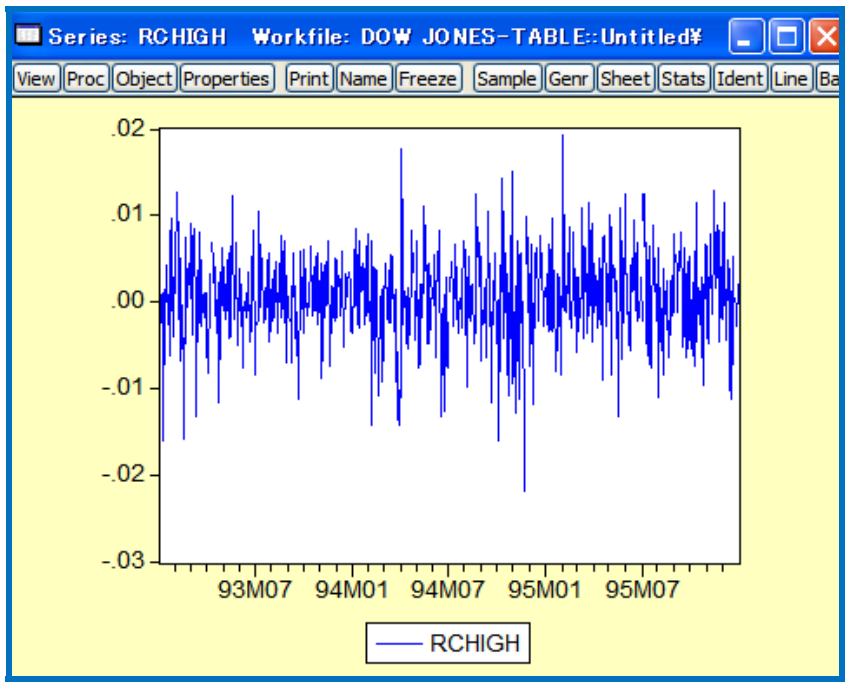
3 章宿題解答例

1.　この解答例では 1993 年 1 月 4 日から 1995 年 12 月 29 日までのダウ平均株価指数を用いて分析を行っています。まず図 3.38 にはダウ平均の対前日変化率がプロットされています。

図 3.38 ダウ平均



次に収益率方程式のラグの次数ですが、このようなモデルの次数選択は情報量基準に基づいて行われることがおおいのですが、最も有名な情報量基準が AIC(Akaike's Information Criteria)統計量です。決定の仕方は簡単で様々な次数で推定を行ってみて、最も AIC 統計量の小さな次数を選べばよいわけです。（AIC に関しては標準的な計量経済学の教科書を参照して下さい。）この例では AR(1)が選択されました。ARCH モデルの推定結果は図 3.39 に示されています。

図 3.39 ARCH モデル推定結果

EViews - [Equation: UNTITLED Workfile: DOW JONES-TABLE::

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/21/08 Time: 09:18
Sample: 1/04/1993 12/29/1995
Included observations: 757
Convergence achieved after 8 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000517	0.000184	2.807619	0.0050
RCHIGH(-1)	0.130625	0.037827	3.453249	0.0006

Variance Equation

C	2.35E-05	1.16E-06	20.30720	0.0000
RESID(-1)^2	0.081340	0.029315	2.774701	0.0055

R-squared	0.021522	Mean dependent var	0.000571
Adjusted R-squared	0.017624	S.D. dependent var	0.005120
S.E. of regression	0.005075	Akaike info criterion	-7.734229
Sum squared resid	0.019393	Schwarz criterion	-7.709767
Log likelihood	2931.406	F-statistic	5.520881
Durbin-Watson stat	1.961612	Prob(F-statistic)	0.000941

ARCH 効果の存在を示唆する結果となっています。次に GARCH(1,1)モデルですが図 3.40 に推定結果が示されています。

図 3.40

EViews - [Equation: UNTITLED Workfile: DOW JONES-TABLE::

