

**Risk Analysis**  
**using**  
**OxMetrics ver. 5**

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# Developers of OxMetrics

- David F. Hendry, Oxford University, UK
- Jurgen Doornik, Oxford University, UK
- Siem Jan Koopman, Free University of the Netherlands
- Andrew C. Harvey, Cambridge University, UK
- Sebatién Laurent, Economics Department at the University of Notre-Dame de la Paix Belgium, fellow of CORE in Louvain-la-Neuve

# Part I

- The OxMetrics Interface
- Importing Data
- Dates
- Exploratory Graphical Analysis
- PcGive Modeling
  - Dynamic models
  - Model diagnostics
  - Post estimation Graphics
  - Forecasting
  - Forecast Evaluation
- Automatic variable and model selection with Autometrics
  - Theory
  - Settings
  - Intervention modeling
  - Output analysis
  - For univariate and multivariate models

# Part II

- Volatility analysis with G@RCH models
  - First generation univariate G@RCH
    - ARCH, GARCH
    - Estimation (QML with bounds and Simulated annealing)
    - Diagnostics
    - Forecasting (simulated confidence intervals)
    - Forecast Evaluation
  - Second generation univariate G@RCH
    - GARCH-in-mean
    - EGARCH
    - GJR GARCH
    - Leverage effects and volatility smiles

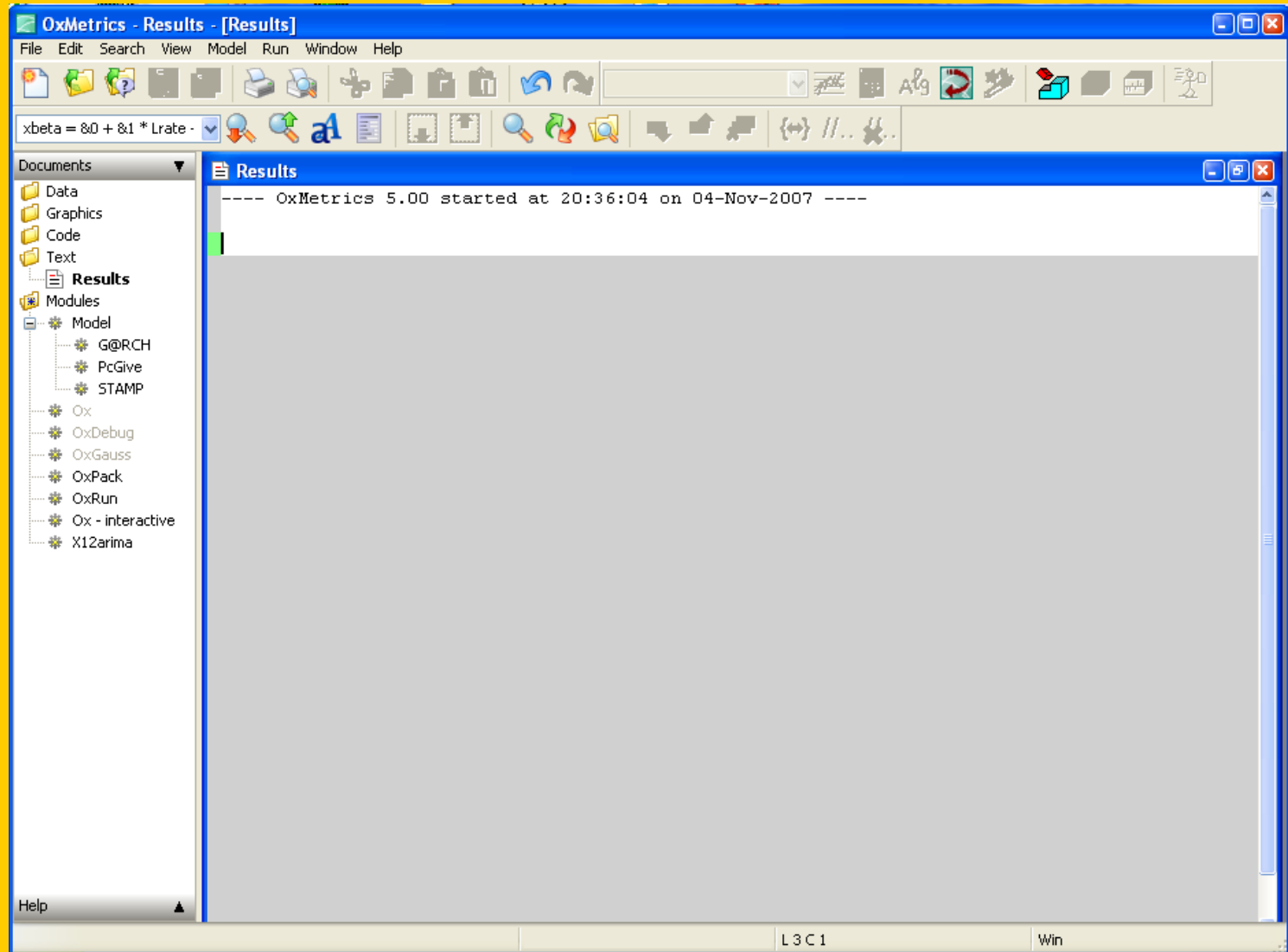
# G@RCH Advances

- VaR forecasting
- Simulations
- Diffusion models (Ox)
  - Stochastic volatility assessment
  - Realized and Integrated volatility with jumps
  - Microstructure noise with jumps
- Long-Memory Models
  - IGARCH
  - APARCH Dingle, Engle, Granger
  - FIGARCH - BBM, Chung
  - FIEGARCH – BBM, Chung
  - HYGARCH

# Multivariate GARCH

- Multivariate GARCH
  - BEKK models
  - Factor garch:
    - OGARCH,
    - GOGARCH
- Dynamic correlations:
  - CCC,
  - DCC

# The OxMetrics Interface



# Importing Excel data

- We download some data from Yahoo finance and create a cvs file.
- We import this data and sort it into ascending order so the data set appears set as follows.



Microsoft Excel - sp500.csv

File Edit View Insert Format Tools Data Window S-PLUS Help Adobe PDF

Type a question for help

Arial 10 B I U

Reply with Changes... End Review...

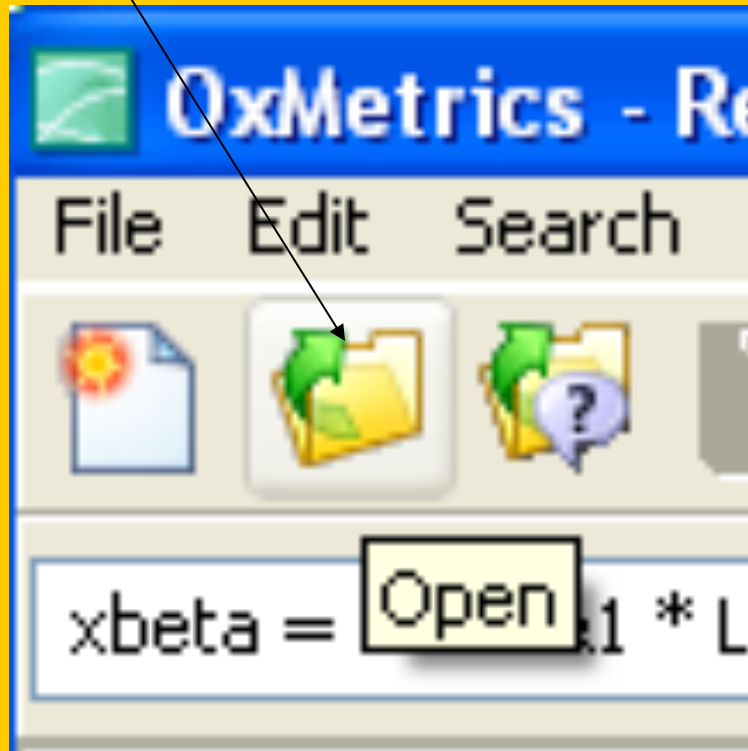
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date	SP500												
2	1/2/1990	359.69												
3	1/3/1990	358.76												
4	1/4/1990	355.67												
5	1/5/1990	352.2												
6	1/8/1990	353.79												
7	1/9/1990	349.62												
8	1/10/1990	347.31												
9	1/11/1990	348.53												
10	1/12/1990	339.93												
11	1/15/1990	337												
12	1/16/1990	340.75												
13	1/17/1990	337.4												
14	1/18/1990	338.19												
15	1/19/1990	339.15												
16	1/22/1990	330.38												
17	1/23/1990	331.61												
18	1/24/1990	330.26												
19	1/25/1990	326.08												
20	1/26/1990	325.8												
21	1/29/1990	325.2												
22	1/30/1990	322.98												
23	1/31/1990	329.08												
24	2/1/1990	328.79												
25	2/2/1990	330.92												
26	2/5/1990	331.85												

# Save the csv file

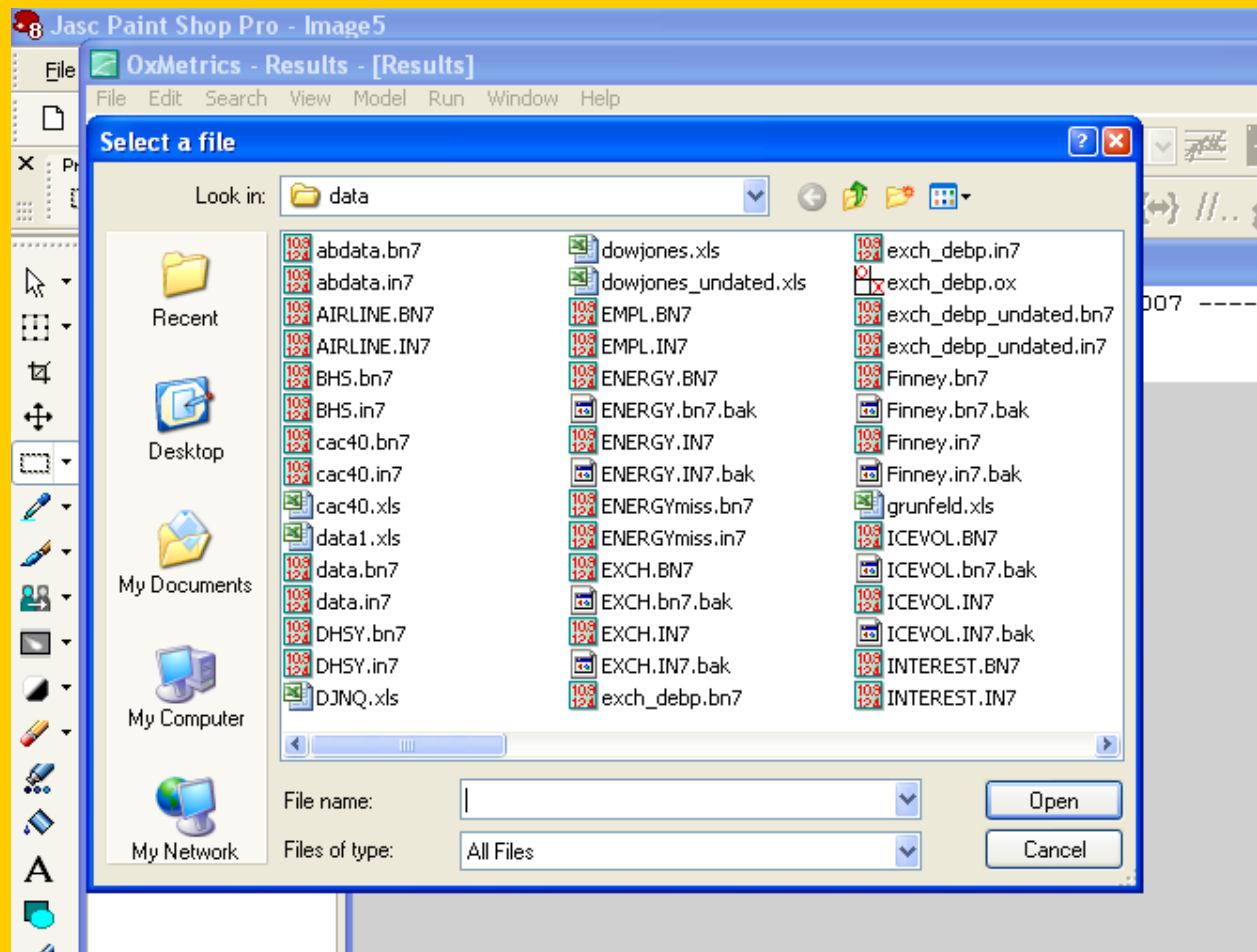
- This file should be saved in the data directory within OxMetrics5.
- OxMetrics is usually stored in the
- C:\program files\OxMetrics5 directory

# Click on the open file folder icon

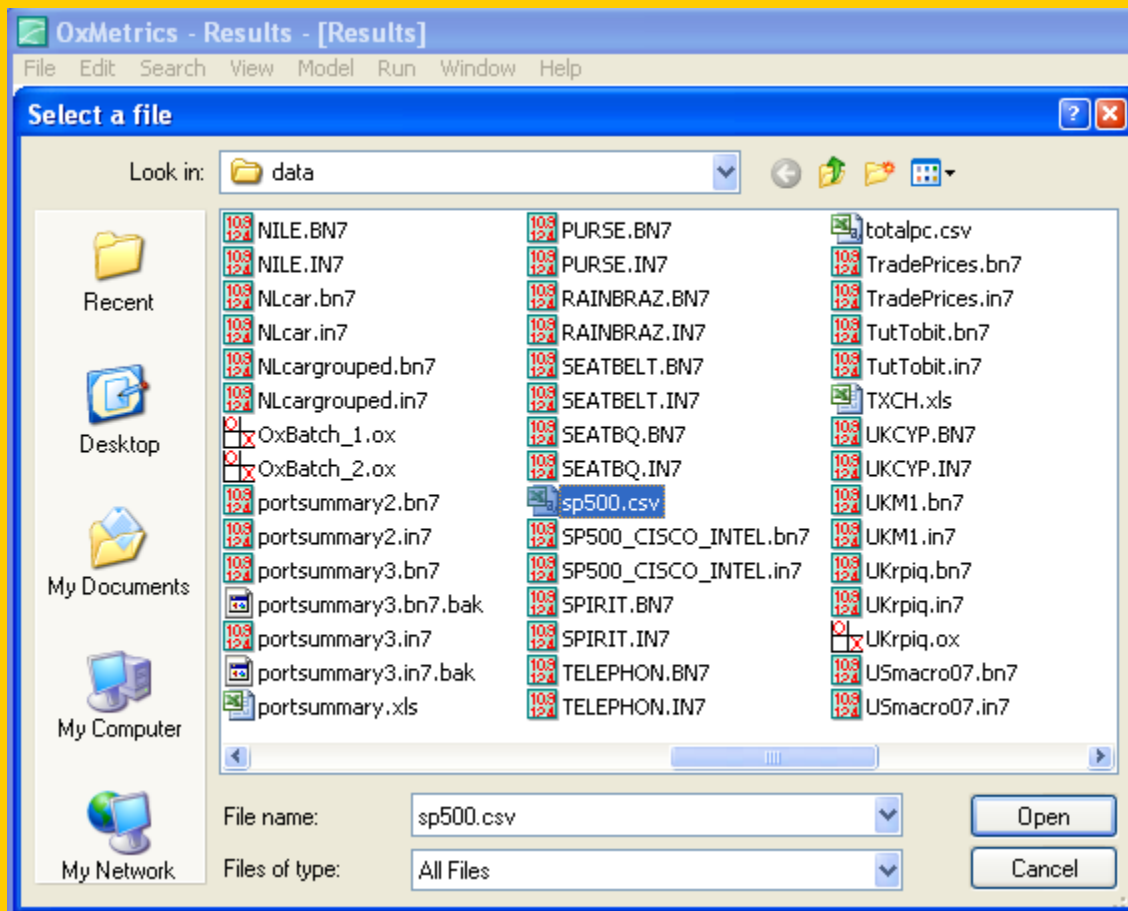
- We click on the open file folder icon in the upper left navigation window



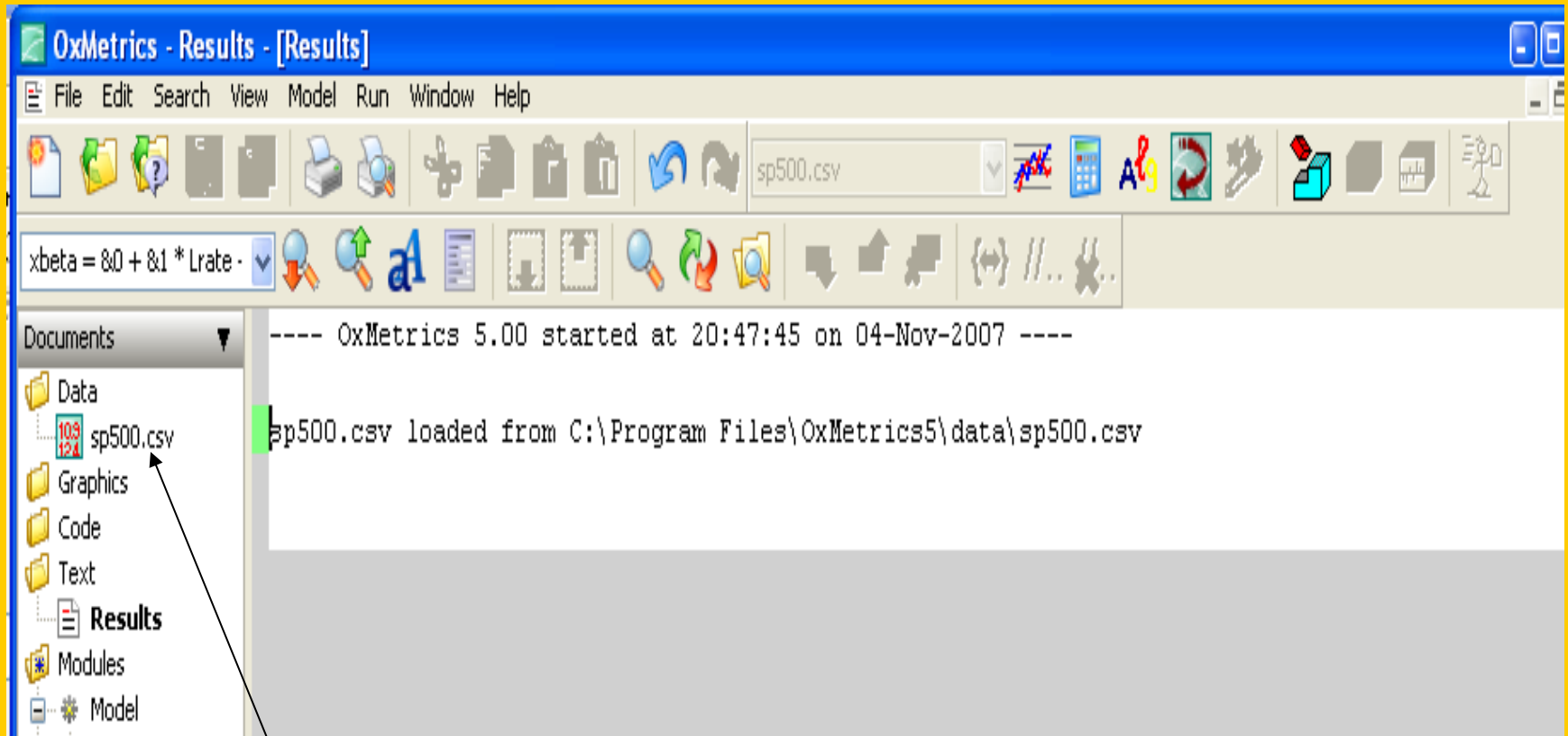
# Find the excel file you saved in the data directory



