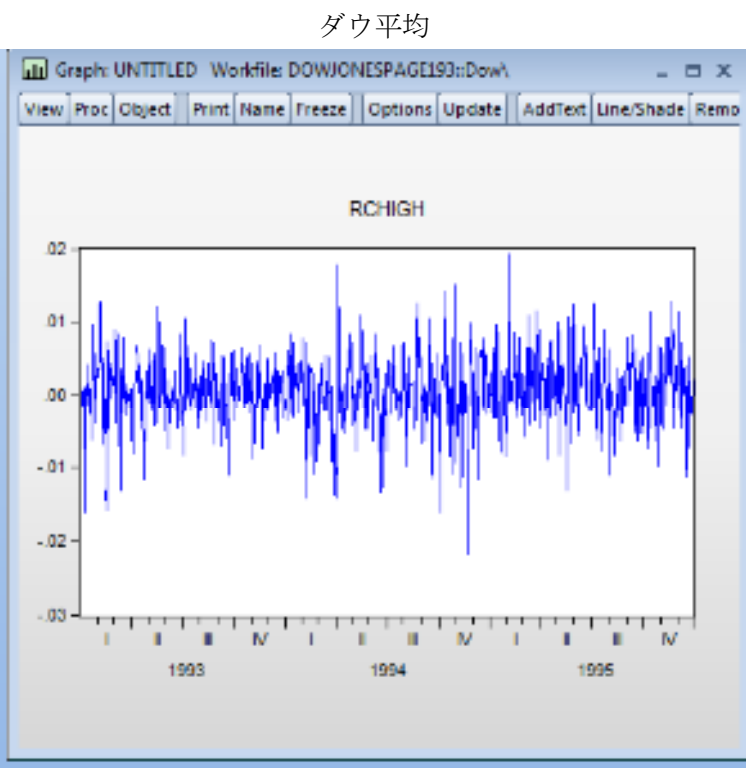
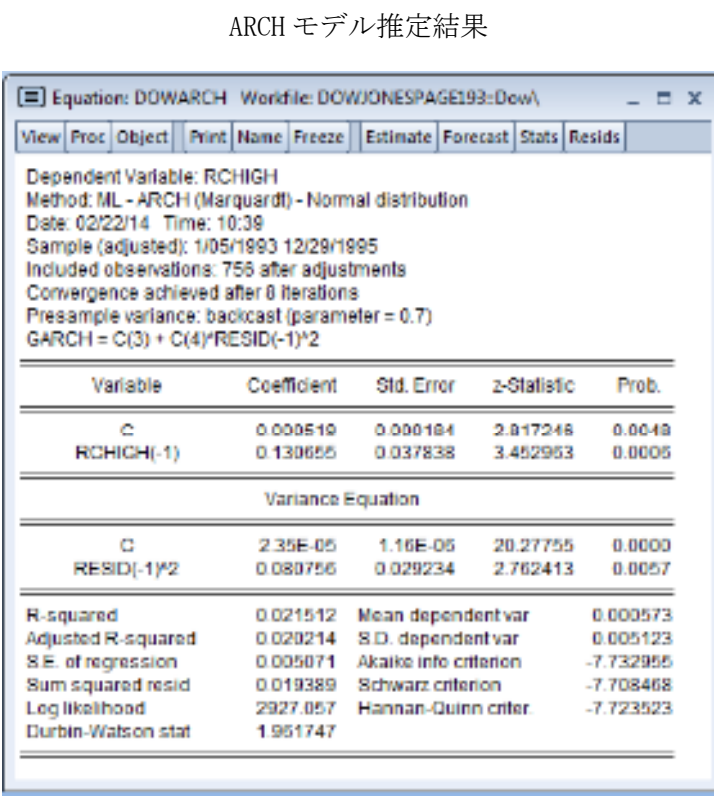


第 4 章 練習問題解答例

(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。まず下の図にはダウ平均の対前日変化率がプロットされています。



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多いのですが、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以下の図に示されています。



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) モデルですが下の図に推定結果が示されています。

推定結果

Equation: DOWGARCH01 Workfile: DOWJONESPAGE193=Dow\

ViewProcObjectPrintNameFreezeEstimateForecastStatsResids

Dependent Variable: RCHIGH
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 02/22/14 Time: 10:36
Sample (adjusted): 1/05/1993 12/29/1995
Included observations: 756 after adjustments
Convergence achieved after 11 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000525	0.000179	2.920048	0.0034
RCHIGH(-1)	0.144563	0.034307	4.213829	0.0000