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/21/08 Time: 09:24
Sample: 1/04/1993 12/29/1995
Included observations: 757
Convergence achieved after 10 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000530	0.000179	2.958661	0.0031
RCHIGH(-1)	0.145328	0.034227	4.245953	0.0000
Variance Equation				
C	5.54E-07	3.29E-07	1.684442	0.0921
RESID(-1)^2	0.030064	0.009517	3.158923	0.0016
GARCH(-1)	0.948031	0.018540	51.13556	0.0000

R-squared	0.021758	Mean dependent var	0.000571
Adjusted R-squared	0.016554	S.D. dependent var	0.005120
S.E. of regression	0.005078	Akaike info criterion	-7.746465
Sum squared resid	0.019388	Schwarz criterion	-7.715888
Log likelihood	2937.037	F-statistic	4.181464
Durbin-Watson stat	1.990553	Prob(F-statistic)	0.002348

GARCH 効果を示唆する結果となっています。この場合、GARCH(2,1)、GARCH(1,2)等のモデルは有意ではありません。最後に、OLS 推定の結果を図 3.41 に示しておきます。

図 3.41 OLS 推定

EViews - [Equation: UNTITLED Workfile: DOW JONES-TABLE::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: Least Squares
Date: 07/21/08 Time: 09:26
Sample: 1/04/1993 12/29/1995
Included observations: 757

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000487	0.000185	2.626444	0.0088
RCHIGH(-1)	0.147765	0.035997	4.104975	0.0000

R-squared	0.021832	Mean dependent var	0.000571
Adjusted R-squared	0.020536	S.D. dependent var	0.005120
S.E. of regression	0.005067	Akaike info criterion	-7.729382
Sum squared resid	0.019386	Schwarz criterion	-7.717151
Log likelihood	2927.571	F-statistic	16.85082
Durbin-Watson stat	1.995497	Prob(F-statistic)	0.000045

この場合は収益率方程式の推定値そのものはそれほど異なりませんが、モデルの説明力は大きく劣っています。

2. 本章 3.5 と同様に、問題 1 で推定した ARCH モデル、GARCH モデルの推定結果に基づいて 1996 年の 1 月の条件付き分散の Static Forecasting を行った結果が図 3.42、図 3.43 にプロットされています。