# Double click on the file

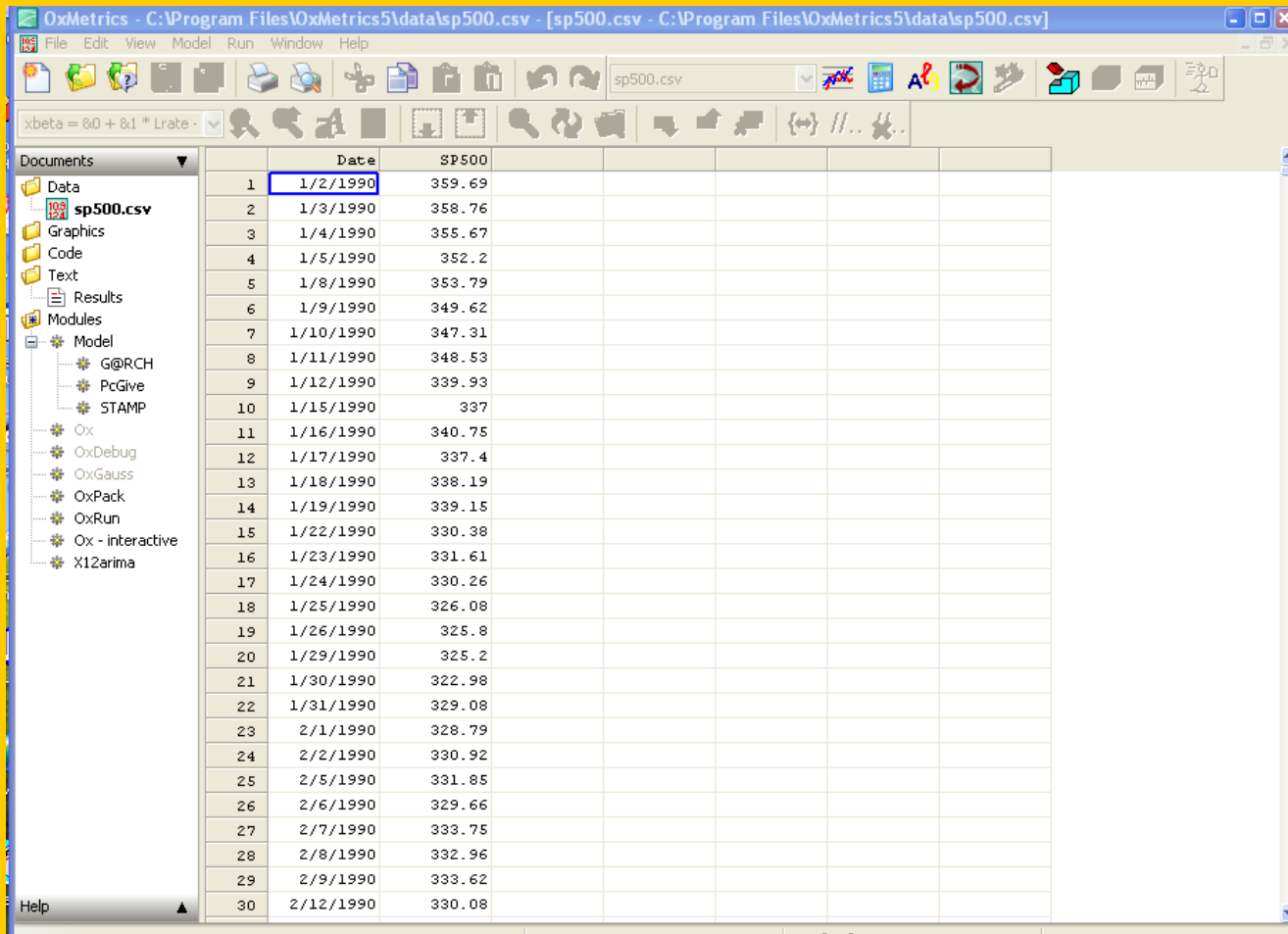


# This loads the file



Double click on the file icon to open the loaded file

# Once the file is open it appears as follows:

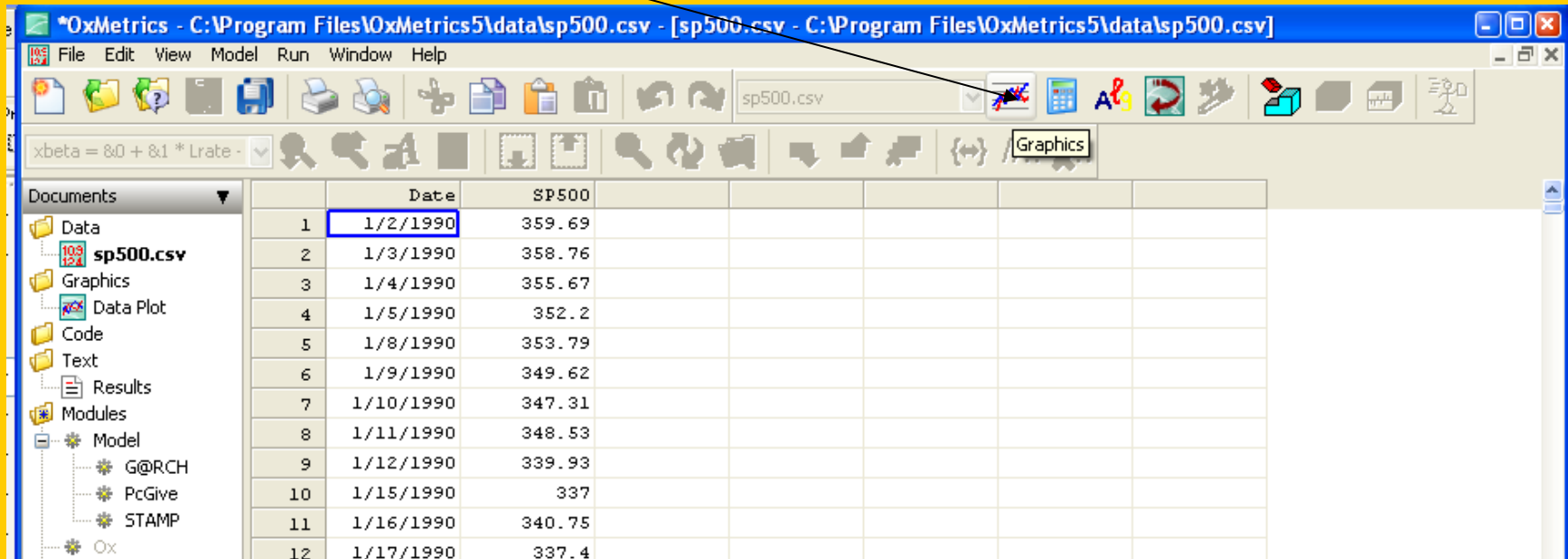


The screenshot shows the OxMetrics software interface with a spreadsheet of SP500 data. The window title is "OxMetrics - C:\Program Files\OxMetrics5\data\sp500.csv - [sp500.csv - C:\Program Files\OxMetrics5\data\sp500.csv]". The menu bar includes File, Edit, View, Model, Run, Window, and Help. The toolbar contains various icons for file operations and modeling. The spreadsheet has a header row with "Date" and "SP500" columns. The data rows are numbered 1 to 30, with the first row (1) highlighted. The "Date" column shows dates from 1/2/1990 to 2/12/1990, and the "SP500" column shows corresponding values ranging from 325.2 to 359.69.

	Date	SP500
1	1/2/1990	359.69
2	1/3/1990	358.76
3	1/4/1990	355.67
4	1/5/1990	352.2
5	1/8/1990	353.79
6	1/9/1990	349.62
7	1/10/1990	347.31
8	1/11/1990	348.53
9	1/12/1990	339.93
10	1/15/1990	337
11	1/16/1990	340.75
12	1/17/1990	337.4
13	1/18/1990	338.19
14	1/19/1990	339.15
15	1/22/1990	330.38
16	1/23/1990	331.61
17	1/24/1990	330.26
18	1/25/1990	326.08
19	1/26/1990	325.8
20	1/29/1990	325.2
21	1/30/1990	322.98
22	1/31/1990	329.08
23	2/1/1990	328.79
24	2/2/1990	330.92
25	2/5/1990	331.85
26	2/6/1990	329.66
27	2/7/1990	333.75
28	2/8/1990	332.96
29	2/9/1990	333.62
30	2/12/1990	330.08

# Graphical Preview

Click on the graphics icon



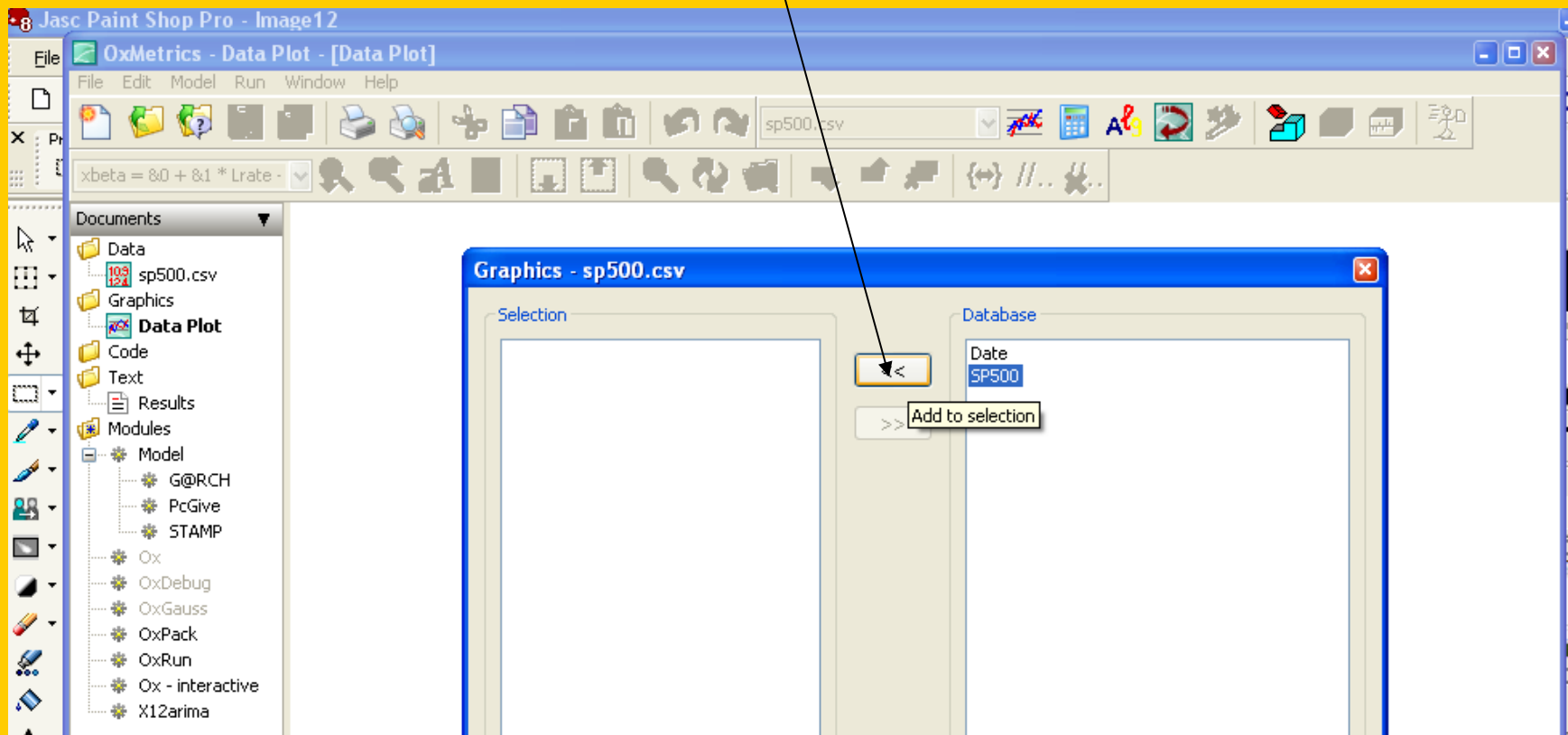
The screenshot shows the OxMetrics software interface. The title bar reads: \*OxMetrics - C:\Program Files\OxMetrics5\data\sp500.csv - [sp500.csv - C:\Program Files\OxMetrics5\data\sp500.csv]. The menu bar includes File, Edit, View, Model, Run, Window, and Help. The toolbar contains various icons, including a 'Graphics' icon (a small cube) which is highlighted by a callout line from the text above. Below the toolbar, a formula bar shows  $x_{beta} = 8.0 + 8.1 * Lrate$ . The main window displays a table with the following data:

	Date	SP500				
1	1/2/1990	359.69				
2	1/3/1990	358.76				
3	1/4/1990	355.67				
4	1/5/1990	352.2				
5	1/8/1990	353.79				
6	1/9/1990	349.62				
7	1/10/1990	347.31				
8	1/11/1990	348.53				
9	1/12/1990	339.93				
10	1/15/1990	337				
11	1/16/1990	340.75				
12	1/17/1990	337.4				

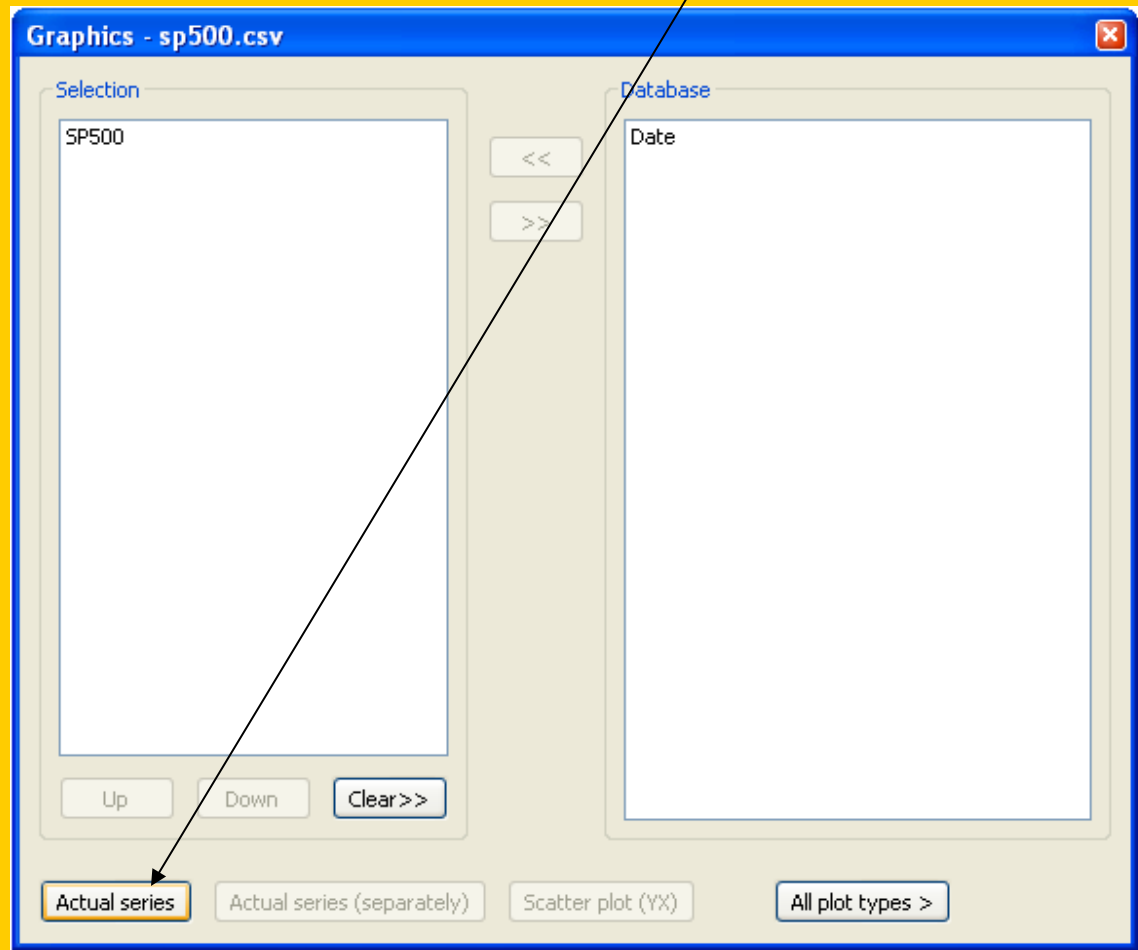
The left sidebar shows a 'Documents' tree with folders for Data, Graphics, Code, Text, Results, and Modules. The 'Data' folder is expanded, showing 'sp500.csv'. The 'Graphics' folder is also visible.



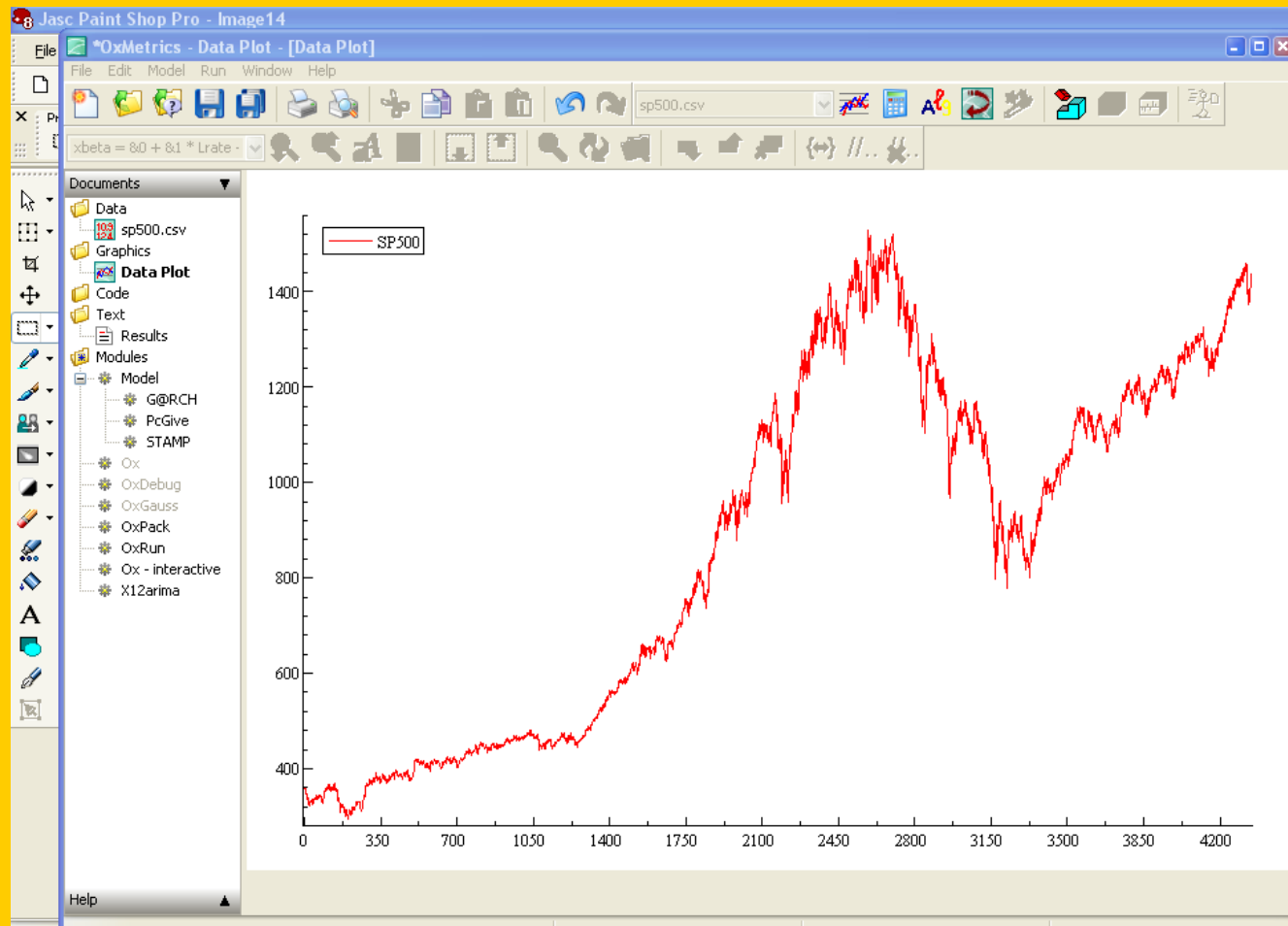
This opens a graphics dialog box  
Select the series and move it into the graph window on the left by clicking on the arrow button



# Click on the actual series button on the lower left



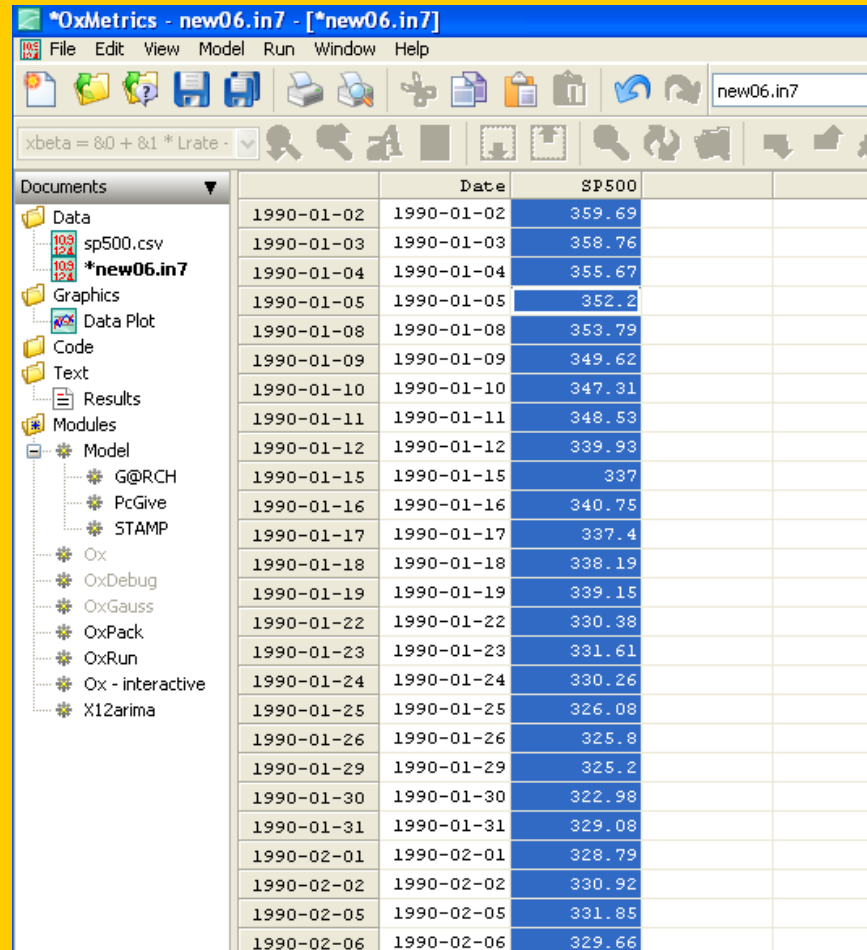
# Generating a time series plot



# Dates

- The horizontal axis consists of observation numbers.
- To construct dates for those periods, we count the number of observations in the Excel file.
- There are 4342 observations beginning in January 2, 1990.
- We will import the data into a OxMetrics file.