Variance Equation

C	5.20E-07	3.01E-07	1.730454	0.0835
RESID(-1)^2	0.029530	0.009380	3.148184	0.0016
GARCH(-1)	0.949606	0.017313	54.85011	0.0000

R-squared 0.021764 Mean dependent var 0.000573
Adjusted R-squared 0.020466 S.D. dependent var 0.005123
S.E. of regression 0.005070 Akaike info criterion -7.747871
Sum squared resid 0.019384 Schwarz criterion -7.717263
Log likelihood 2933.685 Hannan-Quinn criter. -7.736082
Durbin-Watson stat 1.988166

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 推定の結果を次図に示しておきます。

OLS 推定結果

Equation: DOWOLS Workfile: DOWJONESPAGE193=Dow\

ViewProcObjectPrintNameFreezeEstimateForecastStatsResids

Dependent Variable: RCHIGH
Method: Least Squares
Date: 02/22/14 Time: 10:41
Sample (adjusted): 1/05/1993 12/29/1995
Included observations: 756 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000489	0.000188	2.636518	0.0085
RCHIGH(-1)	0.147709	0.036018	4.100999	0.0000

R-squared 0.021019 Mean dependent var 0.000573
Adjusted R-squared 0.020521 S.D. dependent var 0.005123
S.E. of regression 0.005070 Akaike info criterion -7.728227
Sum squared resid 0.019383 Schwarz criterion -7.715984
Log likelihood 2923.270 Hannan-Quinn criter. -7.723511
F-statistic 16.81819 Durbin-Watson stat 1.995459
Prob(F-statistic) 0.000046

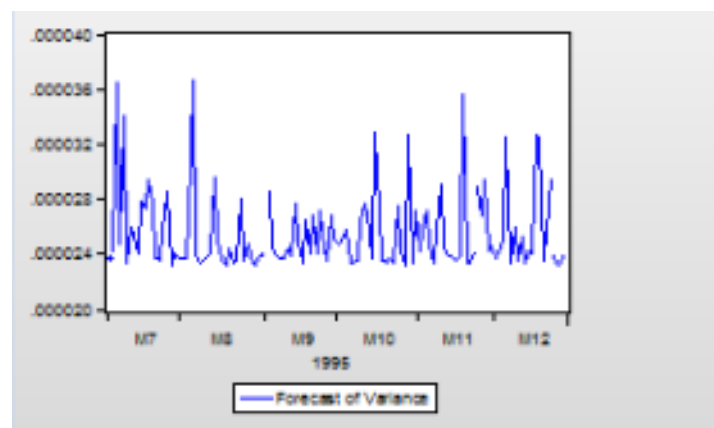
この場合は収益率方程式の推定値そのものはそれほど異なりませんが、モデルの説明力は大きく劣っています。

(2) 本章 3.5 と同様に、1993 年 1 月から 1995 年 6 月までのデータを用いて推定した ARCH モデル、GARCH モデルの結果に基づいて、1996 年の 7 月から 12 月までの条件付き分散の Static Forecasting を行った結果が、以下の二つの図にプロットされています。

ARCH モデル推定結果

Equation: DOWARCH06301995FORECAST Workfile: DOWJONESPA... _ _ X				
View	Proc	Object	Print	Name
Freeze	Estimate	Forecast	Stats	Resids
Dependent Variable: RCHIGH Method: ML - ARCH (Marquardt) - Normal distribution Date: 02/22/14 Time: 10:48 Sample (adjusted): 1/05/1993 6/30/1995 Included observations: 630 after adjustments Convergence achieved after 9 iterations Presample variance: backcast (parameter = 0.7) GARCH = C(3) + C(4)*RESID(-1)^2				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000465	0.000202	2.306501	0.0211
RCHIGH(-1)	0.144624	0.040895	3.536513	0.0004
Variance Equation				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.33E-05	1.20E-06	19.34863	0.0000
RESID(-1)^2	0.087430	0.031873	2.760400	0.0050
R-squared	0.026132	Mean dependent var	0.000512	
Adjusted R-squared	0.024581	S.D. dependent var	0.005131	
S.E. of regression	0.005088	Akaike info criterion	-7.735521	
Sum squared resid	0.016129	Schwarz criterion	-7.707294	
Log likelihood	2440.899	Hannan-Quinn criter.	-7.724557	
Durbin-Watson stat	1.960137			