図 3.42 ARCH モデルによる条件付き分散の予測

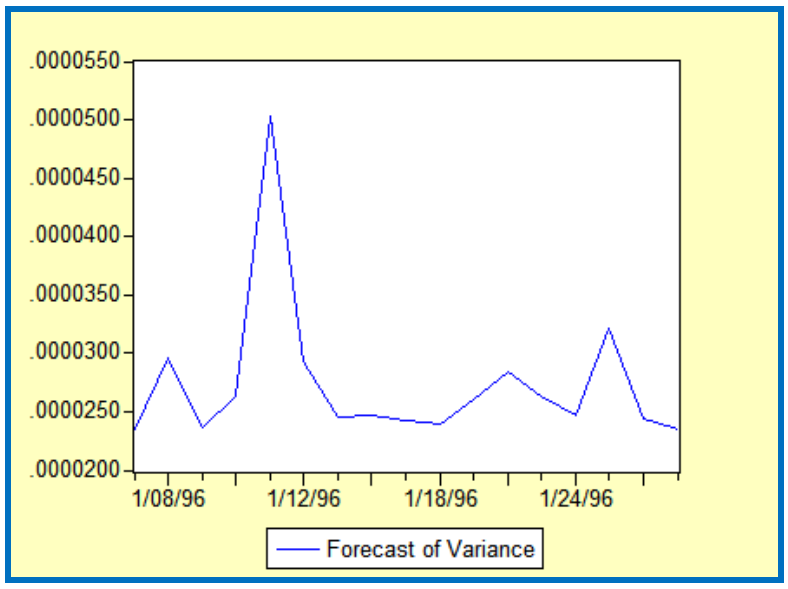
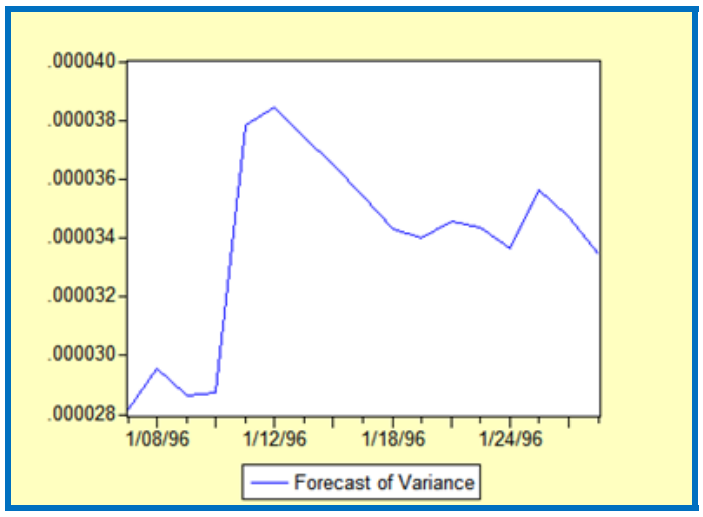
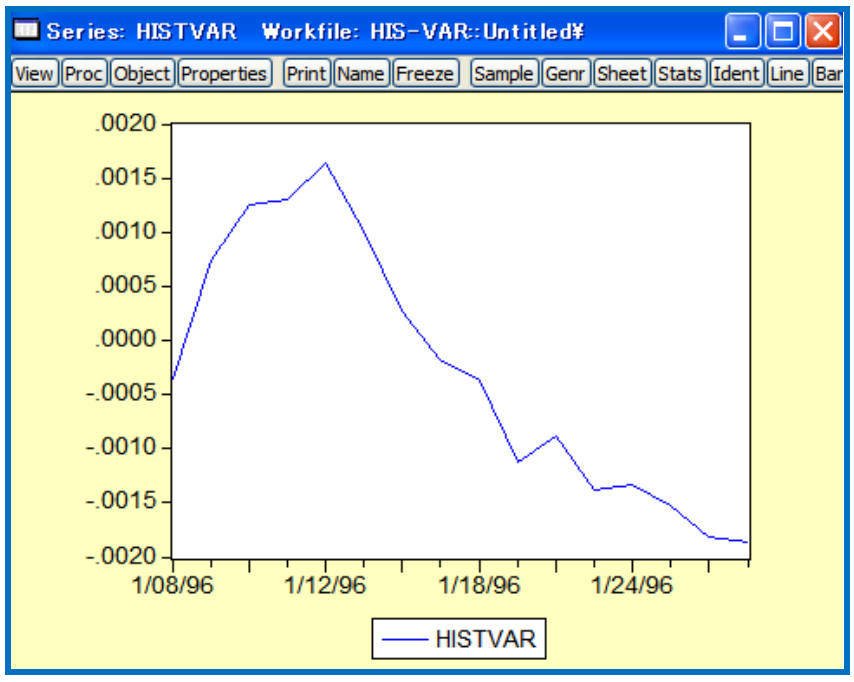


図 3.43 GARCH モデルによる条件付き分散の予測



1 月初旬に関しては二つのモデルは同じようなハイクを示していますが、月中、月末にかけてはかなり異なった分散の予測になっています。最後に、Historical Variance を 20 日間のデータを用いて計算した結果が、図 3.44 に示されています。

図 3.44　Historical Variance



この場合も月初の大きなピークが示唆されています。

3. 本章 4.3 と同様のサンプル期間（2000 年 1 月 3 日から 2007 年 12 月 26 日）を用いて TOPIX と為替レートを用いて BEKK モデルを推定した分析結果が図 3.45 に示されています。