Select the SP500 column in the csv  
file.  
Then click on copy



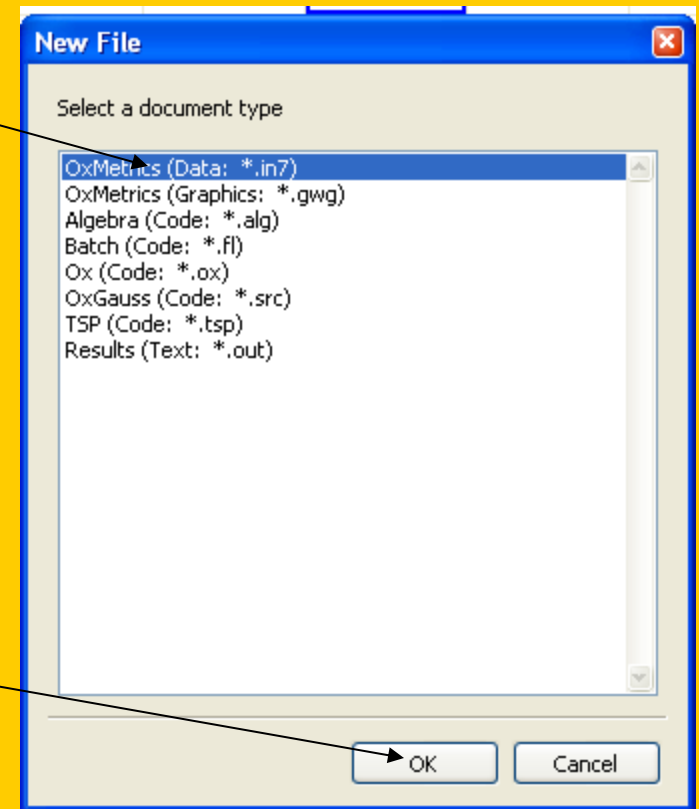
The screenshot shows the OxMetrics software interface. The main window displays a spreadsheet with the following data:

Date	SP500
1990-01-02	359.69
1990-01-03	358.76
1990-01-04	355.67
1990-01-05	352.2
1990-01-08	353.79
1990-01-09	349.62
1990-01-10	347.31
1990-01-11	348.53
1990-01-12	339.93
1990-01-15	337
1990-01-16	340.75
1990-01-17	337.4
1990-01-18	338.19
1990-01-19	339.15
1990-01-22	330.38
1990-01-23	331.61
1990-01-24	330.26
1990-01-25	326.08
1990-01-26	325.8
1990-01-29	325.2
1990-01-30	322.98
1990-01-31	329.08
1990-02-01	328.79
1990-02-02	330.92
1990-02-05	331.85
1990-02-06	329.66

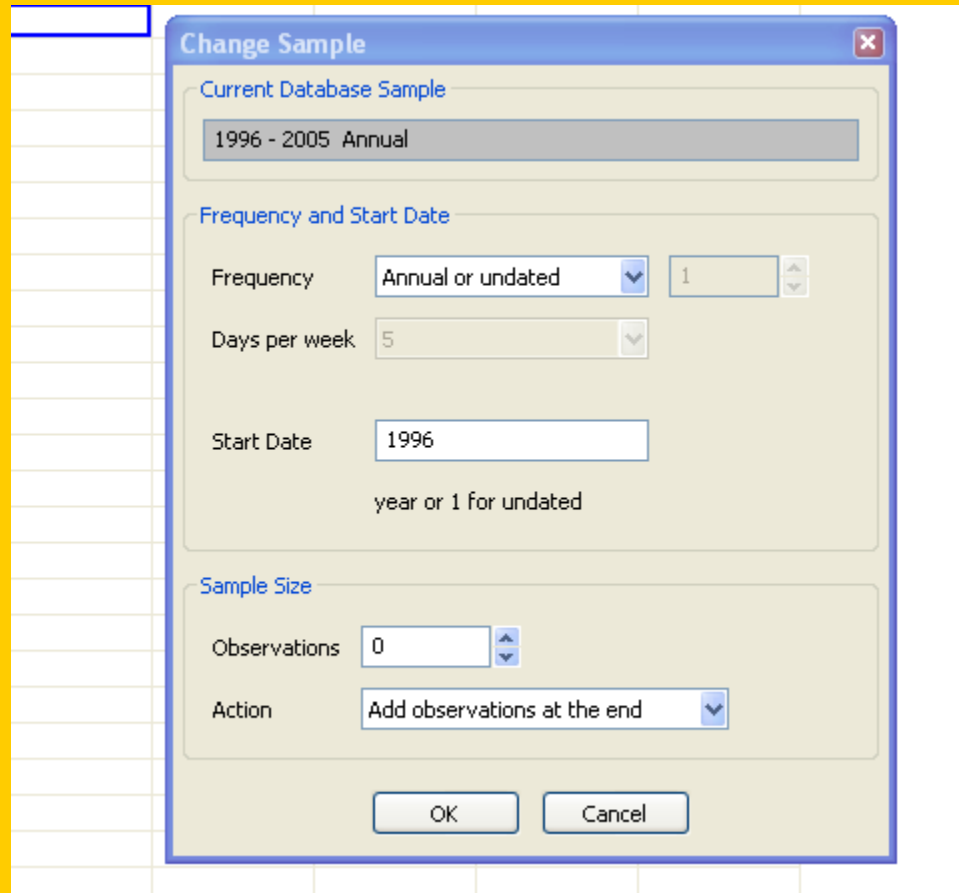
The left sidebar shows a file tree with folders for Data, Graphics, Code, Text, Results, and Modules. The 'Data' folder contains 'sp500.csv' and '\*new06.in7'. The 'Modules' folder contains a 'Model' sub-folder with various modules like G@RCH, PcGive, STAMP, Ox, OxDebug, OxGauss, OxPack, OxRun, Ox - interactive, and X12arima.

# Construction of a dated Ox file

- Click on copy
- Click on file - new and a
  - Dialog box opens
- Select OxMetrics (Data: \*.in7) file
  
- Click on OK



# A Date dialogue box opens



Select these options and indicate the sample size, then click OK

**Change Sample**

Current Database Sample

1996 - 2005 Annual

Frequency and Start Date

Frequency → Dated: daily or weekly ↓ 1 ↑↓

Days per week 5 ↓

Start Date 1990-01-02 1990-01-02 Tue  
yyyy-mm-dd

Sample Size

Observations 4342 ↑↓

Action Add observations at the end ↓

OK Cancel



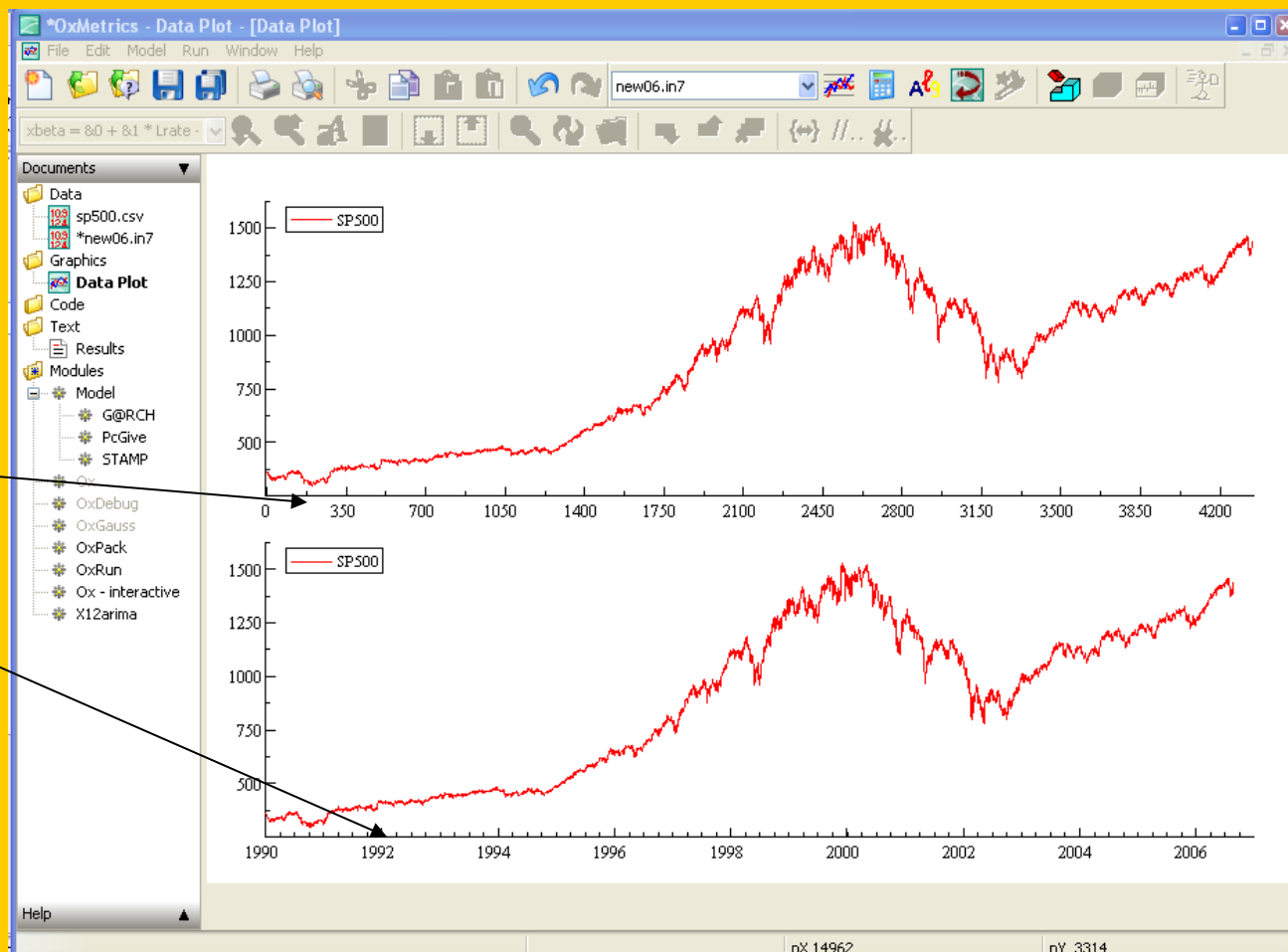
# Paste the SP500 into the new data set

The screenshot shows the OxMetrics software interface. The main window displays a data table with the following columns: Date, SP500, and several empty columns. The data is organized into a table with the following content:

Date	SP500				
1990-01-02	359.69				
1990-01-03	358.76				
1990-01-04	355.67				
1990-01-05	352.2				
1990-01-08	353.79				
1990-01-09	349.62				
1990-01-10	347.31				
1990-01-11	348.53				
1990-01-12	339.93				
1990-01-15	337				
1990-01-16	340.75				
1990-01-17	337.4				
1990-01-18	338.19				
1990-01-19	339.15				
1990-01-22	330.38				
1990-01-23	331.61				
1990-01-24	330.26				
1990-01-25	326.08				
1990-01-26	325.8				
1990-01-29	325.2				
1990-01-30	322.98				
1990-01-31	329.08				
1990-02-01	328.79				
1990-02-02	330.92				
1990-02-05	331.85				
1990-02-06	329.66				
1990-02-07	333.75				
1990-02-08	332.96				
1990-02-09	333.62				
1990-02-12	330.08				

The software interface includes a menu bar (File, Edit, View, Model, Run, Window, Help), a toolbar with various icons, and a left-hand pane showing a file explorer with folders like Data, Graphics, Code, Text, Results, and Modules. The status bar at the bottom shows the current data set is 'SP500'.

# Now Graph the New Series and save the data set



# Dates: frequencies/holidays

**Change Sample**

Current Database Sample

1996 - 2005 Annual

Frequency and Start Date

Frequency: Annual or undated (selected)  
Days per week: 1  
Start Date: year or 1 for undated

