Risk Analysis using OxMetrics ver. 5

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Developers of OxMetrics

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- Jurgen Doornik, Oxford University, UK
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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

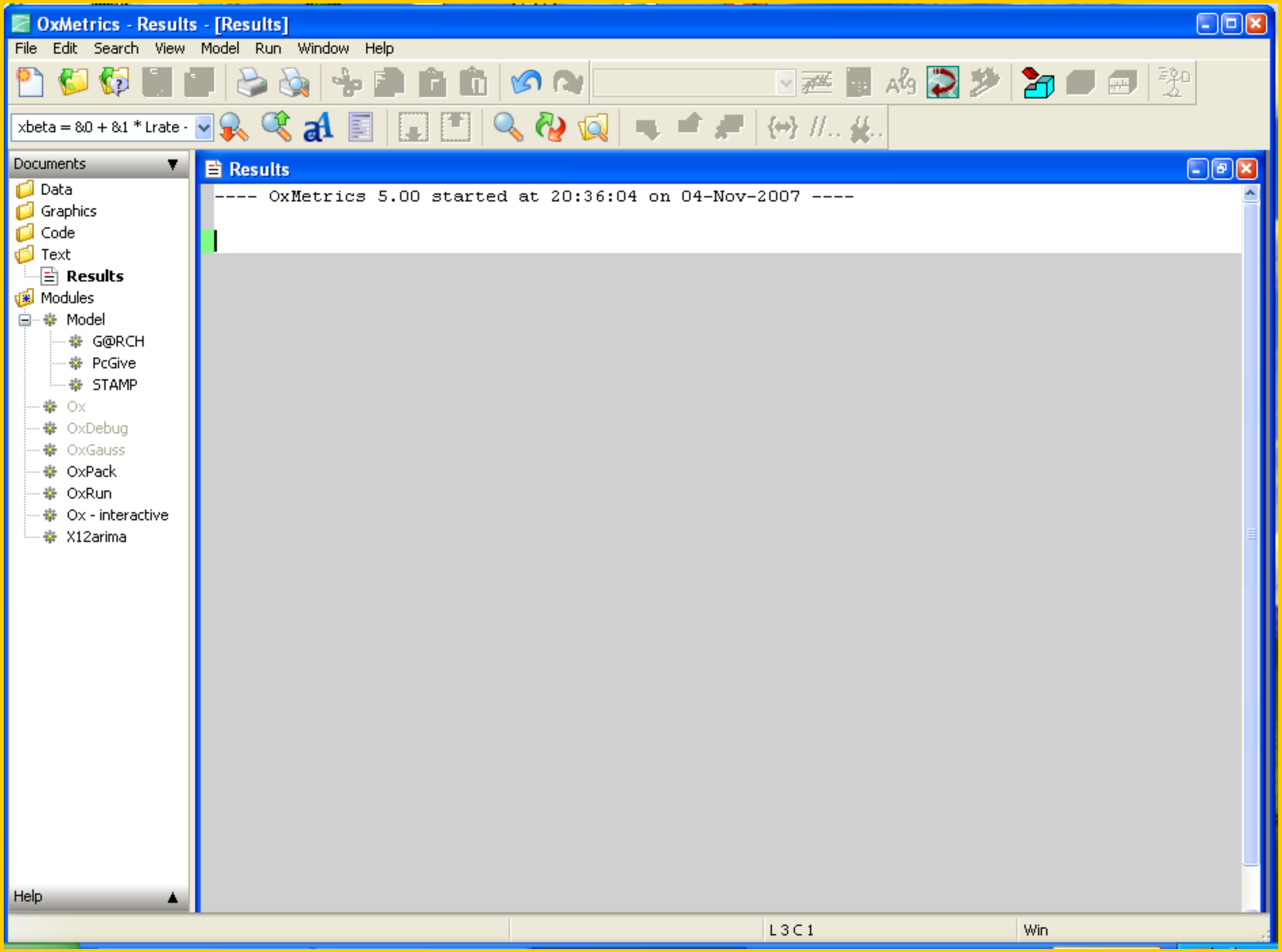
G@RCH Advances

- 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 G@RCH
  - 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

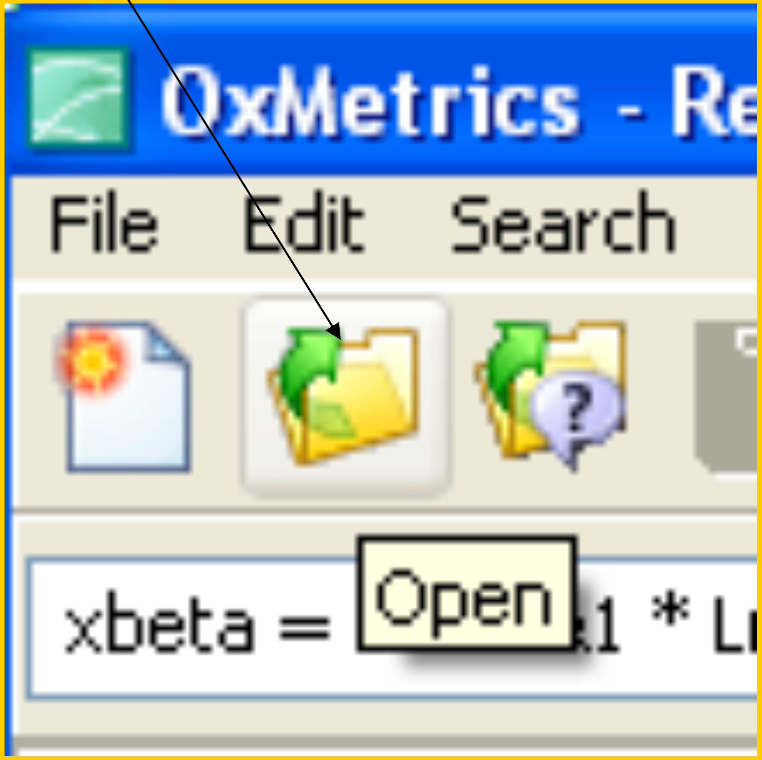
	A	B
1	Date	SP500
2	1/2/1990	359.69
3	1/3/1990	358.76
4	1/4/1990	355.67
5	1/5/1990	352.2
6	1/8/1990	353.79
7	1/9/1990	349.62
8	1/10/1990	347.31
9	1/11/1990	348.53
10	1/12/1990	339.93
11	1/15/1990	337
12	1/16/1990	340.75
13	1/17/1990	337.4
14	1/18/1990	338.19
15	1/19/1990	339.15
16	1/22/1990	330.38
17	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

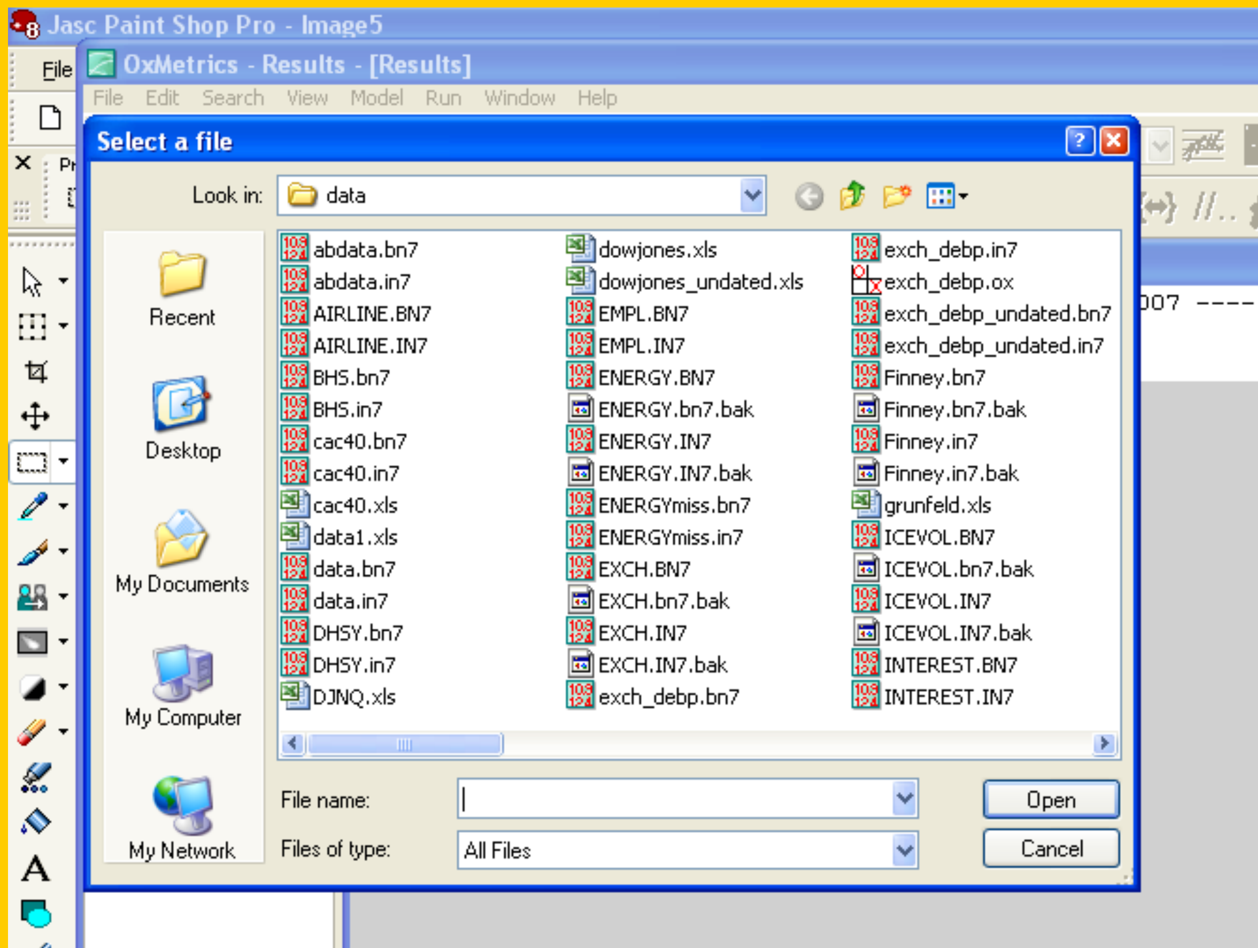
- This file should be saved in the data directory within OxMetrics5.
- OxMetrics is usually stored in the
- C:\program files\OxMetrics5 directory

Click on the open file folder icon

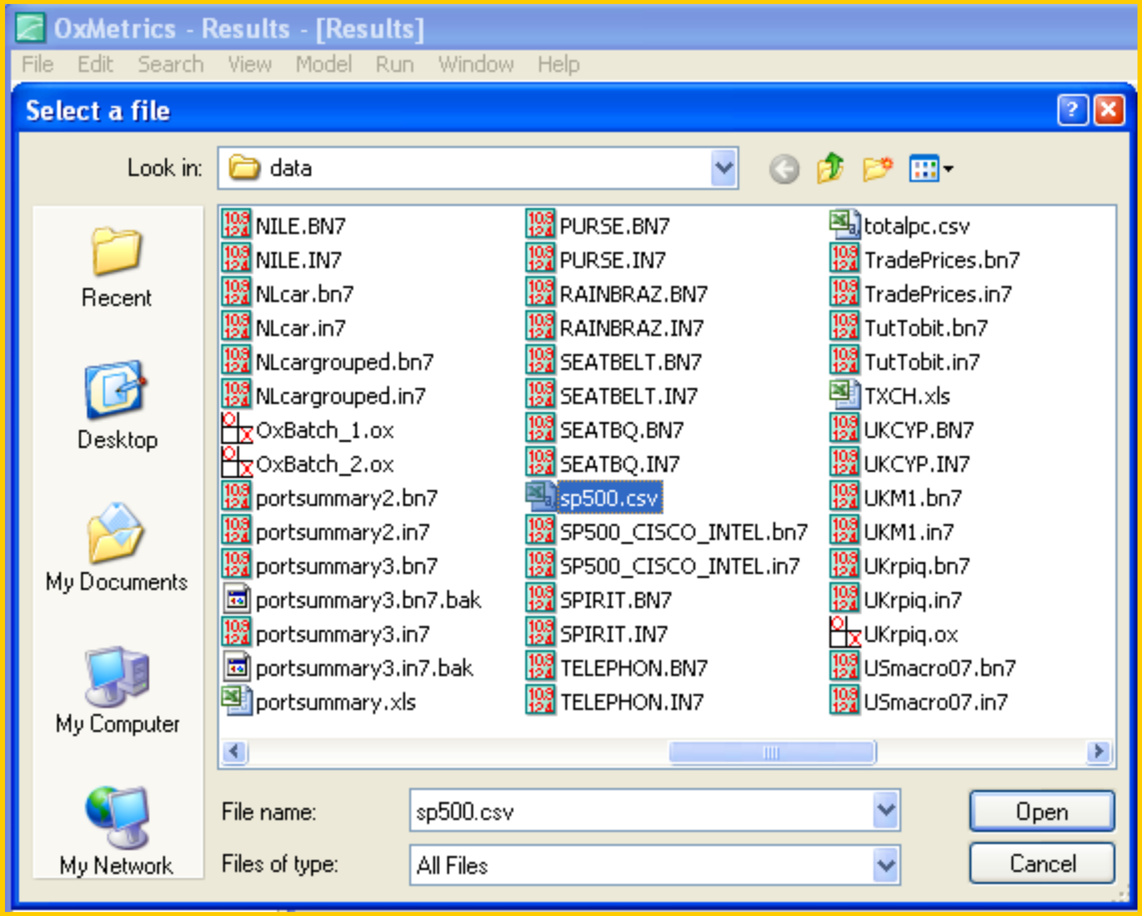
- We click on the open file folder icon in the upper left navigation window



