

Outline II

- Volatility analysis with G@RCH models
 - First generation univariate G@RCH
 - ARCH, GARCH
 - Diagnostics
 - Forecasting
 - Forecast Evaluation
 - Second generation univariate G@RCH
 - GARCH-in-mean
 - EGARCH
 - GJR GARCH
 - Leverage effects and volatility smiles

Outline III

Long-Memory GARCH

- APARCH
- FIGARCH
 - FIGARCH- BBM
 - FIGARCH-Chung
 - FIEGARCH,
- Davidson's HYGARCH
- VaR

Outline IV

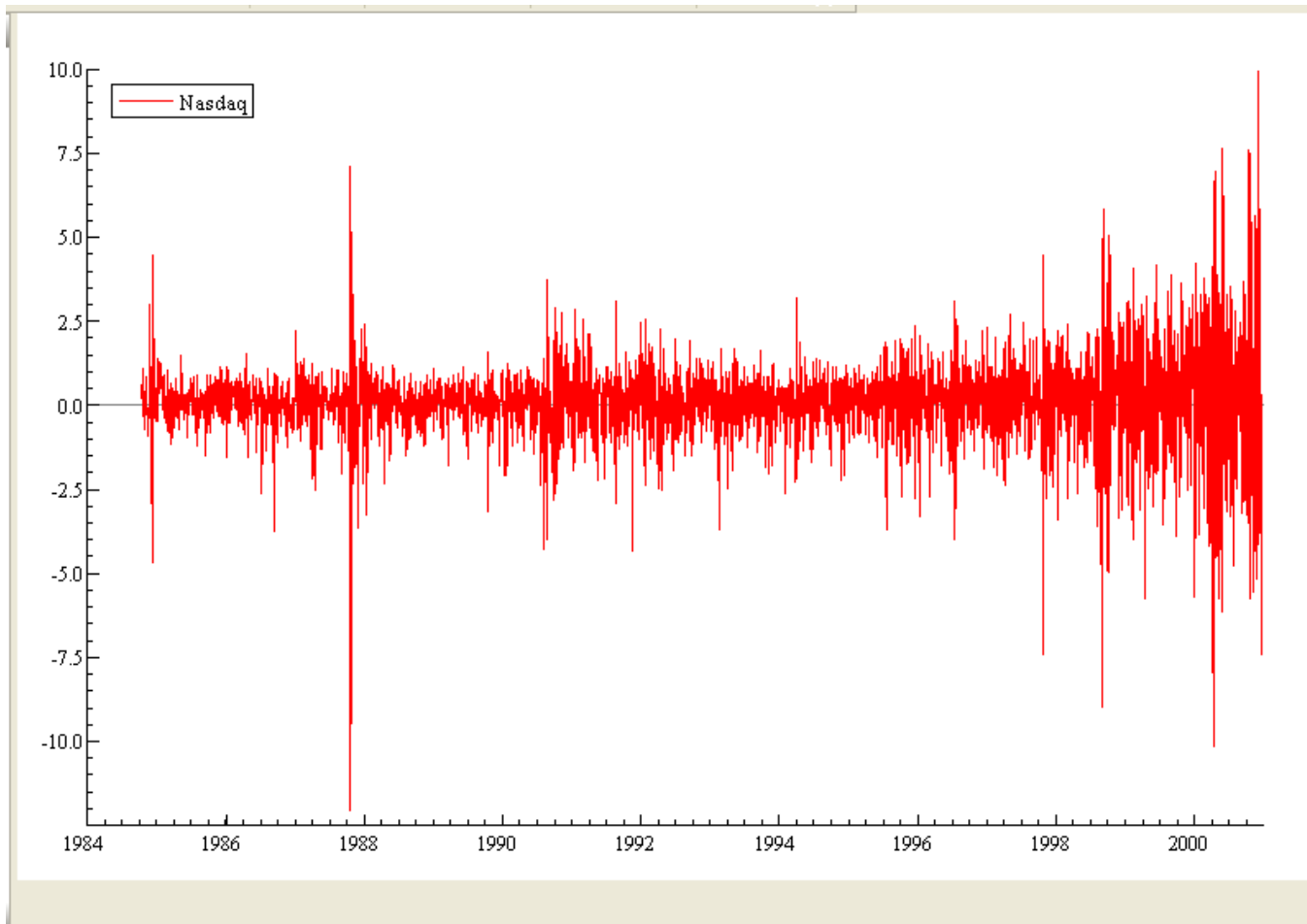
Multivariate GARCH

- Multivariate G@RCH
 - BEKK models
 - Factor garch: OGARCH, GOGARCH
 - Dynamic correlations: CCC, DCC
- Simulations

Risk Analysis with G@RCH

- We analyze volatility of indicators and assets with G@RCH.
- What is new about G@RCH 5?
 - It contains most of the multivariate Garch models
 - One can obtain the Ox Code for the menu model just run
 - One can model outliers and predictors in the mean and variance models
 - Estimation models has been improved. Simulated annealing option included.
 - Simulation of models is now possible
 - Functions to detect high frequency jumps have been included.

Load and Examine Nasdaq Returns



Notice the 1987 crash. We construct a dummy variable for Oct 19, 1987 5

We want record of all variable constructions so I do this with the algebra code

The screenshot shows the OxMetrics software interface. A dialog box titled "Algebra - nasdaq.in7" is open, displaying the following code:

```
// Enter Algebra code here, for example:  
Ly = log(y); DLy = diff(Ly, 1);  
  
1 crash87 = Date == 1987-10-19 ? 1: 0;
```

The dialog box also includes buttons for "Run", "Done", "Load...", "Save As...", and "Recall". Below the code editor, there are sections for "Functions" (with a dropdown menu showing "log(VAR);") and "Database" (with a list of variables: "Date", "Nasdaq", "crash87"). A "Write Algebra Code" button is also present.

The background window shows a spreadsheet with data for the period 1987-09-20 to 1987-11-05. The data includes dates and numerical values, with a column labeled "crash87" containing binary values (0 or 1).

Date	crash87
1987-09-20	0
1987-09-21	0
1987-09-22	0
1987-09-23	0
1987-09-24	0
1987-09-27	0
1987-09-28	0
1987-09-29	0
1987-09-30	0
1987-10-01	0
1987-10-02	0
1987-10-03	0
1987-10-04	0
1987-10-05	0
1987-10-06	0
1987-10-07	0
1987-10-08	0
1987-10-09	0
1987-10-10	0
1987-10-11	0
1987-10-12	0
1987-10-13	0
1987-10-14	0
1987-10-15	0
1987-10-16	0
1987-10-17	0
1987-10-18	0
1987-10-19	1
1987-10-20	0
1987-10-21	0
1987-10-22	0
1987-10-23	0
1987-10-24	0
1987-10-25	0
1987-10-26	0
1987-10-27	0
1987-10-28	0
1987-10-29	0
1987-10-30	0
1987-10-31	0
1987-11-01	0
1987-11-02	0
1987-11-03	0
1987-11-04	0
1987-11-05	0

This constructs our dummy variable

The screenshot shows the OxMetrics software interface. The title bar reads: *OxMetrics - C:\Program Files\OxMetrics5\data\nasdaq.in7 - [*nasdaq.in7 - C:\Progr...]. The menu bar includes File, Edit, View, Model, Run, Window, and Help. The toolbar contains various icons for file operations and model management. Below the toolbar, a status bar displays the equation: $x\beta = 80 + 81 * Late$. The main window is divided into a left sidebar and a main data table.

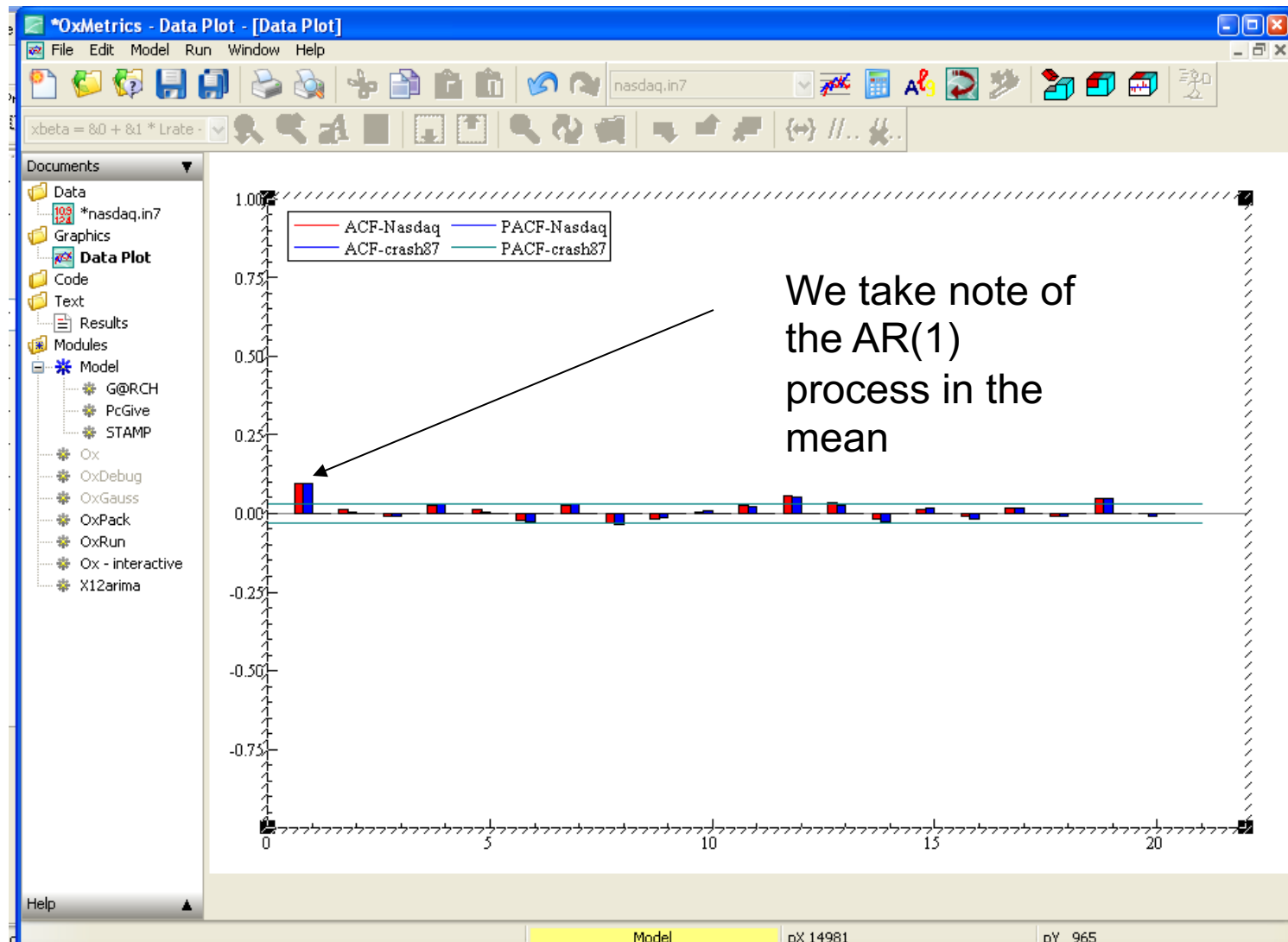
The left sidebar shows a tree view of the project structure under 'Documents':