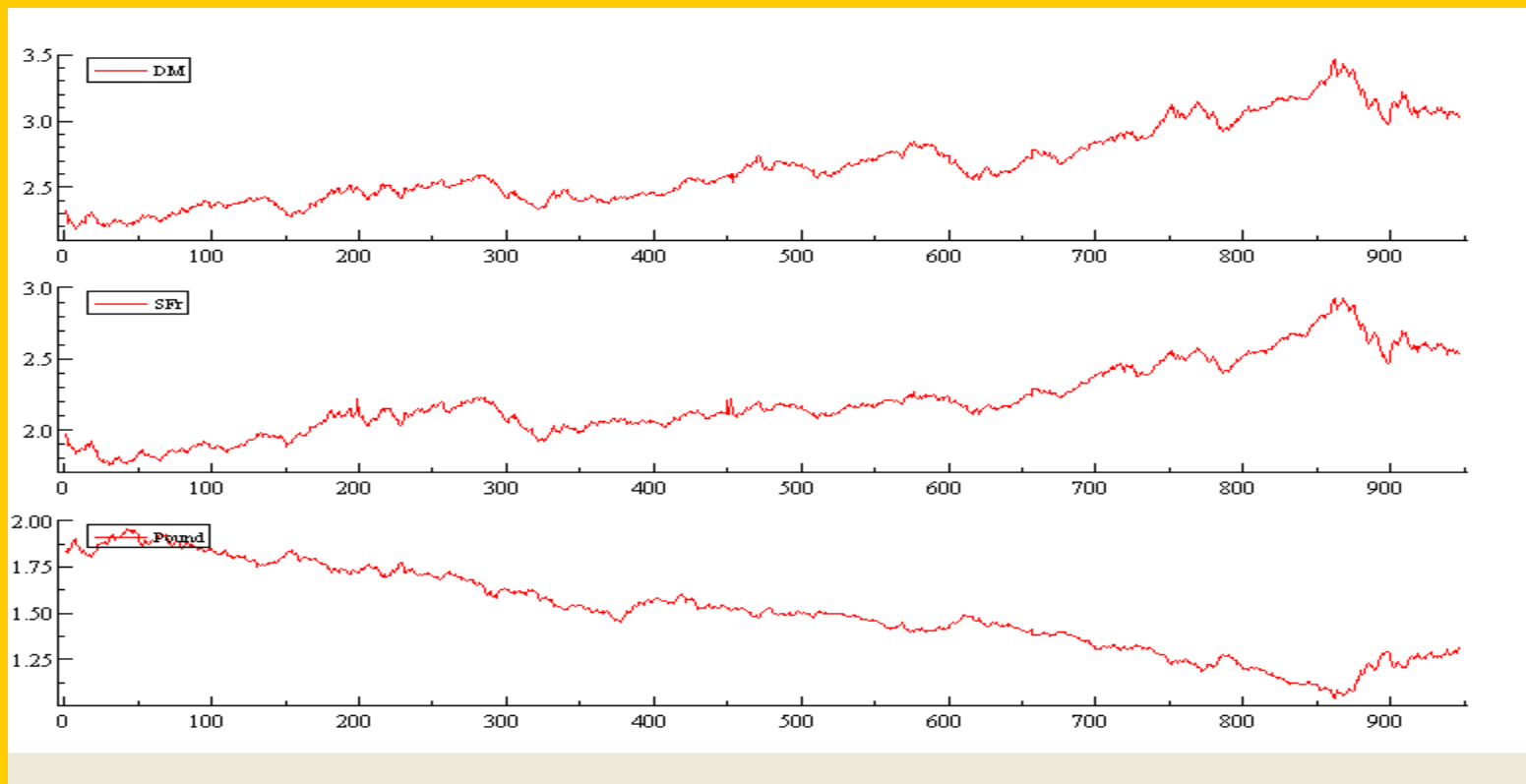
Sample Size

Observations: 0  
Action: Add observations at the end

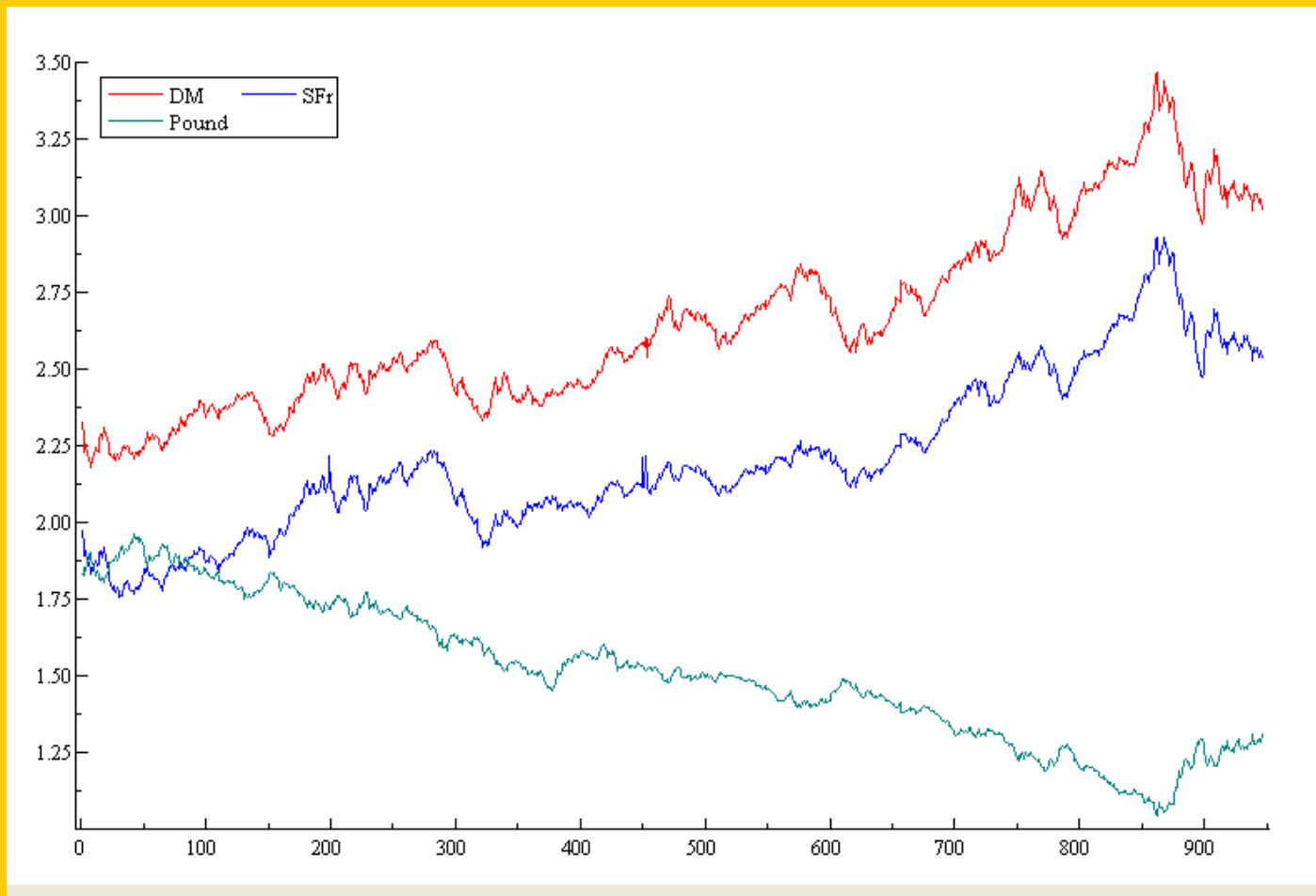
OK Cancel

# Other graphics

- Paneled time series plots

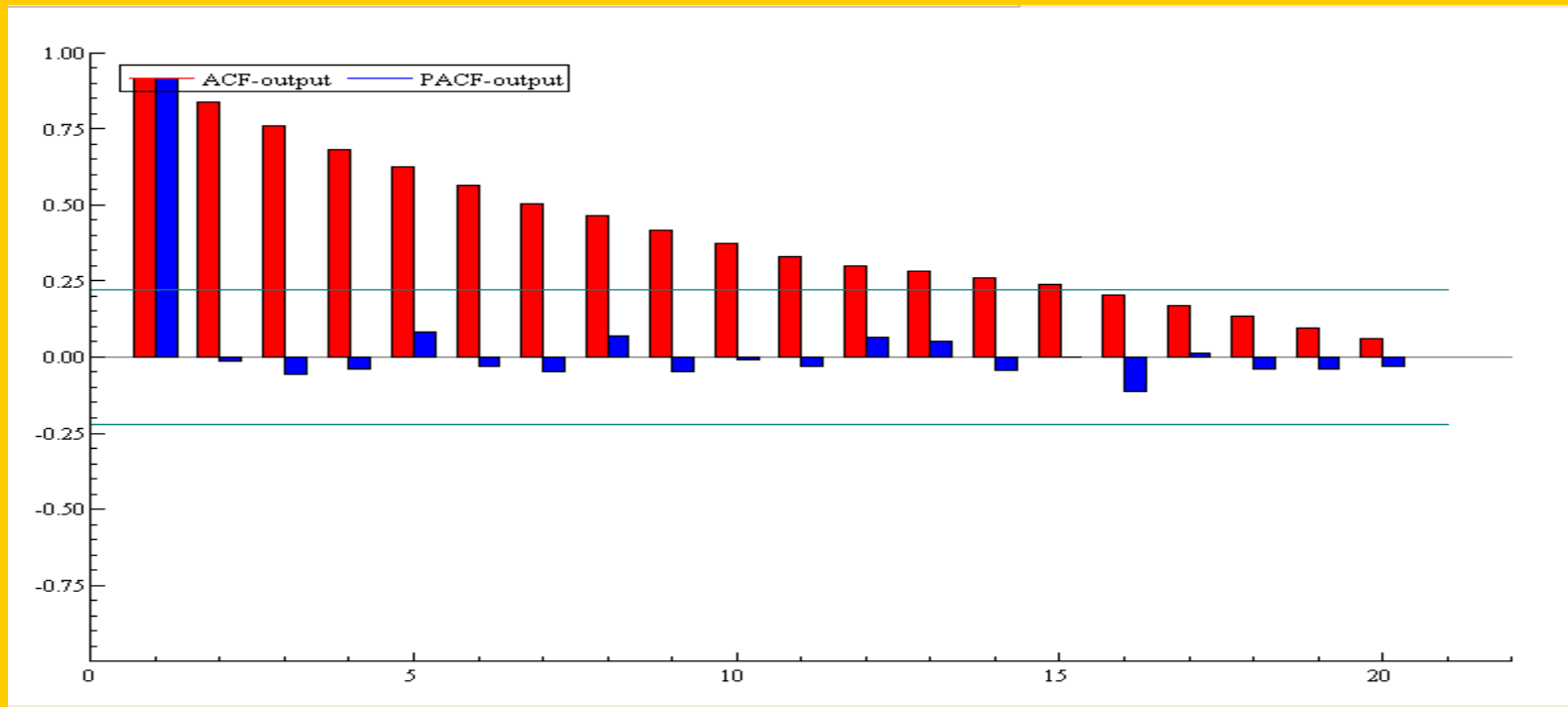


# Overlaid Time Series Plots

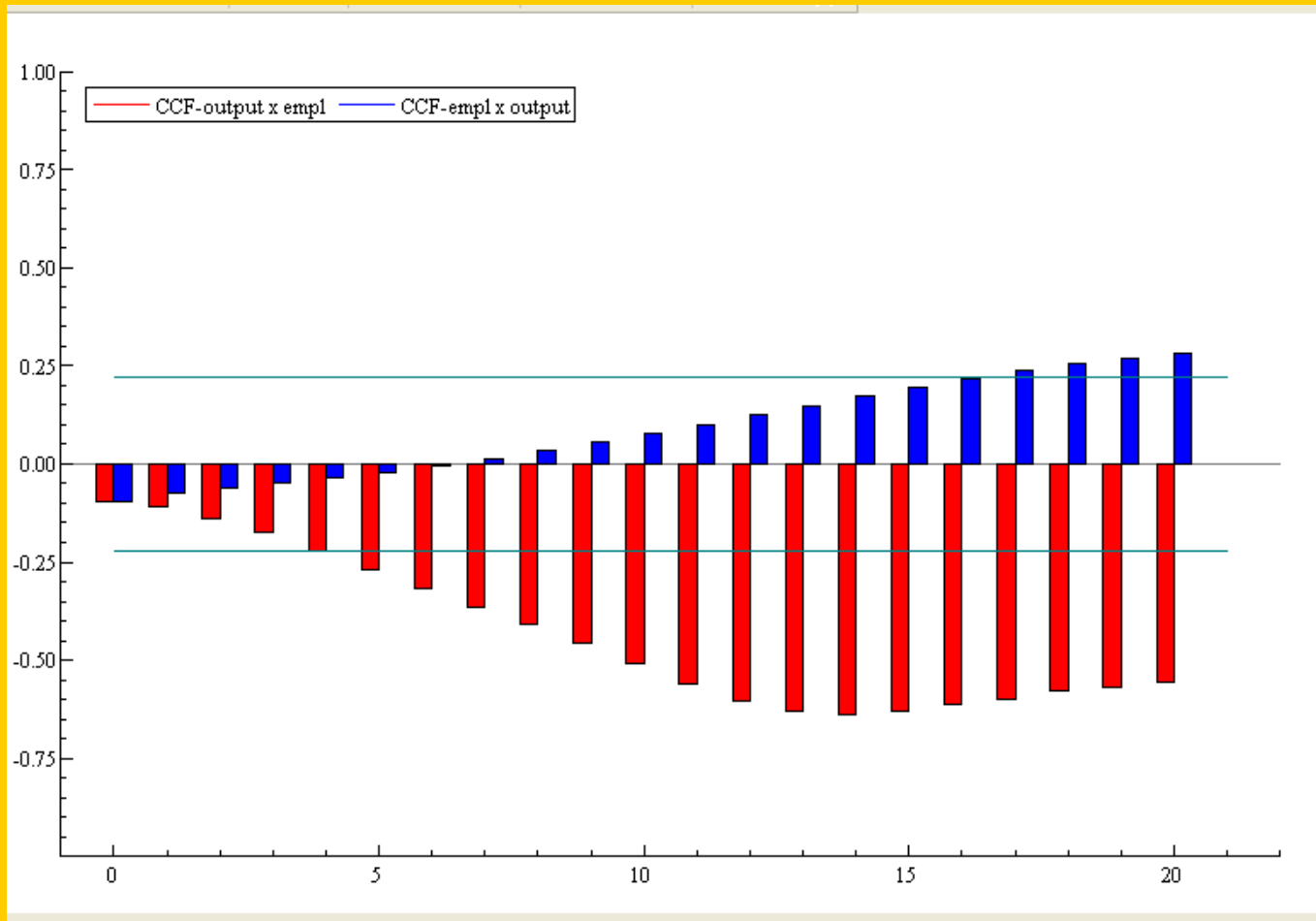


# Time series Properties

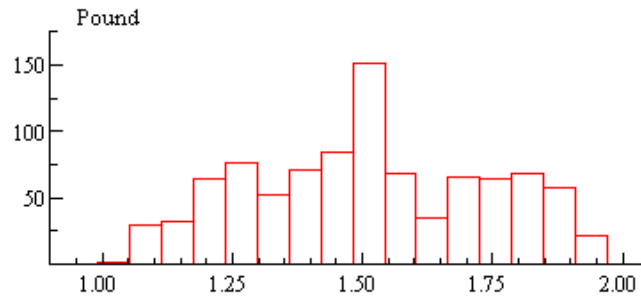
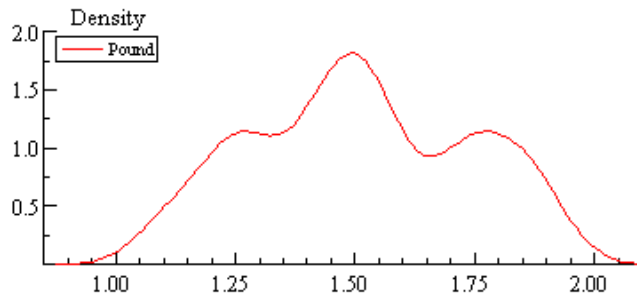
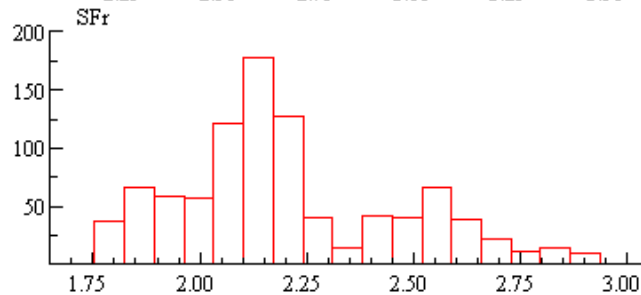
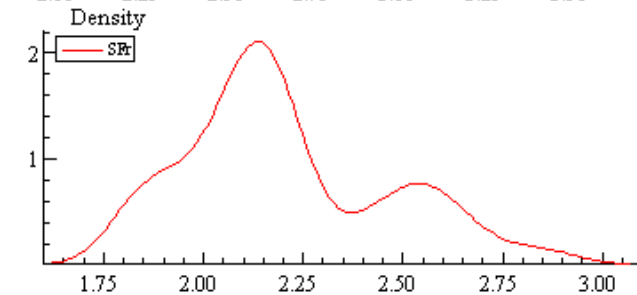
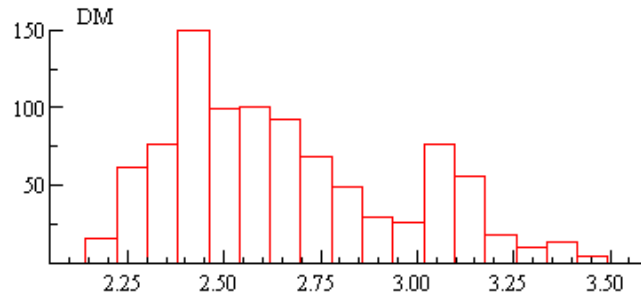
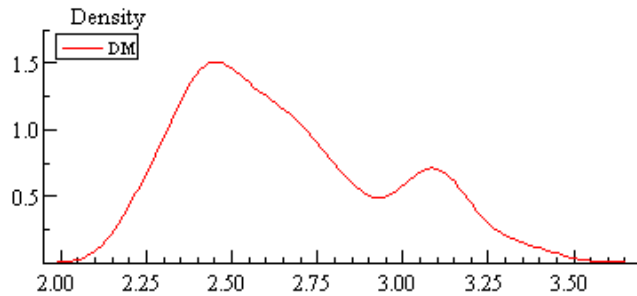
- ACF and PACF correlograms



# Cross Correlation Function

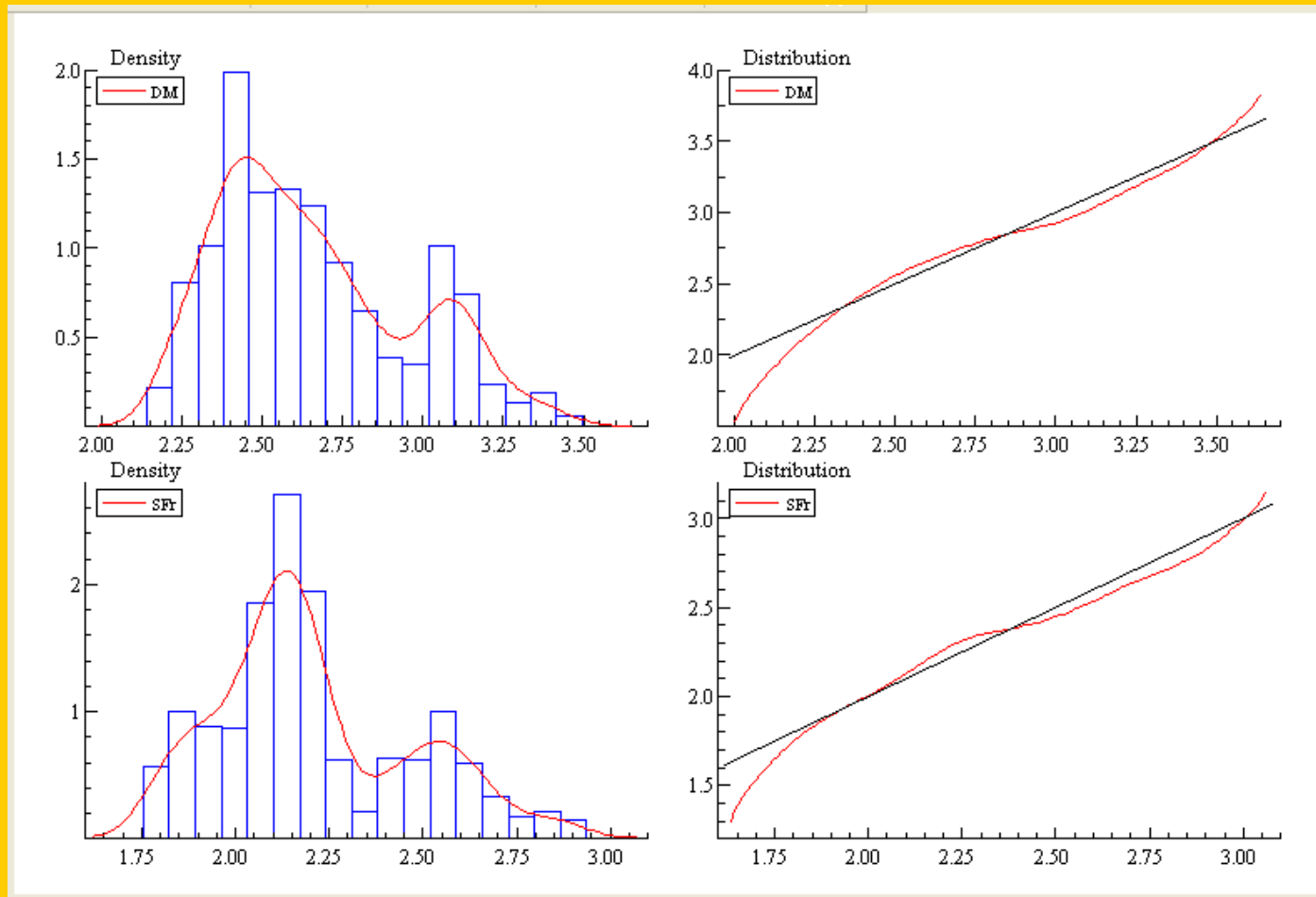


# Distributional Plots

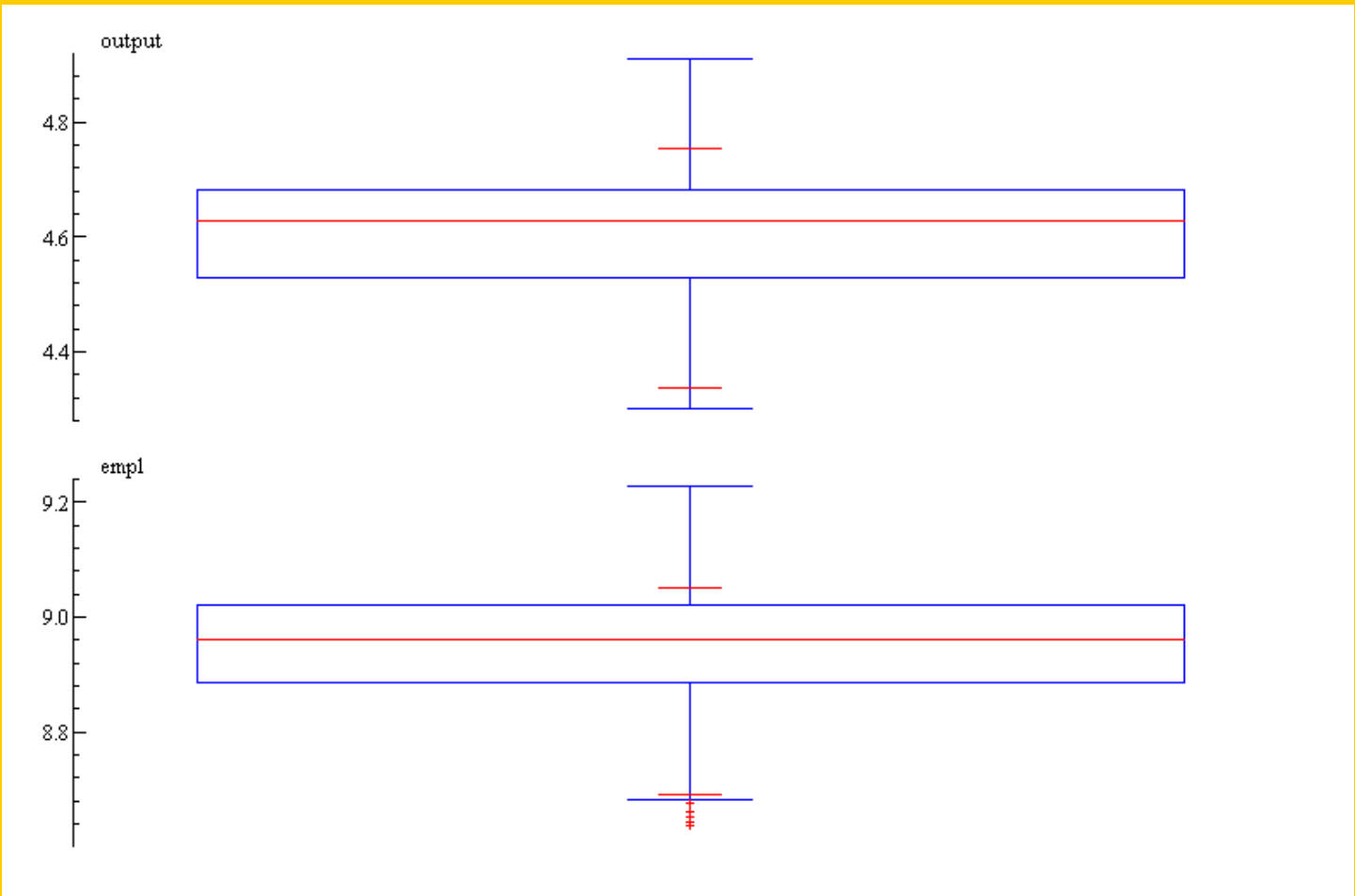




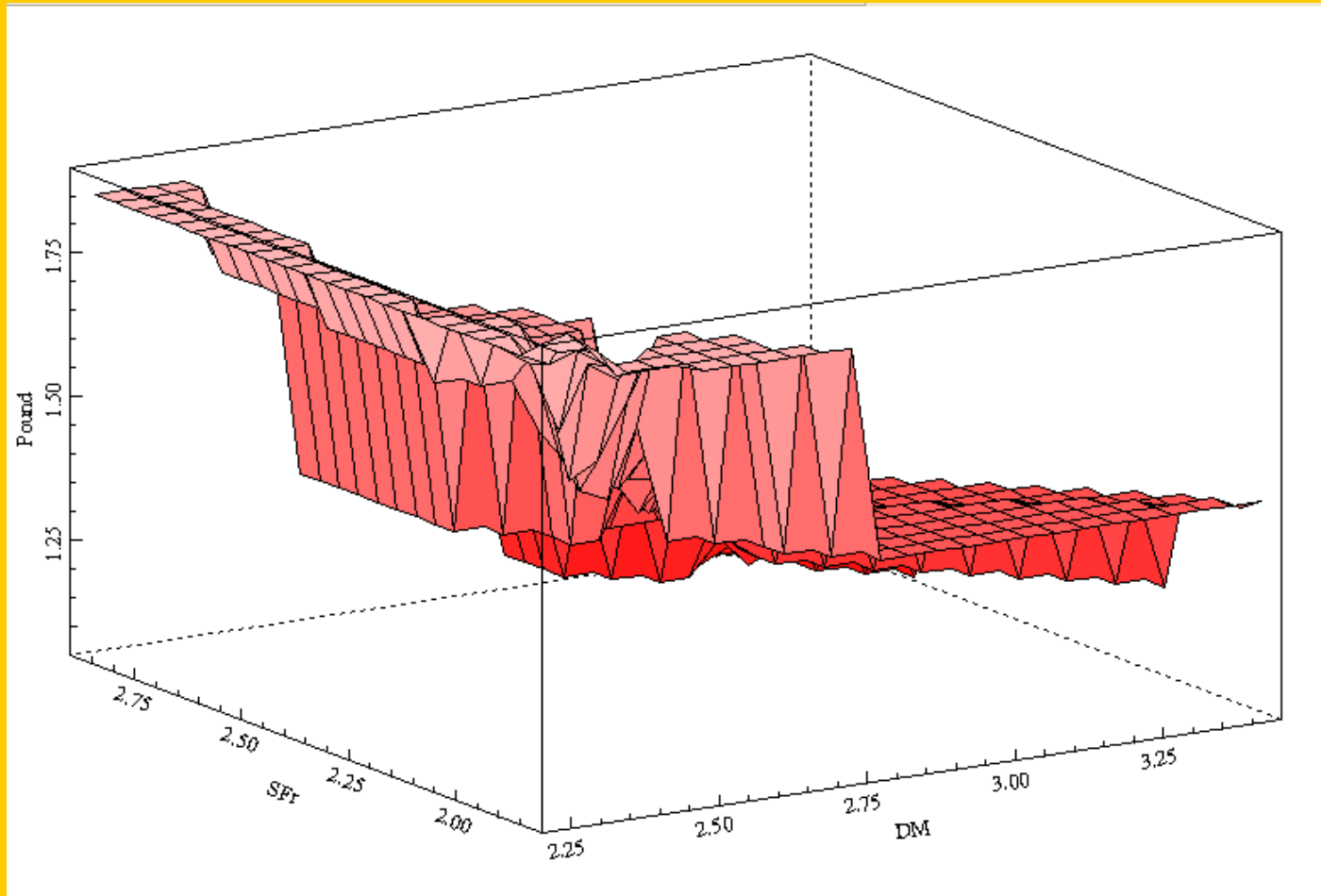
# Distributional Kernel Density Plots and Normal Quantile plots