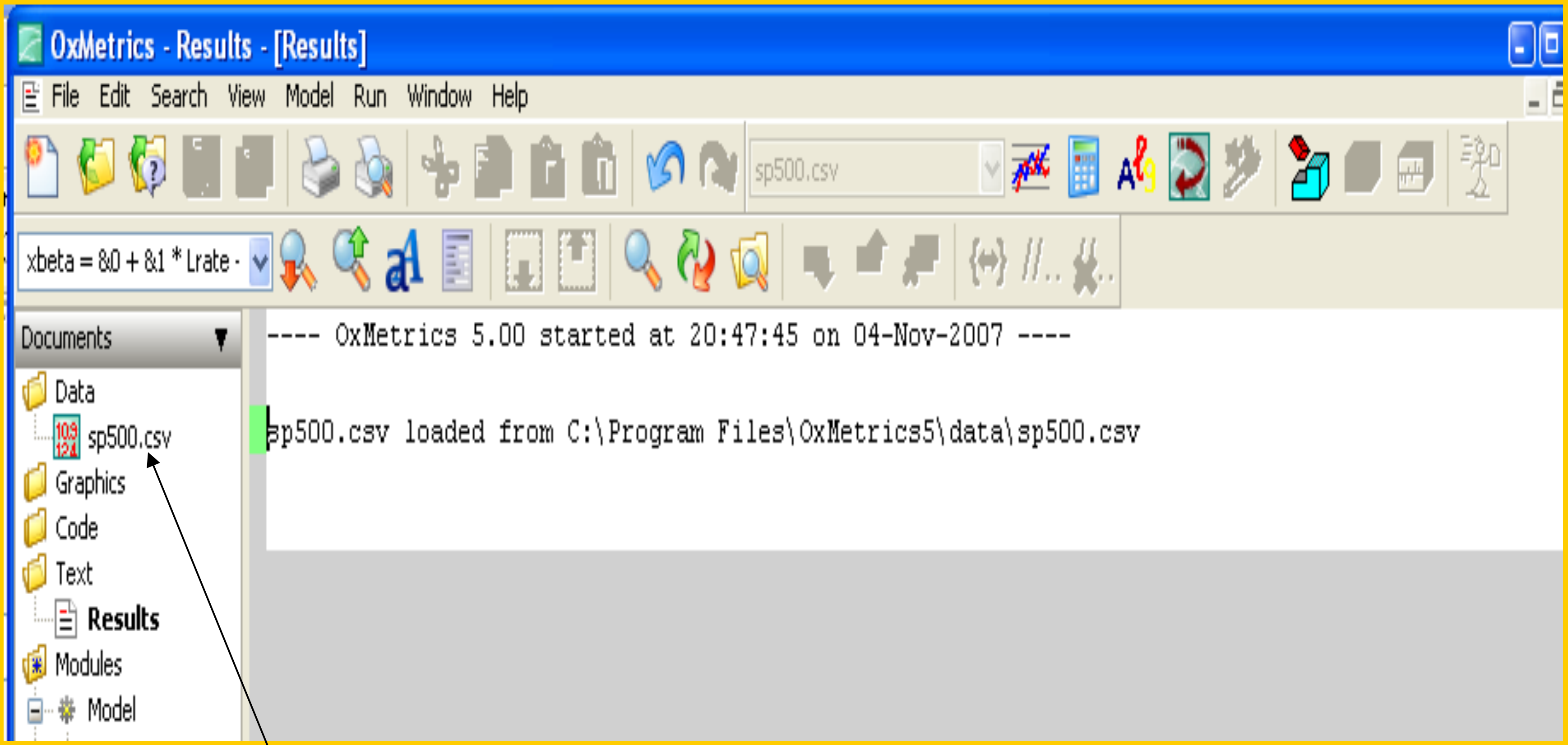
Find the excel file you saved in the data directory



Double click on the file

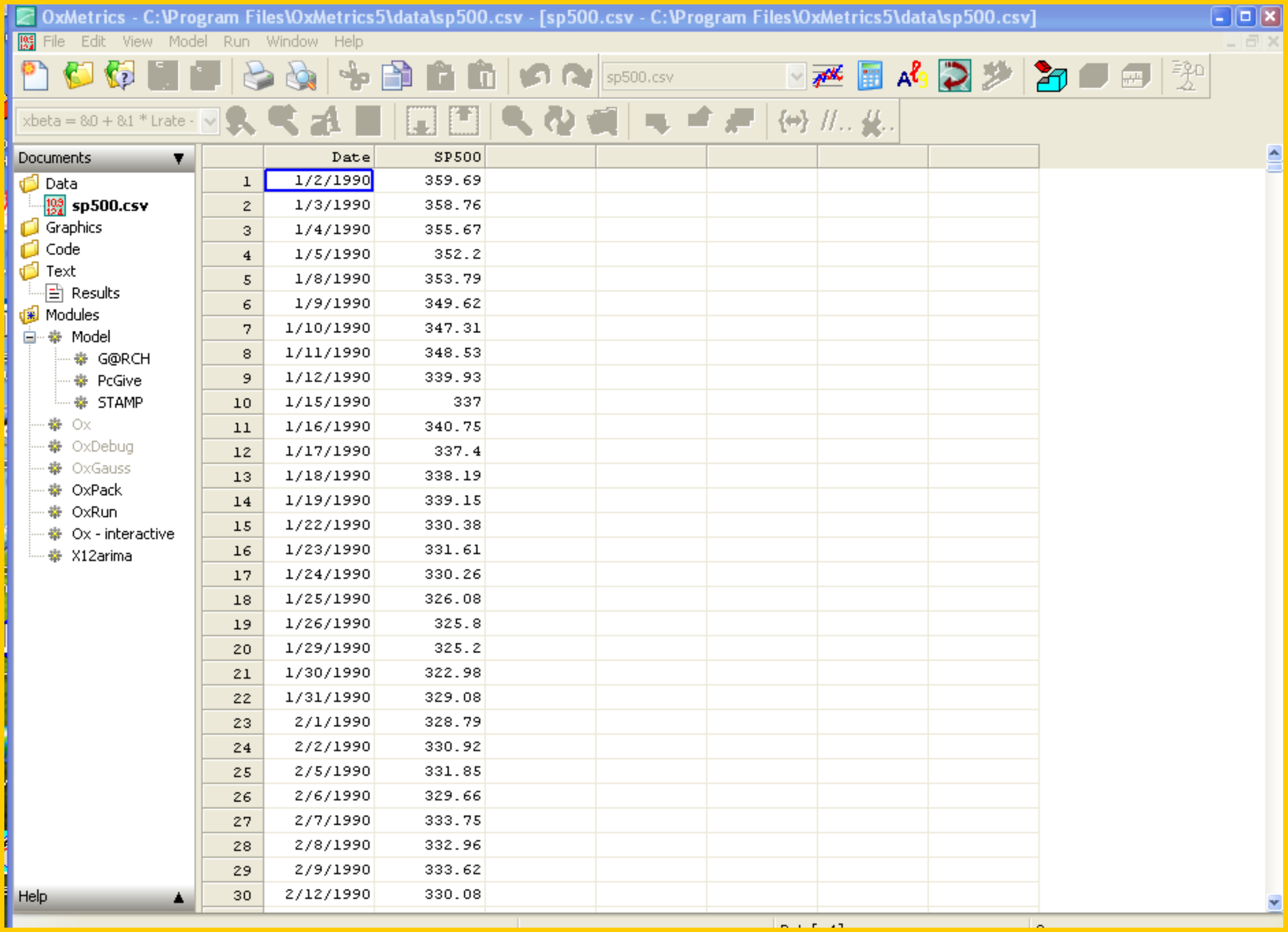


This loads the file



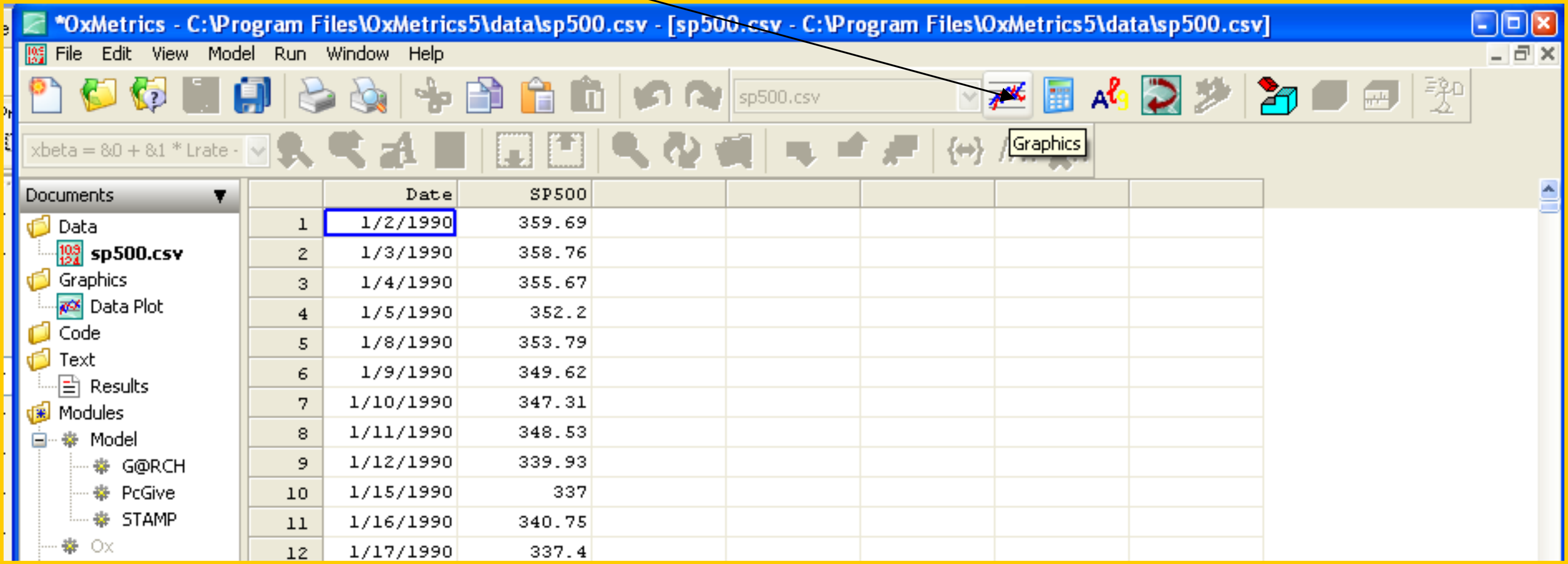
Double click on the file icon to open the loaded file

Once the file is open it appears as follows:

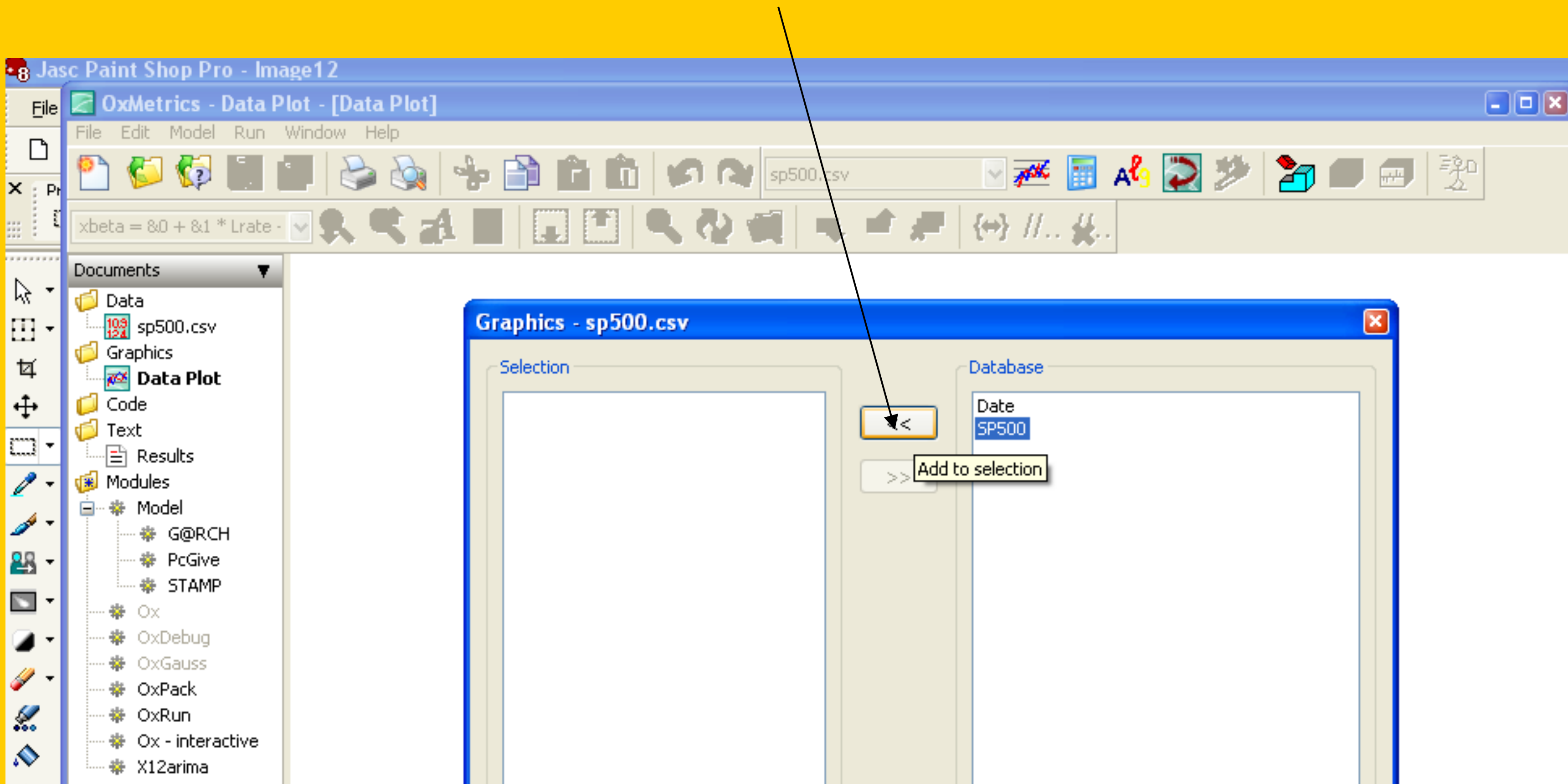


Graphical Preview

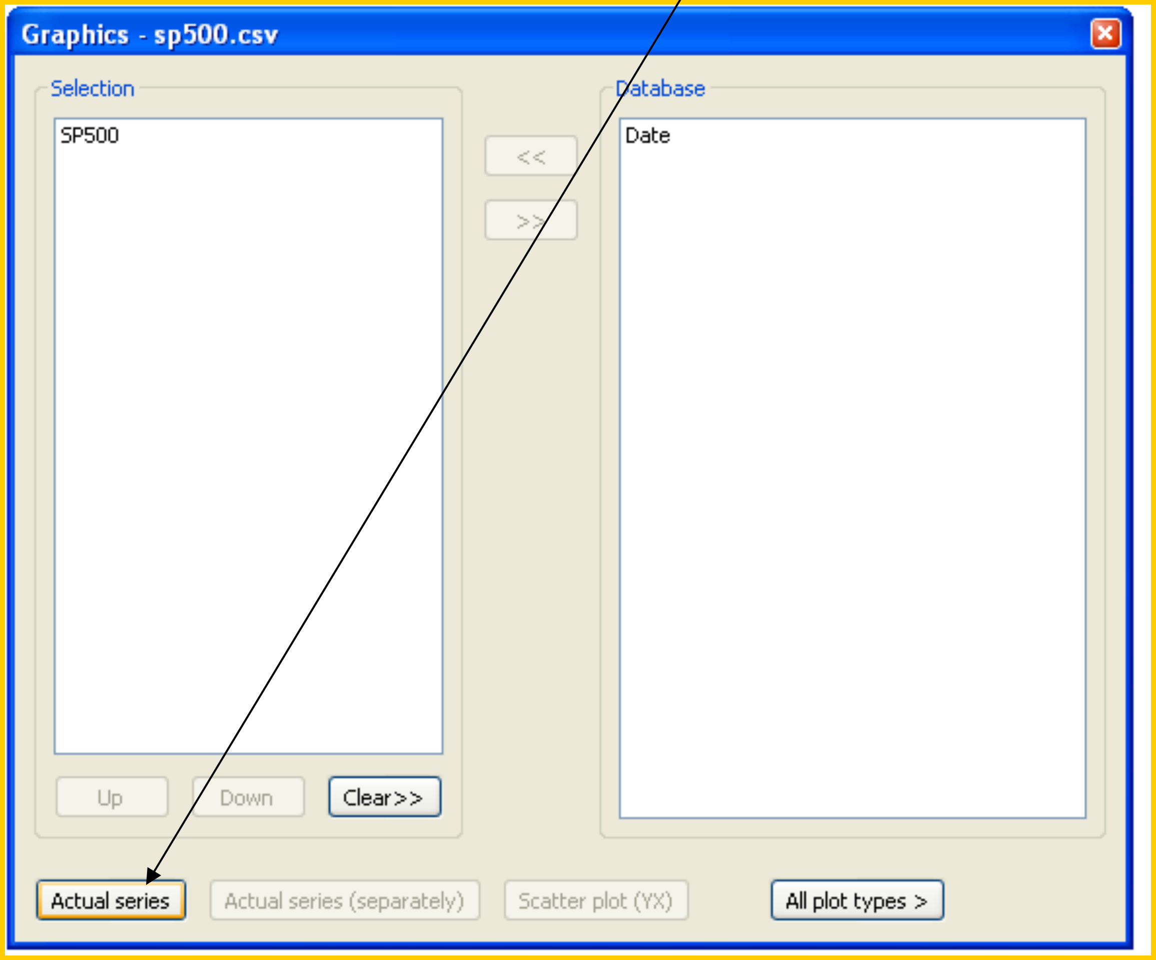
Click on the graphics icon



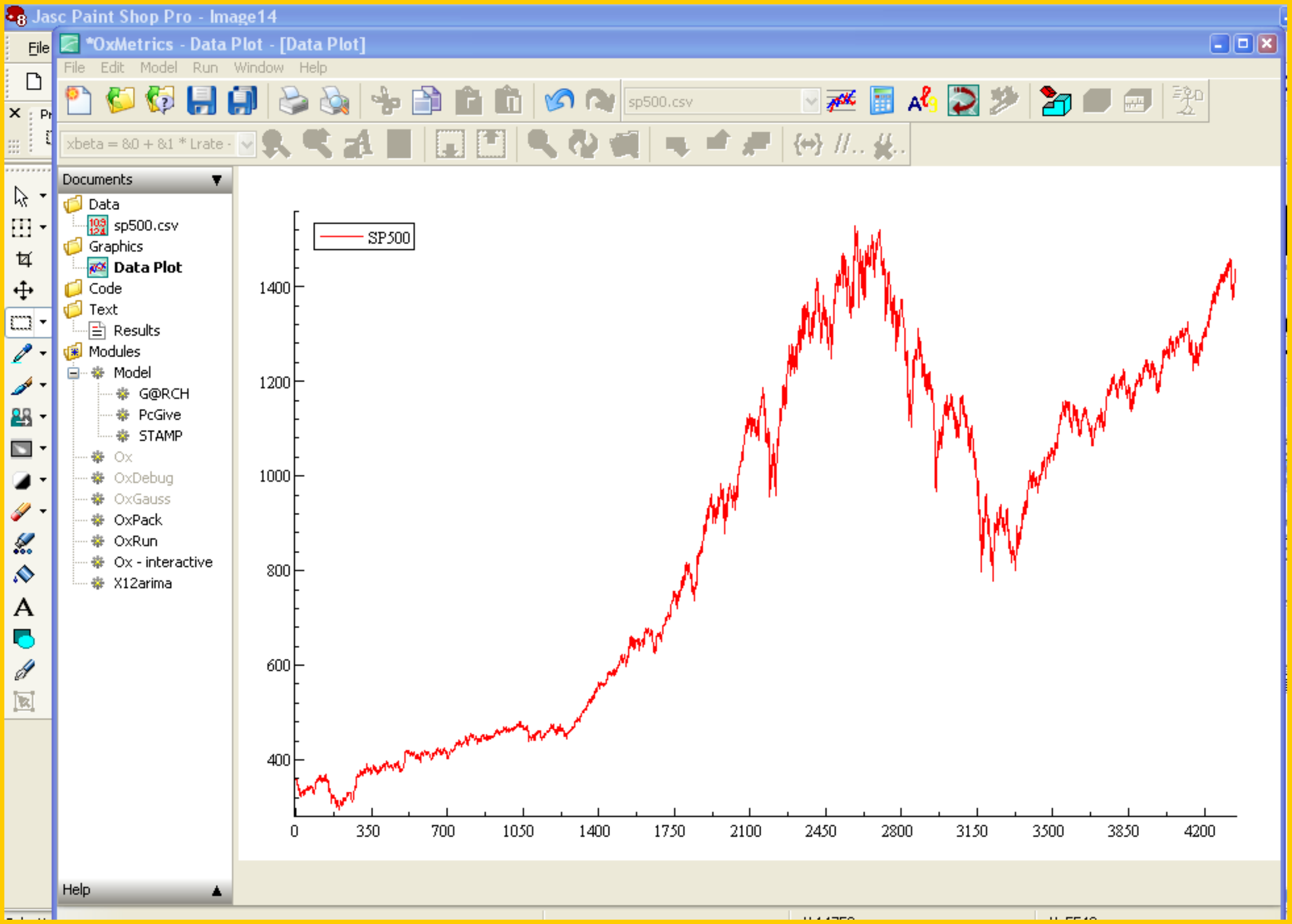
This opens a graphics dialog box
Select the series and move it into the graph window on the left by clicking on the arrow button



Click on the actual series button on the lower left



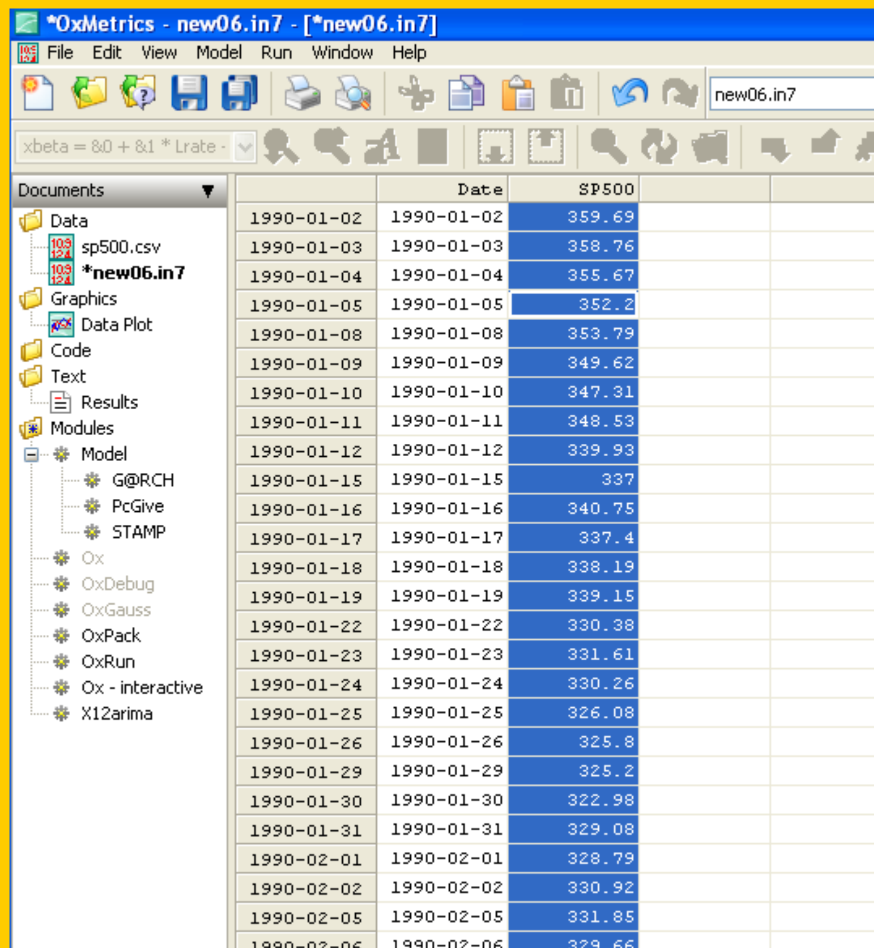
Generating a time series plot



Dates

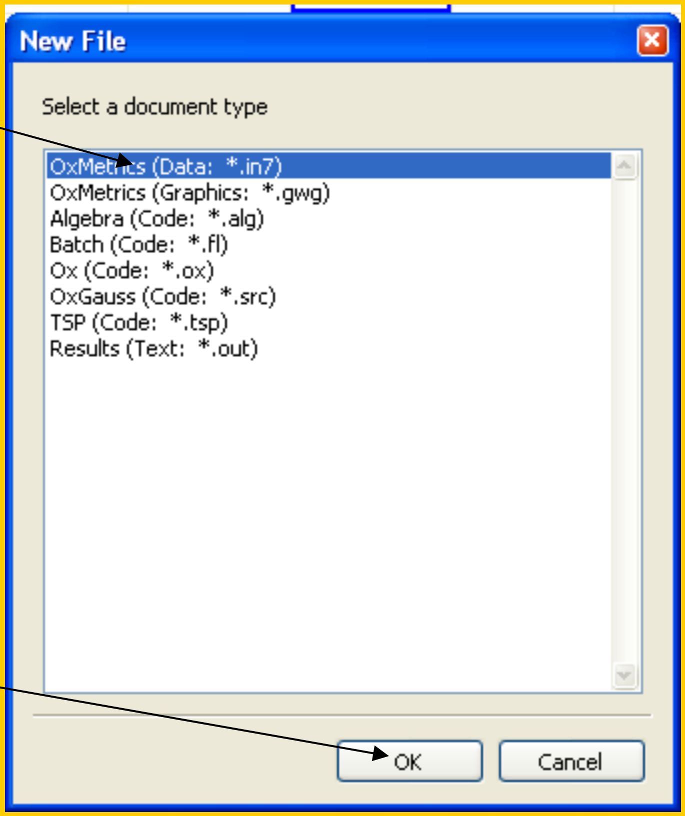
- The horizontal axis consists of observation numbers.
- To construct dates for those periods, we count the number of observations in the Excel file.
- There are 4342 observations beginning in January 2, 1990.
- We will import the data into a OxMetrics file.