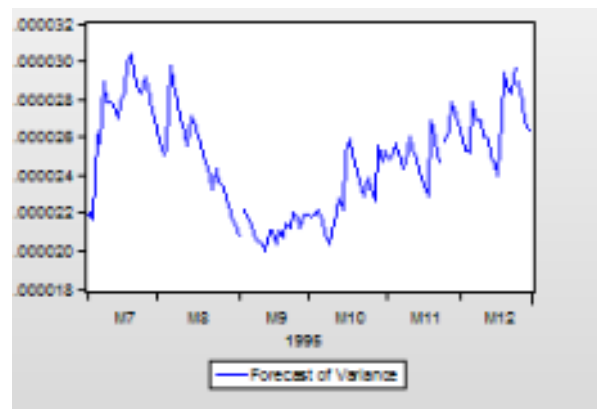
ARCH モデルによる条件付き分散の予測



GARCH モデル推定結果

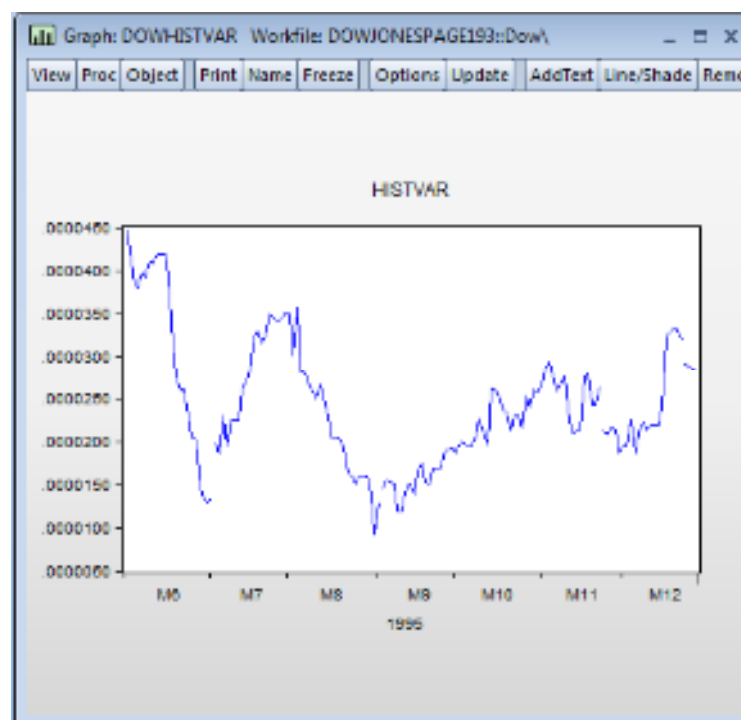
Equation: UNTITLED Workfile: DOWJONESPAGE193::Dow\ _ _ X				
View	Proc	Object	Print	Name
Freeze	Estimate	Forecast	Stats	Resids
Dependent Variable: RCHIGH Method: ML - ARCH (Marquardt) - Normal distribution Date: 02/22/14 Time: 10:57 Sample (adjusted): 1/05/1993 6/30/1995 Included observations: 630 after adjustments Convergence achieved after 12 iterations Presample variance: backcast (parameter = 0.7) GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.090489	0.000194	2.523201	0.0116
RCHIGH(-1)	0.159371	0.037285	4.276864	0.0000
Variance Equation				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	5.51E-07	3.19E-07	1.727589	0.0841
RESID(-1)^2	0.033755	0.010589	3.187770	0.0014
GARCH(-1)	0.943713	0.018978	49.73082	0.0000
R-squared	0.026350	Mean dependent var	0.000512	
Adjusted R-squared	0.024799	S.D. dependent var	0.005131	
S.E. of regression	0.005087	Akaike info criterion	-7.758048	
Sum squared resid	0.016125	Schwarz criterion	-7.720763	
Log likelihood	2448.155	Hannan-Quinn criter.	-7.742341	
Durbin-Watson stat	1.989204			