図 3.45 BEKK モデル推定結果

EViews - [System: UNTITLED Workfile: HWBEKK01::Hwbekk01¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze MergeText Estimate Spec Stats Resids

System: UNTITLED
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal VECH
Date: 07/21/08 Time: 10:47
Sample: 1/03/2000 12/26/2007
Included observations: 2083
Total system (balanced) observations 4166
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 9 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000164	0.000120	1.363453	0.1727
C(2)	0.000310	0.000237	1.307539	0.1910

Variance Equation Coefficients

C(3)	1.21E-06	3.00E-07	4.044671	0.0001
C(4)	2.50E-07	7.83E-08	3.194311	0.0014
C(5)	2.42E-06	5.78E-07	4.187920	0.0000
C(6)	0.045187	0.007889	5.727638	0.0000
C(7)	0.043318	0.005527	7.837021	0.0000
C(8)	0.069522	0.008591	8.092093	0.0000
C(9)	0.917465	0.014714	62.35111	0.0000
C(10)	0.936612	0.009227	101.5090	0.0000
C(11)	0.916068	0.010281	89.10600	0.0000

Log likelihood	14255.21	Schwarz criterion	-13.64683
Avg. log likelihood	3.421797	Hannan-Quinn criter.	-13.66571
Akaike info criterion	-13.67663		

Equation: RCEXR = C(1)

R-squared	-0.000383	Mean dependent var	5.39E-05
Adjusted R-squared	-0.000383	S.D. dependent var	0.005642
S.E. of regression	0.005643	Sum squared resid	0.066292
Prob(F-statistic)	2.069845		

Equation: RCTOPIX = C(2)

R-squared	-0.000948	Mean dependent var	-6.36E-05
Adjusted R-squared	-0.000948	S.D. dependent var	0.012126
S.E. of regression	0.012131	Sum squared resid	0.306410
Prob(F-statistic)	1.890276		

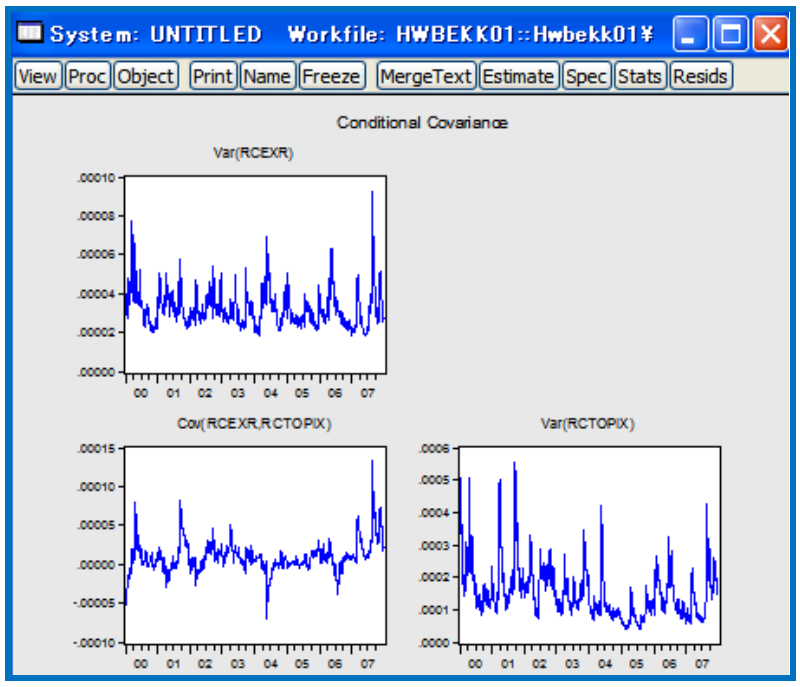
Covariance specification: Diagonal VECH
GARCH = M + A1.*RESID(-1)*RESID(-1)' + B1.*GARCH(-1)
M is an indefinite matrix
A1 is an indefinite matrix
B1 is an indefinite matrix