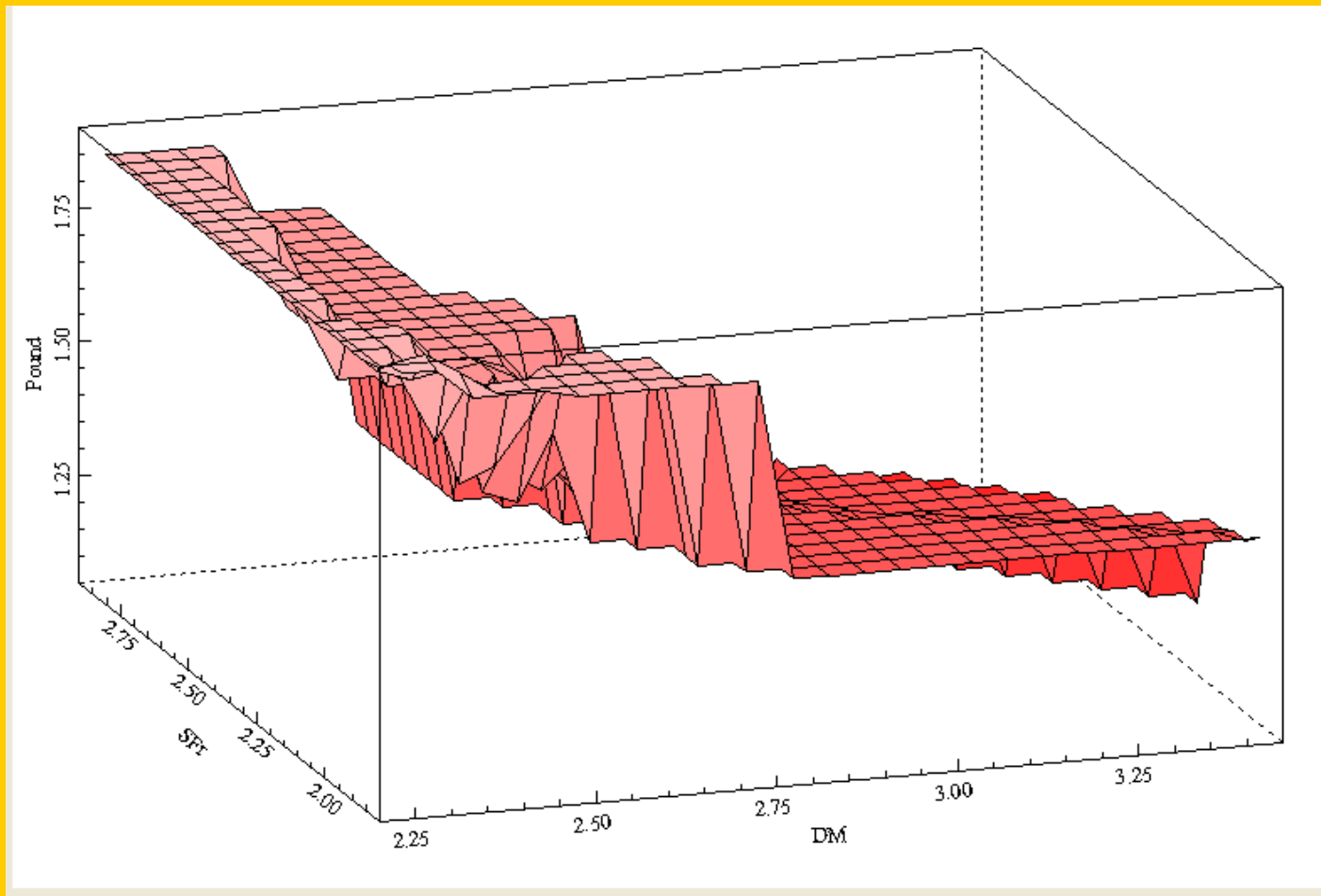
# BoxPlots



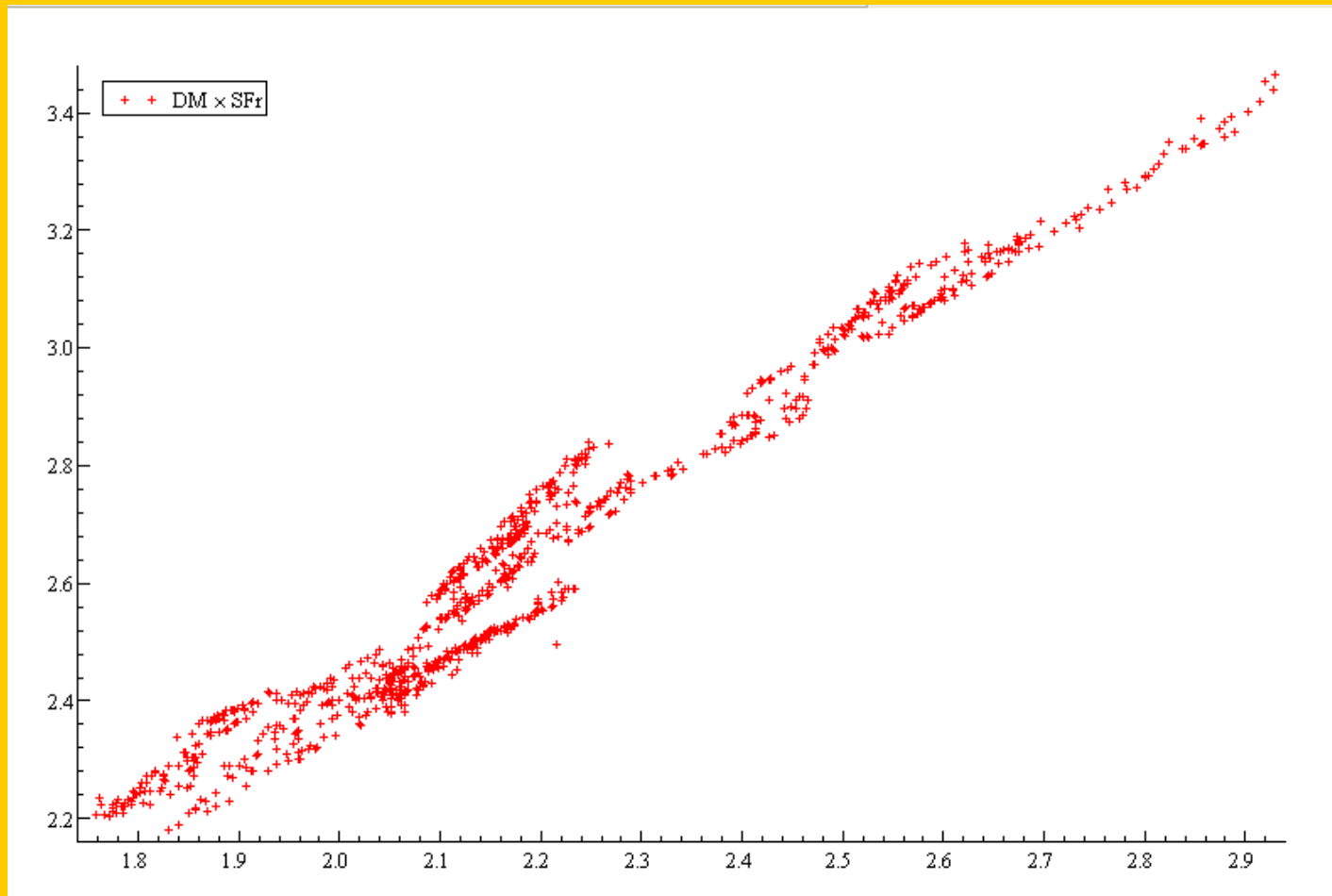
# 3-D rotating plots



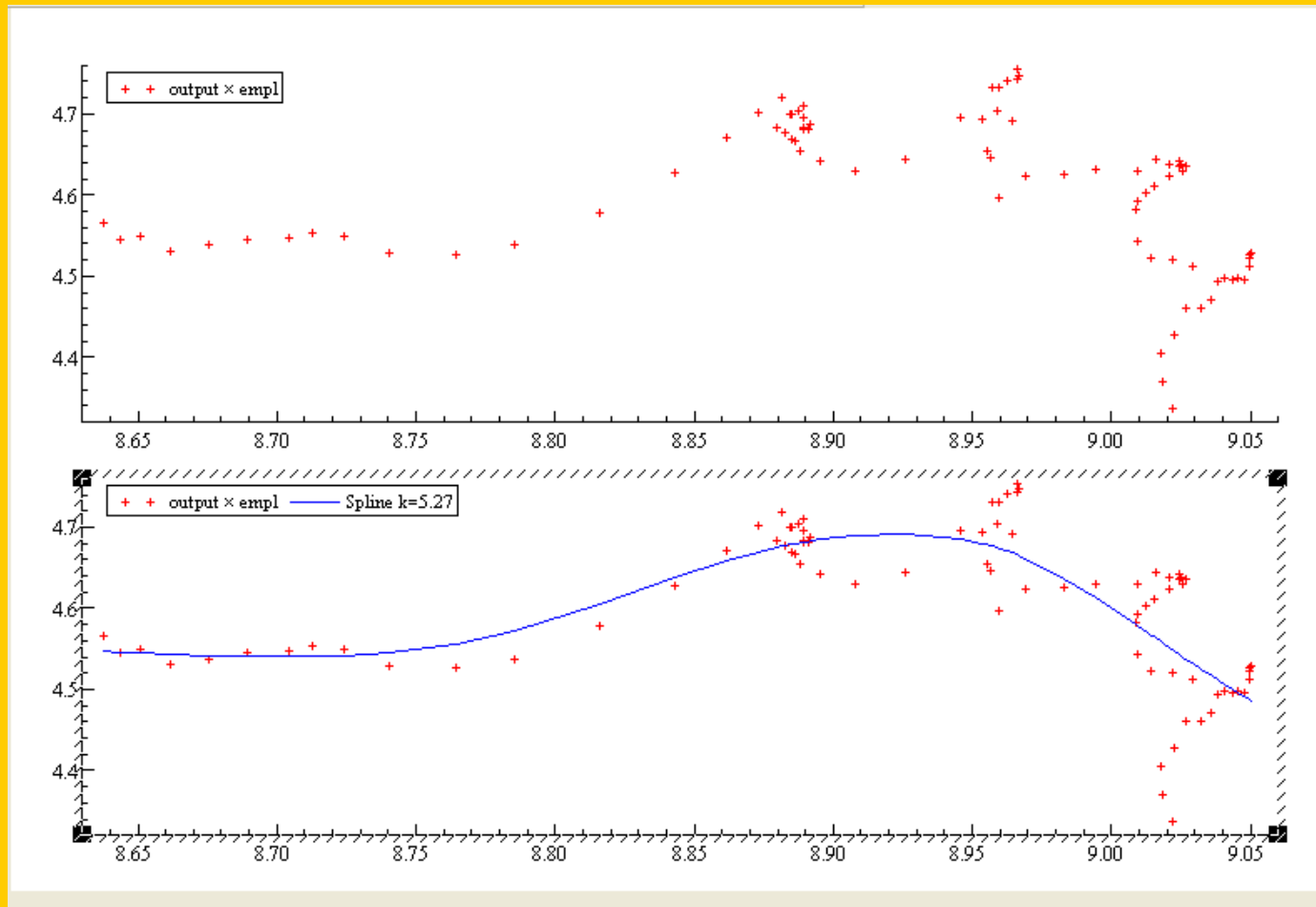
# Rotated 3-D plot



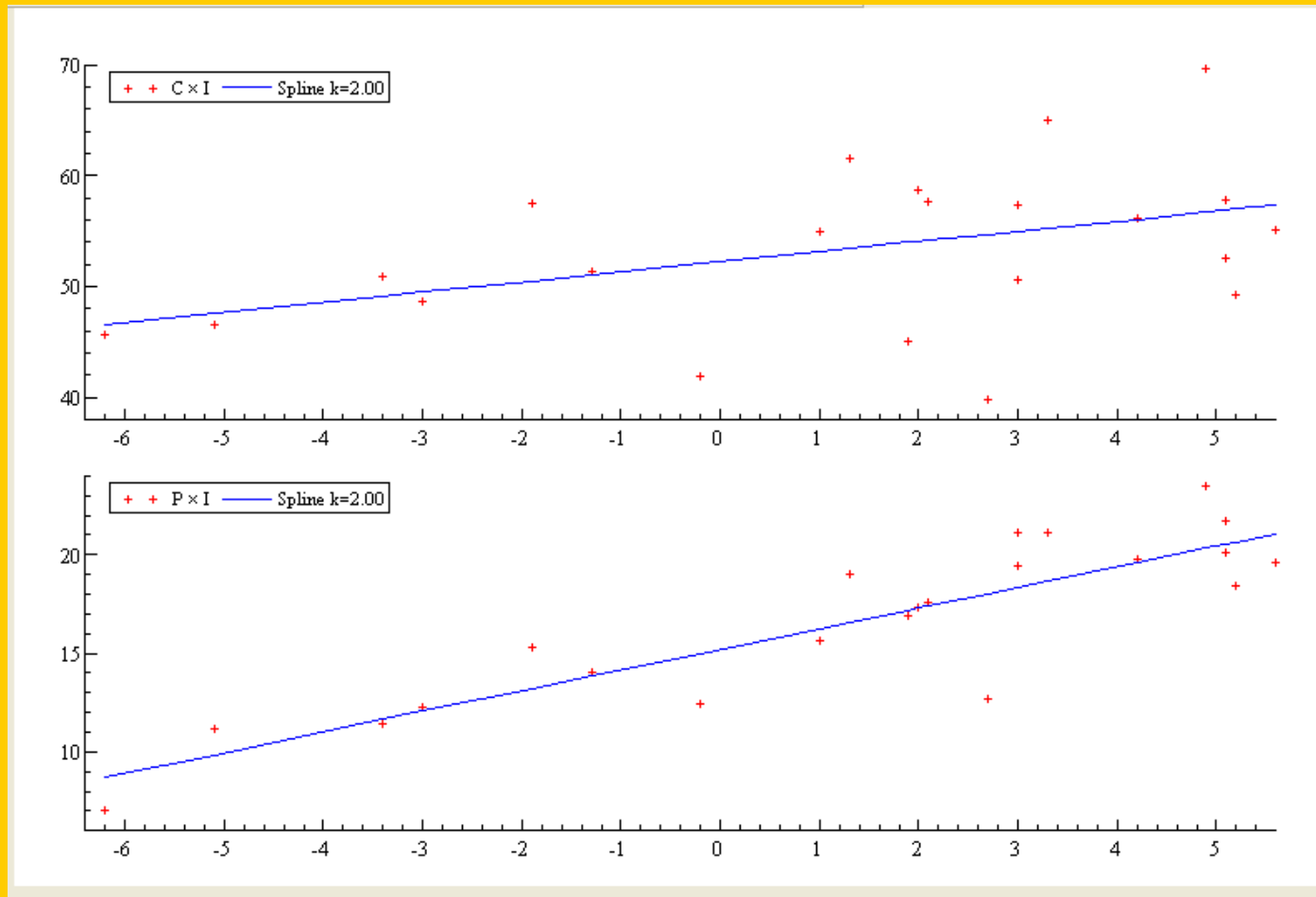
# Scatterplots



# Scatterplots with spline smoothing



# Paneled Scatterplot with smoothers



# PcGive 12

## Modeling and Forecasting

- Cross-sectional
  - Discrete choice:
    - Count data
    - logit and probit model
    - Multinomial discrete choice
- Univariate dynamic modeling
  - OLS and Autoregressive error models
- ARIFIMA modeling
- Panel data analysis
  - Static
  - Dynamic (GMM)
- Multivariate dynamic modeling
  - Unrestricted VAR
  - Cointegrated VAR
  - Simultaneous equation modeling
  - Constrained sem
- Automatic Modeling
  - Automatic outlier identification and modeling
    - For univariate and multivariate models



# What's new in PcGive 12?

- Autometrics has been included
  - Autometrics can work with univariate or multivariate models, such as VAR.
  - Autometrics can handle more variables than observations, previously thought impossible
  - Can employ dummy saturation
  - Can automatically model univariate and multivariate time series models
- PcNaive has been included in the Monte Carlo methods

# Estimation methods

- Estimation (OLS, IV, ALS, recursive estimation)
- Panel-GMM with robust standard errors

# Autometrics demonstration

- Function: Automatic variable selection, model building, and model selection for time series or econometric data.
- Value: Crisis analysis
  - when data are available.
  - When time is short
  - When stakes are high
  - When consequences are serious
  - Autometrics may reduce the **risk** of improper response.
- Value: Econometric Data mining
  - Exploratory data analysis when response time is critical
  - When there are a lot of variables and modeling paths to analyze

# Methodology

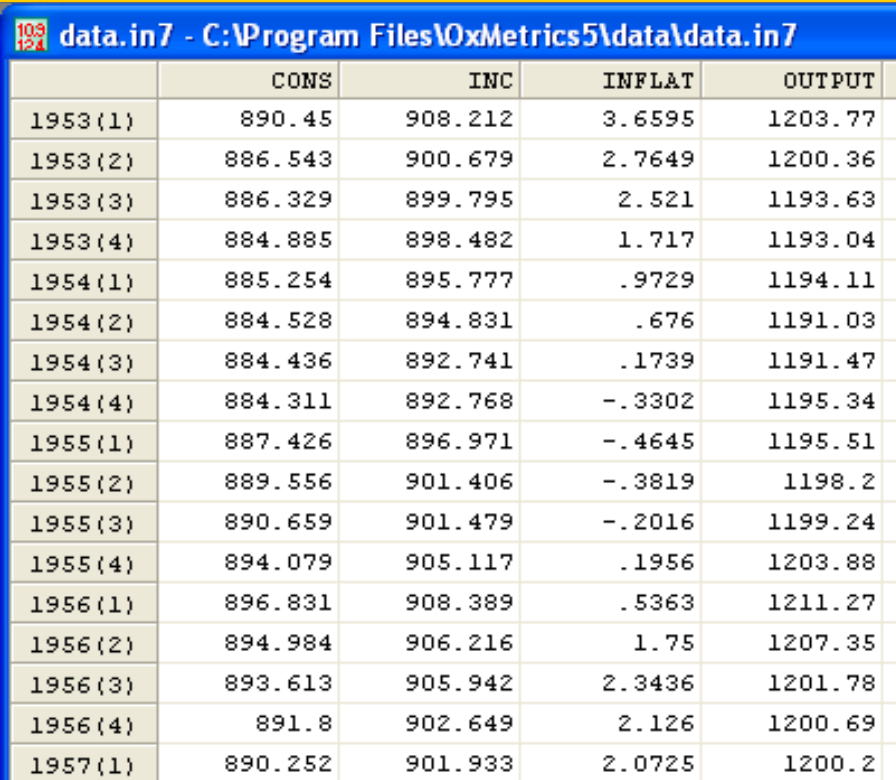
- Begin with a General Unrestricted Model (GUM).
- The chosen variables should be as congruent as possible.
- The GUM is subjected to a series of misspecification tests. If it passes, the reductions will also pass.
- Reduction of the model by eliminating variables with significance levels of .05 or more.
- Each reduction must pass a series of tests.
- If there are  $k$  regressors, there will be  $2^k$  reduction paths.

# Methodology II

- There may be several terminal models following reduction. The Schwartz criterion is used to determine the better of these.
- If a reduction causes the previous model to fail a misspecification test, then the variable, though possibly not significant, will be retained in the model.

# Example

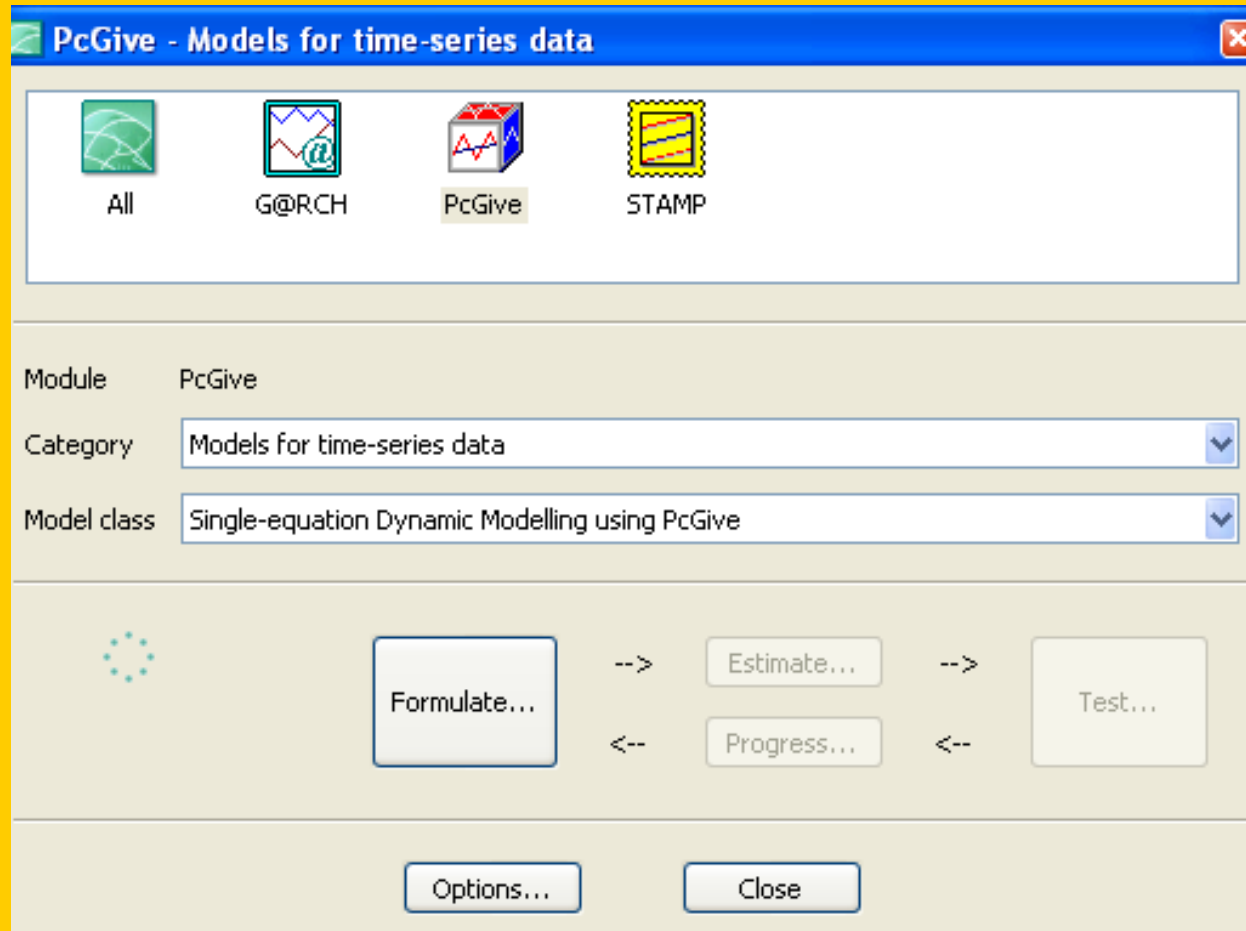
- We select data.in7 and load the quarterly data into the spreadsheet



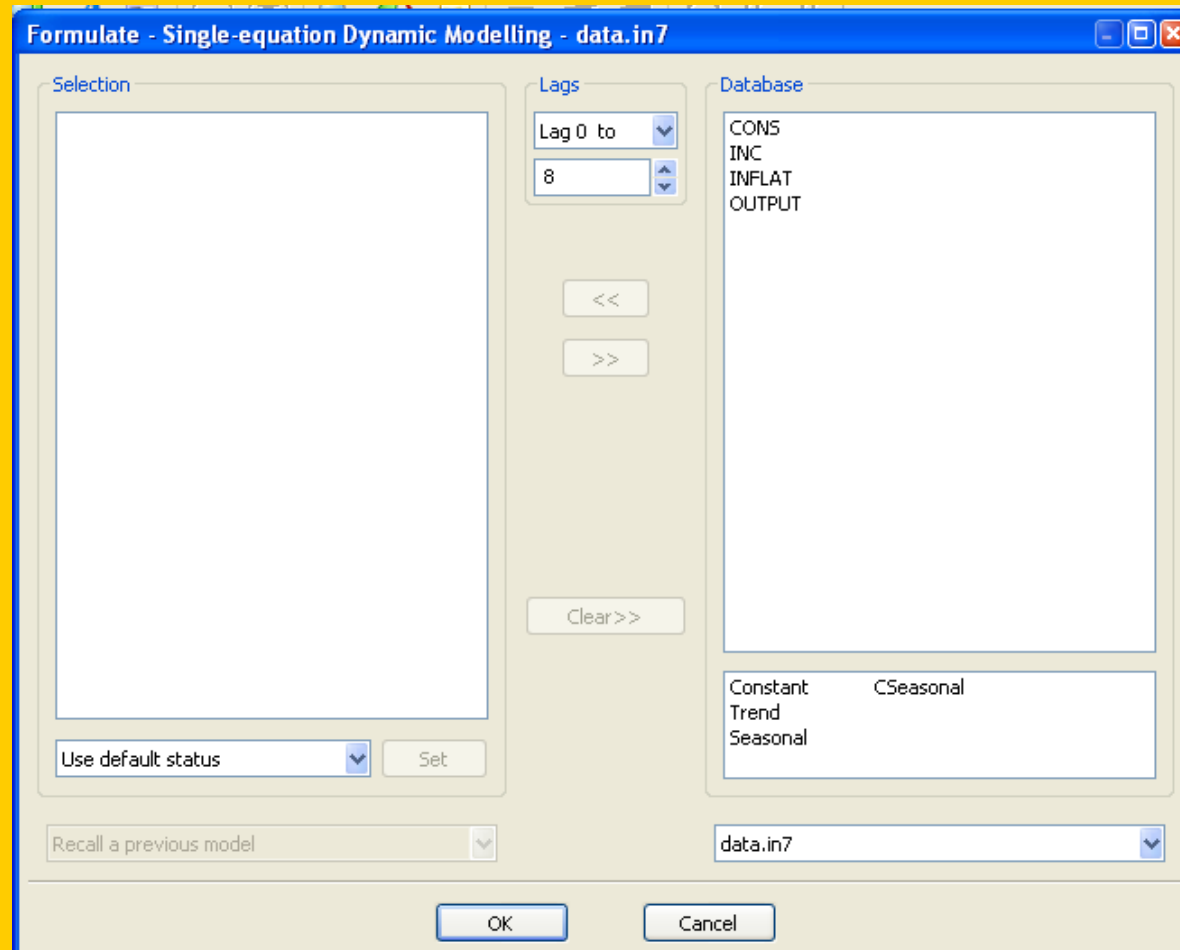
The image shows a screenshot of a spreadsheet application window titled "data.in7 - C:\Program Files\OxMetrics5\data\data.in7". The spreadsheet contains a table with 5 columns and 20 rows of data. The columns are labeled CONS, INC, INFLAT, and OUTPUT. The rows represent quarterly data from 1953 to 1957, with each year having four entries (e.g., 1953(1) through 1953(4)).