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



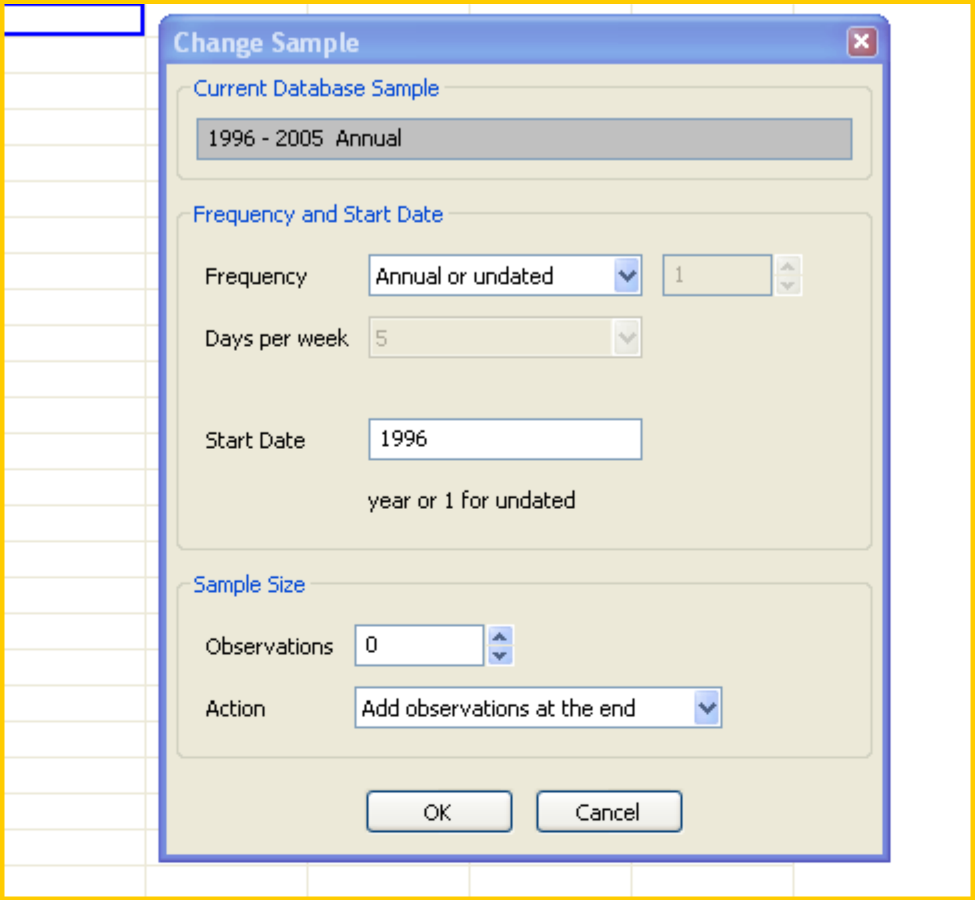
Construction of a dated Ox file

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

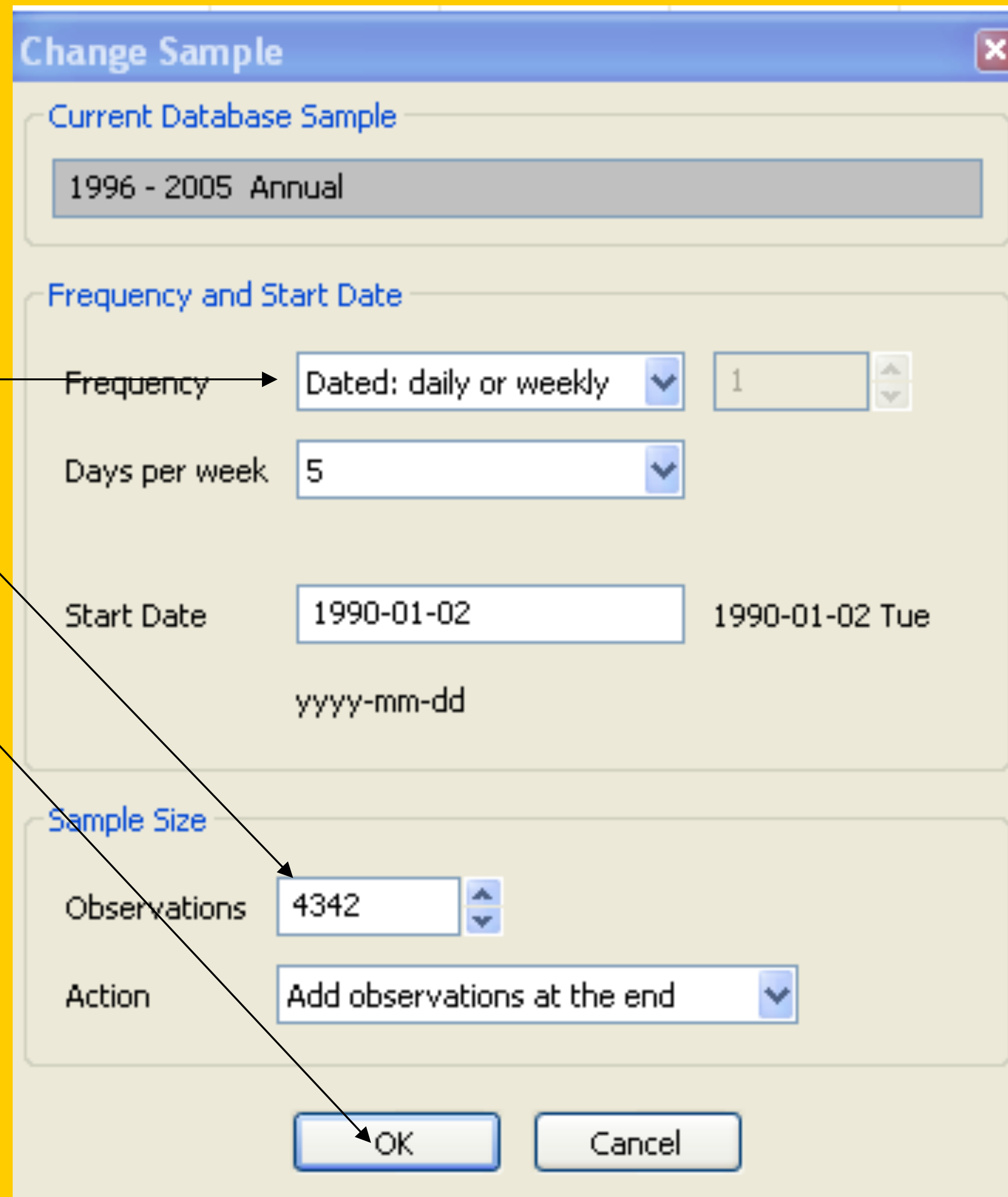


- Click on OK

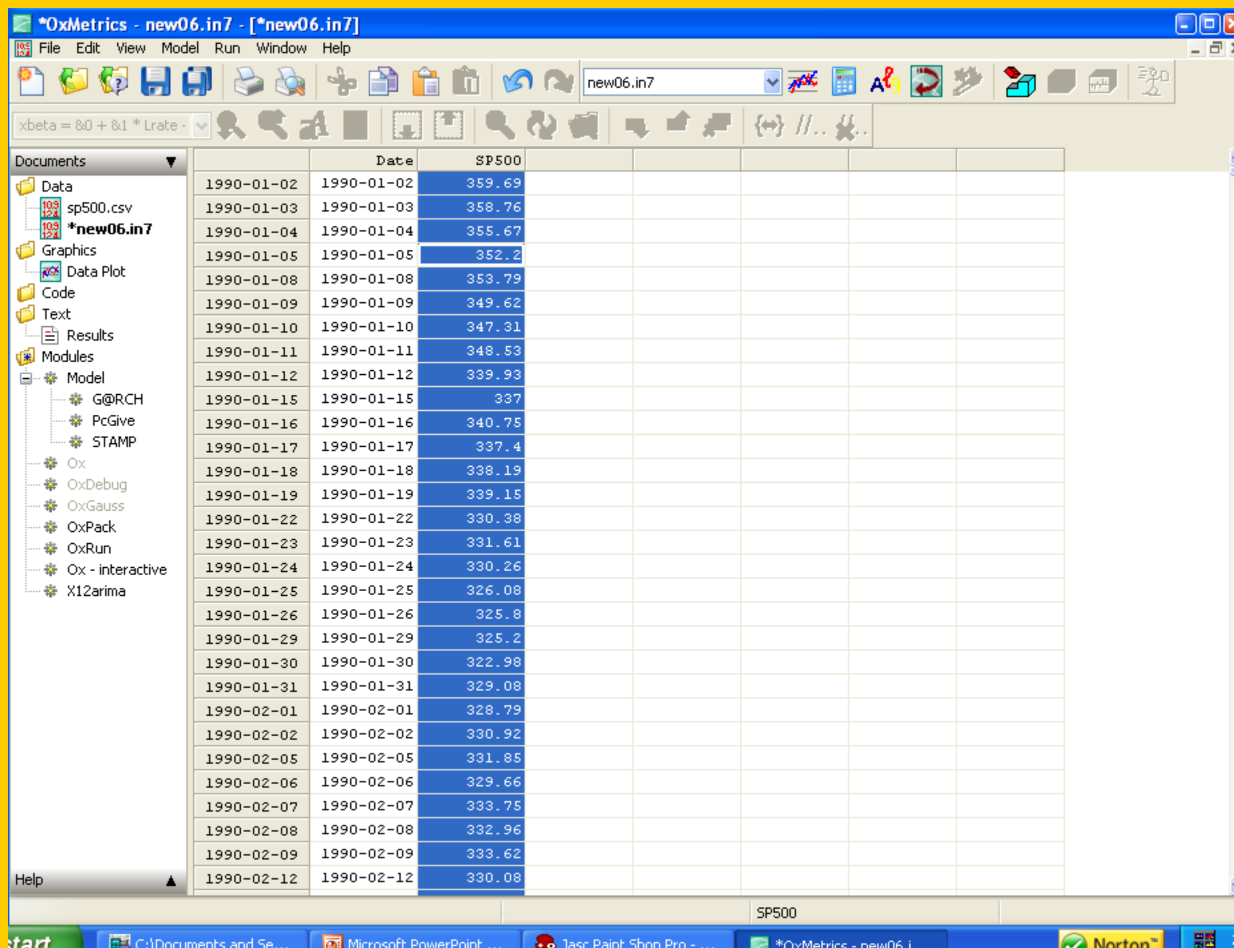
A Date dialogue box opens



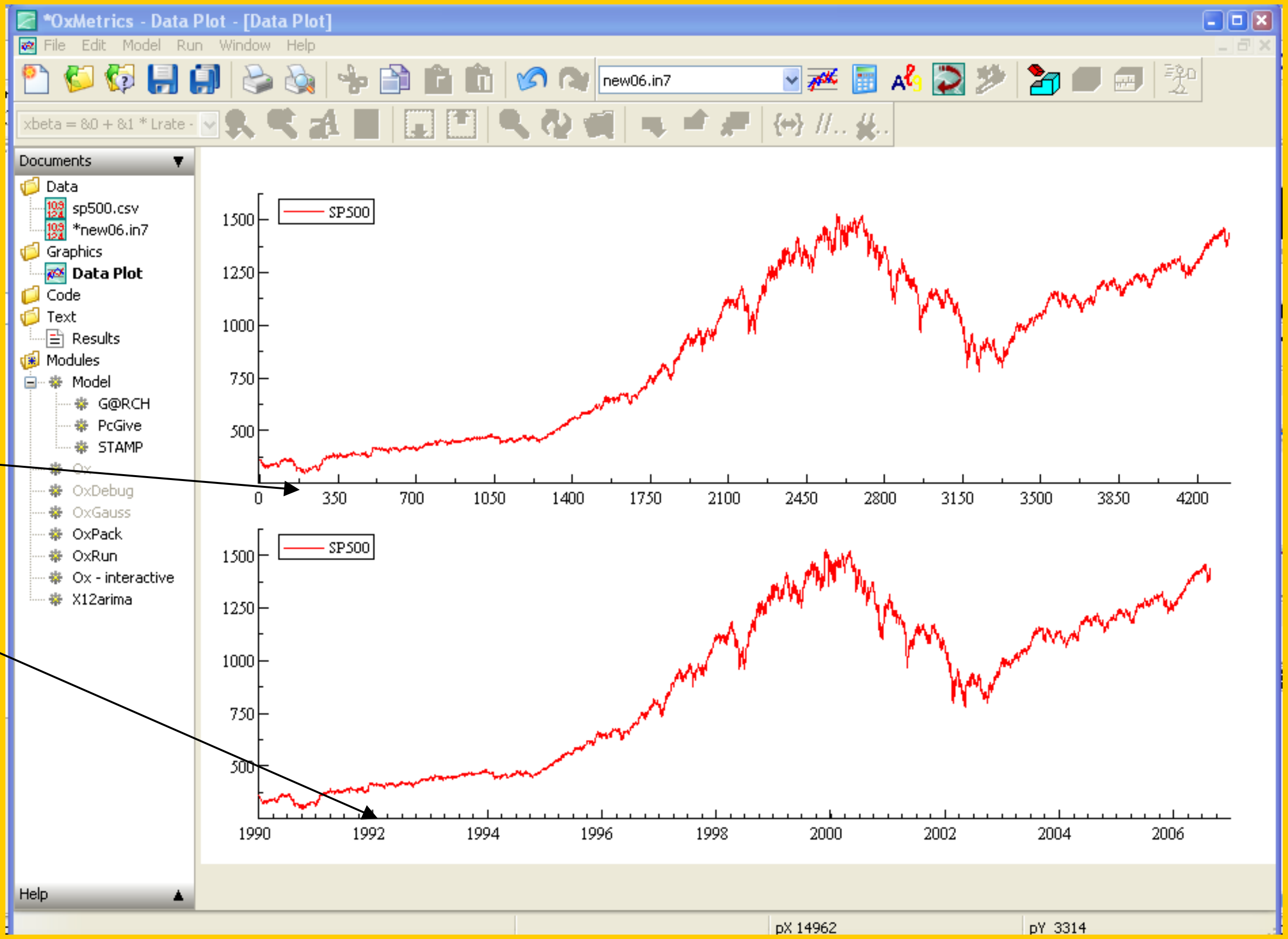
Select these options and indicate the sample size, then click OK