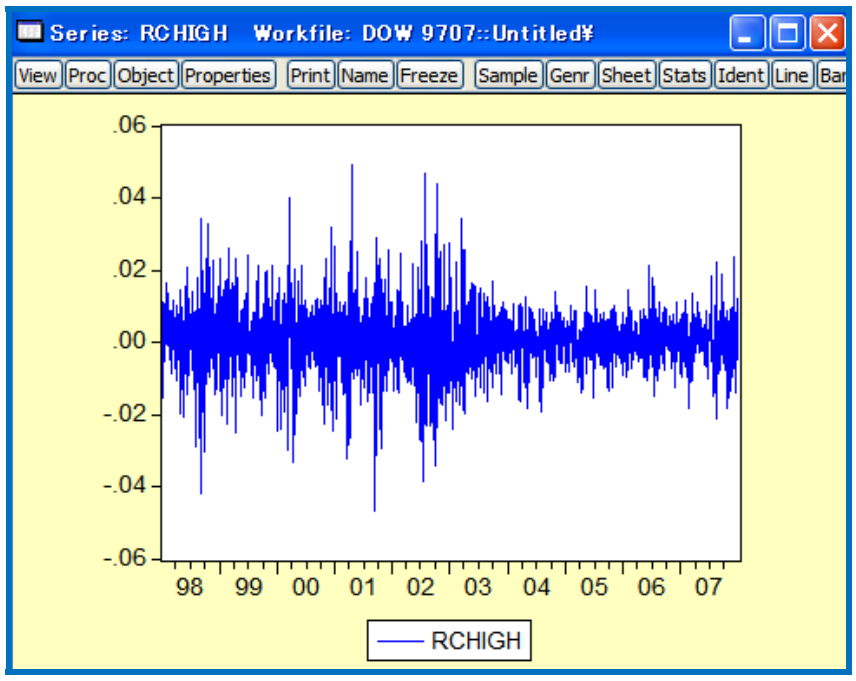
Tranformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	1.21E-06	3.00E-07	4.044671	0.0001
M(1,2)	2.50E-07	7.83E-08	3.194311	0.0014
M(2,2)	2.42E-06	5.78E-07	4.187920	0.0000
A1(1,1)	0.045187	0.007889	5.727638	0.0000
A1(1,2)	0.043318	0.005527	7.837021	0.0000
A1(2,2)	0.069522	0.008591	8.092093	0.0000
B1(1,1)	0.917465	0.014714	62.35111	0.0000
B1(1,2)	0.936612	0.009227	101.5090	0.0000
B1(2,2)	0.916068	0.010281	89.10600	0.0000

この推定結果に基づいて条件付き分散・共分散を求めた結果が図 3.46 に示されています。TOPIX を用いた場合も日経株価指数を用いた 4.3 の場合と同様の結論が示唆されていることがわかります。

図 3.46 条件付き分散・共分散





EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:06
Sample (adjusted): 1/06/1998 12/31/2007
Included observations: 2512 after adjustments
Convergence achieved after 8 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000359	0.000159	2.265439	0.0235
RCHIGH(-1)	0.176318	0.017309	10.18624	0.0000
Variance Equation				
C	5.92E-05	1.48E-06	39.94684	0.0000
RESID(-1)^2	0.229710	0.025372	9.053786	0.0000