- Data
- Graphics
- Data Plot
- Code
- Text
- Results
- Modules
 - Model
 - G@RCH
 - PcGive
 - STAMP
 - Ox
 - OxDebug
 - OxGauss
 - OxPack
 - OxRun
 - Ox - interactive
 - X12arima

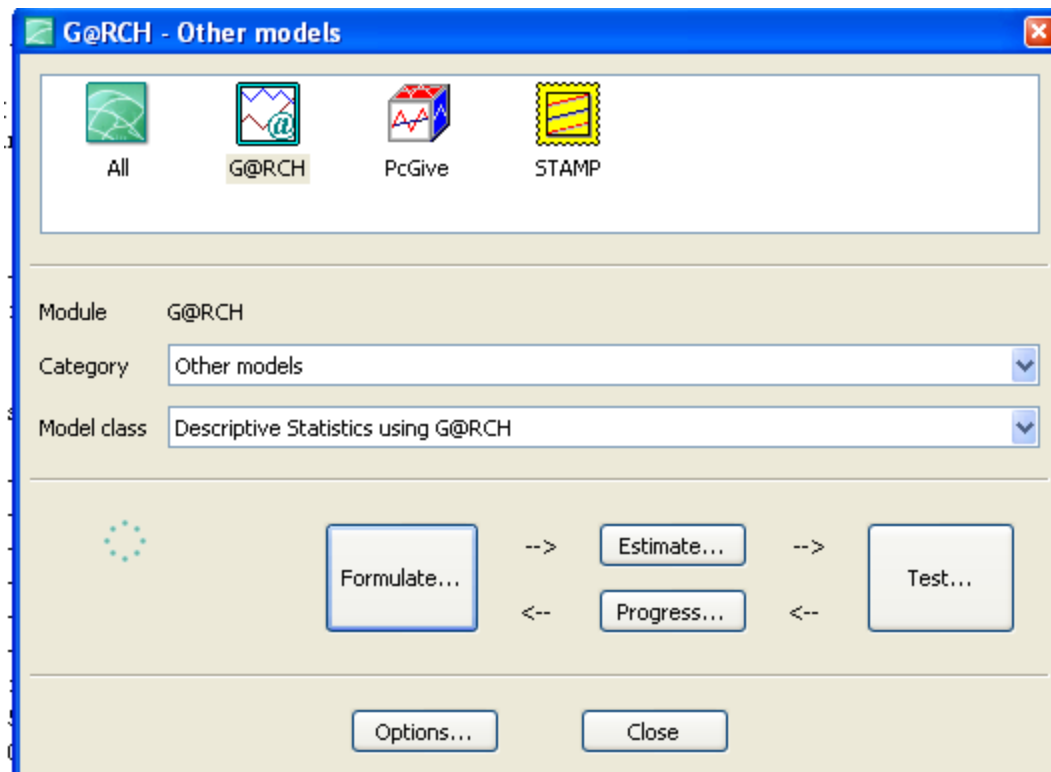
The main data table has the following columns: Date, Nasdaq, and crash87. The data is as follows:

Date	Nasdaq	crash87
1987-10-02	.688815	0
1987-10-05	.441892	0
1987-10-06	-1.35392	0
1987-10-07	-.650154	0
1987-10-08	-1.04003	0
1987-10-09	-.364299	0
1987-10-12	-1.2394	0
1987-10-13	.414843	0
1987-10-14	-1.50623	0
1987-10-15	-1.36344	0
1987-10-16	-3.90976	0
1987-10-19	-12.0432	1
1987-10-20	-9.42558	0
1987-10-21	7.09434	0
1987-10-22	-4.59383	0
1987-10-23	-2.28719	0
1987-10-26	-9.44278	0
1987-10-27	-.873661	0
1987-10-28	-1.49612	0
1987-10-29	5.07621	0
1987-10-30	5.14073	0
1987-11-02	1.53471	0
1987-11-03	-2.34217	0

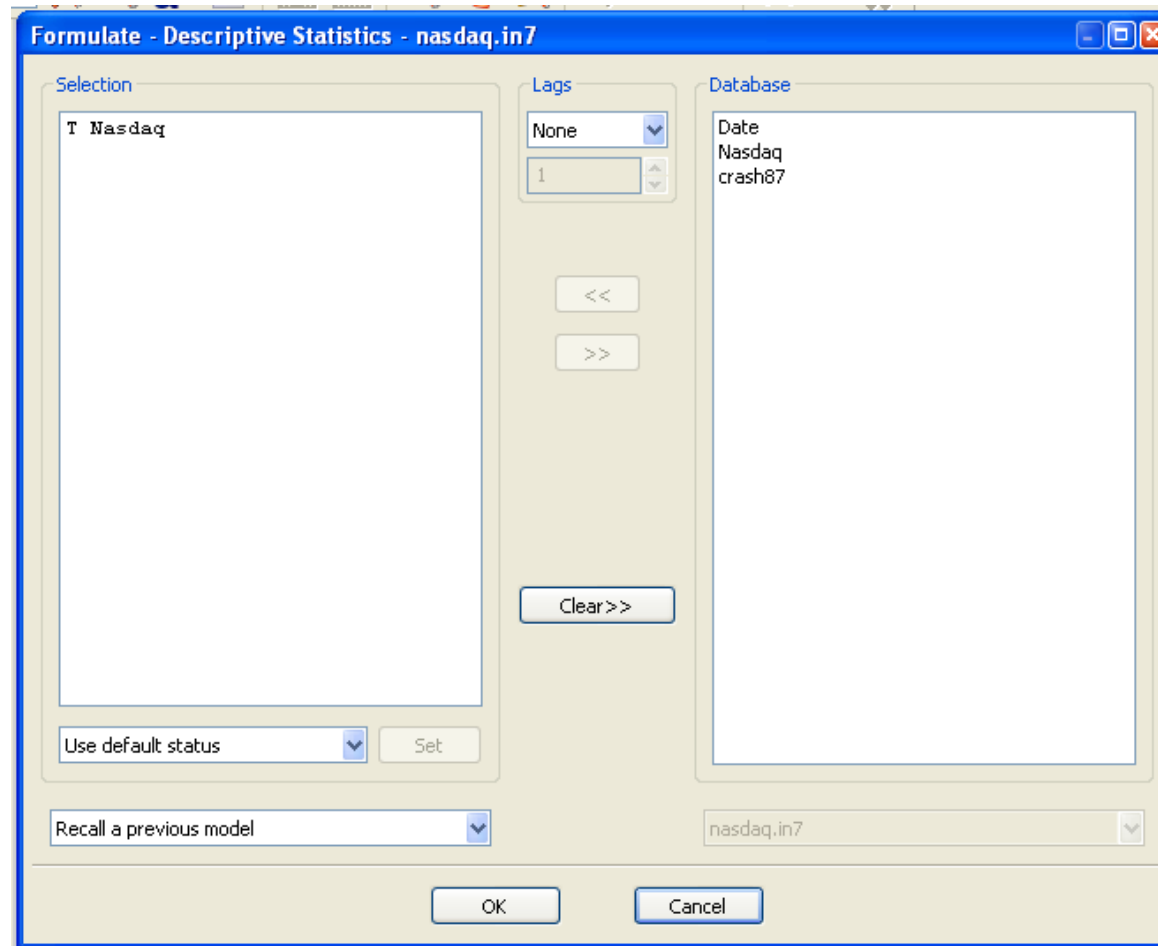
Correlograms reveal an AR(1) and possibly some seasonality



Basic Pre-Model Analysis



Select the variable



Define the sample

Mode: Feather: | Create selection from:

Estimate - Descriptive Statistics ✕

Choose the estimation sample:

Selection sample	1984-10-12 - 2000-12-21
Estimation starts at	1984-10-12
Estimation ends at	2000-12-21

Choose the estimation method:

Estimation method: Tests

OK Cancel

Specify the preliminary tests

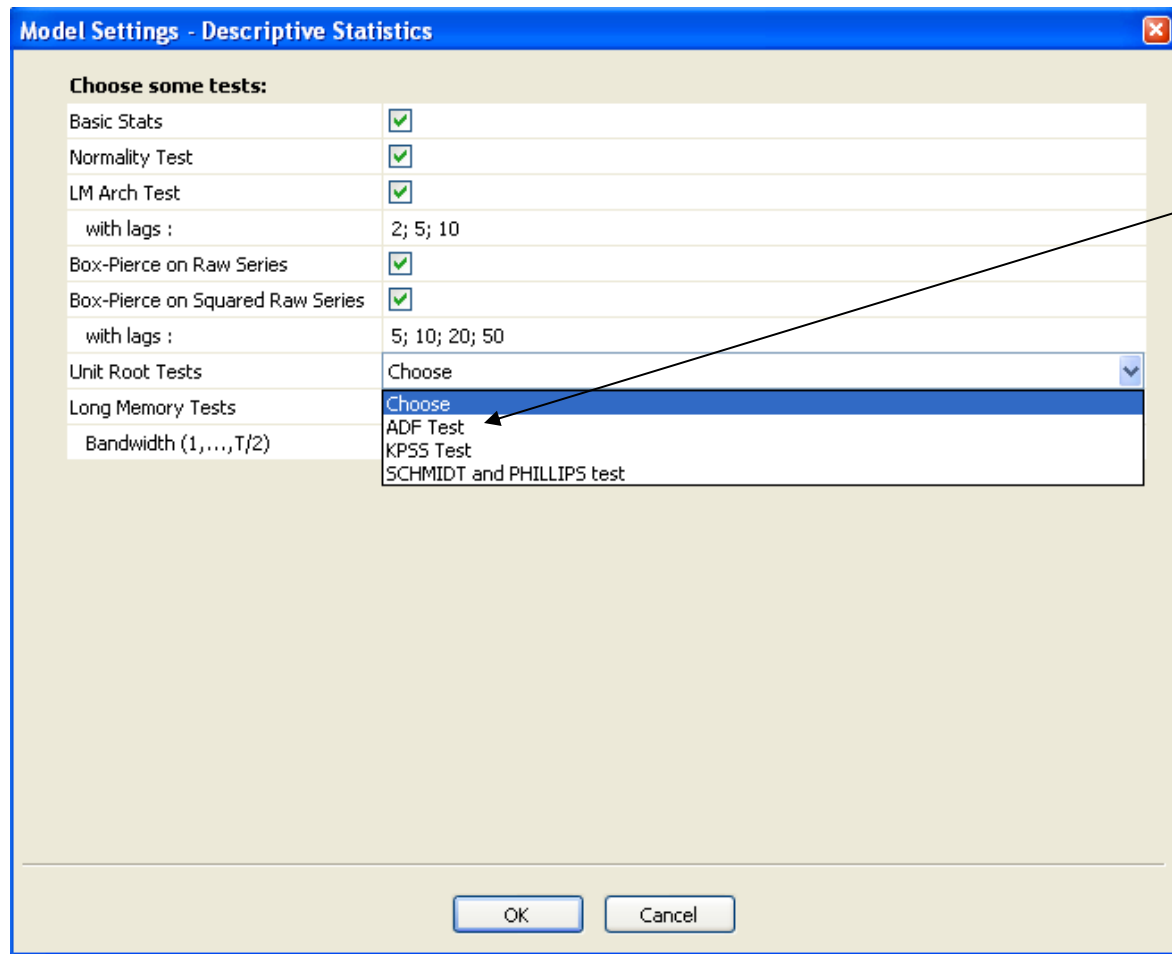
Model Settings - Descriptive Statistics

Choose some tests:

Basic Stats	<input checked="" type="checkbox"/>
Normality Test	<input checked="" type="checkbox"/>
LM Arch Test	<input checked="" type="checkbox"/>
with lags :	2; 5; 10
Box-Pierce on Raw Series	<input checked="" type="checkbox"/>
Box-Pierce on Squared Raw Series	<input checked="" type="checkbox"/>
with lags :	5; 10; 20; 50
Unit Root Tests	Choose
Long Memory Tests	Choose
Bandwidth (1,...,T/2)	2046

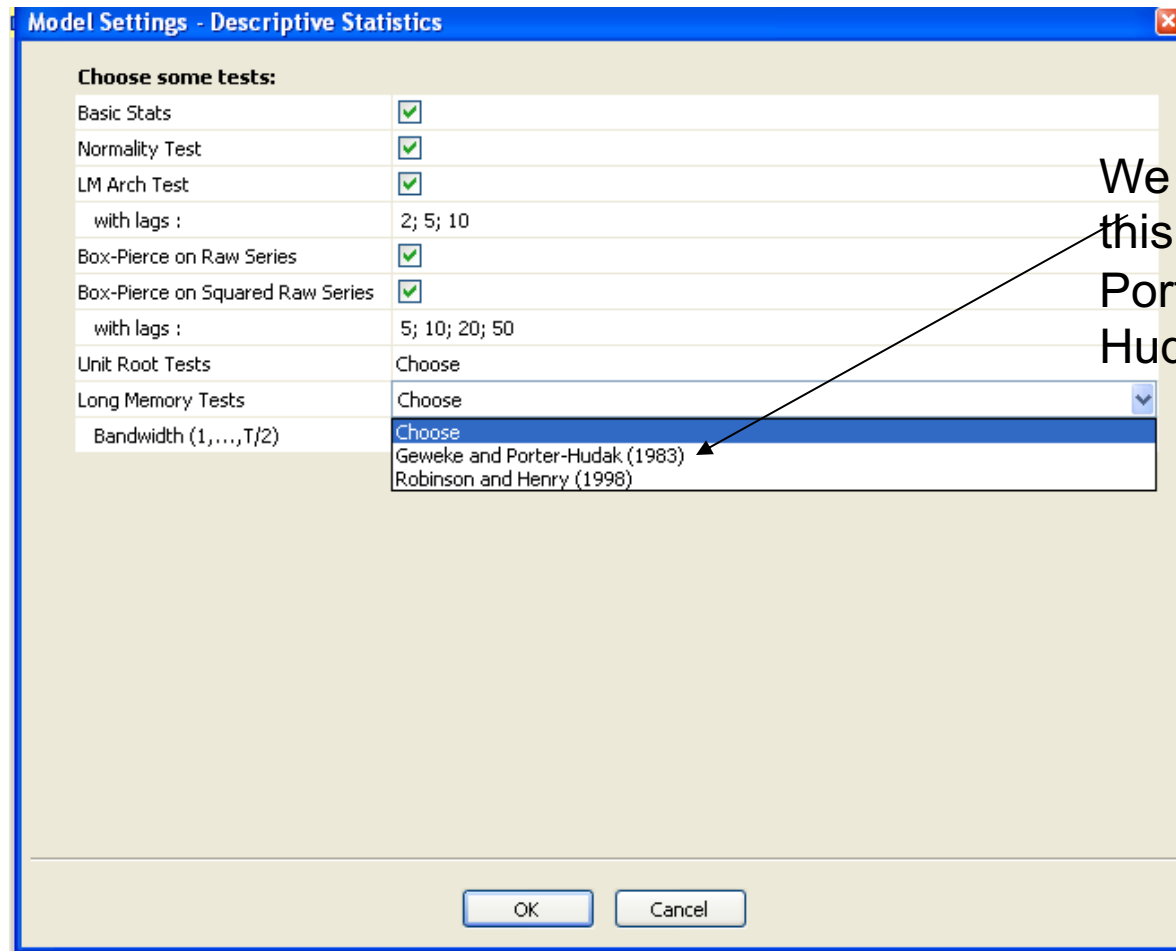
OK Cancel

Choose the Stationarity tests



We select ADF test

Choose the Long-Memory Test



We select
this Geweke
Porter-
Hudak test

Obtain the results

----- Database information -----
Sample: 1984-10-12 - 2000-12-21 (4093 observations)
Frequency: 1
Variables: 4

Variable	#obs	#miss	type	min	mean	max	std.dev
Date	4093	0	date	1984-10-12		2000-12-21	
Nasdaq	4093	0	double	-12.043	0.055166	9.9636	1.2617
Constant	4093	0	double	1	1	1	0
Trend	4093	0	double	1	2047	4093	1181.5