Paste the SP500 into the new data set



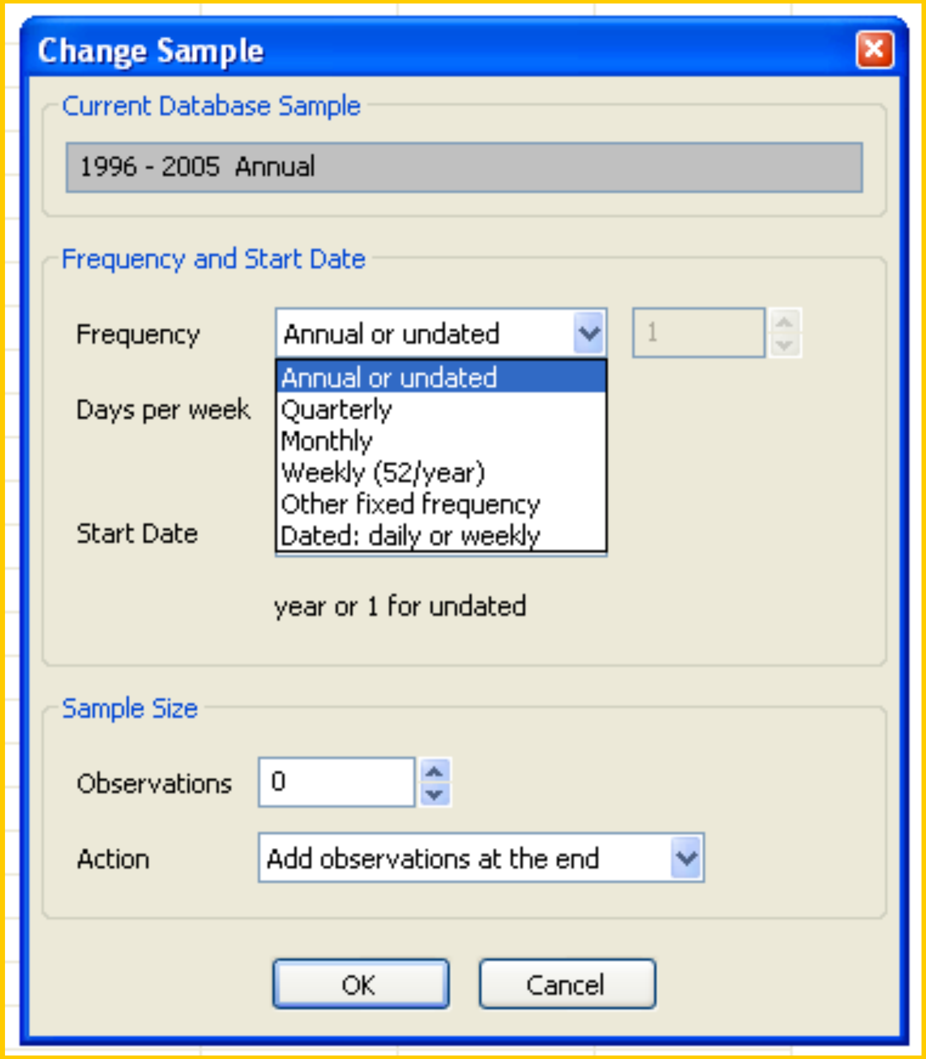
Now Graph the New Series and save the data set