R-squared	0.018884	Mean dependent var	0.000202
Adjusted R-squared	0.017710	S.D. dependent var	0.008710
S.E. of regression	0.008632	Akaike info criterion	-6.699922
Sum squared resid	0.186887	Schwarz criterion	-6.690640
Log likelihood	8419.102	F-statistic	16.09070
Durbin-Watson stat	2.048761	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:11
Sample (adjusted): 1/07/1998 12/31/2007
Included observations: 2511 after adjustments
Convergence achieved after 10 iterations
Variance backcast: ON
GARCH = C(4) + C(5)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000372	0.000159	2.346480	0.0190
RCHIGH(-1)	0.184027	0.018125	10.15300	0.0000
RCHIGH(-2)	-0.032292	0.012489	-2.585601	0.0097
Variance Equation				
C	5.93E-05	1.50E-06	39.43356	0.0000
RESID(-1)^2	0.224951	0.025737	8.740425	0.0000

R-squared	0.020415	Mean dependent var	0.000206
Adjusted R-squared	0.018851	S.D. dependent var	0.008709
S.E. of regression	0.008627	Akaike info criterion	-6.700468
Sum squared resid	0.186509	Schwarz criterion	-6.688862
Log likelihood	8417.437	F-statistic	13.05651
Durbin-Watson stat	2.066649	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:13
Sample (adjusted): 1/08/1998 12/31/2007
Included observations: 2510 after adjustments
Convergence achieved after 10 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000375	0.000159	2.356554	0.0184
RCHIGH(-1)	0.183359	0.018174	10.08936	0.0000
RCHIGH(-2)	-0.031713	0.012606	-2.515611	0.0119
RCHIGH(-3)	-0.001361	0.015071	-0.090317	0.9280
Variance Equation				
C	5.93E-05	1.51E-06	39.34835	0.0000
RESID(-1)^2	0.224693	0.025780	8.715802	0.0000

R-squared	0.020295	Mean dependent var	0.000209
Adjusted R-squared	0.018338	S.D. dependent var	0.008710
S.E. of regression	0.008630	Akaike info criterion	-6.699365
Sum squared resid	0.186482	Schwarz criterion	-6.685433
Log likelihood	8413.703	F-statistic	10.37402
Durbin-Watson stat	2.065404	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:22
Sample (adjusted): 1/07/1998 12/31/2007
Included observations: 2511 after adjustments
Convergence achieved after 14 iterations
Variance backcast: ON
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*RESID(-2)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000351	0.000144	2.430563	0.0151
RCHIGH(-1)	0.134711	0.018181	7.409502	0.0000
RCHIGH(-2)	0.009574	0.017968	0.532819	0.5942

Variance Equation

C	4.50E-05	1.70E-06	26.42666	0.0000
RESID(-1)^2	0.171380	0.024094	7.113089	0.0000
RESID(-2)^2	0.253034	0.023599	10.72232	0.0000

R-squared	0.019301	Mean dependent var	0.000206
Adjusted R-squared	0.017343	S.D. dependent var	0.008709
S.E. of regression	0.008634	Akaike info criterion	-6.757092
Sum squared resid	0.186721	Schwarz criterion	-6.743165
Log likelihood	8489.529	F-statistic	9.859963
Durbin-Watson stat	1.970895	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:24
Sample (adjusted): 1/06/1998 12/31/2007
Included observations: 2512 after adjustments
Convergence achieved after 11 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000378	0.000135	2.798956	0.0051
RCHIGH(-1)	0.129374	0.021122	6.124946	0.0000

Variance Equation

C	5.75E-07	1.58E-07	3.647362	0.0003
RESID(-1)^2	0.068929	0.007442	9.262549	0.0000
GARCH(-1)	0.924434	0.007842	117.8761	0.0000