GARCH モデルによる条件付き分散の予測



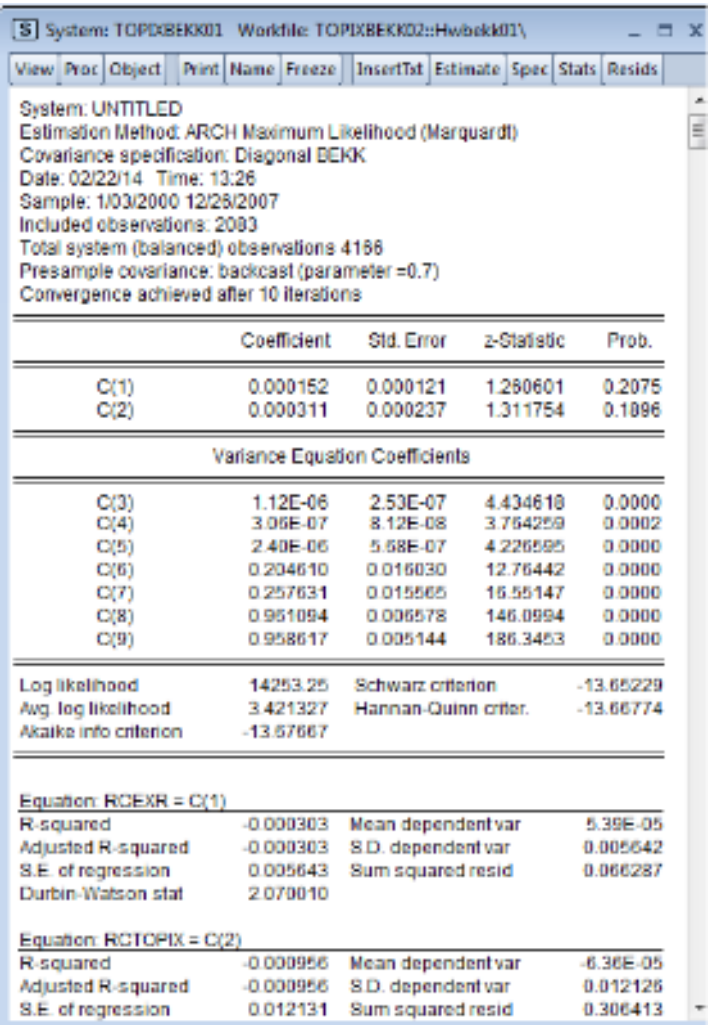
1 月初旬に関しては二つのモデルは同じようなハイクを示していますが、月中、月末にかけてはかなり異なった分散の予測になっています。最後に、Historical Variance を 20 日間のデータを用いて計算した結果が、下の図に示されています。

Historical Variance

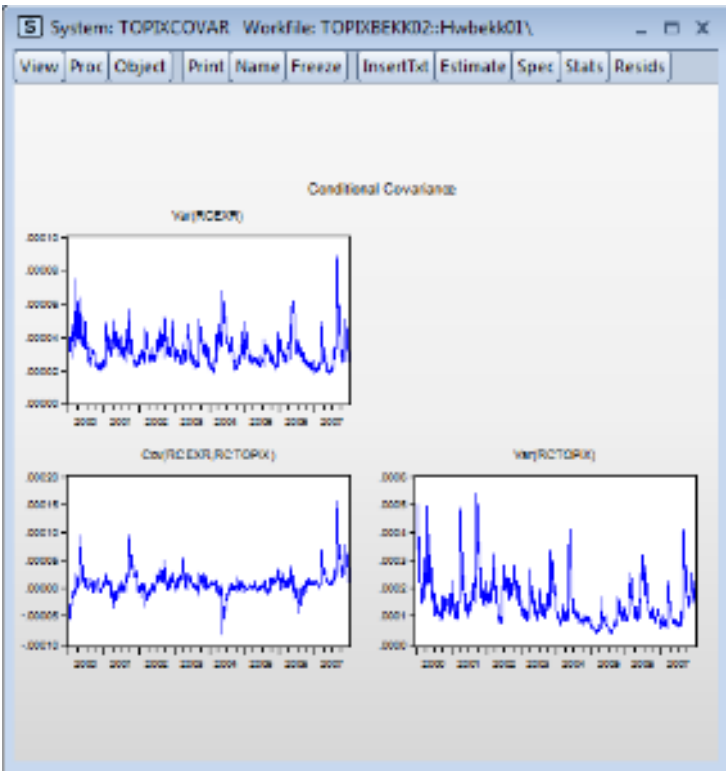


(3) 本章 4.3 と同様のサンプル期間（2000 年 1 月 3 日から 2007 年 12 月 26 日）を用いて TOPIX と為替レートを用いて BEKK モデルを推定した分析結果が以下の図に示されています。