Series #1/1: Nasdaq

Normality Test

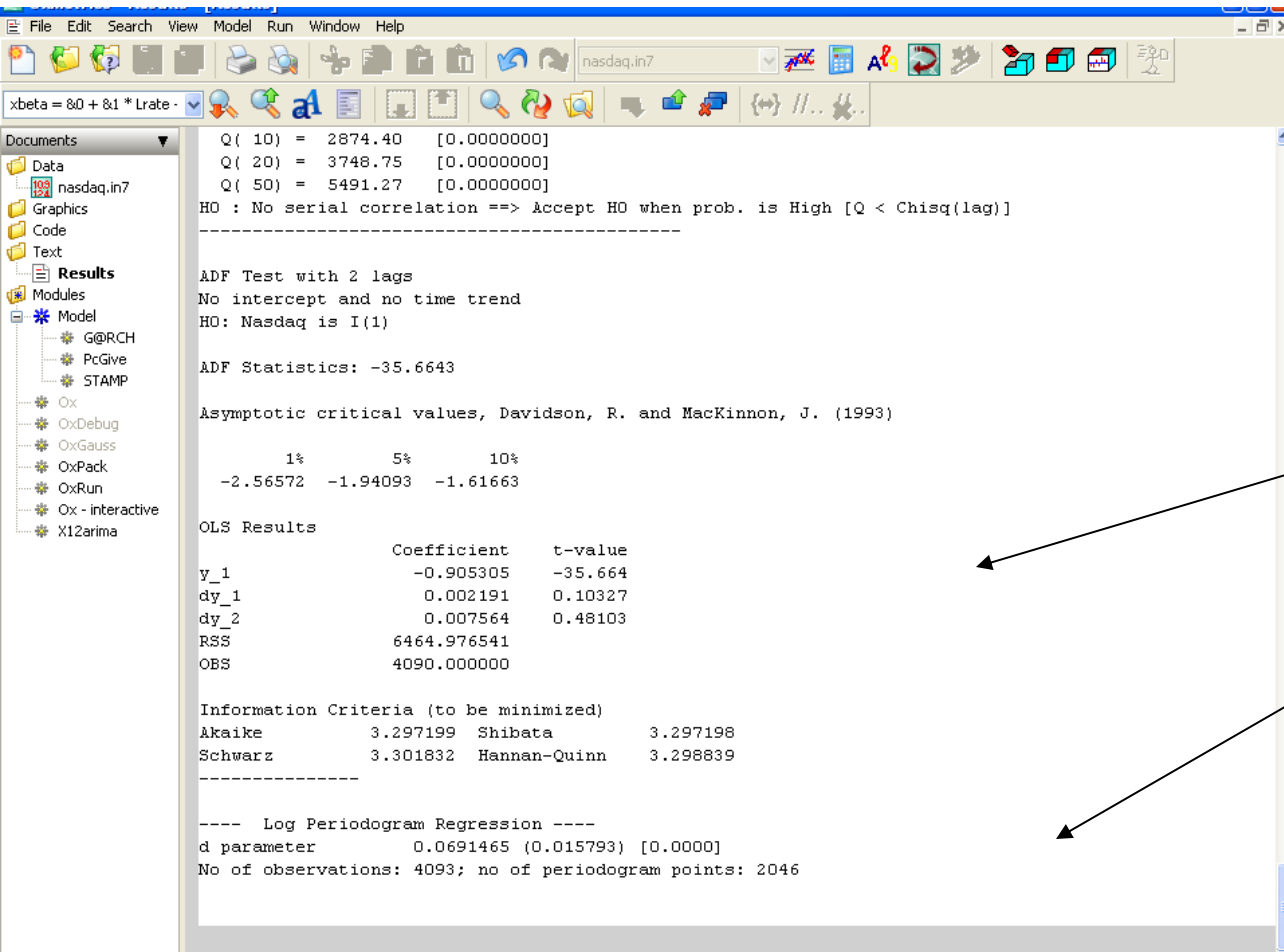
	Statistic	t-Test	P-Value
Skewness	-0.74128	19.368	1.4336e-083
Excess Kurtosis	11.255	147.07	0.00000
Jarque-Bera	21979.	.NaN	0.00000

ARCH 1-2 test: F(2,4088) = 420.80 [0.0000]**
ARCH 1-5 test: F(5,4082) = 228.90 [0.0000]**
ARCH 1-10 test: F(10,4072) = 118.16 [0.0000]**

Q-Statistics on Raw data
Q(5) = 41.8697 [0.0000001]
Q(10) = 50.9695 [0.0000002]
Q(20) = 83.6251 [0.0000000]
Q(50) = 167.368 [0.0000000]
H0 : No serial correlation ==> Accept H0 when prob. is High [Q < Chisq(lag)]

Q-Statistics on Squared data
Q(5) = 1988.77 [0.0000000]
Q(10) = 2874.40 [0.0000000]
Q(20) = 3748.75 [0.0000000]

Nonstationarity and Long-Memory Results



$$\Delta y_t = (\beta - 1)y_{t-1} + e_t$$

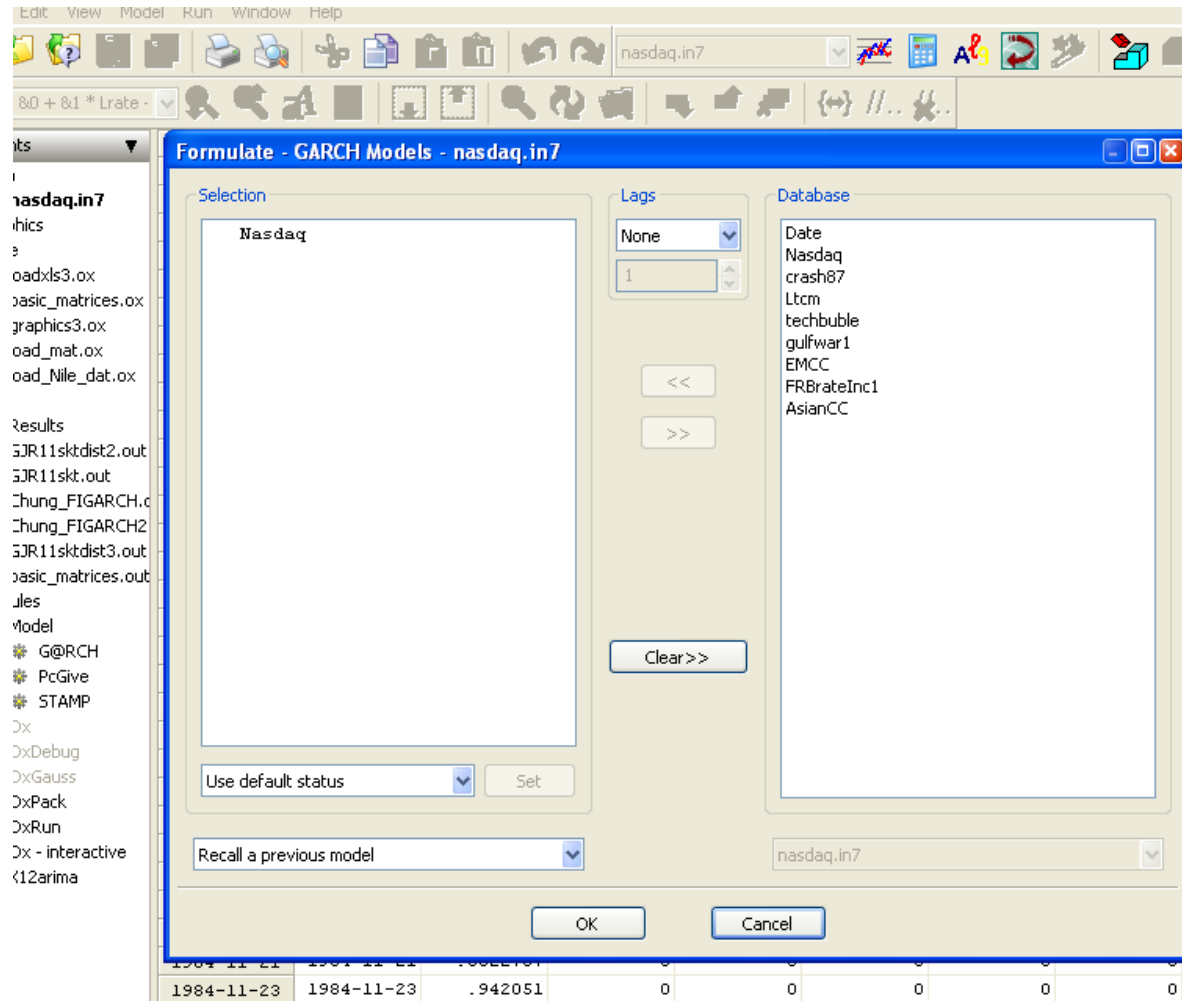
Nonstationary

Long memory parameter is weak—should be .2 to .5 for persistence.

Pre-Model Analysis

- The Jarque-Bera tests suggests nonnormality--- we should probably try a t distribution
- The ARCH tests suggest ARCH effects
- The Portmanteau tests suggest autocorrelation
- The Nasdaq returns are nonstationary and there is long memory

Variable Selection



Baseline model parameter selection

Model Settings - GARCH Models

AR(FI)MA Orders (m,d,l)

AR order (m)	1
MA order (l)	0
ARFIMA	<input type="checkbox"/>

GARCH Orders

Garch order (p)	1
Arch order (q)	1

Model

Fractionally Integrated Models

ARCH-in-Mean

Distribution

Gauss	<input checked="" type="radio"/>
Student	<input type="radio"/>
GED	<input type="radio"/>
Skewed Student	<input type="radio"/>

Constants

OK Cancel

AR(1) GARCH(1,1) normal distribution is our baseline model

GARCH(1,1) model output

```
*****
** GARCH( 1) SPECIFICATIONS **
*****
Dependent variable : Nasdaq
Mean Equation : ARMA (1, 0) model.
No regressor in the conditional mean
Variance Equation : GARCH (1, 1) model.
No regressor in the conditional variance
Normal distribution.

Strong convergence using numerical derivatives
Log-likelihood = -5395.14
Please wait : Computing the Std Errors ...

Robust Standard Errors (Sandwich formula)
      Coefficient  Std.Error  t-value  t-prob
Cst(M)           0.084113   0.015616   5.386   0.0000
AR(1)            0.193052   0.017187  11.23   0.0000
Cst(V)           0.025299   0.0071185  3.554   0.0004
ARCH(Alpha1)     0.167673   0.029686   5.648   0.0000
GARCH(Beta1)     0.820858   0.028236  29.07   0.0000

No. Observations :      4093  No. Parameters   :        5
Mean (Y)          :  0.05517  Variance (Y)    :  1.59189
Skewness (Y)     : -0.74128  Kurtosis (Y)   : 14.25531
Log Likelihood   : -5395.144  Alpha[1]+Beta[1]:  0.98853

The sample mean of squared residuals was used to start recursion.
The positivity constraint for the GARCH (1,1) is observed.
This constraint is  $\alpha[L]/[1 - \beta(L)] \geq 0$ .
The unconditional variance is 2.2058
The conditions are  $\alpha[0] > 0$ ,  $\alpha[L] + \beta[L] < 1$  and  $\alpha[i] + \beta[i] \geq 0$ .
=> See Doornik & Ooms (2001) for more details.
The condition for existence of the fourth moment of the GARCH is not observed.
The constraint equals 1.03342 and should be  $< 1$ .
=> See Ling & McAleer (2001) for details.
```

Selecting Post-Estimation tests

Tests - GARCH Models

Available Tests :