R-squared	0.019754	Mean dependent var	0.000202
Adjusted R-squared	0.018190	S.D. dependent var	0.008710
S.E. of regression	0.008630	Akaike info criterion	-6.903575
Sum squared resid	0.186721	Schwarz criterion	-6.891973
Log likelihood	8675.890	F-statistic	12.63041
Durbin-Watson stat	1.959072	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 22:23
Sample (adjusted): 1/07/1998 12/31/2007
Included observations: 2511 after adjustments
Convergence achieved after 12 iterations
Variance backcast: ON
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000386	0.000136	2.843632	0.0045
RCHIGH(-1)	0.132190	0.021324	6.199209	0.0000
RCHIGH(-2)	-0.013063	0.020528	-0.636352	0.5245
Variance Equation				
C	5.70E-07	1.57E-07	3.637144	0.0003
RESID(-1)^2	0.068430	0.007395	9.253133	0.0000
GARCH(-1)	0.925025	0.007796	118.6554	0.0000

R-squared	0.020787	Mean dependent var	0.000206
Adjusted R-squared	0.018832	S.D. dependent var	0.008709
S.E. of regression	0.008627	Akaike info criterion	-6.903371
Sum squared resid	0.186438	Schwarz criterion	-6.889444
Log likelihood	8673.182	F-statistic	10.63537
Durbin-Watson stat	1.965050	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: Least Squares
Date: 07/20/08 Time: 22:17
Sample (adjusted): 1/06/1998 12/31/2007
Included observations: 2512 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000173	0.000172	1.003440	0.3157
RCHIGH(-1)	0.143097	0.019752	7.244598	0.0000

R-squared	0.020482	Mean dependent var	0.000202
Adjusted R-squared	0.020092	S.D. dependent var	0.008710
S.E. of regression	0.008622	Akaike info criterion	-6.668249
Sum squared resid	0.186582	Schwarz criterion	-6.663608
Log likelihood	8377.320	F-statistic	52.48420
Durbin-Watson stat	1.986500	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: Least Squares
Date: 07/20/08 Time: 22:18
Sample (adjusted): 1/07/1998 12/31/2007
Included observations: 2511 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000184	0.000172	1.071084	0.2842
RCHIGH(-1)	0.149479	0.019946	7.494086	0.0000
RCHIGH(-2)	-0.041231	0.019943	-2.067393	0.0388

R-squared	0.022288	Mean dependent var	0.000206
Adjusted R-squared	0.021509	S.D. dependent var	0.008709
S.E. of regression	0.008615	Akaike info criterion	-6.669361
Sum squared resid	0.186152	Schwarz criterion	-6.662398
Log likelihood	8376.383	F-statistic	28.58671
Durbin-Watson stat	1.999512	Prob(F-statistic)	0.000000

EViews - [Equation: UNTITLED Workfile: DOW 9707::Untitled¥]

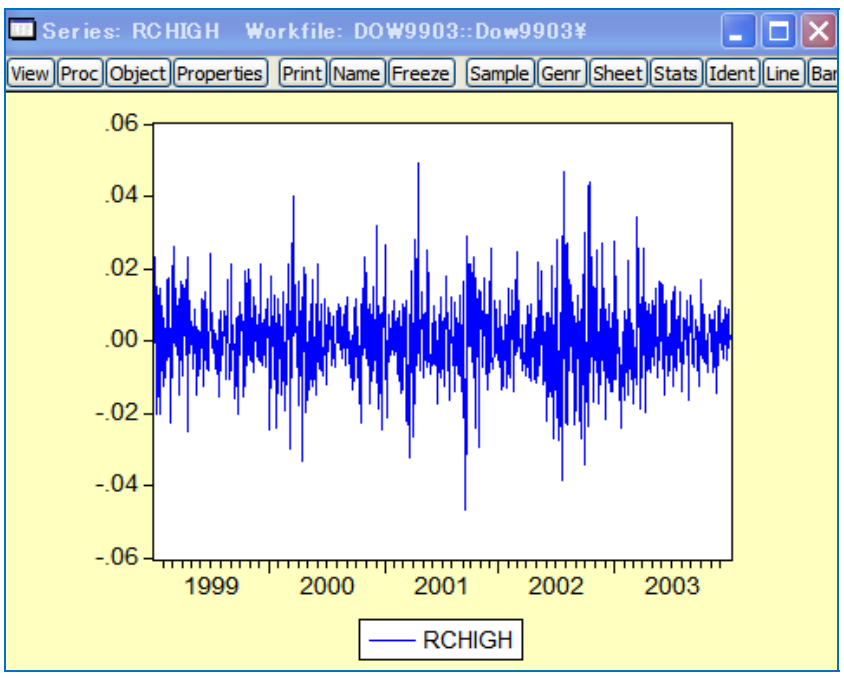
File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: Least Squares
Date: 07/20/08 Time: 22:19
Sample (adjusted): 1/08/1998 12/31/2007
Included observations: 2510 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000185	0.000172	1.071947	0.2838
RCHIGH(-1)	0.149580	0.019975	7.488411	0.0000
RCHIGH(-2)	-0.042408	0.020174	-2.102066	0.0356
RCHIGH(-3)	0.009853	0.019967	0.493454	0.6217