BEKK モデル推定結果



この結果に基づいて計算された条件付き共分散が以下の図に示されています。基本的には日経 225 と同様な動きを示しています。



(4) まず GARCH の場合の分散計算式は図 4. 16 の推定結果から

$$h_t = 0.055 + 0.197u_{t-1}^2 + 0.680h_{t-1}$$

となります。インパクト・カーブの計算においては h_{t-1} の項には、収益率方程式の推定結果から得られる（無条件）誤差分散を用います。-1 から 1 の間の値をとる乱数を成し、その平方値を u_{t-1}^2 として式に代入することによって h_t が計算されます。

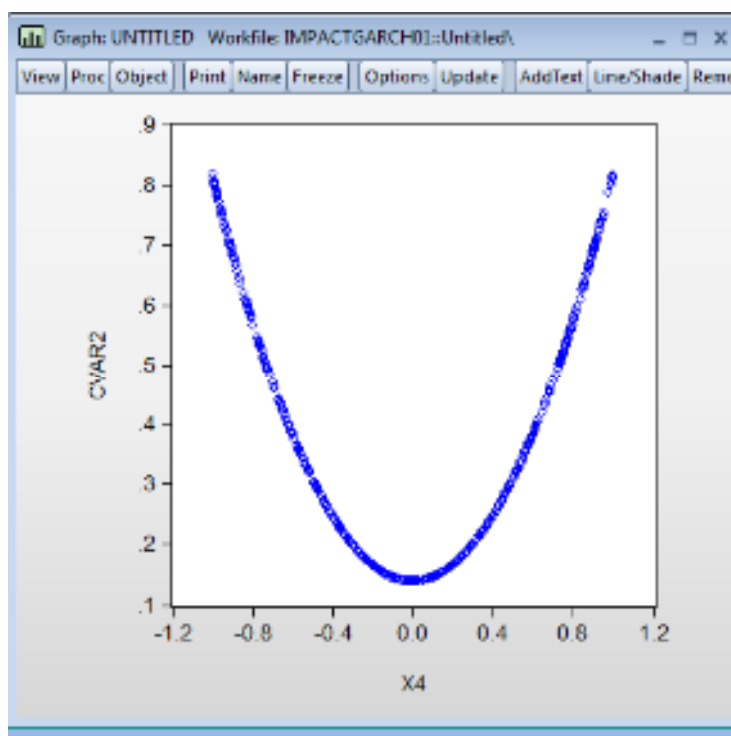
TARCH モデルの場合は図 4. 21 の推定結果から

$$h_t = 0.052 + 0.041u_{t-1}^2 + 0.266h_{t-1} + 0.707u_{t-1}^2I_{t-1}$$

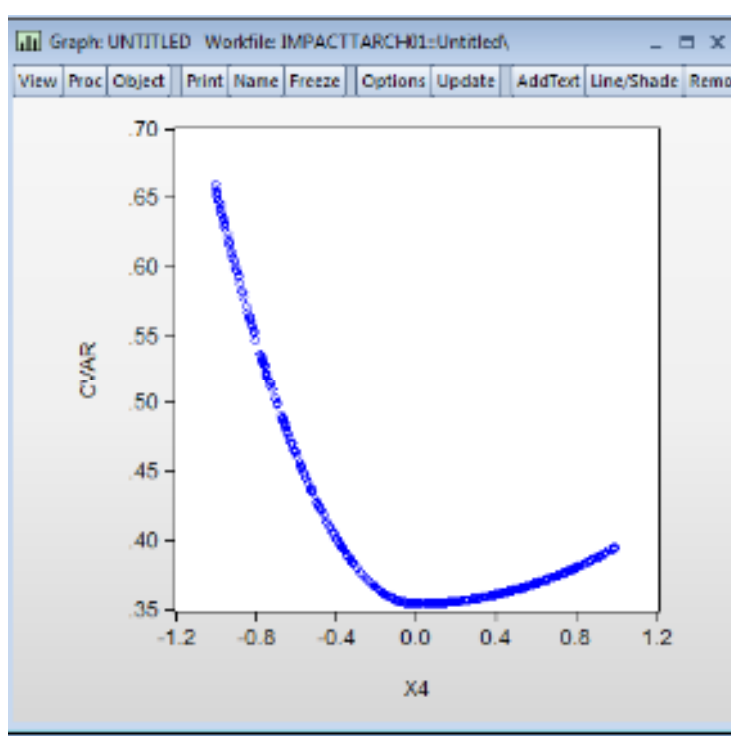
となります。

GARCH モデルと TARCH モデルのインパクト・カーブはそれぞれ以下のようにになります。

GARCH モデル

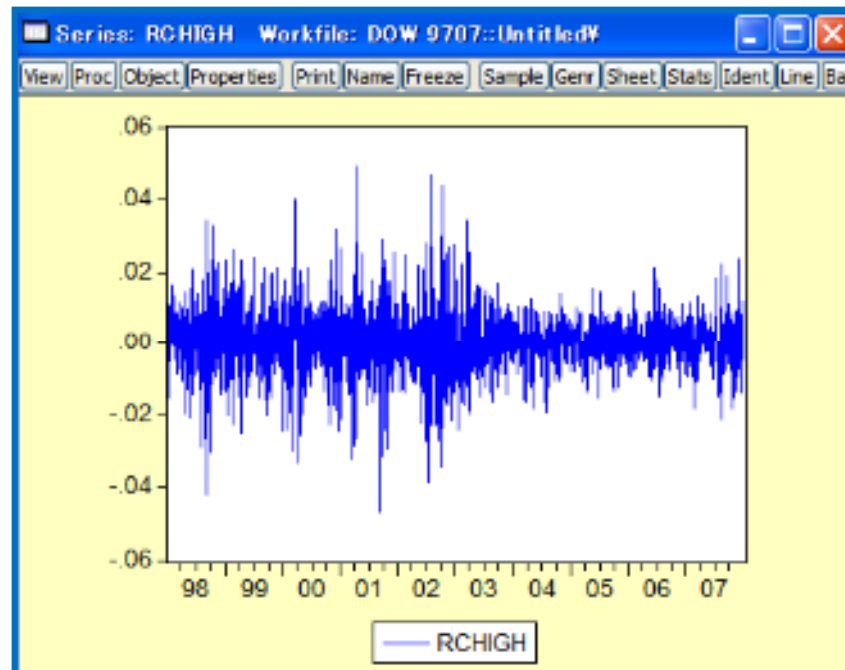


TARCH モデル



予想された通りに、GARCH モデルのインパクト・カーブは対照的です。すなわち、正負のショックに対して同様に反応

していますが、TARCH モデルのインパクト・カーブは非対称的です。負のショックに対する反応ははるかに大きなものとなっています。



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

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledV]