Information Criteria	<input checked="" type="checkbox"/>
Normality Test	<input checked="" type="checkbox"/>
Box/Pierce on Standardized Residuals	<input checked="" type="checkbox"/>
Box/Pierce on Squared Standardized Residuals	<input checked="" type="checkbox"/>
with lags :	5; 10; 20; 50
Sign Bias Test	<input checked="" type="checkbox"/>
Arch Test	<input checked="" type="checkbox"/>
with lags :	2; 5; 10
Nyblom Stability Test	<input checked="" type="checkbox"/>
Adjusted Pearson Chi-square Goodness-of-fit	<input checked="" type="checkbox"/>
with Cells number :	40; 50; 60
Residual-Based Diagnostic for Conditional Heteroskedasticity	<input checked="" type="checkbox"/>
with lags :	2; 5; 10

VaR in-sample Tests :

VaR levels (>0.5):	0.95; 0.975; 0.99; 0.995; 0.9975
Kupiec LRT (and ESF measures)	<input checked="" type="checkbox"/>
Dynamic Quantile Test (DQT) of Engle and Manganelli (2002)	<input checked="" type="checkbox"/>
Number of lags in DQT (Hit variable):	7

Further Outputs :

Print Variance-Covariance Matrix	<input type="checkbox"/>
----------------------------------	--------------------------

OK Cancel

Test Results I

```
*****
** TESTS **
*****

TESTS :
-----
Information Criteria (to be minimized)
Akaike          2.638722  Shibata          2.638719
Schwarz         2.646439  Hannan-Quinn  2.641454
-----

Normality Test

                Statistic      t-Test      P-Value
Skewness        -0.69210          18.083  4.3269e-073
Excess Kurtosis  2.8275           36.947  0.00000
Jarque-Bera     1690.2             .NaN     0.00000
-----

Q-Statistics on Standardized Residuals
--> P-values adjusted by 1 degree(s) of freedom
Q( 5) = 4.93617 [0.2939093]
Q(10) = 6.12809 [0.7270328]
Q(20) = 20.1258 [0.3870456]
Q(50) = 63.5812 [0.0787143]
HO : No serial correlation ==> Accept HO when prob. is High [Q < Chisq(lag)]
-----

Q-Statistics on Squared Standardized Residuals
--> P-values adjusted by 2 degree(s) of freedom
Q( 5) = 3.20892 [0.3605224]
Q(10) = 6.56843 [0.5838280]
Q(20) = 14.7703 [0.6776756]
Q(50) = 44.0824 [0.6340817]
HO : No serial correlation ==> Accept HO when prob. is High [Q < Chisq(lag)]
-----
```

Test Results II

Diagnostic test based on the news impact curve (EGARCH vs. GARCH)

	Test	P-value
Sign Bias t-Test	2.48129	0.01309
Negative Size Bias t-Test	1.20393	0.22862
Positive Size Bias t-Test	1.42296	0.15475
Joint Test for the Three Effects	25.46329	0.00001

ARCH 1-2 test: F(2,4086) = 1.2301 [0.2924]
ARCH 1-5 test: F(5,4080) = 0.62728 [0.6790]
ARCH 1-10 test: F(10,4070) = 0.63998 [0.7805]

Joint Statistic of the Nyblom test of stability: 6.34273

Individual Nyblom Statistics:

Cst(M)	0.09948
AR(1)	3.47893
Cst(V)	0.63865
ARCH(Alpha1)	1.25070
GARCH(Beta1)	1.58594

Rem: Asymptotic 1% critical value for individual statistics = 0.75.
Asymptotic 5% critical value for individual statistics = 0.47.

Adjusted Pearson Chi-square Goodness-of-fit test

# Cells(g)	Statistic	P-Value(g-1)	P-Value(g-k-1)
40	176.3672	0.000000	0.000000
50	210.1884	0.000000	0.000000
60	219.8317	0.000000	0.000000

Rem.: k = 5 = # estimated parameters

Test Results III

Residual-Based Diagnostic for Conditional Heteroskedasticity of Tse (2002)

RBD(2) = -6.40705 [1.0000000]
 RBD(5) = 0.485674 [0.9926385]
 RBD(10) = 4.53051 [0.9202588]

 P-values in brackets

In-sample Value-at-Risk Backtesting

Kupiec LR test

- Short positions -					
Quantile	Failure rate	Kupiec LRT	P-value	ESF1	ESF2
0.95000	0.96628	25.679	4.0322e-007	2.4334	1.2525
0.97500	0.98534	21.040	4.4975e-006	2.7129	1.2327
0.99000	0.99365	6.3191	0.011945	3.3298	1.2057
0.99500	0.99682	3.1457	0.076125	3.7132	1.2360
0.99750	0.99780	0.15517	0.69364	4.2753	1.2153
- Long positions -					
Quantile	Failure rate	Kupiec LRT	P-value	ESF1	ESF2
0.050000	0.058881	6.4458	0.011121	-2.3226	1.4410
0.025000	0.035915	17.662	2.6386e-005	-2.5715	1.3855
0.010000	0.019301	28.117	1.1419e-007	-2.9948	1.3767
0.0050000	0.013926	44.033	3.2289e-011	-3.2095	1.3548
0.0025000	0.0092841	44.368	2.7216e-011	-3.6826	1.3830

Test Results IV

Dynamic Quantile Test of Engle and Manganelli (2002)

- Short positions -

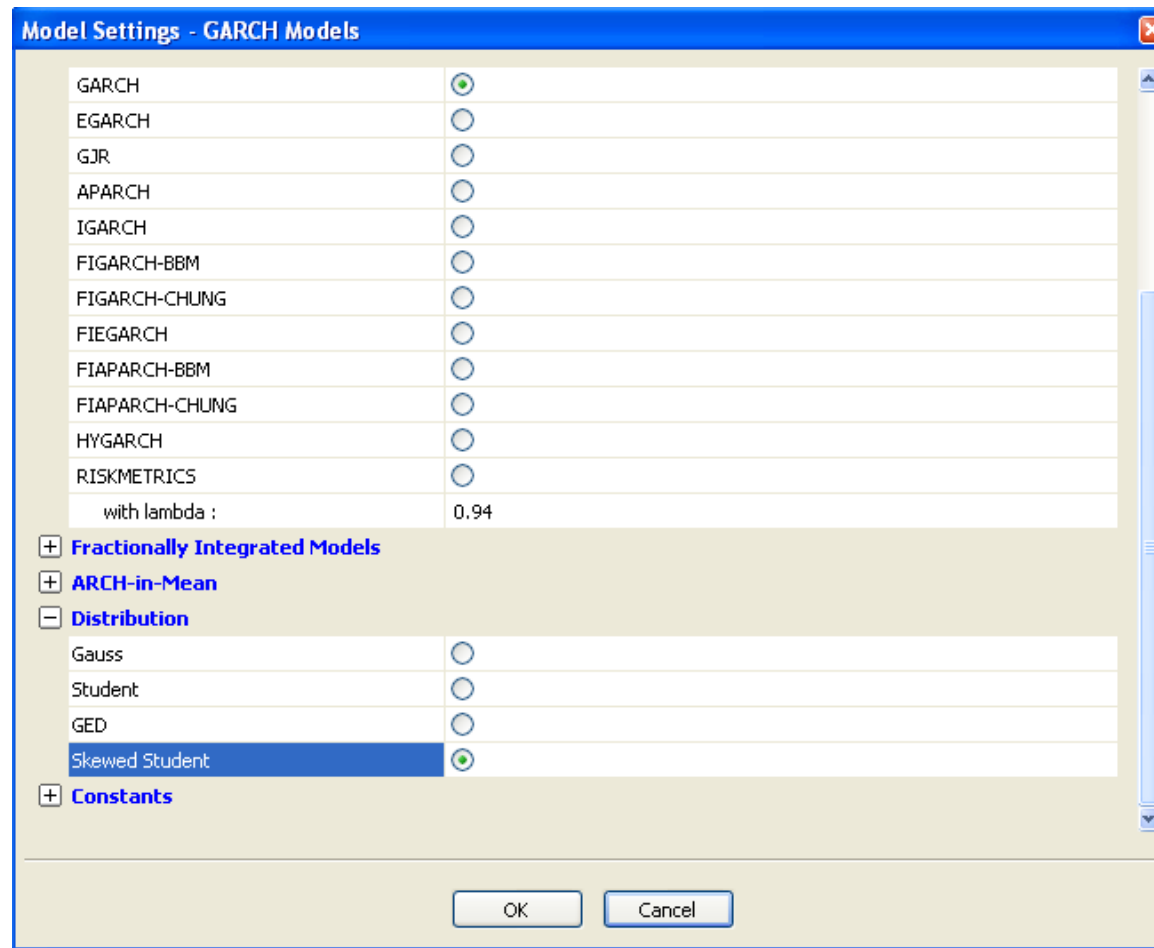
Quantile	Stat.	P-value
0.95000	25.551	0.0012532
0.97500	20.863	0.0075214
0.99000	8.8216	0.35757
0.99500	2.9260	0.93892
0.99750	0.27316	0.99999

- Long positions -

Quantile	Stat.	P-value
0.050000	13.109	0.10814
0.025000	36.600	1.3629e-005
0.010000	48.500	7.9279e-008
0.0050000	77.972	1.2501e-013
0.0025000	90.662	3.3307e-016

Remark: In the Dynamic Quantile Regression, $p=7$.

