Richaya H.
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1.

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

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

. reg rfuture rspot
```

Source	SS	df	MS
Model	.01531231	1	.01531231
Residual	.017327485	7,681	2.2559e-06
Total	.032639795	7,682	4.2489e-06

Number of obs	=	7,683
F(1, 7681)	=	6787.70
Prob > F	=	0.0000
R-squared	=	0.4691
Adj R-squared	=	0.4691
Root MSE	=	.0015

rfuture	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
rspot	.7889924	.0095766	82.39	0.000	.7702196	.8077651
_cons	7.58e-06	.0000171	0.44	0.658	-.000026	.0000412

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

lags(*p*)	chi2	df	Prob > chi2
1	6.951	1	0.0084

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

According to the estimated results, the p-value of the ARCH effect test is less than level of significance (0.0084 < 0.05). Therefore, the null hypothesis is rejected, and there exists a significant ARCH effect in this model.

2.

```
. arch rfuture rspot, arch(1) nolog

ARCH family regression

Sample: 2 - 7684                              Number of obs   =      7,683
Distribution: Gaussian                        Wald chi2(1)    =  110869.06
Log likelihood =  39218.14                    Prob > chi2     =     0.0000
```

rfuture	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
rfuture						
rspot	.8122742	.0024395	332.97	0.000	.8074929	.8170555
_cons	-1.78e-06	.0000129	-0.14	0.890	-.000027	.0000234
ARCH						
arch L1.	.2336904	.0081368	28.72	0.000	.2177425	.2496383
_cons	1.84e-06	8.36e-09	219.94	0.000	1.82e-06	1.86e-06

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. estat ic

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |          Obs  ll(null)  ll(model)      df         AIC        BIC
-------------+---------------------------------------------------------------
           . |        7,683         .   39218.14       4   -78428.29   -78400.5
-----------------------------------------------------------------------------
               Note: N=Obs used in calculating BIC; see [R] BIC note.

. arch rfuture rspot, arch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                                Number of obs     =      7,683
Distribution: Gaussian                          Wald chi2(1)      =  108339.74
Log likelihood =  39351.85                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
     rfuture |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rfuture      |
       rspot |   .8356571   .0025388   329.15   0.000     .8306811    .8406332
       _cons |  -.0000147   9.46e-06    -1.55   0.122    -.0000332    3.90e-06
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .2468027   .0079396    31.09   0.000     .2312414     .262364
         L2. |   .1914993   .0060912    31.44   0.000     .1795608    .2034378
             |
       _cons |   1.50e-06   1.03e-08   145.53   0.000     1.48e-06    1.52e-06
------------------------------------------------------------------------------

. estat ic

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |          Obs  ll(null)  ll(model)      df         AIC        BIC
-------------+---------------------------------------------------------------
           . |        7,683         .   39351.85       5   -78693.69  -78658.96
-----------------------------------------------------------------------------
               Note: N=Obs used in calculating BIC; see [R] BIC note.

. arch rfuture rspot, arch(1) garch(1) nolog

ARCH family regression

Sample: 2 - 7684                                Number of obs     =      7,683
Distribution: Gaussian                          Wald chi2(1)      =  144308.34
Log likelihood =  39695.02                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
     rfuture |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rfuture      |
       rspot |   .8163529    .002149   379.88   0.000     .8121409    .8205648
       _cons |   9.03e-06   .0000117     0.77   0.442     -.000014     .000032
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1583902   .0035413    44.73   0.000     .1514495     .165331
             |
       garch |
         L1. |   .7734087   .0038485   200.97   0.000     .7658659    .7809516
             |
       _cons |   1.95e-07   5.80e-09    33.59   0.000     1.84e-07    2.06e-07
------------------------------------------------------------------------------
```

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```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	7,683	.	39695.02	5	-79380.04	-79345.3

Note: N=Obs used in calculating BIC; see [R] BIC note.

```
. arch rfuture rspot, arch(1) garch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                              Number of obs   =      7,683
Distribution: Gaussian                        Wald chi2(1)    =  118873.81
Log likelihood =  39697.75                    Prob > chi2     =     0.0000
```

rfuture	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
rfuture						
rspot	.8153013	.0023647	344.78	0.000	.8106665	.819936
_cons	8.43e-06	.0000118	0.71	0.476	-.0000148	.0000316
ARCH						
arch						
L1.	.172934	.0061174	28.27	0.000	.1609441	.1849239
garch						
L1.	.6135791	.0310701	19.75	0.000	.5526828	.6744754
L2.	.1402146	.0250325	5.60	0.000	.0911518	.1892774
_cons	2.09e-07	8.64e-09	24.17	0.000	1.92e-07	2.26e-07

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	7,683	.	39697.75	6	-79383.5	-79341.82

Note: N=Obs used in calculating BIC; see [R] BIC note.

```
. arch rfuture rspot, arch(1/2) garch(1) nolog
flat log likelihood encountered, cannot find uphill direction
r(430);
```

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```
. arch rfuture rspot, arch(1/2) garch(1/2) nolog

ARCH family regression

Sample: 2 - 7684                              Number of obs     =      7,683
Distribution: Gaussian                        Wald chi2(1)      =  110222.84
Log likelihood =  39717.26                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
     rfuture |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
rfuture      |
       rspot |   .8240949   .0024822   332.00   0.000     .8192298      .82896
       _cons |   9.85e-06   .0000119     0.83   0.409    -.0000135    .0000332
-------------+----------------------------------------------------------------
ARCH         |
        arch |
         L1. |   .1329643   .0033009    40.28   0.000     .1264947    .1394339
         L2. |   .1345768   .0032471    41.45   0.000     .1282126     .140941
             |
       garch |
         L1. |  -.1805627     .00401   -45.03   0.000    -.1884221   -.1727033
         L2. |   .8101002   .0034601   234.12   0.000     .8033184    .8168819
             |
       _cons |   2.94e-07   1.07e-08    27.39   0.000     2.73e-07    3.15e-07
------------------------------------------------------------------------------

. estat ic

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |        Obs  ll(null)  ll(model)      df         AIC        BIC
-------------+---------------------------------------------------------------
           . |      7,683         .   39717.26       7   -79420.51  -79371.89
-----------------------------------------------------------------------------
               Note: N=Obs used in calculating BIC; see [R] BIC note.
```

To identify the order of GARCH(p,q), we do it by estimating GARCH models in several orders and choose the model with the lowest BIC or as known as SIC. From the result, the model arch(1/2) garch(1/2) or GARCH22 has the lowest SIC with the value of -79371.89, thus, the order of GARCH(p,q) should be p = 2 and q = 2 or GARCH(2,2).

3.

```
. predict sigmahat, v

. line sigmahat t
```