Obs numbers

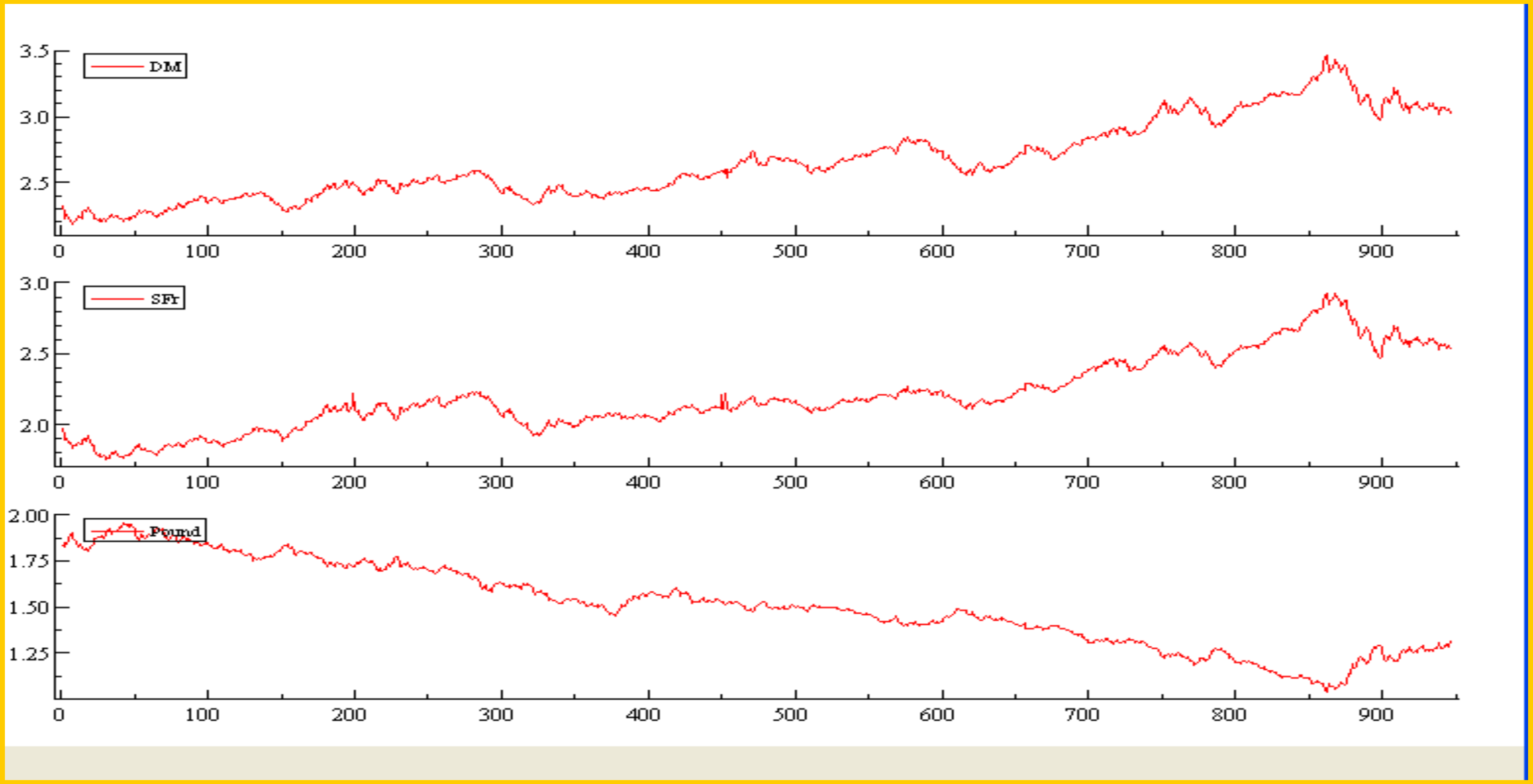
dates

Dates: frequencies/holidays

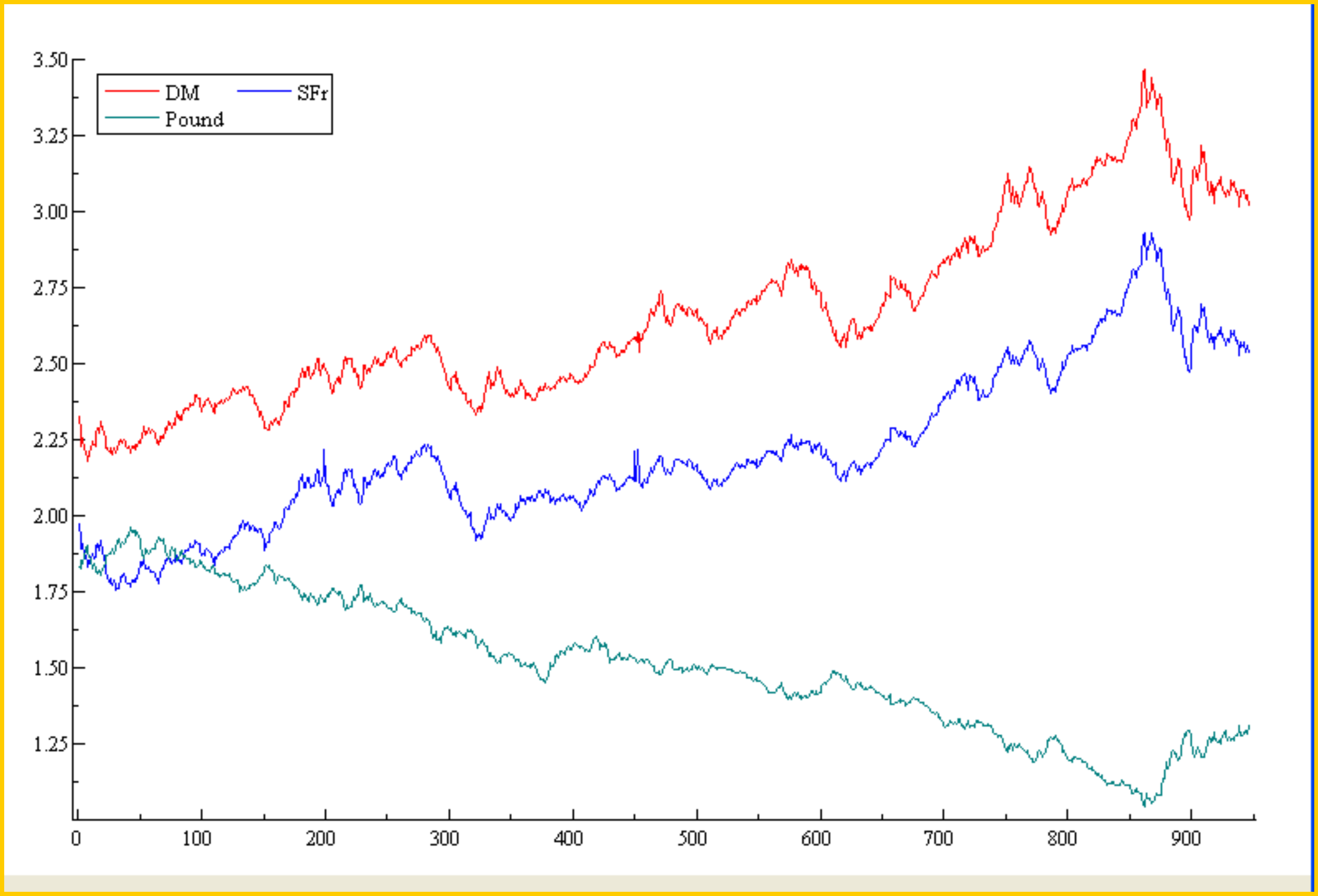


Other graphics

- Paneled time series plots

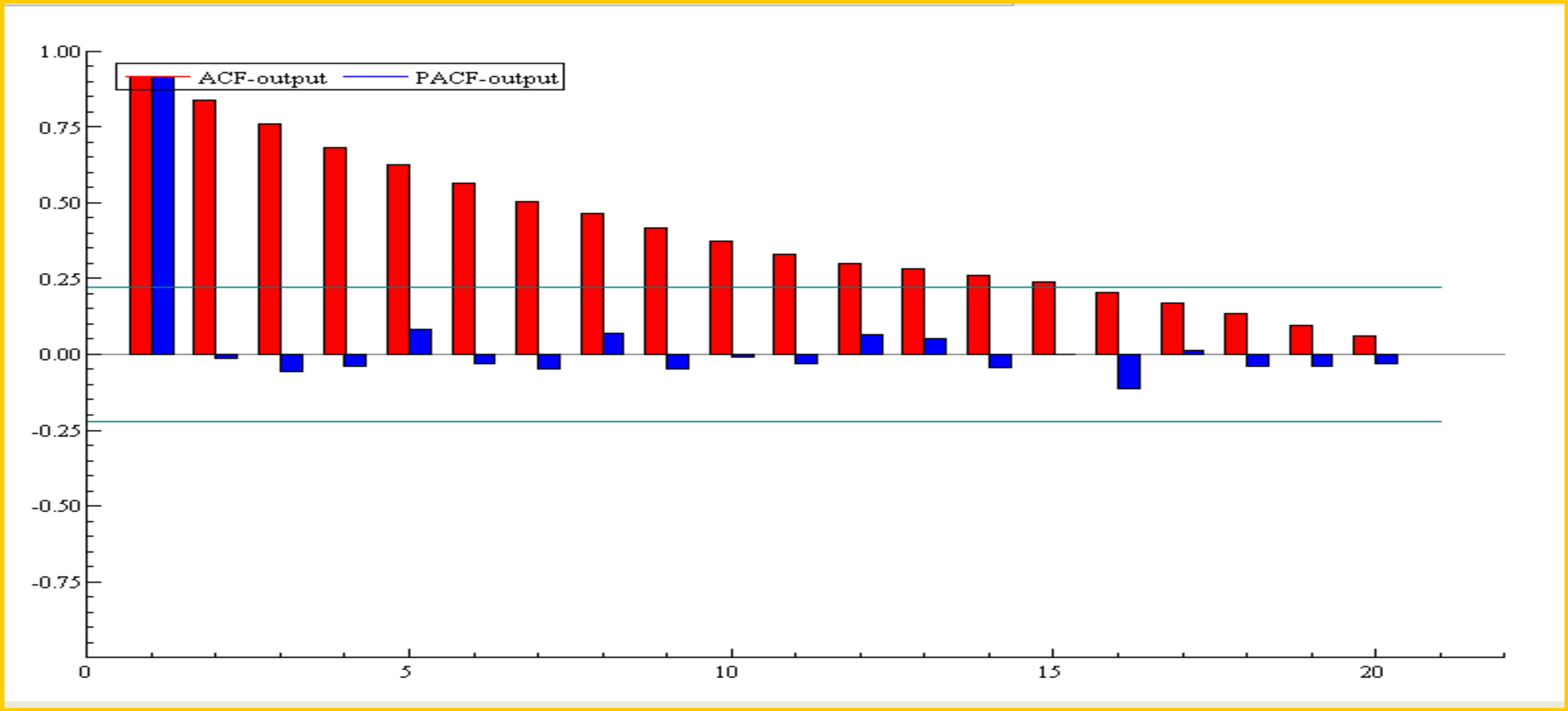


Overlaid Time Series Plots

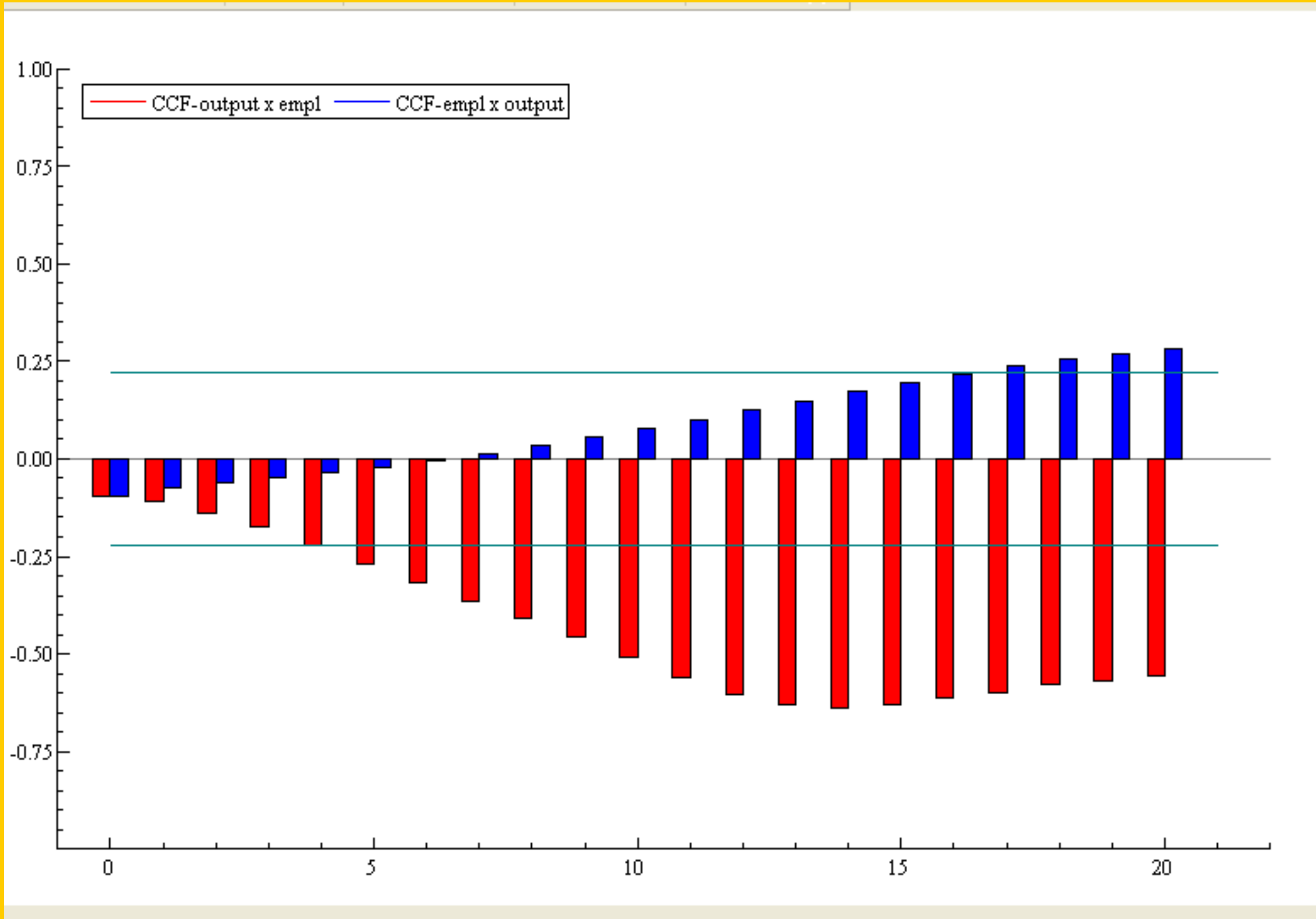


Time series Properties