AR(1) GARCH(1,1) sk(t)



AR(1)-GARCH(1,1) sk(t) output

```
*****
** GARCH( 2) SPECIFICATIONS **
*****
Dependent variable : Nasdaq
Mean Equation : ARMA (1, 0) model.
No regressor in the conditional mean
Variance Equation : GARCH (1, 1) model.
No regressor in the conditional variance
Skewed Student distribution, with 6.36561 degrees of freedom.
and asymmetry coefficient (log xi) -0.176807.

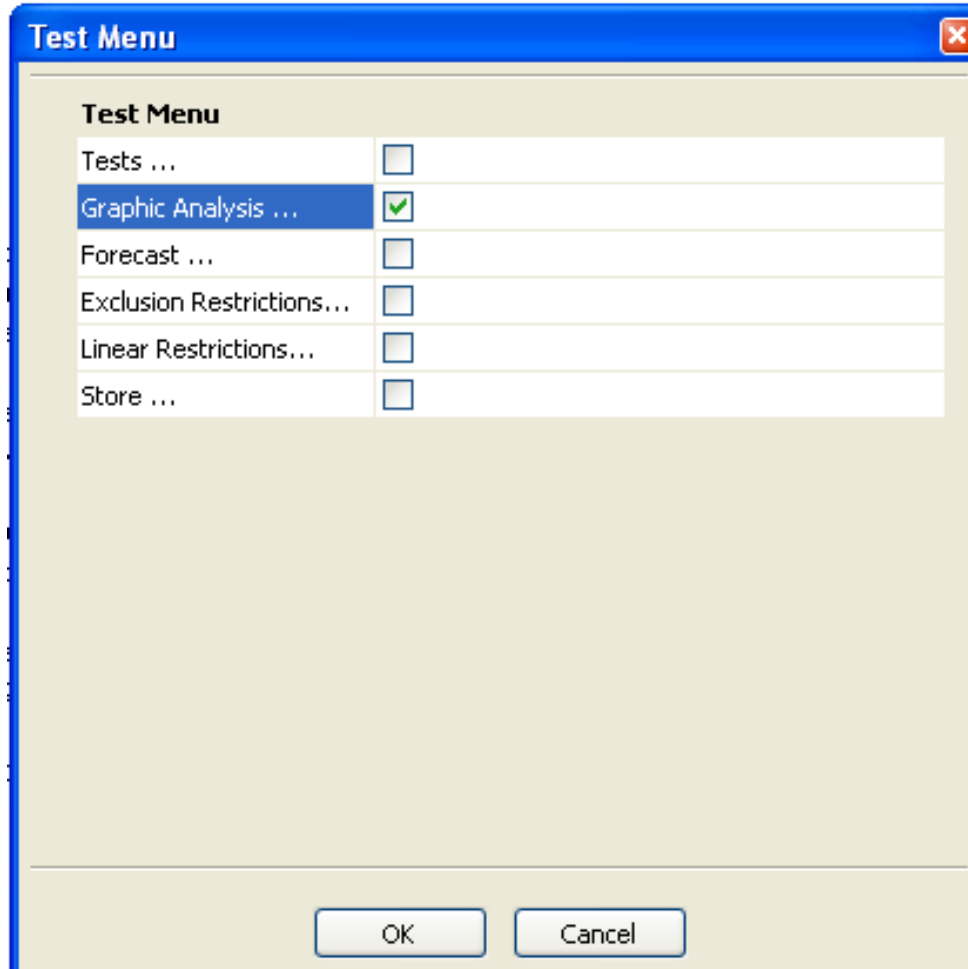
Strong convergence using numerical derivatives
Log-likelihood = -5228.77
Please wait : Computing the Std Errors ...

Robust Standard Errors (Sandwich formula)
      Coefficient  Std.Error  t-value  t-prob
Cst(M)          0.074547   0.013749   5.422   0.0000
AR(1)           0.172029   0.015928  10.80   0.0000
Cst(V)          0.013518   0.0041361  3.268   0.0011
ARCH(Alpha)     0.135317   0.022145   6.111   0.0000
GARCH(Beta1)    0.862093   0.021804  39.54   0.0000
Asymmetry       -0.176807   0.022959  -7.701   0.0000
Tail            6.365606   0.62455   10.19   0.0000

No. Observations :      4093  No. Parameters :          7
Mean (Y)          :  0.05517  Variance (Y)          :  1.59189
Skewness (Y)     : -0.74128  Kurtosis (Y)          : 14.25531
Log Likelihood   : -5228.772  Alpha[1]+Beta[1]:    0.99741

The sample mean of squared residuals was used to start recursion.
The positivity constraint for the GARCH (1,1) is observed.
This constraint is alpha[L]/[1 - beta(L)] >= 0.
The unconditional variance is 5.21841
The conditions are alpha[0] > 0, alpha[L] + beta[L] < 1 and alpha[i] + beta[i] >= 0.
=> See Doornik & Ooms (2001) for more details.
```

Graphical Analysis



Graph selection

Graphics - GARCH Models

Series

Raw Series (Y)	<input checked="" type="checkbox"/>
Residuals	<input checked="" type="checkbox"/>
Squared Residuals	<input checked="" type="checkbox"/>
Standardized Residuals	<input checked="" type="checkbox"/>
Conditional Variance	<input checked="" type="checkbox"/>

Histogram

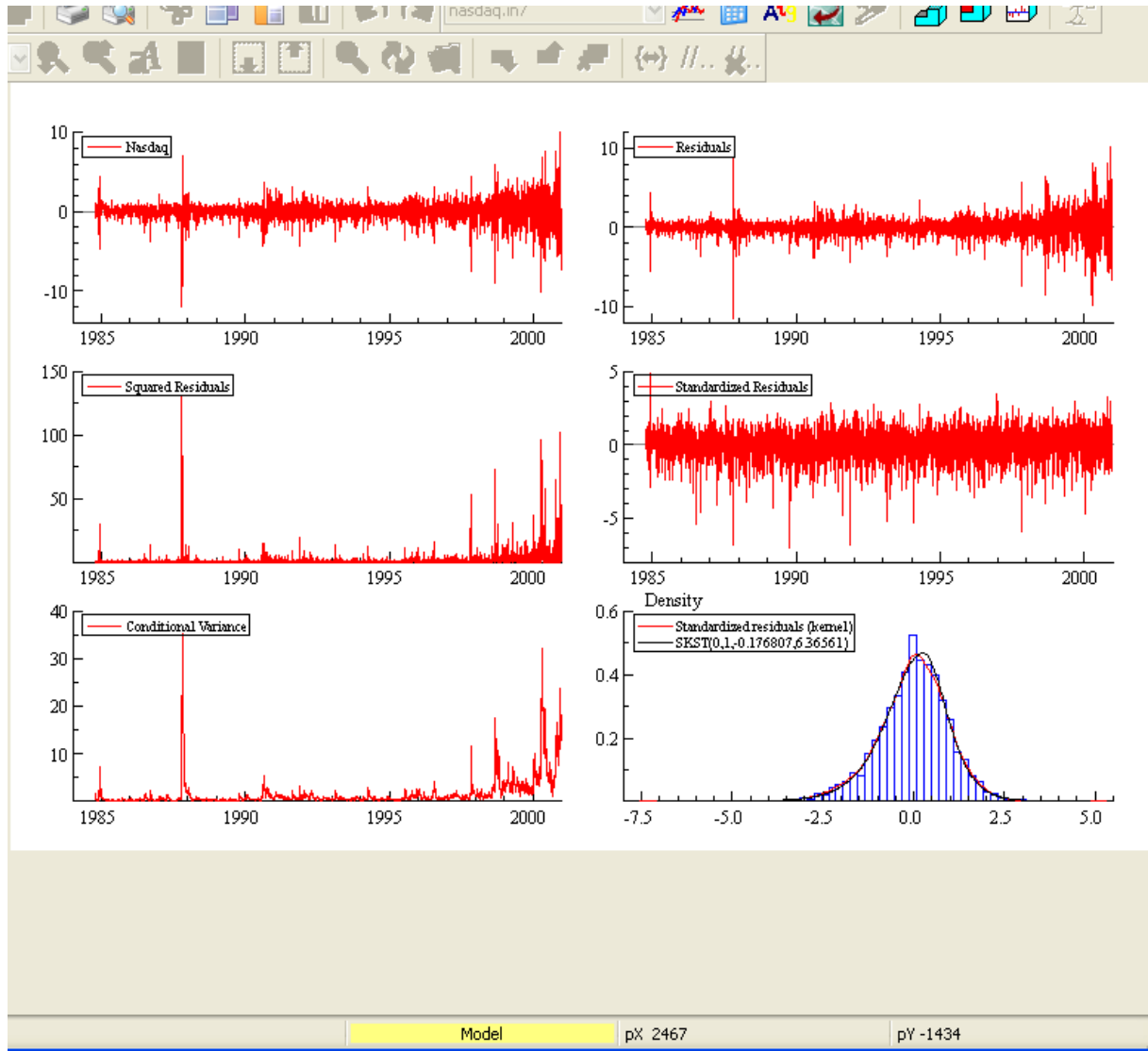
Standardized Residuals vs. Fitted Density	<input checked="" type="checkbox"/>
---	-------------------------------------

In-Sample VaR Forecasts

None	<input checked="" type="radio"/>
Empirical Quantiles	<input type="radio"/>
Theoretical Quantiles	<input type="radio"/>
with the following quantiles :	0.025; 0.975

