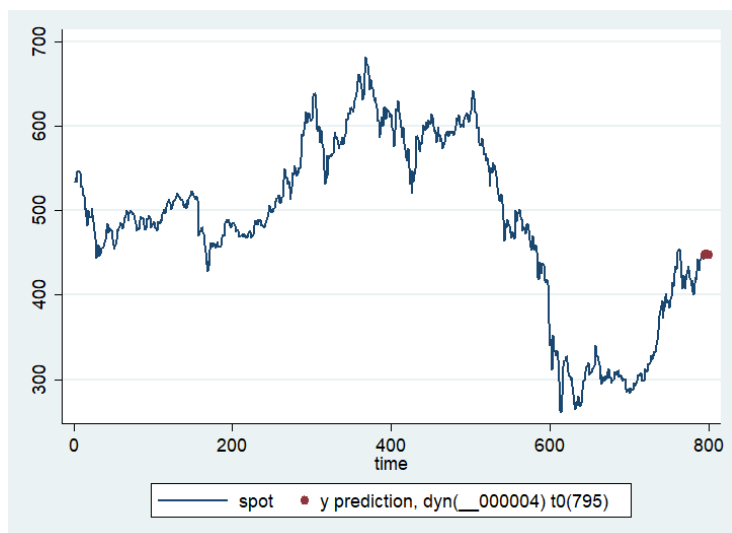
Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

```
. predict yhat2, y dynamic(.) t0(795)
```

Note: beginning dynamic predictions in period 4.

(794 missing values generated)

```
. twoway (line future time, sort) (scatter yhat2 time, sort)
```



```
. graph save Graph "C:\Users\user\Documents\BE TU\Year2\EE426\HW14\Graph2.gph"
```

(file C:\Users\user\Documents\BE TU\Year2\EE426\HW14\Graph2.gph saved)

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.

```
. gen rspot = (spot-l.spot)/l.spot
```

```
(1 missing value generated)
```

```
. gen rfuture = (future-l.future)/l.future
```

```
(1 missing value generated)
```

```
. reg rfuture rspot
```

Source	SS	df	MS	Number of obs =	794
-----+-----				F(1, 792)	= 6189.46
Model	.338771077	1	.338771077	Prob > F	= 0.0000
Residual	.043348982	792	.000054734	R-squared	= 0.8866
-----+-----				Adj R-squared	= 0.8864
Total	.382120059	793	.000481866	Root MSE	= .0074

rfuture	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
-----+-----						
rspot	1.108778	.0140935	78.67	0.000	1.081113	1.136443
_cons	.0000525	.0002626	0.20	0.841	-.0004629	.0005679

```
. estat archlm
```

```
LM test for autoregressive conditional heteroskedasticity (ARCH)
```

```
-----
```

lags(p)	chi2	df	Prob > chi2
1	43.545	1	0.0000

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

Because the p-value of the ARCHLM-test is less than 0.05, there exist significant ARCH effects.

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.

```
. do "C:\Users\user\AppData\Local\Temp\STD030000000.tmp"
. qui arch rfuture rspot, arch(1) garch(1) nolog
. est store garch11
. qui arch rfuture rspot, arch(1) garch(1/2) nolog
. est store garch12
. qui arch rfuture rspot, arch(1/2) garch(1) nolog
. est store garcht21
. qui arch rfuture rspot, arch(1/2) garch(1/2) nolog
. est store garch22
. est table garch*, star(0.1 0.05 0.01) stat(N ll chi2 aic bic)
```

Variable	garch11	garch12	garcht21	garch22
rfuture				
rspot	1.066779***	1.0662306***	1.0686232***	1.0681952***
_cons	.00003063	.00002879	.00002254	.00002247
ARCH				
arch				
L1.	.08462311***	.11369072***	.21216577***	.21614012***
L2.			-.14954554***	-.17303676***
garch				
L1.	.89700599***	.54514869	.92239362***	1.1227163***

```

L2. | .31487286 - .17547518
|
_cons | 9.850e-07*** 1.380e-06** 7.744e-07*** 5.016e-07**
-----+-----
Statistics |
N | 794 794 794 794
ll | 2856.1421 2857.27 2860.4654 2860.969
chi2 | 10757.643 10547.688 10668.219 11008.254
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
.

```

end of do-file

According BIC, the most appropriated lags order is GARCH(2,1).

5. From (6), predict the variance of future return (rfuture).

```

. predict sigmahat, v
. line sigmahat time

```