	CONS	INC	INFLAT	OUTPUT
1953(1)	890.45	908.212	3.6595	1203.77
1953(2)	886.543	900.679	2.7649	1200.36
1953(3)	886.329	899.795	2.521	1193.63
1953(4)	884.885	898.482	1.717	1193.04
1954(1)	885.254	895.777	.9729	1194.11
1954(2)	884.528	894.831	.676	1191.03
1954(3)	884.436	892.741	.1739	1191.47
1954(4)	884.311	892.768	-.3302	1195.34
1955(1)	887.426	896.971	-.4645	1195.51
1955(2)	889.556	901.406	-.3819	1198.2
1955(3)	890.659	901.479	-.2016	1199.24
1955(4)	894.079	905.117	.1956	1203.88
1956(1)	896.831	908.389	.5363	1211.27
1956(2)	894.984	906.216	1.75	1207.35
1956(3)	893.613	905.942	2.3436	1201.78
1956(4)	891.8	902.649	2.126	1200.69
1957(1)	890.252	901.933	2.0725	1200.2

# Select the Module, Category and model class



# Select 2 years of data (8 lags)

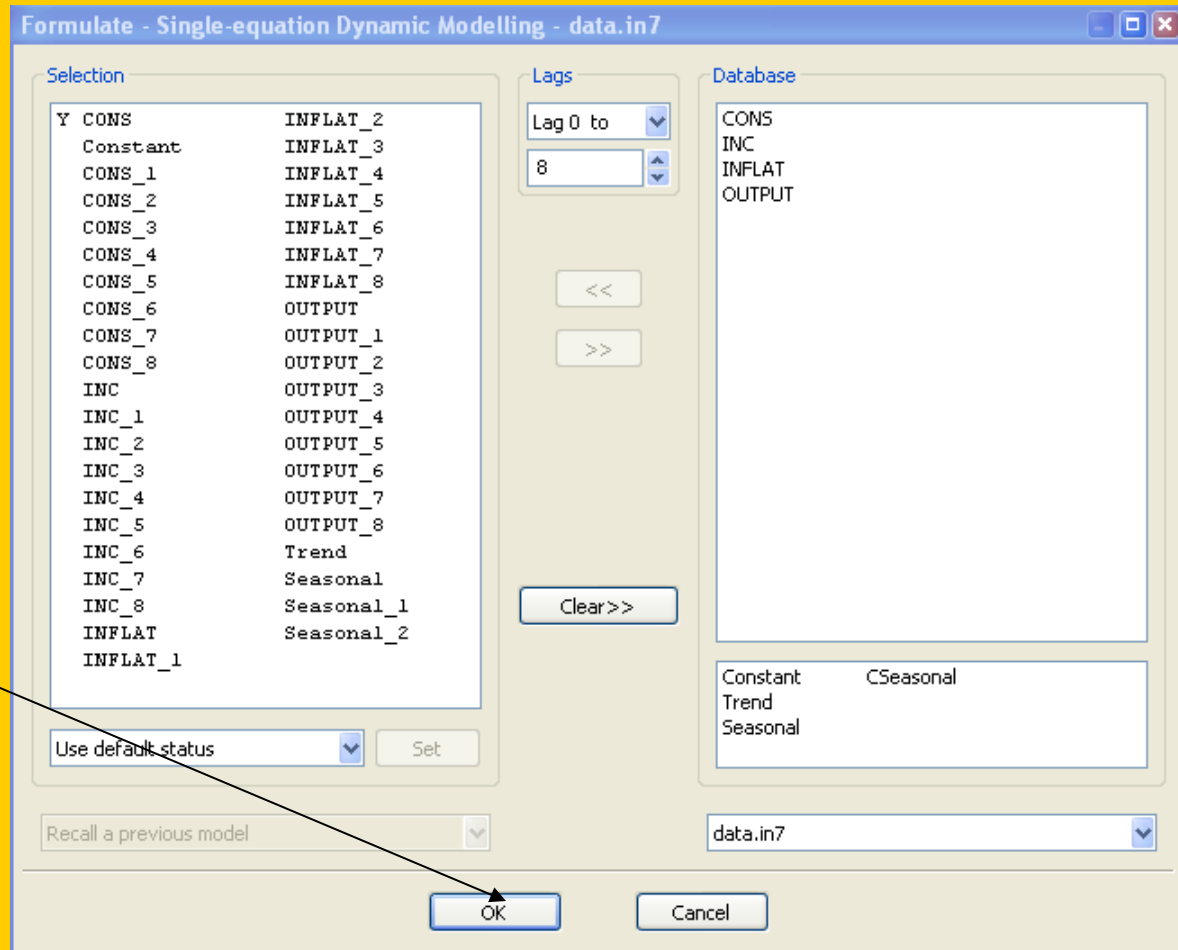




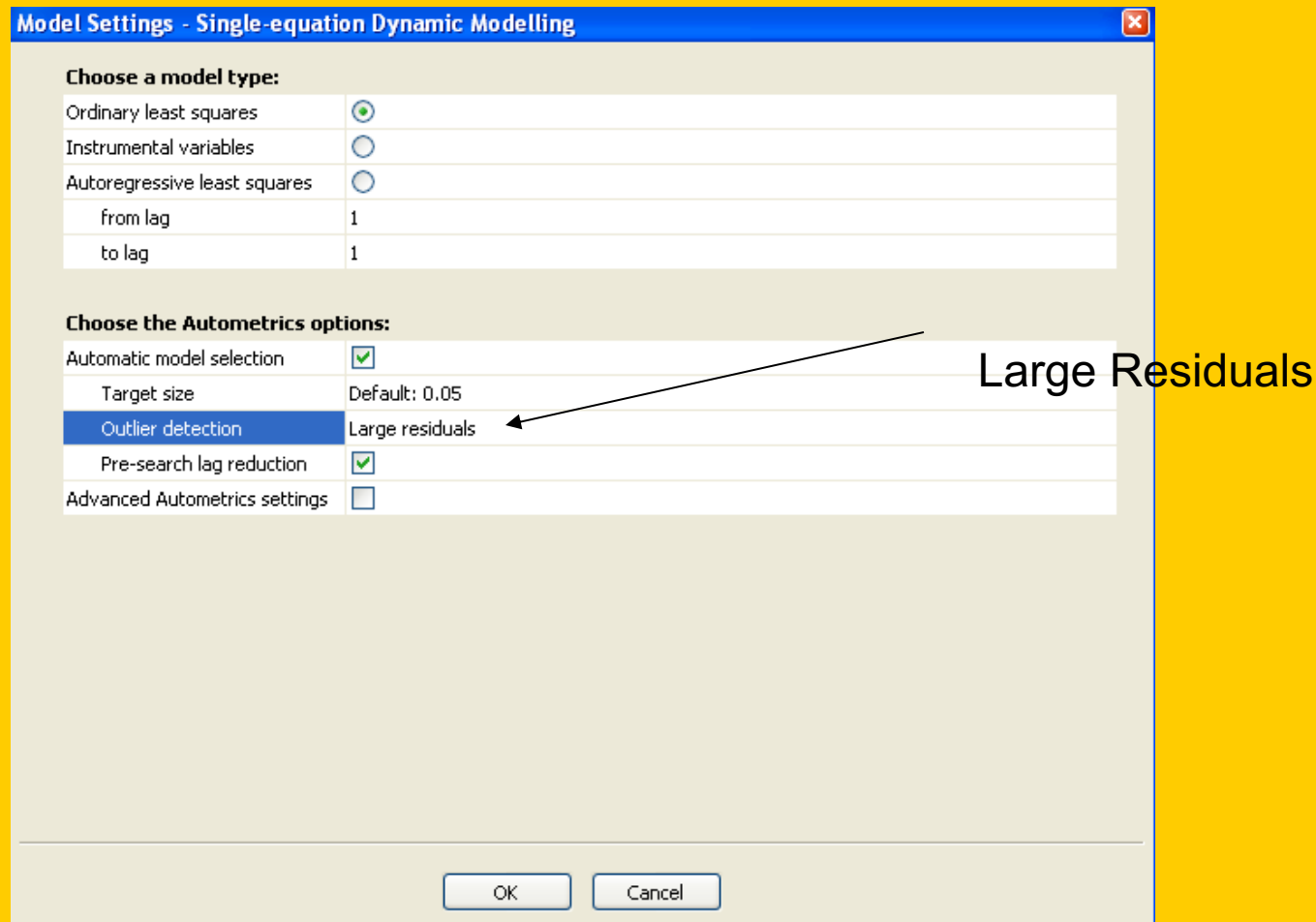
# Modeling consumption

- Move the variables from the Database window to the Selection window.
- Their lags are automatically constructed and included.
- Also include a Trend variable
- Include Seasonal dummies as well

# The Variable Selection



# In the Model settings dialog box, we set those settings



# Model Setting

- Leave model type on OLS
- Click Automatic model selection
- Select outlier detection to large residuals
- Click on Pre-search lag reduction
- Then click on OK

# Delimiting for the estimation sample

- For validation, we set aside 3 years for validation (12 forecasts) and click OK

**Estimate - Single-equation Dynamic Modelling**

**Choose the estimation sample:**

Selection sample	1955(1) - 1992(3)
Estimation starts at	1955(1)
Estimation ends at	1992(3)
Less forecasts	12

**Choose the estimation method:**

Estimation method:	Ordinary Least Squares
Recursive estimation	<input type="checkbox"/>
Initialization	10

OK Cancel

# Autometrics yields an optimal model

- In less than 1 minute, Autometrics generates the model with results of misspecification tests up front

```
p-values of diagnostic checks for model validity
      Initial GUM      cut-off      Final GUM      cut-off      Final model
AR(5)      0.94162      0.01000      0.61142      0.01000      0.53842
ARCH(4)    0.43715      0.01000      0.25648      0.01000      0.51872
Normality  0.53256      0.01000      0.79925      0.01000      0.93163
Hetero     0.99898      0.01000      0.58323      0.01000      0.45873
Chow(70%) 0.05426      0.01000      0.06419      0.01000      0.04416

Summary of Autometrics search
initial search space      2^40      final search space      2^11
no. estimated models      208      no. terminal models      4
test form                  LR-F      target size              Default:0.05
outlier detection          0.025     presearch reduction      lags
backtesting                 GUM0     tie-breaker              SC
diagnostics p-value        0.01     search effort            standard
time                        0.85     Autometrics version      1.5
```

File Edit Search View Model Run Window Help

data.in7

xbeta =  $\beta_0 + \beta_1 * \text{Lrate}$

Documents

- Data
  - vixsp500b.in7
  - data.in7
- Graphics
- Model
- Code
  - loadxls3.ox
  - basic\_matrices.ox
  - graphics3.ox
  - load\_mat.ox
  - load\_Nile\_dat.ox
- Text
- Results
  - GJR11sktdist2.out
  - GJR11skt.out
  - Chung\_FIGARCH.out
  - Chung\_FIGARCH2.out
  - GJR11sktdist3.out
  - basic\_matrices.out
- Modules
  - Model
    - G@RCH
    - PcGive
    - STAMP
  - Ox
    - OxDebug
    - OxGauss
    - OxPack
    - OxRun
    - Ox - interactive
    - X12arima

**Results**

EQ( 2) Modelling CONS by OLS  
 The dataset is: C:\Program Files\OxMetrics5\data\data.in7  
 The estimation sample is: 1955(1) - 1989(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
CONS_1	0.874432	0.02687	32.5	0.0000	0.8877
CONS_5	-0.0438114	0.01760	-2.49	0.0140	0.0442
INC	0.482387	0.02943	16.4	0.0000	0.6673
INC_1	-0.314234	0.03374	-9.31	0.0000	0.3929
INFLAT	-0.911402	0.08797	-10.4	0.0000	0.4448

sigma 1.07608 RSS 155.164728  
 log-likelihood -204.878 DW 2.04  
 no. of observations 139 no. of parameters 5  
 mean(CONS) 876.668 var(CONS) 181.815

Instability tests:  
 variance 0.53710\*  
 joint 0.91942

Individual instability tests:  
 CONS\_1 0.082496  
 CONS\_5 0.083334  
 INC 0.082523  
 INC\_1 0.082720  
 INFLAT 0.073546

1-step (ex post) forecast analysis 1989(4) - 1992(3)  
 Parameter constancy forecast tests:  
 Forecast  $\chi^2(12) = 14.506$  [0.2696]  
 Chow  $F(12,134) = 1.1773$  [0.3055]

# Collinearity diagnostics, parameter constancy tests, and a summary of misspecification tests are generated

```

1-step (ex post) forecast analysis 1989(4) - 1992(3)
Parameter constancy forecast tests:
Forecast  Chi^2(12) =  14.506 [0.2696]
Chow      F(12,134) =   1.1773 [0.3055]

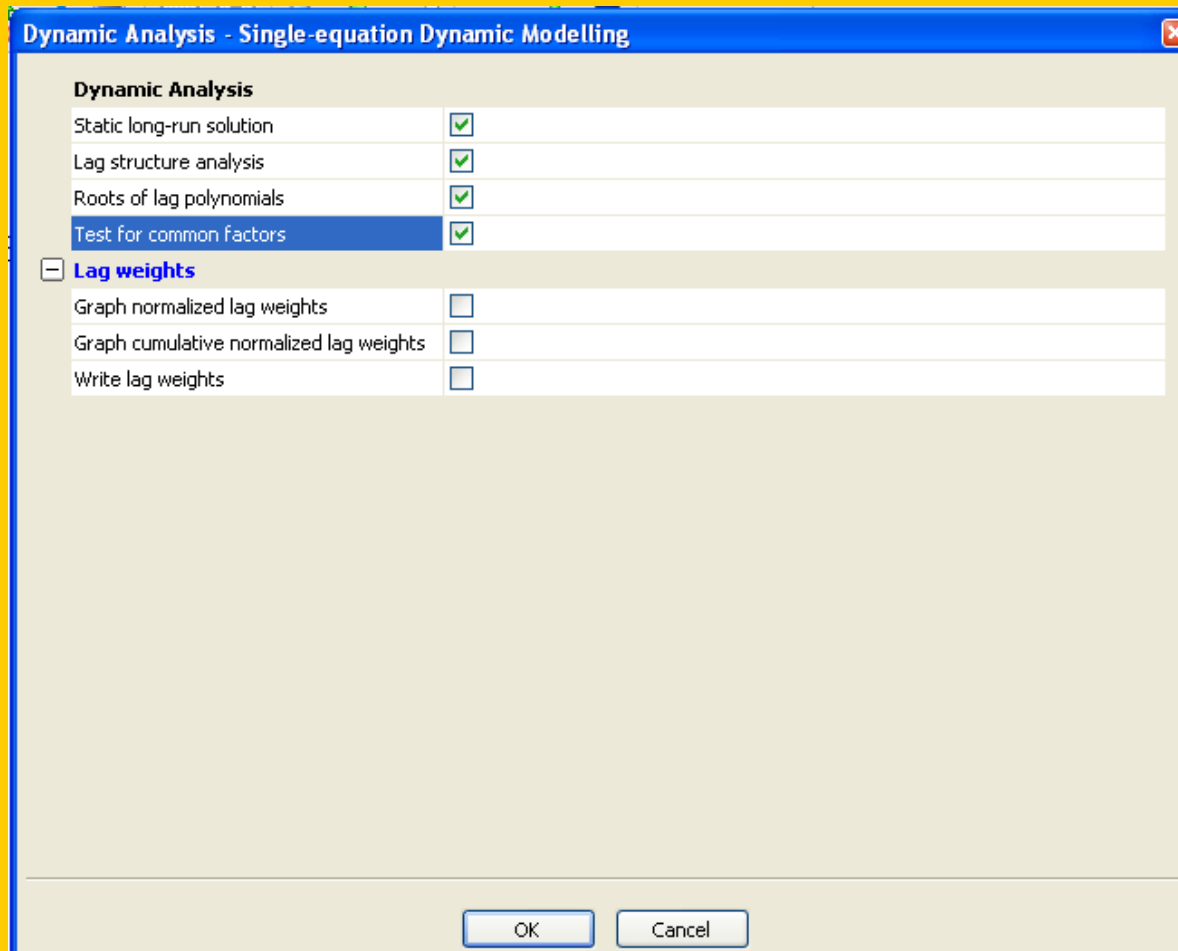
Descriptive statistics of variables used in the model:
Means
      CONS      CONS_1      CONS_5      INC      INC_1      INFLAT
      876.67     876.83     877.48     892.40     892.53     1.7908
Standard deviations (using T-1)
      CONS      CONS_1      CONS_5      INC      INC_1      INFLAT
      13.533     13.488     13.313     10.670     10.555     1.3219
Correlation matrix:
      CONS      CONS_1      CONS_5      INC      INC_1      INFLAT
CONS      1.0000     0.98675     0.87823     0.94106     0.91444
CONS_1    0.98675     1.0000     0.91055     0.93138     0.94063
CONS_5    0.87823     0.91055     1.0000     0.86143     0.88359
INC       0.94106     0.93138     0.86143     1.0000     0.95412
INC_1     0.91444     0.94063     0.88359     0.95412     1.0000
INFLAT   -0.35465     -0.27388     -0.11480     -0.13230     -0.074755
      INFLAT
CONS      -0.35465
CONS_1    -0.27388
CONS_5    -0.11480
INC       -0.13230
INC_1     -0.074755
INFLAT    1.0000

AR 1-5 test:      F(5,129) =  0.81877 [0.5384]
ARCH 1-4 test:    F(4,126) =  0.81365 [0.5187]
Normality test:   Chi^2(2) =  0.14163 [0.9316]
Hetero test:      F(10,123) =  0.98657 [0.4587]
Hetero-X test:    F(20,113) =  0.88671 [0.6039]
RESET test:       F(1,133) =  2.0920 [0.1504]

```



# Dynamic Analysis is available



# Output of dynamic analysis

```
Solved static long-run equation for CONS
                Coefficient  Std.Error  t-value  t-prob
INC                0.992759   0.001339   741.   0.0000
INFLAT             -5.38082    0.6321   -8.51  0.0000
Long-run sigma = 6.35306

ECM = CONS - 0.992759*INC + 5.38082*INFLAT;
WALD test: Chi^2(2) = 2.60735e+006 [0.0000] **

Analysis of lag structure, coefficients:
                Lag 0   Lag 1   Lag 2   Lag 3   Lag 4   Lag 5   Sum   SE(Sum)
CONS                -1   0.874    -0     -0     -0  -0.0438  -0.169  0.0223
INC                 0.482  -0.314    0      0      0      0      0.168  0.022
INFLAT             -0.911    0      0      0      0      0     -0.911  0.088

Tests on the significance of each variable
Variable   F-test           Value [ Prob]   Unit-root t-test
CONS       F(2,134) =      717.54 [0.0000]**   -7.6108**
INC        F(2,134) =      147.19 [0.0000]**    7.6586
INFLAT     F(1,134) =      107.34 [0.0000]**   -10.361

Tests on the significance of each lag
Lag 5      F(1,134) =       6.1943 [0.0140]*
Lag 1      F(2,134) =     533.55 [0.0000]**

Tests on the significance of all lags up to 5
Lag 5 - 5  F(1,134) =       6.1943 [0.0140]*
Lag 4 - 5  F(1,134) =       6.1943 [0.0140]*
Lag 3 - 5  F(1,134) =       6.1943 [0.0140]*
Lag 2 - 5  F(1,134) =       6.1943 [0.0140]*
Lag 1 - 5  F(3,134) =     518.77 [0.0000]**
```