OK Cancel

Graphical Output



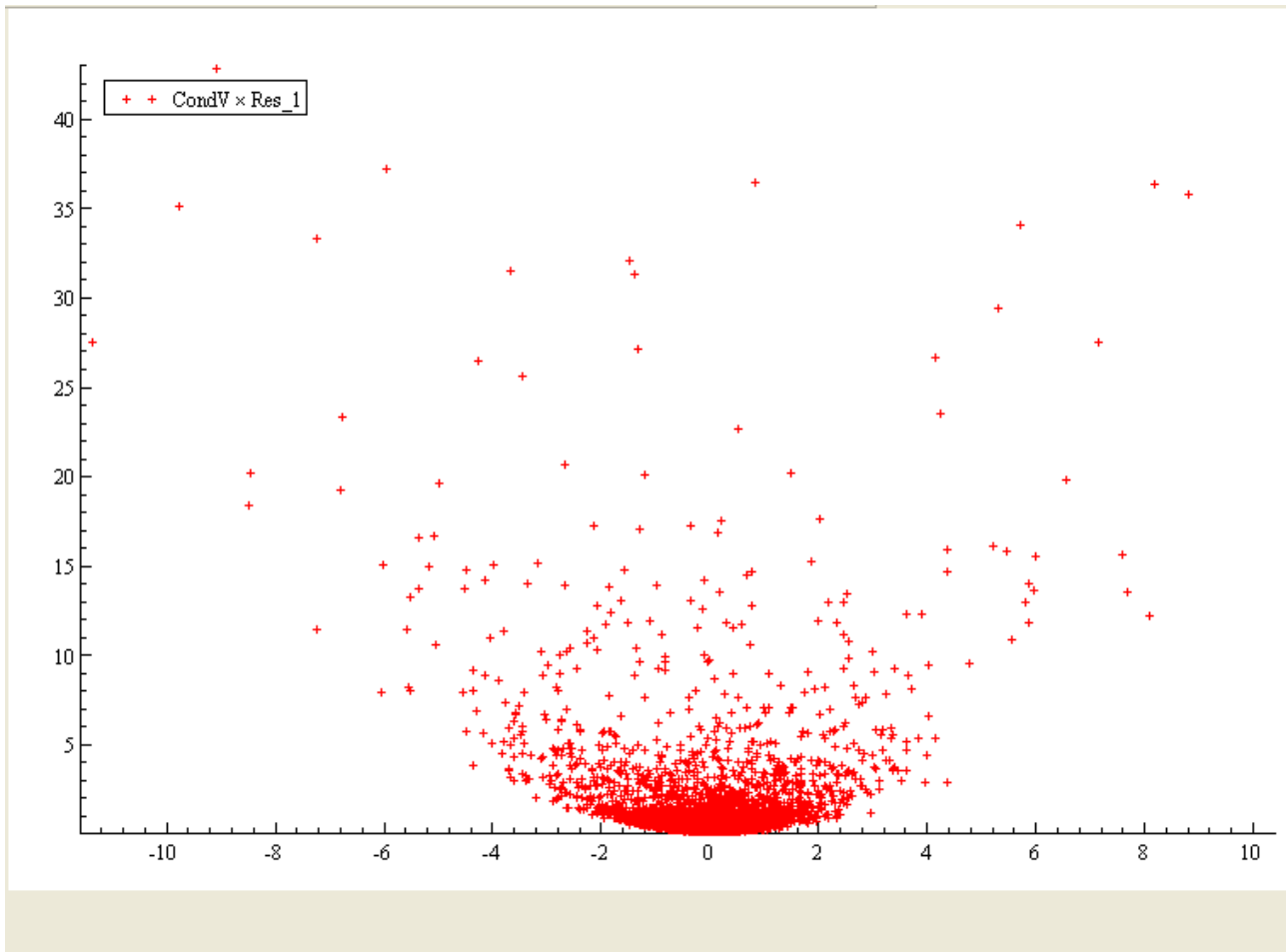
Model Comparison

Model	Iterations	Log Likelihood	Method
<input checked="" type="checkbox"/> G@RCH(2)	7 x 4093	-5228.77	BFGS
<input type="checkbox"/> G@RCH(1)	5 x 4093	-5395.14	BFGS
<input type="checkbox"/> G@RCH(0)	7 x 4093	-5367.13	BFGS

Simulation of CEV confidence intervals

- Demonstrate Simulation of CEV confidence intervals

Volatility Smile



Asymmetry tests

- Sign bias tests
- Positive
- Negative
- Joint

GJR Asymmetric GARCH(1,1)

```
** GARCH( 3) SPECIFICATIONS **
*****
Dependent variable : Nasdaq
Mean Equation : ARMA (1, 0) model.
No regressor in the conditional mean
Variance Equation : GJR (1, 1) model.
No regressor in the conditional variance
Skewed Student distribution, with 6.54157 degrees of freedom.
and asymmetry coefficient (log xi) -0.17954.

Strong convergence using numerical derivatives
Log-likelihood = -5184.52
Please wait : Computing the Std Errors ...

Robust Standard Errors (Sandwich formula)

```

	Coefficient	Std.Error	t-value	t-prob
Cst (M)	0.062393	0.014353	4.347	0.0000
AR(1)	0.185970	0.016883	11.02	0.0000
Cst (V)	0.017264	0.0052401	3.295	0.0010
ARCH(Alpha)	0.096650	0.015176	6.369	0.0000
GARCH(Beta)	0.850005	0.023975	35.45	0.0000
GJR(Gamma)	0.092444	0.030406	3.040	0.0024
Asymmetry	-0.179540	0.023111	-7.769	0.0000
Tail	6.541571	0.66287	9.869	0.0000

```

No. Observations :      4081  No. Parameters :          8
Mean (Y)          :  0.06050  Variance (Y)         :  1.55316
Skewness (Y)     : -0.72562  Kurtosis (Y)        : 14.49309
Log Likelihood   : -5184.518

The sample mean of squared residuals was used to start recursion.
The condition for existence of the second moment of the GJR is not observed.
This condition is alpha(1) + beta(1) + k gamma(1) < 1 (with k = 0.588818 with this distributio
In this estimation, this sum equals 1.00109.
The condition for existence of the fourth moment of the GJR is not observed.
The constraint equals 1.12247 (should be < 1). => See Ling & McAleer (2001) for details.
```

Model Comparison

Progress to date

Model	T	p		log-likelihood	SC	HQ	AIC
GARCH(0)	4093	7	BFGS	-5367.1337	2.6368	2.6298	2.6260
GARCH(1)	4093	5	BFGS	-5395.1442	2.6464	2.6415	2.6387
GARCH(2)	4093	7	BFGS	-5228.7723	2.5692	2.5622	2.5584
GARCH(3)	4081	8	BFGS	-5184.5175	2.5571<	2.5491<	2.5447<

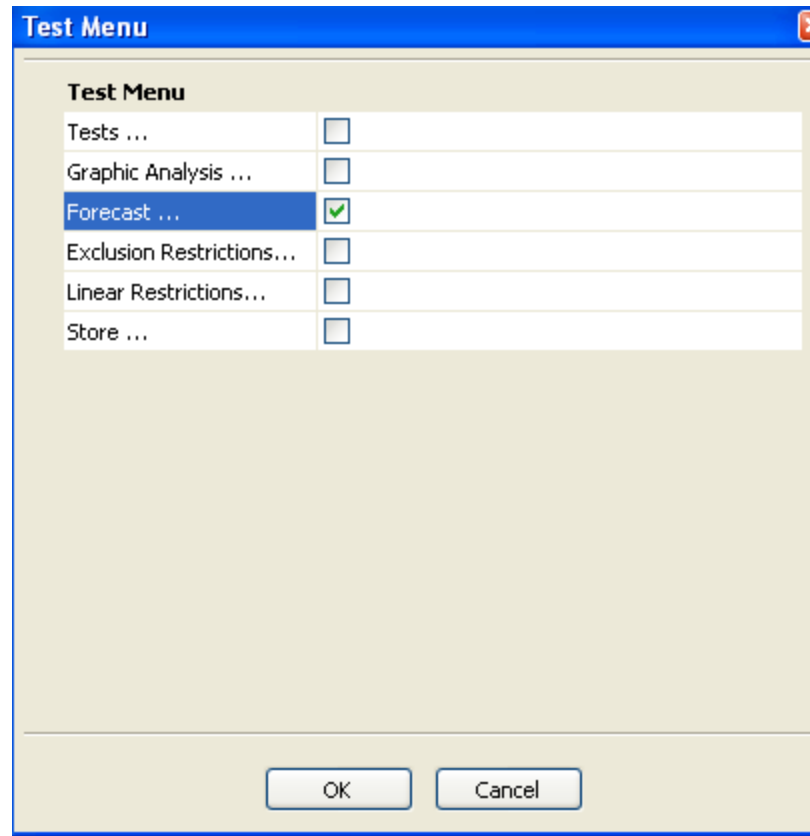
Tests of model reduction (please ensure models are nested for test validity)

GARCH(0) --> GARCH(1): Chi^2(2) = 56.021 [0.0000] **

Forecasts

- Conditional mean, with confidence intervals
- Conditional variance
 - Intervals can be simulated
- VaR intervals serve as confidence intervals

Click on the test icon



Forecast selection

Forecast - GARCH Models

Forecasting

Number of forecasts	12
---------------------	----

Options

Print Forecasts Errors Measures	<input checked="" type="checkbox"/>
Print Forecasts	<input checked="" type="checkbox"/>
Plot Forecasts	<input checked="" type="checkbox"/>
Add sample average of conditional variance	<input checked="" type="checkbox"/>
Number of pre-observations	49