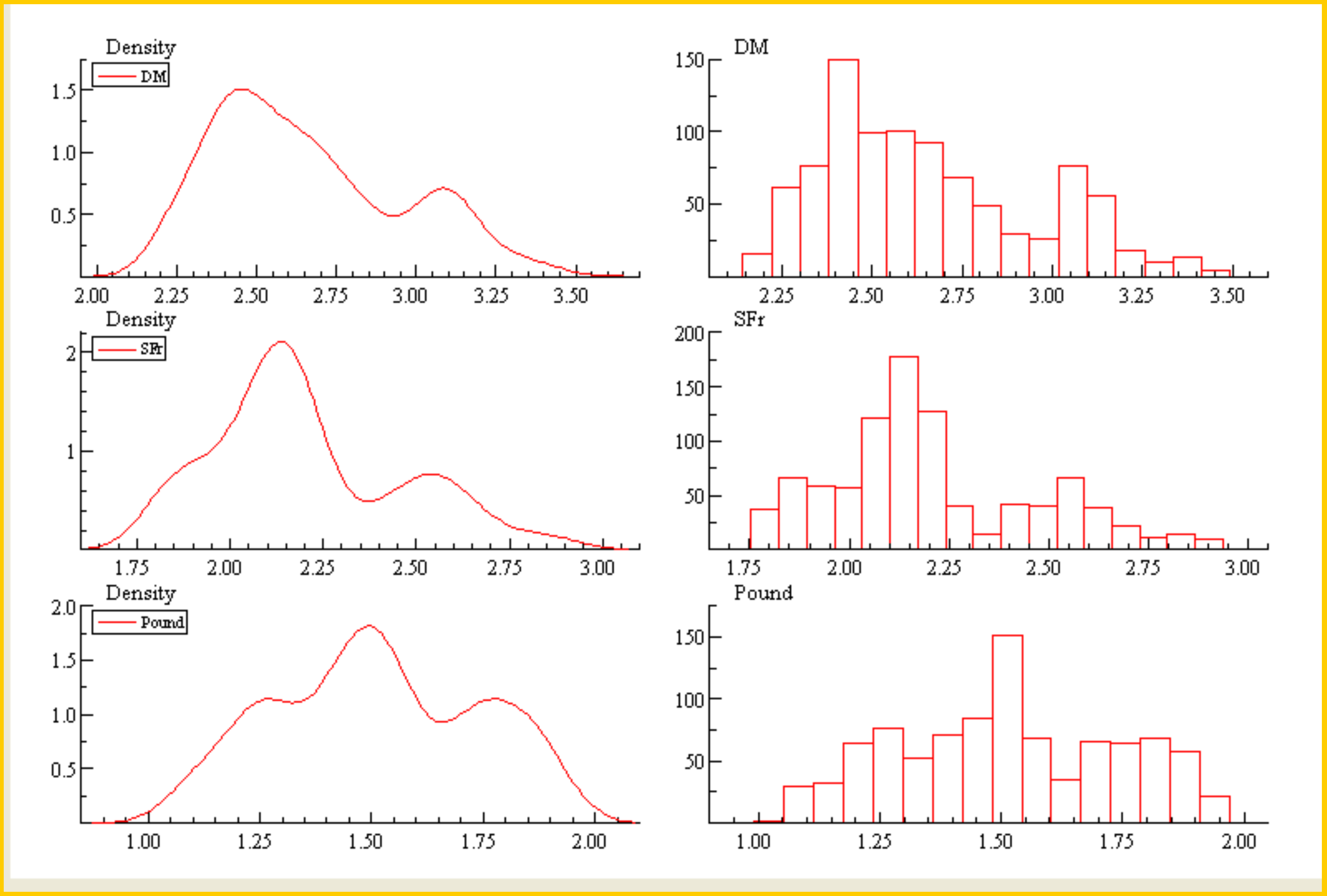
- ACF and PACF correlograms



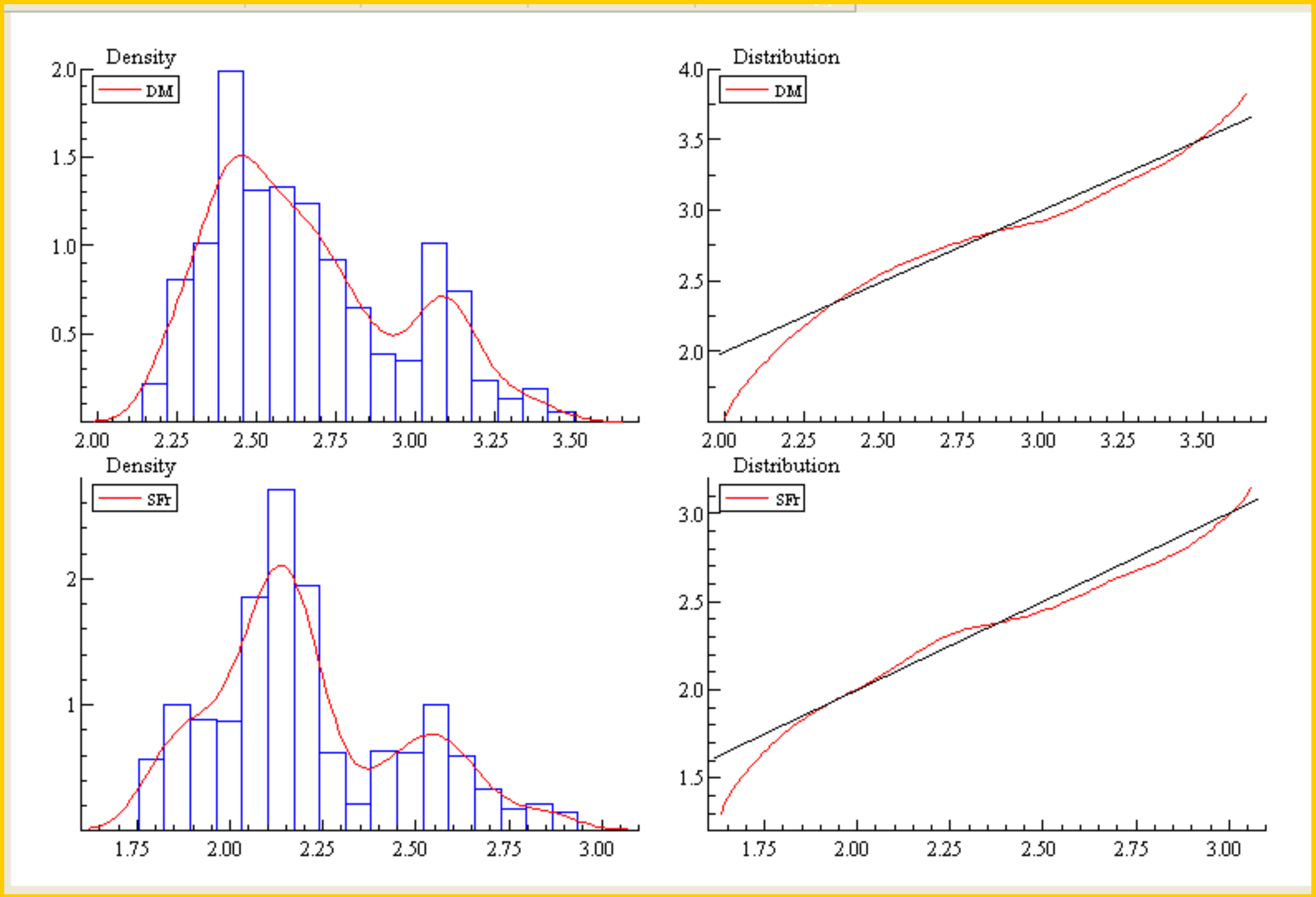
Cross Correlation Function



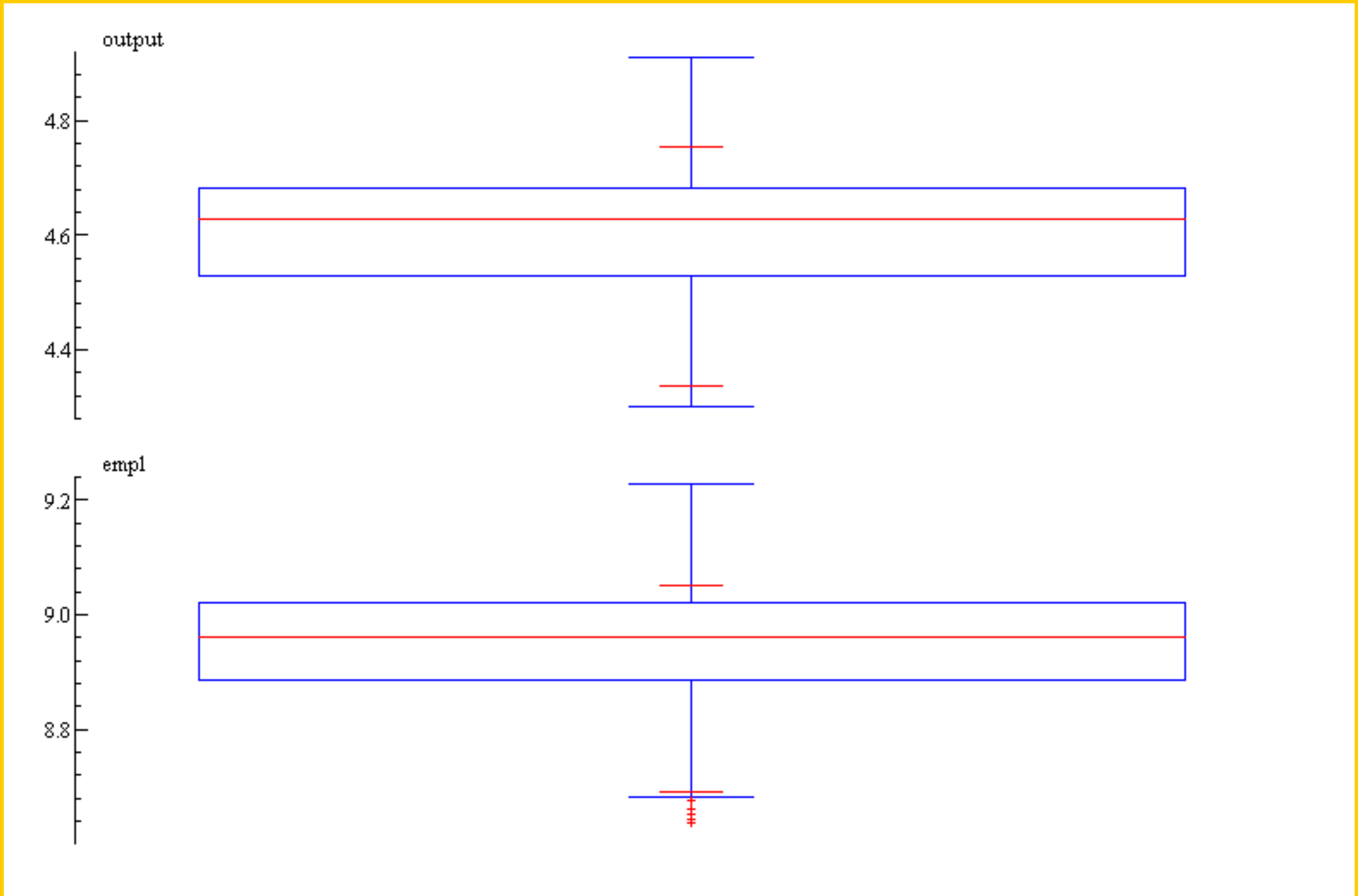
Distributional Plots



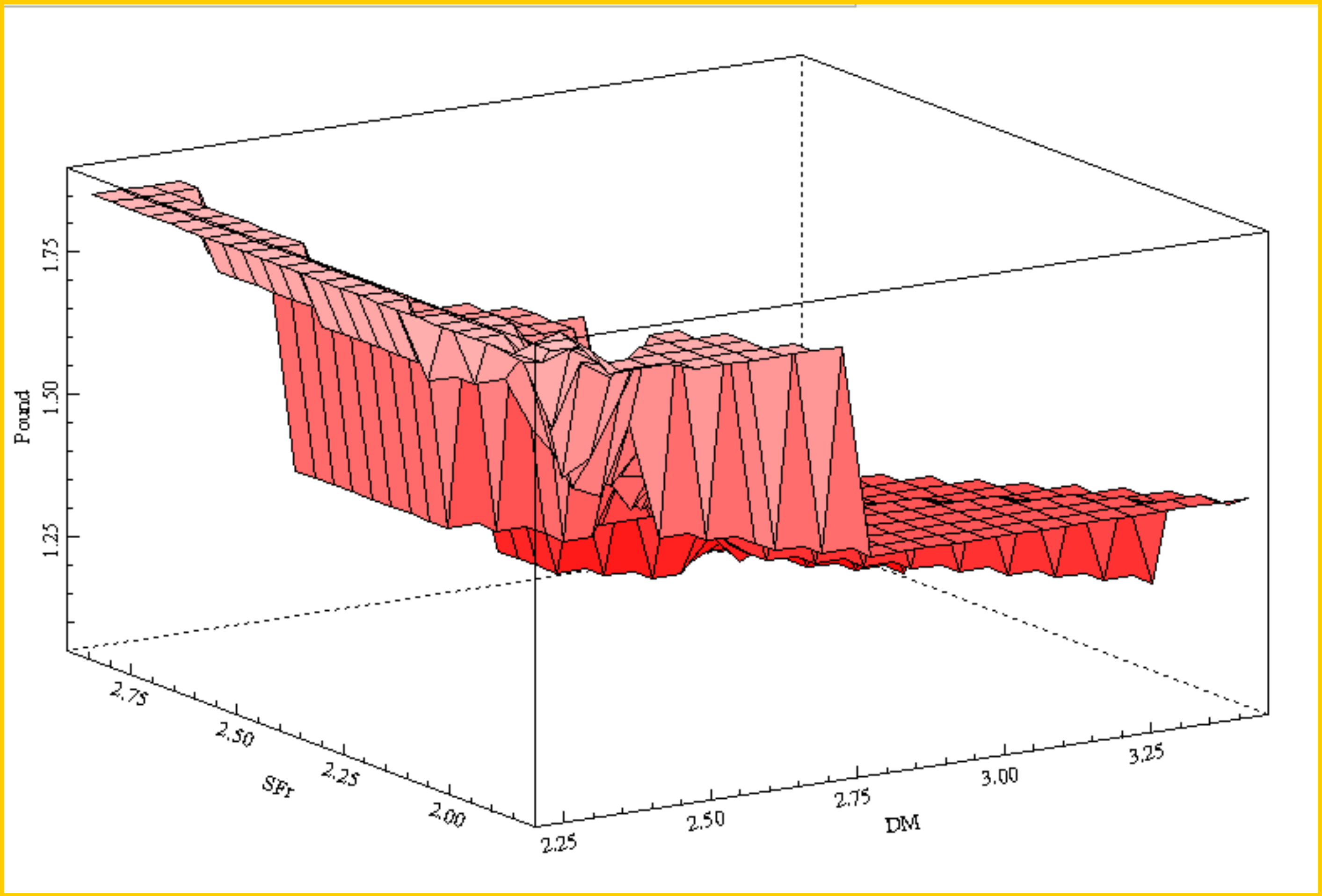
Distributional Kernal Density Plots and Normal Quantile plots