# More dynamic analysis output

```
Variable      F-test          Value [ Prob]      Unit-root t-test
CONS          F(2,134) =      717.54 [0.0000]**  -7.6108**
INC           F(2,134) =      147.19 [0.0000]**   7.6586
INFLAT       F(1,134) =      107.34 [0.0000]**  -10.361

Tests on the significance of each lag
Lag 5        F(1,134) =       6.1943 [0.0140]*
Lag 1        F(2,134) =     533.55 [0.0000]**

Tests on the significance of all lags up to 5
Lag 5 - 5    F(1,134) =       6.1943 [0.0140]*
Lag 4 - 5    F(1,134) =       6.1943 [0.0140]*
Lag 3 - 5    F(1,134) =       6.1943 [0.0140]*
Lag 2 - 5    F(1,134) =       6.1943 [0.0140]*
Lag 1 - 5    F(3,134) =     518.77 [0.0000]**

Tests on the significance of all lags up to 4
Lag 1 - 4    F(2,134) =     533.55 [0.0000]**

Tests on the significance of all lags up to 3
Lag 1 - 3    F(2,134) =     533.55 [0.0000]**

Tests on the significance of all lags up to 2
Lag 1 - 2    F(2,134) =     533.55 [0.0000]**

Roots of CONS lag polynomial:
      real      imag      modulus
      0.70272   0.047116   0.70429
      0.70272  -0.047116   0.70429
     -0.051380  0.45123    0.45415
     -0.051380 -0.45123    0.45415
     -0.42824   0.00000    0.42824

Roots of INC lag polynomial:
      real      imag      modulus
      0.65141   0.00000    0.65141
```

# You can request information criteria and output in equation format

**Further Output - Single-equation Dynamic Modelling**

**Further results and reports**

Information criteria	<input checked="" type="checkbox"/>
Heteroscedasticity consistent standard errors	<input type="checkbox"/>
R <sup>2</sup> relative to difference and seasonals	<input type="checkbox"/>
Correlation matrix of regressors	<input type="checkbox"/>
Covariance matrix of estimated parameters	<input type="checkbox"/>
Reduced form estimates	<input type="checkbox"/>
Static (1-step) forecasts	<input type="checkbox"/>
Print large residuals	<input checked="" type="checkbox"/>
Exceeding standard error by factor	3.5

**Write model results**

Equation format	<input checked="" type="checkbox"/>
LaTeX format	<input type="checkbox"/>
Non-linear model format	<input type="checkbox"/>
Significant digits for parameters:	4
Significant digits for std.errors:	3

OK Cancel

# Information criteria and equation format

When the log-likelihood constant is NOT included:

AIC	0.181956	SC	0.287512
HQ	0.224851	FPE	1.19960

When the log-likelihood constant is included:

AIC	3.01983	SC	3.12539
HQ	3.06273	FPE	20.4885

No residuals exceed 3.5 standard errors

CONS = + 0.8744\*CONS\_1 - 0.04381\*CONS\_5 + 0.4824\*INC - 0.3142\*INC\_1  
(SE) (0.0269) (0.0176) (0.0294) (0.0337)  
- 0.9114\*INFLAT  
(0.088)

# A Vast variety of tests may be requested

The dialog box 'Test - Single-equation Dynamic Modelling' contains the following tests and settings:

Test Name	Checked	Value
Residual autocorrelations and Portmanteau statistic	<input type="checkbox"/>	
with length		12
Error autocorrelation test	<input type="checkbox"/>	
from lag		1
to lag		5
Normality test	<input type="checkbox"/>	
Heteroscedasticity test (using squares)	<input checked="" type="checkbox"/>	
Heteroscedasticity test (using squares and cross products)	<input checked="" type="checkbox"/>	
ARCH test	<input type="checkbox"/>	
with order		4
RESET test (using squares)	<input type="checkbox"/>	
Instability tests	<input type="checkbox"/>	
Encompassing tests	<input type="checkbox"/>	

Buttons: OK, Cancel

# Heteroskedasticity tests for individual variables

The screenshot shows the OxMetrics software interface. The main window displays the following text:

xbeta =  $\beta_0 + \beta_1 \cdot \text{Lrate}$

Heteroscedasticity coefficients:

	Coefficient	Std. Error	t-value
CONS_1	1.0095	3.3437	0.30190
CONS_5	-1.8339	2.3927	-0.76644
INC	3.8138	3.9656	0.96171
INC_1	-0.92414	4.5435	-0.20340
INFLAT	0.36530	0.27526	1.3271
CONS_1^2	-0.00055919	0.0019149	-0.29203
CONS_5^2	0.0010317	0.0013676	0.75443
INC^2	-0.0021432	0.0022196	-0.96556
INC_1^2	0.00050604	0.0025454	0.19881
INFLAT^2	-0.066640	0.049688	-1.3412

RSS = 315.274    sigma = 1.601    effective no. of parameters = 11  
Regression in deviation from mean

# White's test with Squares and Cross-products

```
Heteroscedasticity coefficients:
      Coefficient   Std.Error   t-value
CONS_1      -5.5185     6.8225   -0.80888
CONS_5       0.35170    3.4720    0.10130
INC          8.8870     4.8902    1.8173
INC_1        0.18354     7.0257    0.026125
INFLAT      -1.6414     18.487   -0.088782
CONS_1^2     -0.014014    0.011420   -1.2271
CONS_5^2     0.0037279    0.0052004  0.71685
INC^2        -0.022690    0.013895   -1.6329
INC_1^2      -0.020476    0.015845   -1.2923
INFLAT^2    -0.043740    0.091384   -0.47864
CONS_1*CONS_5 0.0011317    0.010481  0.10798
CONS_5*INC   -0.014104    0.0096119  -1.4673
INC*INC_1    0.026377     0.027445  0.96109
INC_1*INFLAT -0.044168    0.060444  -0.73073
CONS_1*INC   0.023204     0.016234  1.4293
CONS_5*INC_1 0.0052349    0.010645  0.49177
INC*INFLAT   0.048572     0.045915  1.0579
CONS_1*INC_1 0.0094504    0.023285  0.40585
CONS_5*INFLAT 0.0075926    0.036289  0.20923
CONS_1*INFLAT -0.0099337    0.054494  -0.18229

RSS = 294.365  sigma = 1.614  effective no. of parameters = 21
Regression in deviation from mean

Testing for heteroscedasticity using squares and cross products
Chi^2(20) = 18.855 [0.5312]  and F-form F(20,113) = 0.88671 [0.6039]
```



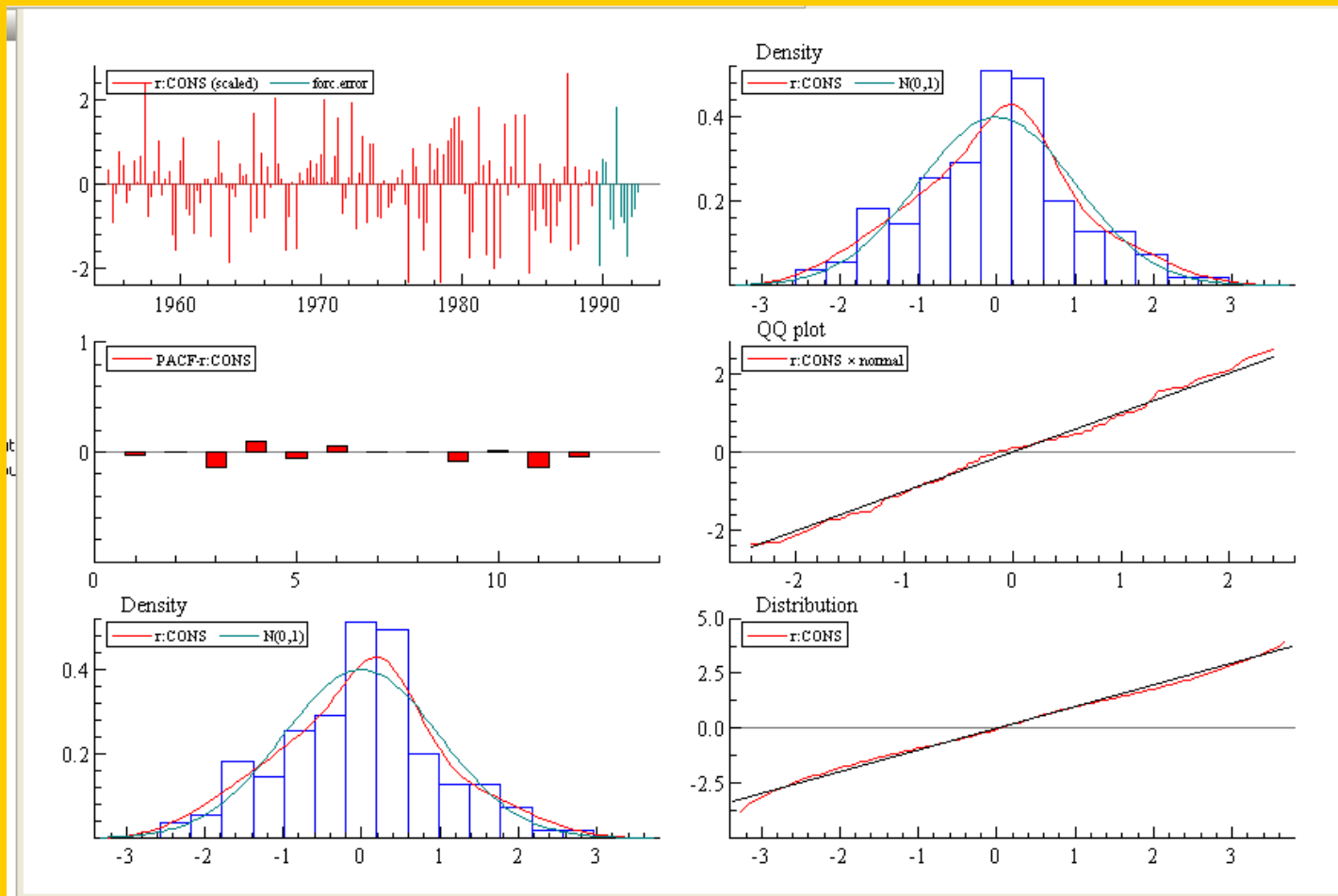
# Robust Standard errors: White's, Newey-West, and Jackknifed

Heteroscedasticity consistent standard errors

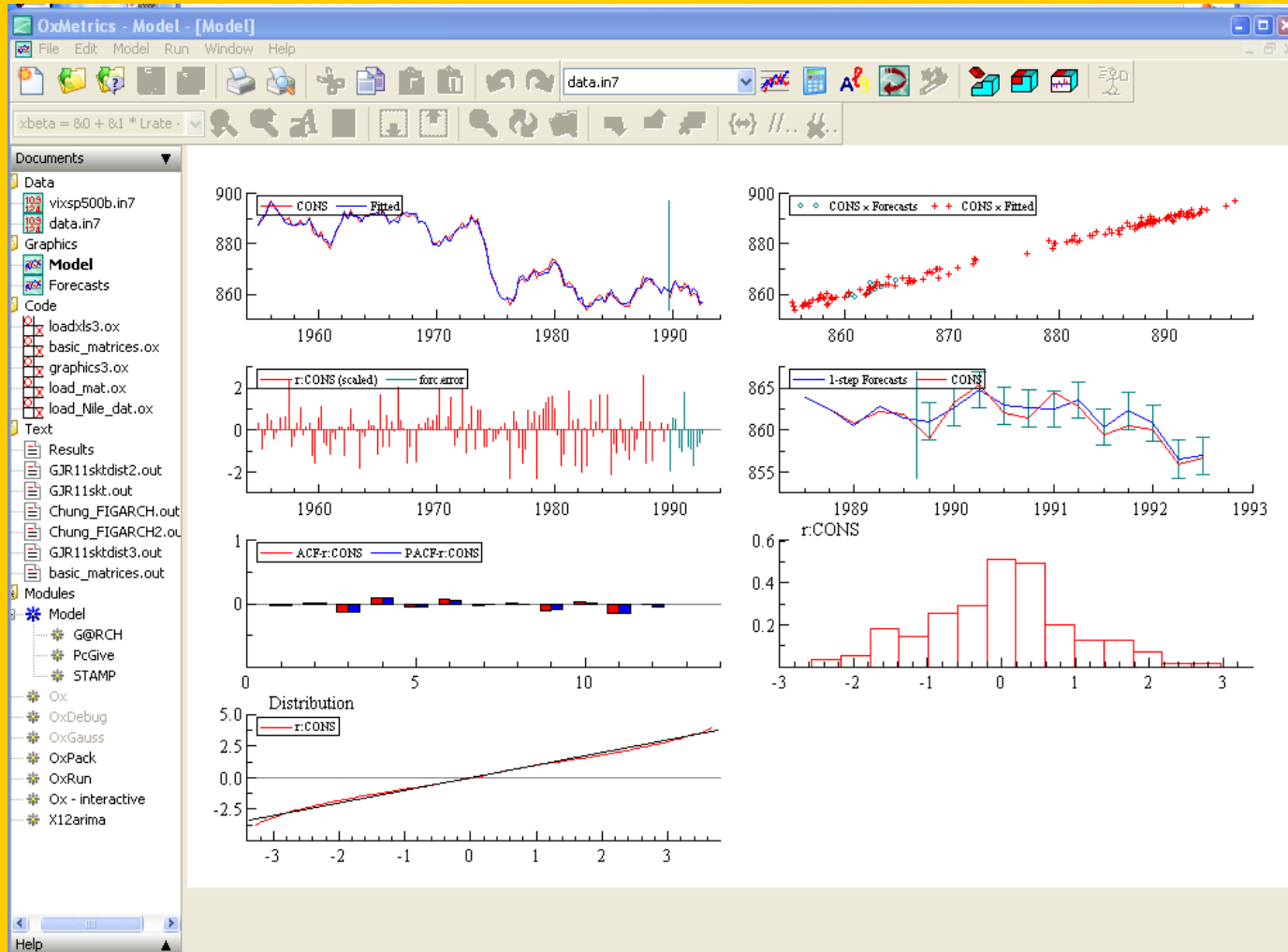
	Coefficients	SE	HACSE	HCSE	JHCSE
CONS_1	0.87443	0.026869	0.020131	0.024021	0.024825
CONS_5	-0.043811	0.017603	0.015224	0.017811	0.018201
INC	0.48239	0.029428	0.025429	0.026583	0.027186
INC_1	-0.31423	0.033742	0.026054	0.030809	0.031688
INFLAT	-0.91140	0.087969	0.071854	0.080678	0.084607

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
CONS_1	0.87443	32.544	43.437	36.403	35.224
CONS_5	-0.043811	-2.4888	-2.8779	-2.4597	-2.4071
INC	0.48239	16.392	18.970	18.147	17.744
INC_1	-0.31423	-9.3128	-12.061	-10.199	-9.9166
INFLAT	-0.91140	-10.361	-12.684	-11.297	-10.772