Confidence Interval

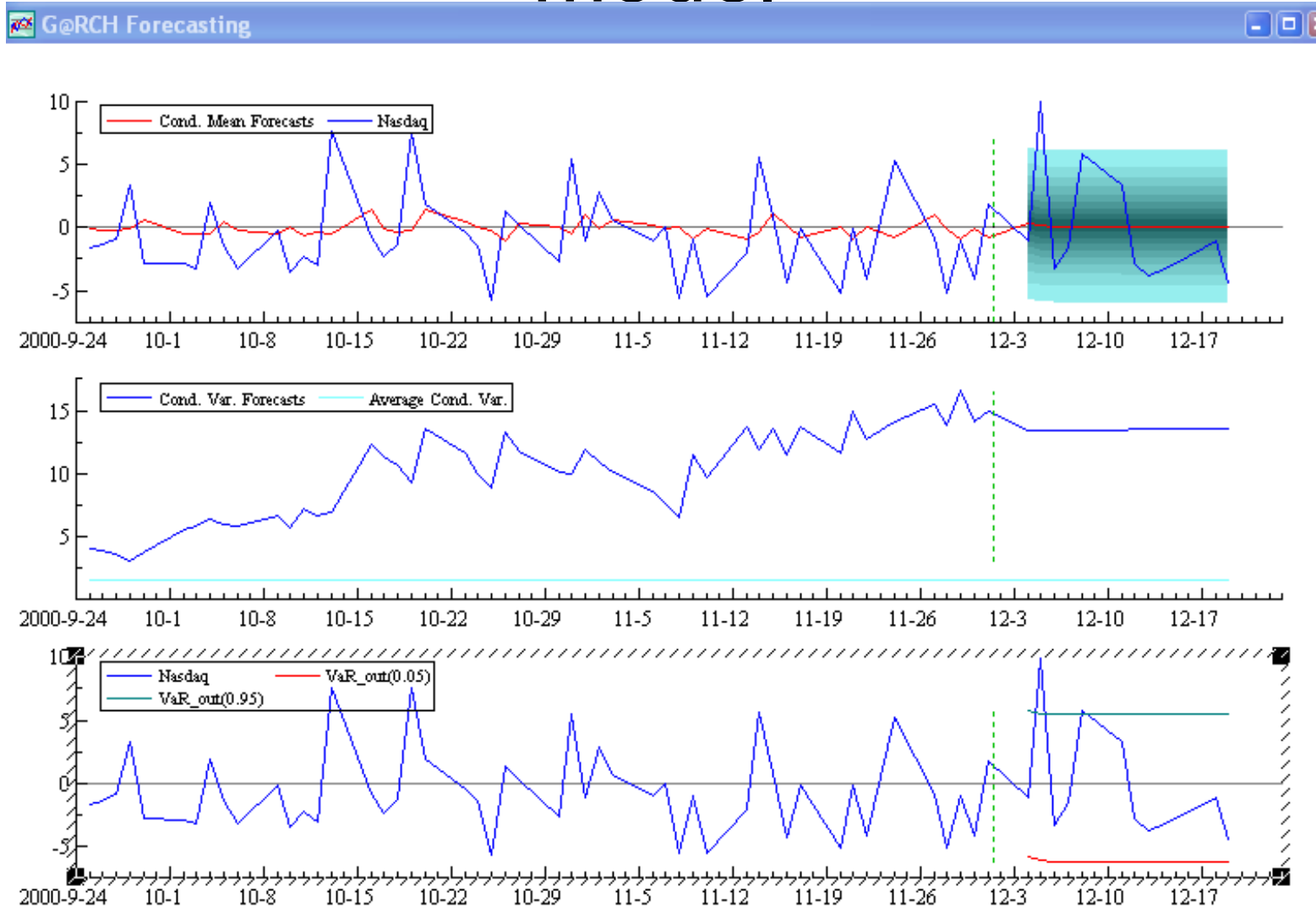
None	<input type="radio"/>
Error Bands	<input type="radio"/>
Error Bars	<input type="radio"/>
Error Fans	<input checked="" type="radio"/>
Critical Value	2

VaR Forecasts

Print VaR Forecasts	<input checked="" type="checkbox"/>
Plot VaR Forecasts	<input checked="" type="checkbox"/>
VaR levels:	0.05; 0.95

OK Cancel

Forecasts graphed from GJR model



Forecasts printed

```
*****  
** VaR FORECASTS **  
*****  
Number of Forecasts: 12  
  
Horizon      0.05      0.95  
  1      -5.716      8.482  
  2      -7.222      6.989  
  3      -7.508      6.717  
  4      -7.567      6.671  
  5      -7.584      6.668  
  6      -7.594      6.673  
  7      -7.601      6.679  
  8      -7.609      6.685  
  9      -7.616      6.692  
 10      -7.624      6.698  
 11      -7.631      6.705  
 12      -7.639      6.711
```

Forecast Evaluation

Forecast Evaluation Measures

	Mean	Variance
Mean Squared Error (MSE)	18.41	674
Median Squared Error (MedSE)	10.85	33.91
Mean Error (ME)	-0.5271	4.921
Mean Absolute Error (MAE)	3.664	13.71
Root Mean Squared Error (RMSE)	4.291	25.96
Mean Absolute Percentage Error (MAPE)	.NaN	2.144
Adjusted Mean Absolute Percentage Error (AMAPE)	.NaN	0.3743
Percentage Correct Sign (PCS)	0.25	.NaN
Theil Inequality Coefficient (TIC)	0.9714	0.5777
Logarithmic Loss Function (LL)	.NaN	1.559

Long Memory Models

- APARCH
- FIGARCH-BBM
- FIGARCH-Chung
- FIAPARCH-BBM
- FIAPARCH-Chung
- FIEGARCH
- Davidson's Hyperbolic GARCH

Long-Memory Models

- We run the basic descriptives test on it
 - And find that it has long memory with a GPH
 - $d = .2885$ with $p = 0.0000$.
 - Therefore we try a long-memory model.
 - A FIGARCH - Chung model

The Long Memory Model Menu

Model Settings - GARCH Models

AR(FI)MA Orders (m,d,l)

AR order (m)	1
MA order (l)	0
ARFIMA	<input checked="" type="checkbox"/>

GARCH Orders

Garch order (p)	1
Arch order (q)	1

Model

GARCH	<input type="radio"/>
EGARCH	<input type="radio"/>
GJR	<input type="radio"/>
APARCH	<input type="radio"/>
IGARCH	<input type="radio"/>
FIGARCH-BBM	<input type="radio"/>
FIGARCH-CHUNG	<input checked="" type="radio"/>
FIEGARCH	<input type="radio"/>
FIAPARCH-BBM	<input type="radio"/>
FIAPARCH-CHUNG	<input type="radio"/>
HYGARCH	<input type="radio"/>
RISKMETRICS	<input type="radio"/>
with lambda :	0.94

Fractionally Integrated Models

OK Cancel

Chung's Method

```
*****
** G@RCH( 5) SPECIFICATIONS **
*****
Dependent variable : Nasdaq
Mean Equation : ARMA (1, 0) model.
No regressor in the conditional mean
Variance Equation : FIGARCH (1, d, 1) model estimated with Chung's method.
No regressor in the conditional variance
Normal distribution.

Strong convergence using numerical derivatives
Log-likelihood = -5385.77
Please wait : Computing the Std Errors ...

Robust Standard Errors (Sandwich formula)
      Coefficient  Std.Error  t-value  t-prob
Cst(M)           0.088338   0.016143   5.472   0.0000
AR(1)            0.197900   0.018280  10.83   0.0000
Cst(V)           0.821616   0.27665   2.970   0.0030
d-Figarch        0.358937   0.048296   7.432   0.0000
ARCH(Phi1)       0.045390   0.16180   0.2805   0.7791
GARCH(Beta1)     0.240098   0.18513   1.297   0.1947

No. Observations :      4093  No. Parameters :      6
Mean (Y)          :  0.05517  Variance (Y)       :  1.59189
Skewness (Y)     : -0.74128  Kurtosis (Y)      : 14.25531
Log Likelihood   : -5385.775

The sample mean of squared residuals was used to start recursion.
The positivity constraint for the FIGARCH (1,d,1) is
observed.
=> See Chung (1999), Appendix A, for more details.
```

Chung's Model after some trimming

```

File Edit Search View Model Run Window Help
nasdaq.in7
xbeta = &0 + &1 * Lrate -
Documents
* nasdaq.in7
aphics
G@RCH Forecasting
Data Plot
de
xt
Results
GJR11sktdist2.out
GJR11skt.out
Chung_FIGARCH.out
Chung_FIGARCH2.out
GJR11sktdist3.out
basic_matrices.out
ules
Model
  * G@RCH
  * PcGive
  * STAMP
  Ox
  OxDebug
  OxGauss
  OxPack
  OxRun
  Ox - interactive
  X12arima
*****
** G@RCH( 3) SPECIFICATIONS **
*****
Dependent variable : Nasdaq
Mean Equation : ARMA (1, 0) model.
No regressor in the conditional mean
Variance Equation : FIGARCH (1, d, 1) model estimated with Chung's method.
No regressor in the conditional variance
Skewed Student distribution, with 7.28811 degrees of freedom.
and asymmetry coefficient (log xi) -0.172222.

Strong convergence using numerical derivatives
Log-likelihood = -5191.14
Please wait : Computing the Std Errors ...

Robust Standard Errors (Sandwich formula)
          Coefficient  Std.Error  t-value  t-prob
Cst (M)      0.082381   0.013617   6.050   0.0000
AR (1)       0.174820   0.016583   10.54   0.0000
Cst (V)      0.565073   0.183443   3.081   0.0021
d-Figarch    0.410681   0.042187   9.735   0.0000
ARCH(Phi1)   0.110219   0.086098   1.280   0.2006
GARCH(Beta1) 0.396601   0.10643    3.726   0.0002
Asymmetry    -0.172222   0.022033  -7.817   0.0000
Tail         7.288110   0.68609   10.62   0.0000

No. Observations :      4083  No. Parameters :          8
Mean (Y)           :  0.05928  Variance (Y)           :  1.55579
Skewness (Y)       : -0.72576  Kurtosis (Y)          : 14.44751
Log Likelihood     : -5191.143

The sample mean of squared residuals was used to start recursion.
The positivity constraint for the FIGARCH (1,d,1) is
observed.

=> See Chung (1999), Appendix A, for more details.

```

Multivariate GARCH

- BEKK
 - Diagonal
 - Scalar
- RiskMetrics
- Factor GARCH
 - Carol Alexander's OGARCH
 - GOGARCH

Conditional Correlation Models

- Bollerslev's Constant Conditional Correlation
- Tse and Tsui(2002) Dynamic Conditional Correlation
- Engle(2002) Dynamic Conditional Correlation

Outlier Modeling

- Mean model outliers
- Variance model outliers
- Cross-model outliers