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledV]

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledY]

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledY]

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledW]

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

	Coefficient	Std. Error	z-Statistic	Prob.
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::UntitledW]

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::UntitledY]

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::UntitledY]

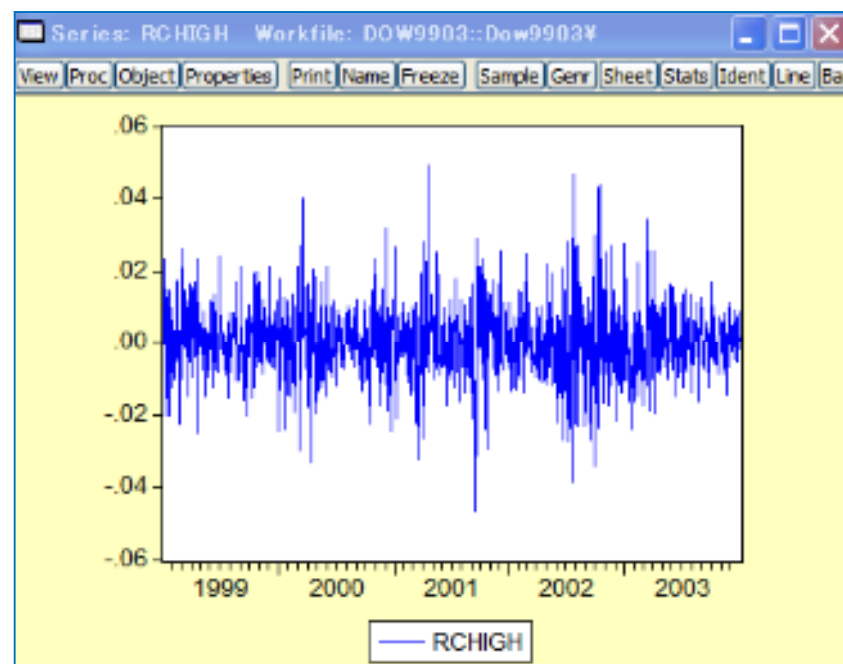
File Edit Object View Proc Quick Options Window Help

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



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): 1/06/1999 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	