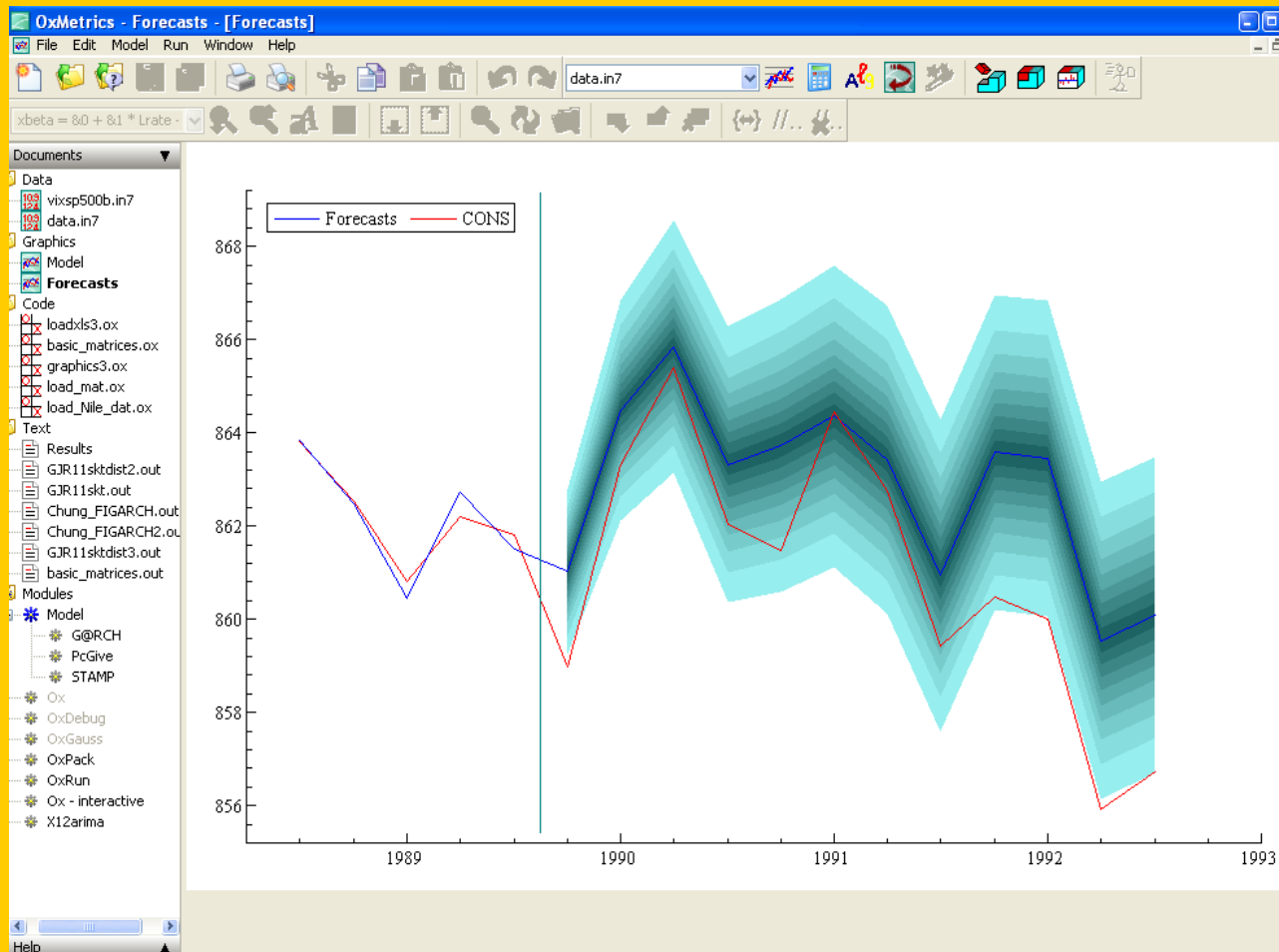
# Graphical Residual Analysis



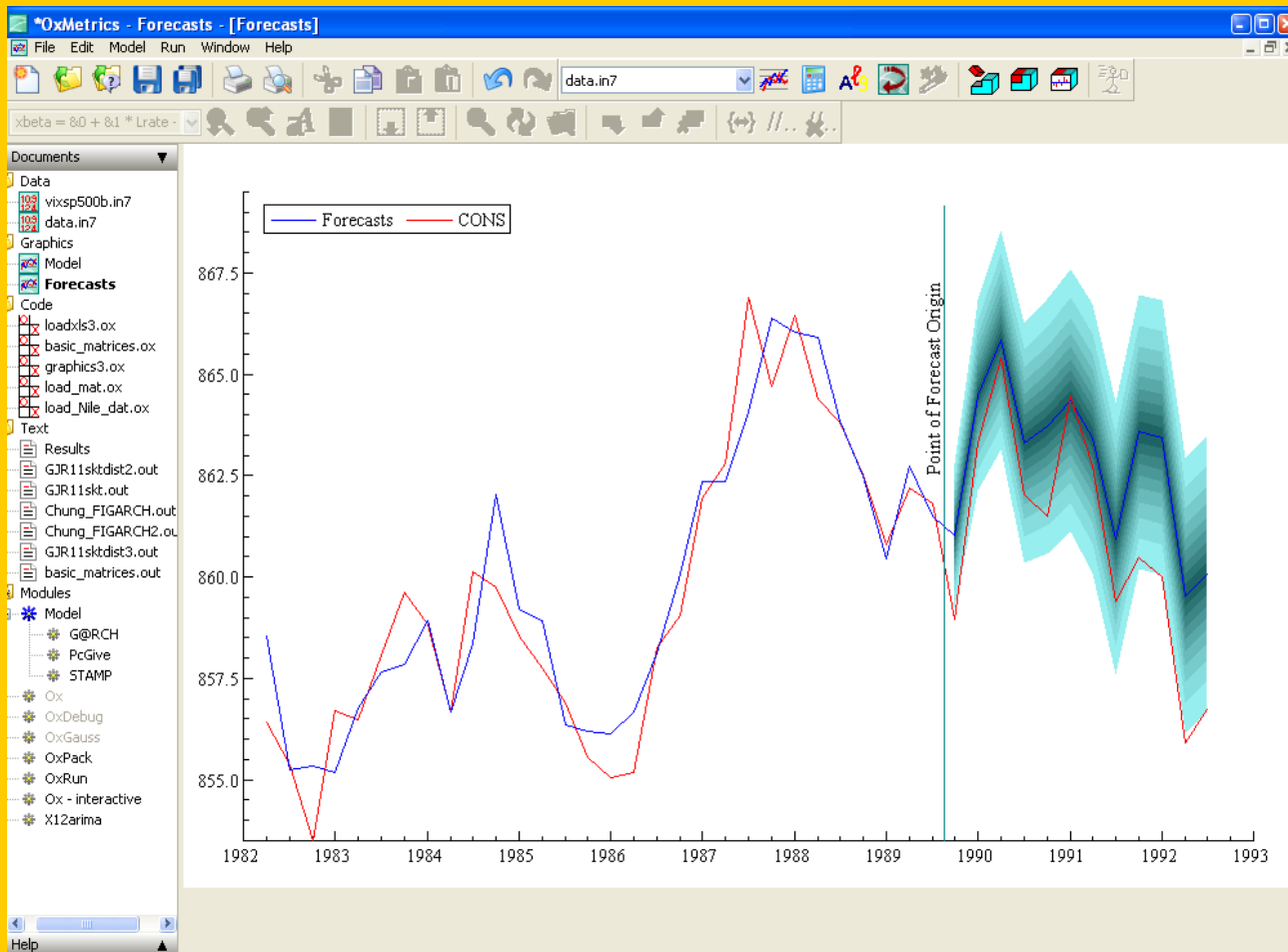
# Model Graphics can be paneled



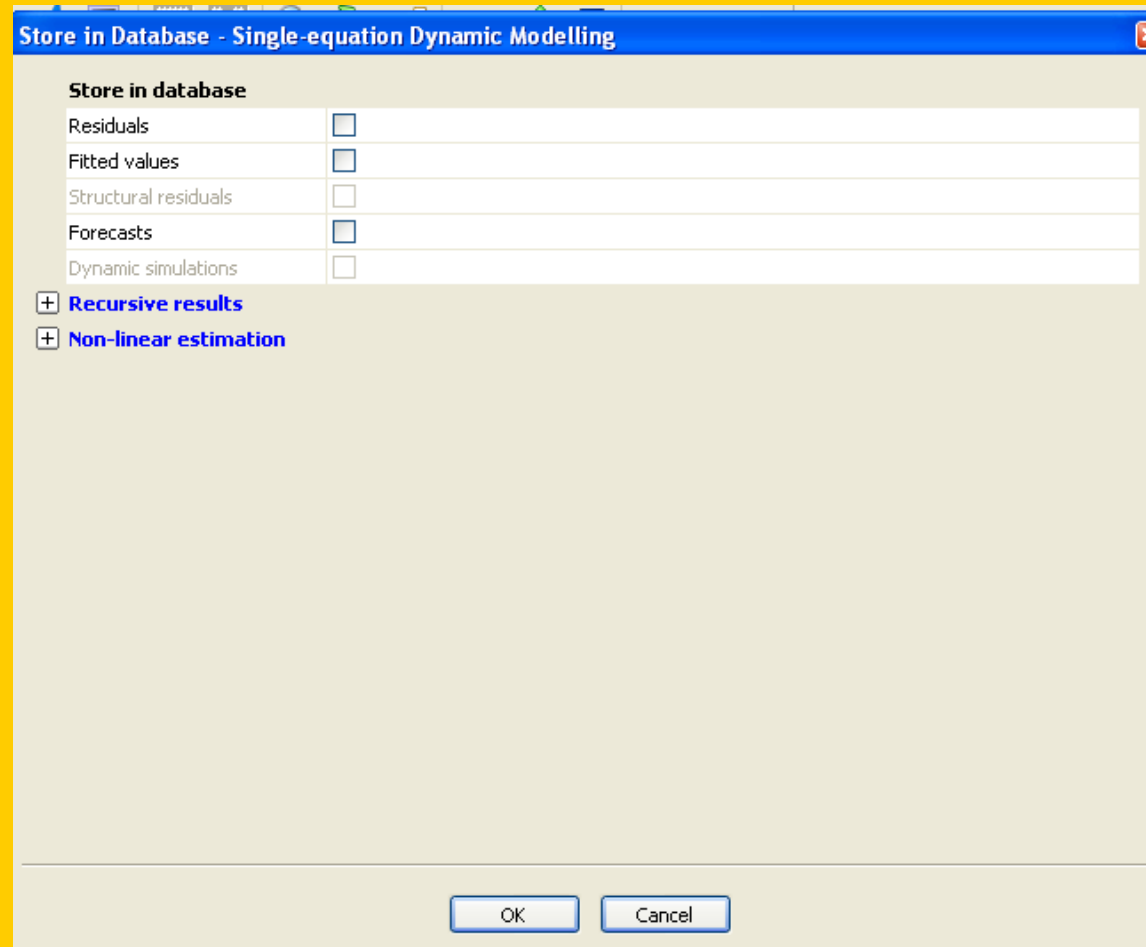
# Out-of-Sample Forecasting (Or Generated Individually)



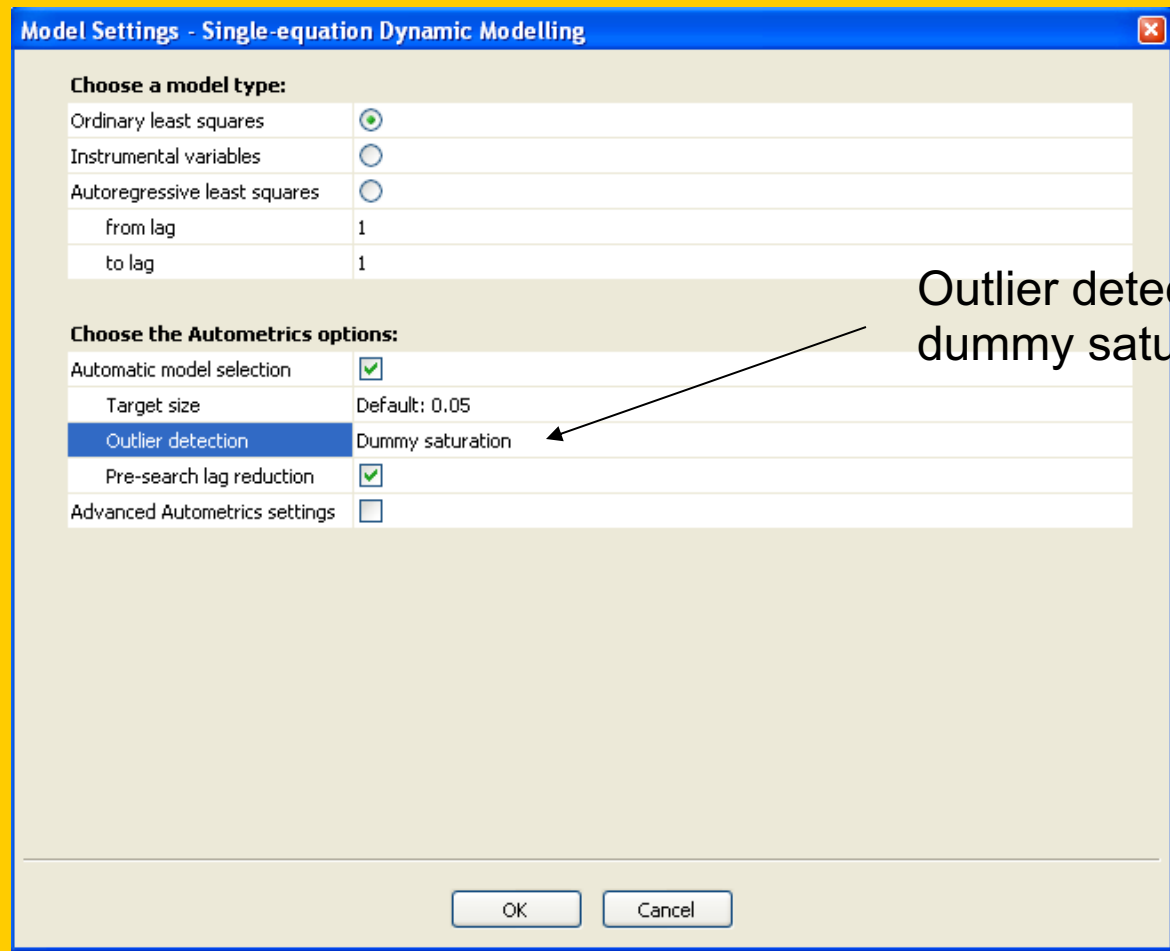
# Or Customized to your needs



# Residuals, Fitted values, and forecasts may be stored for future analysis.



# Dummy Saturation is another outlier detection option



Outlier detection with  
dummy saturation

# The Dummy Saturation Option

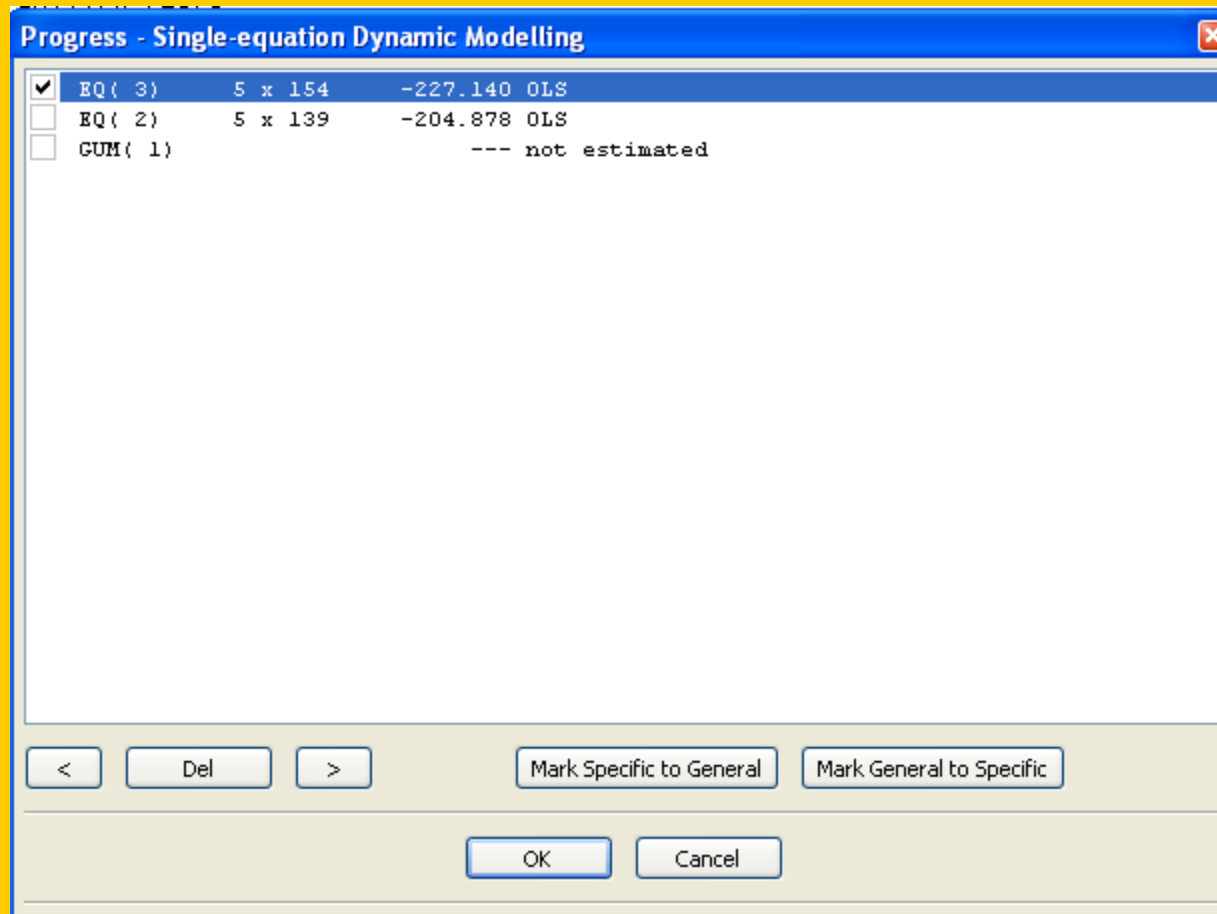
- Opting for dummy saturation will automatically reveal additive outliers in the data.

```
The dataset is: C:\Program Files\OxMetrics5\data\data.in7
The estimation sample is: 1955(1) - 1992(3)
```

	Coefficient	Std.Error	t-value	t-prob	Part.R <sup>2</sup>
CONS_1	0.835649	0.02154	38.8	0.0000	0.9127
INC	0.497909	0.02722	18.3	0.0000	0.6992
INC_1	-0.297895	0.03336	-8.93	0.0000	0.3564
INFLAT	-0.947522	0.08393	-11.3	0.0000	0.4695
OUTPUT_3	-0.0275453	0.01317	-2.09	0.0383	0.0295
I:1976(2)	-2.84717	1.070	-2.66	0.0087	0.0469
I:1987(3)	3.30161	1.057	3.12	0.0022	0.0634
sigma	1.04351	RSS		156.804968	
log-likelihood	-217.108	DW		1.97	
no. of observations	151	no. of parameters		7	
mean(CONS)	875.415	var(CONS)		186.147	



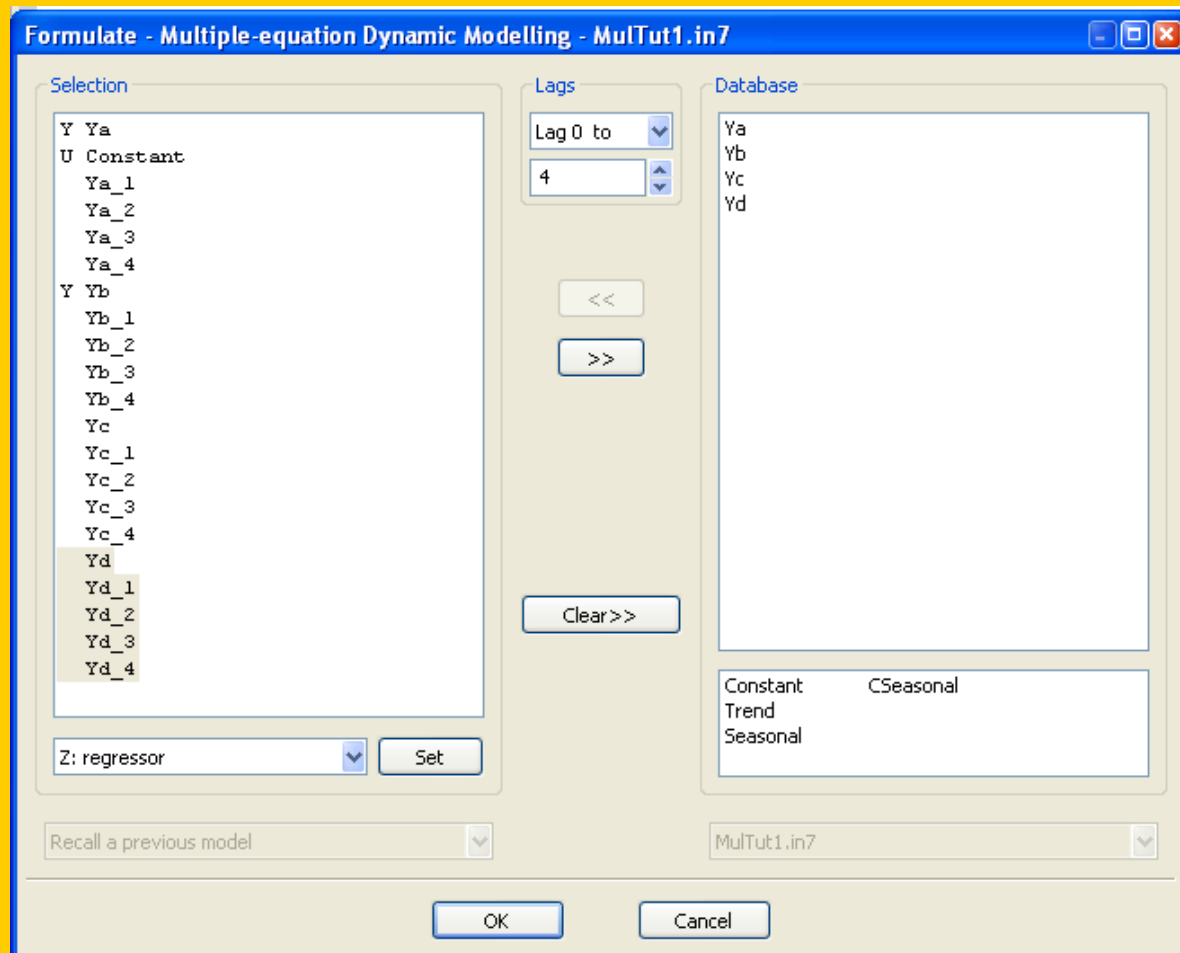
# Comparative Model Analysis (progress)



# Autometrics can also model multivariate models

- Unrestricted Vector Autoregression
- Automatic outlier identification and modeling
- Blockwise modeling allows models with observations  $< \#$  variables
  - For omitted regressors
  - For lag reduction
  - For specification criteria
  - For outlier detection and modeling

# An Unrestricted Vector Autoregression



# Check the Autometrics selection

**Model Settings - Multiple-equation Dynamic Modelling**

**Choose a model type:**

Unrestricted system	<input checked="" type="radio"/>
Cointegrated VAR	<input type="radio"/>
Simultaneous equations model	<input type="radio"/>
Constrained simultaneous equations model	<input type="radio"/>

**Choose the Autometrics options:**

Automatic model selection	<input checked="" type="checkbox"/>
Target size	Default: 0.05
Outlier detection	None
Pre-search lag reduction	<input checked="" type="checkbox"/>
Advanced Autometrics settings	<input type="checkbox"/>

OK Cancel

# Define the estimation sample

**Estimate - Multiple-equation Dynamic Modelling**

**Choose the estimation sample:**

Selection sample	1951(1) - 2004(4)
Estimation starts at	1951(1)
Estimation ends at	2004(4)
Less forecasts	8

**Choose the estimation method:**

Estimation method:	Ordinary Least Squares
Recursive estimation	<input type="checkbox"/>
Initialization	10

OK Cancel

# Vector Autoregression output

```

SYS( 2) Estimating the system by OLS
The dataset is: C:\Program Files\OxMetrics5\data\MulTut1.in7
The estimation sample is: 1951(1) - 2002(4)

URF equation for: Ya

```

	Coefficient	Std.Error	HACSE	t-HACSE	t-prob	
Ya_1	0.606263	0.06542	0.06185	9.80	0.0000	
Ya_2	0.286423	0.05999	0.05640	5.08	0.0000	
Yb_1	0.295147	0.08190	0.07584	3.89	0.0001	
Yb_2	-0.191287	0.08320	0.07687	-2.49	0.0137	
Yc	-0.905628	0.1345	0.1279	-7.08	0.0000	
Yc_1	0.176671	0.1450	0.1478	1.20	0.2332	
Yd	-0.523929	0.07297	0.07766	-6.75	0.0000	
Yd_1	-0.232570	0.08625	0.08749	-2.66	0.0085	
Constant	U	0.0671307	0.06883	0.05665	1.18	0.2375

```

sigma = 0.0127038  RSS = 0.03211594175

URF equation for: Yb

```

	Coefficient	Std.Error	HACSE	t-HACSE	t-prob	
Ya_1	-0.0122296	0.05299	0.04804	-0.255	0.7993	
Ya_2	-0.00553180	0.04860	0.04348	-0.127	0.8989	
Yb_1	0.843141	0.06635	0.06285	13.4	0.0000	
Yb_2	0.168830	0.06740	0.06426	2.63	0.0093	
Yc	-0.369900	0.1089	0.1033	-3.58	0.0004	
Yc_1	0.379201	0.1175	0.1189	3.19	0.0017	
Yd	0.102550	0.05911	0.07263	1.41	0.1595	
Yd_1	-0.255820	0.06987	0.07986	-3.20	0.0016	
Constant	U	0.0791111	0.05576	0.05069	1.56	0.1202

```

sigma = 0.0102912  RSS = 0.02107593279

log-likelihood      1279.03305  -T/2log|Omega|      1869.31148
|Omega|             1.56288247e-008  log|Y'Y/T|         -3.66896302
R^2 (LR)            0.999999  R^2 (LM)            0.999002
no. of observations      208  no. of parameters    18
When the log-likelihood constant is NOT included:

```

# Misspecification test output

```
F-test on regressors except unrestricted: F(16,396) = 31591.2 [0.0000] **
F-tests on retained regressors, F(2,198) =
  Ya_1      42.7338 [0.000]**      Ya_2      11.3421 [0.000]**
  Yb_1      88.3598 [0.000]**      Yb_2      5.57155 [0.004]**
  Yc        29.0741 [0.000]**      Yc_1      6.05194 [0.003]**
  Yd        26.7710 [0.000]**      Yd_1      10.6148 [0.000]**
  Constant U 1.52068 [0.221]

correlation of URF residuals (standard deviations on diagonal)
      Ya      Yb
Ya    0.012704  -0.032341
Yb   -0.032341  0.010291
correlation between actual and fitted
      Ya      Yb
0.99977  0.99954

1-step (ex post) forecast analysis 2003(1) - 2004(4)
Parameter constancy forecast tests:
using Omega Chi^2(16) = 13.829 [0.6115]   F(16,199) = 0.86430 [0.6111]
using V[e]  Chi^2(16) = 12.877 [0.6817]   F(16,199) = 0.80482 [0.6792]
using V[E]  Chi^2(16) = 13.567 [0.6310]   F(16,199) = 0.84791 [0.6300]

Ya      : Portmanteau(12): 5.98075
Yb      : Portmanteau(12): 5.69824
Ya      : AR 1-5 test:      F(5,194) = 0.94690 [0.4518]
Yb      : AR 1-5 test:      F(5,194) = 0.43524 [0.8236]
Ya      : Normality test:  Chi^2(2) = 0.16233 [0.9220]
Yb      : Normality test:  Chi^2(2) = 0.11950 [0.9420]
Ya      : ARCH 1-4 test:    F(4,191) = 0.27419 [0.8944]
Yb      : ARCH 1-4 test:    F(4,191) = 1.8443 [0.1220]
Ya      : Hetero test:      F(16,182) = 1.4975 [0.1045]
Yb      : Hetero test:      F(16,182) = 0.67227 [0.8188]
Ya      : Hetero-X test:    F(44,154) = 1.4901 [0.0402]*
Yb      : Hetero-X test:    F(44,154) = 1.1106 [0.3150]

Hetero-Portmanteau(12): 22.8581
```

# Multivariate and cointegration tests

```
Vector Portmanteau(12): 30.8591
Vector AR 1-5 test:      F(20,376) = 1.0451 [0.4076]
Vector Normality test:  Chi^2(4) = 0.30101 [0.9897]
Vector Hetero test:     F(48,536) = 1.1607 [0.2199]
Vector Hetero-X test:   F(132,456) = 1.2253 [0.0662]

I(1) cointegration analysis, 1951(1) - 2002(4)
eigenvalue      loglik for rank
                1141.543  0
    0.70840      1269.711  1
    0.085735     1279.033  2

rank Trace test [ Prob]    Max test [ Prob]    Trace test (T-rm)    Max test (T-rm)
  0      274.98 [0.000]**    256.34 [0.000]**    269.69 [0.000]**    251.41 [0.000]**
  1       18.64 [0.000]**     18.64 [0.000]**     18.29 [0.000]**     18.29 [0.000]**
```



# Graphical forecasts from VAR