R-squared	0.022274	Mean dependent var	0.000209
Adjusted R-squared	0.021103	S.D. dependent var	0.008710
S.E. of regression	0.008618	Akaike info criterion	-6.668418
Sum squared resid	0.186105	Schwarz criterion	-6.659131
Log likelihood	8372.865	F-statistic	19.02971
Durbin-Watson stat	2.000641	Prob(F-statistic)	0.000000


Series: RCHIGH Workfile: DOW9903::Dow9903¥
View
Proc
Object
Properties
Print
Name
Freeze
Sample
Genr
Sheet
Stats
Ident
Line
Bar
.06
.04
.02
.00
-.02
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1999
2000
2001
2002
2003
RCHIGH

EViews - [Equation: UNTITLED Workfile: DOW9903::Dow9903¥]

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 21:47
Sample (adjusted): 1/06/1999 12/31/2003
Included observations: 1254 after adjustments
Convergence achieved after 9 iterations
Variance backcast: ON
GARCH = C(3) + C(4)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000203	0.000287	0.706029	0.4802
RCHIGH(-1)	0.151118	0.029049	5.202185	0.0000
Variance Equation				
C	9.41E-05	3.46E-06	27.18395	0.0000
RESID(-1)^2	0.103036	0.030368	3.392905	0.0007

R-squared	0.021222	Mean dependent var	8.87E-05
Adjusted R-squared	0.018873	S.D. dependent var	0.010334
S.E. of regression	0.010236	Akaike info criterion	-6.332230
Sum squared resid	0.130961	Schwarz criterion	-6.315854
Log likelihood	3974.308	F-statistic	9.034423
Durbin-Watson stat	1.993089	Prob(F-statistic)	0.000006

EViews - [Equation: UNTITLED Workfile: DOW9903::Dow9903

File Edit Object View Proc Quick Options Window Help

View Proc Object Print Name Freeze Estimate Forecast Stats Resids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 07/20/08 Time: 21:55
Sample (adjusted): 1/08/1999 12/31/2003
Included observations: 1252 after adjustments
Convergence achieved after 11 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000195	0.000287	0.680700	0.4961
RCHIGH(-1)	0.158133	0.029949	5.280079	0.0000
RCHIGH(-2)	-0.038384	0.023216	-1.653325	0.0983
RCHIGH(-3)	-0.001674	0.024918	-0.067179	0.9464
Variance Equation				
C	9.40E-05	3.55E-06	26.45888	0.0000
RESID(-1)^2	0.100062	0.031098	3.217633	0.0013

R-squared	0.022927	Mean dependent var	6.98E-05
Adjusted R-squared	0.019006	S.D. dependent var	0.010322
S.E. of regression	0.010223	Akaike info criterion	-6.333025
Sum squared resid	0.130219	Schwarz criterion	-6.308428
Log likelihood	3970.473	F-statistic	5.847366
Durbin-Watson stat	2.008128	Prob(F-statistic)	0.000024