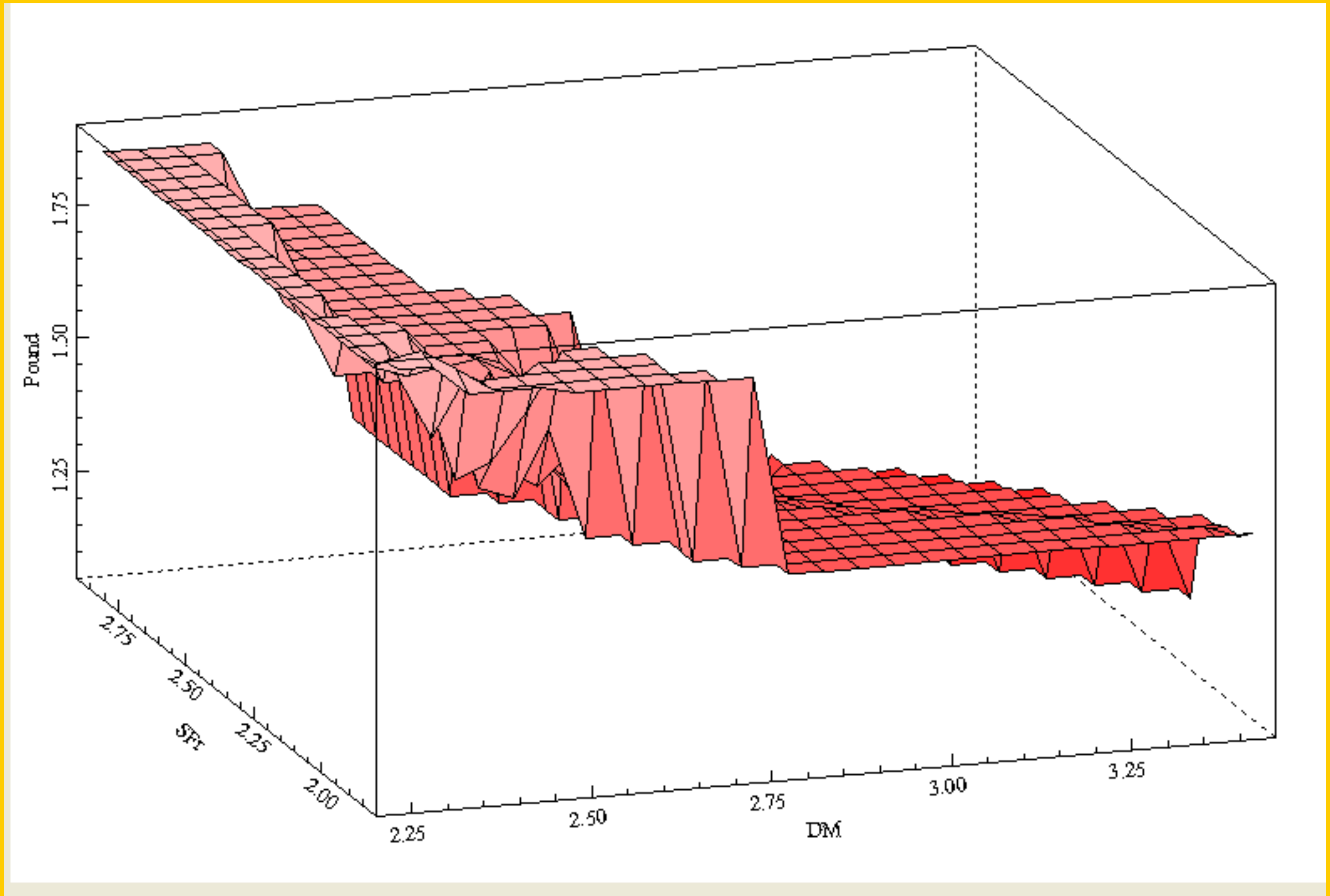
BoxPlots



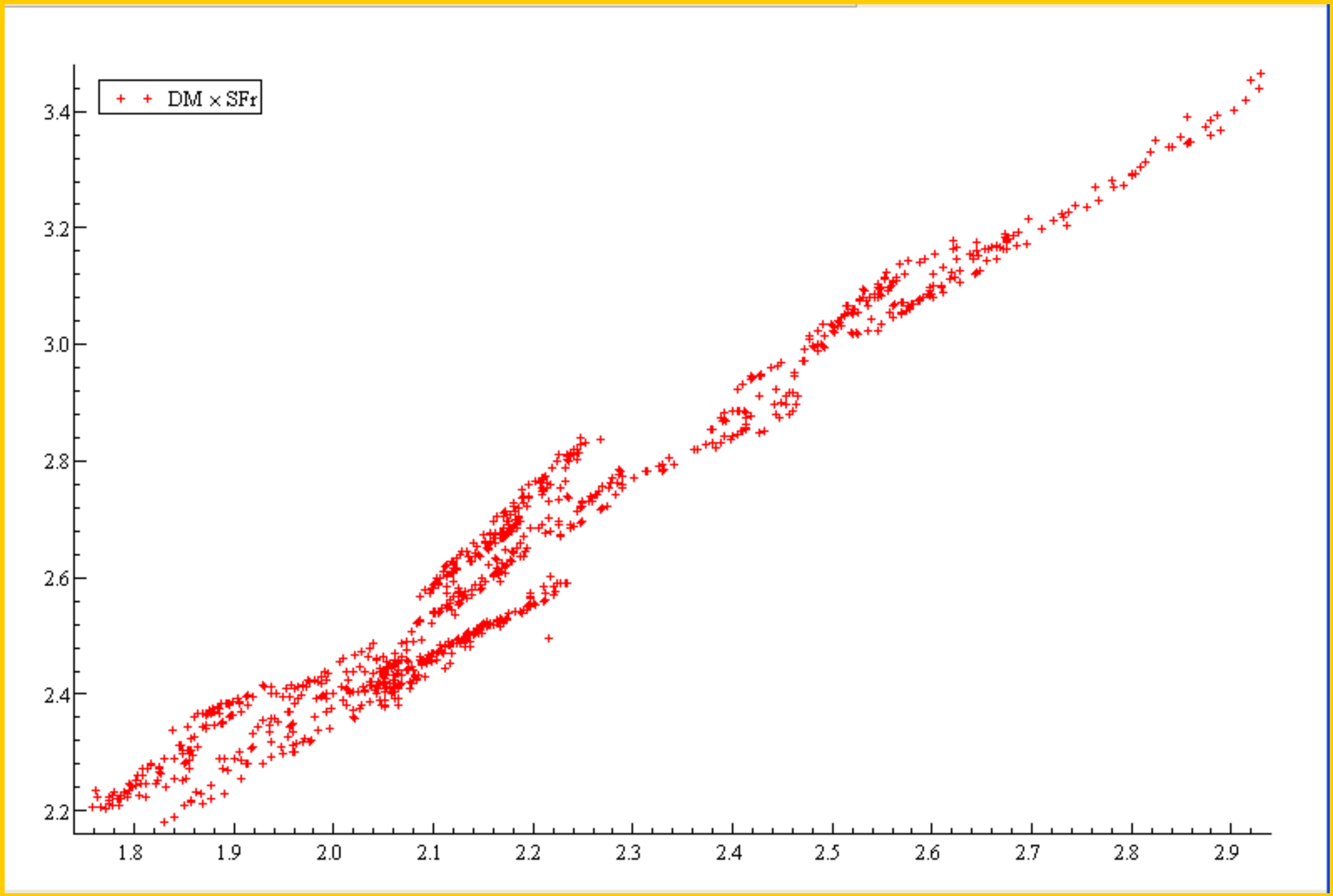
3-D rotating plots



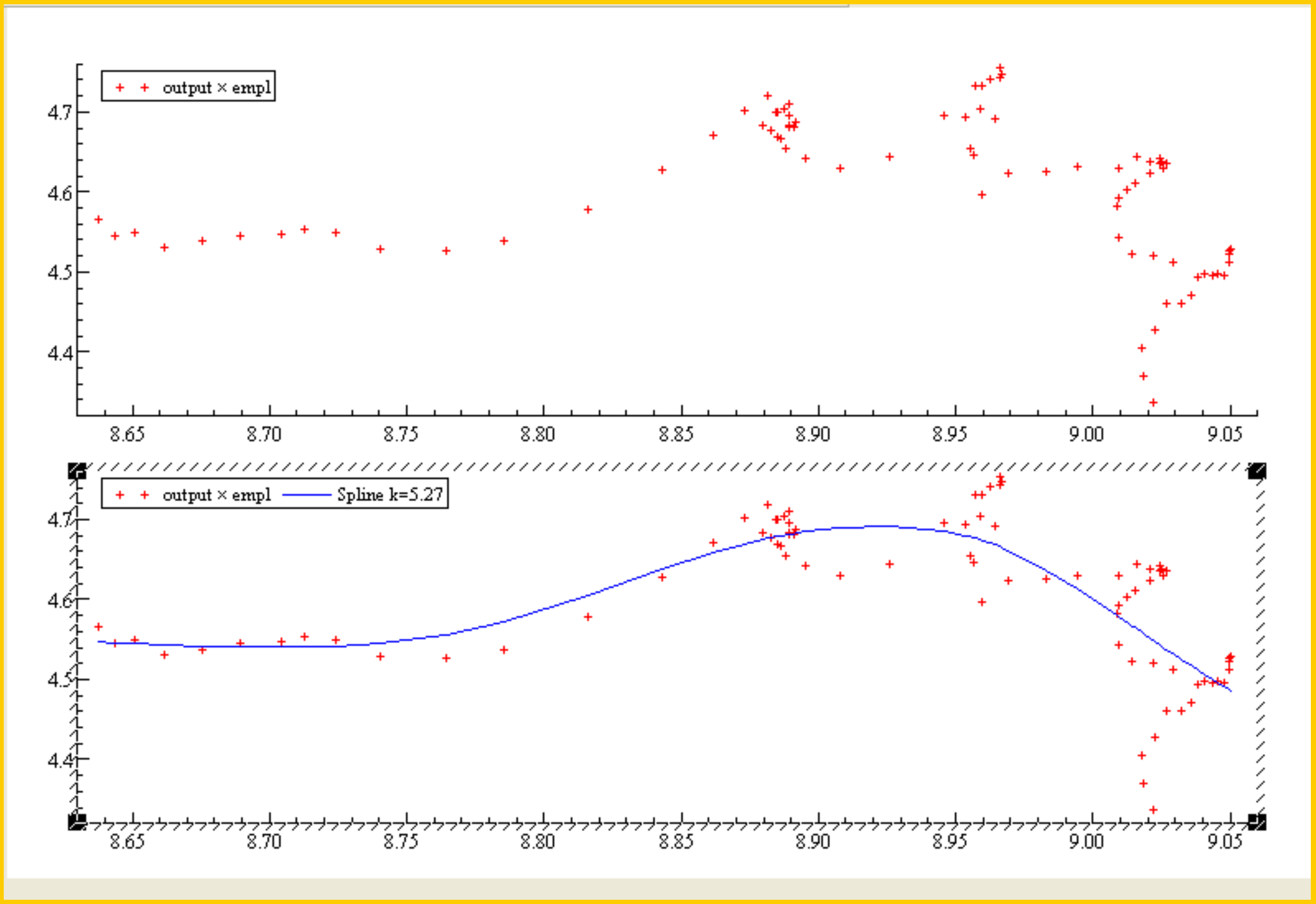
Rotated 3-D plot



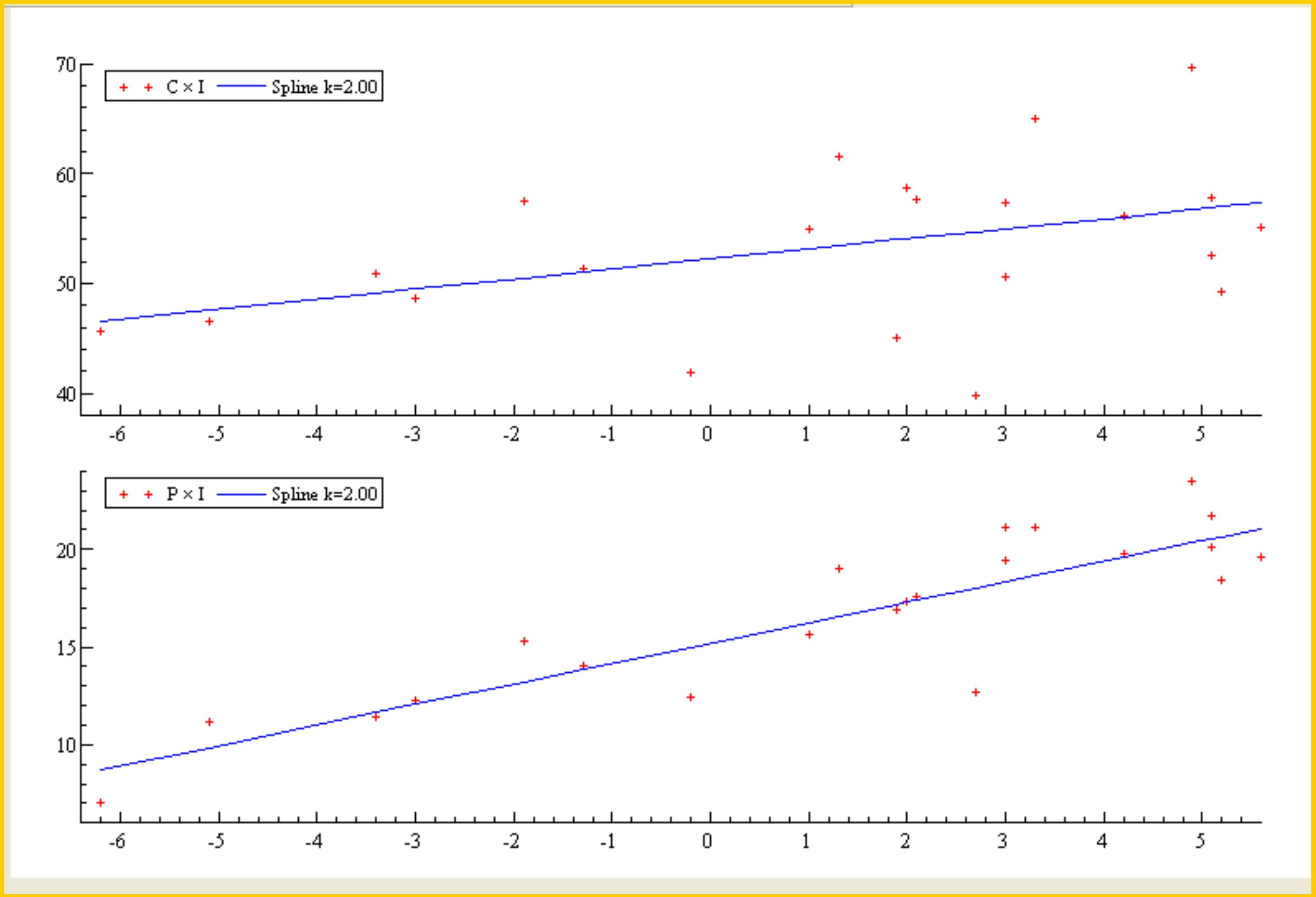
Scatterplots



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 multivariaate 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.

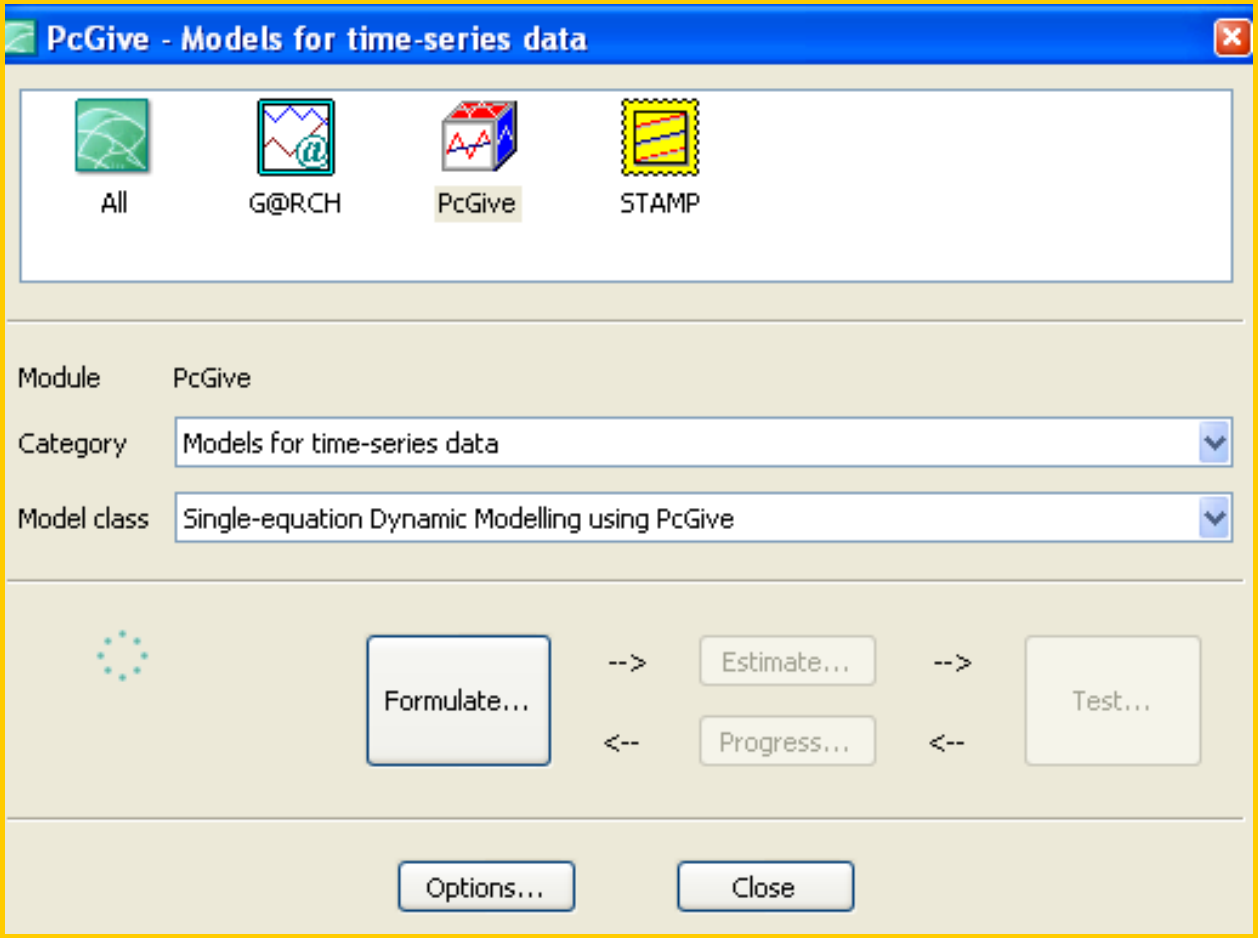
Example

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

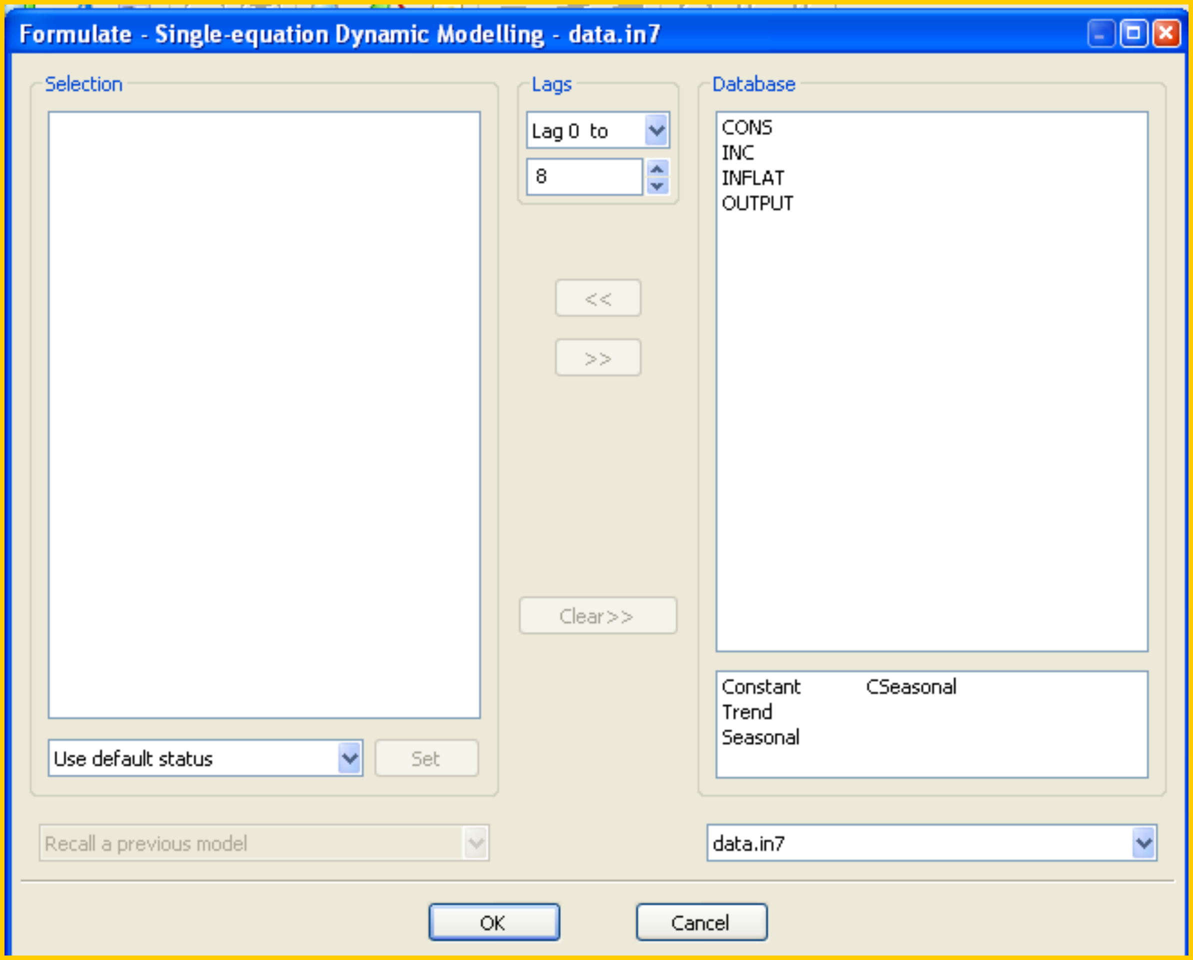
data.in7 - C:\Program Files\OxMetrics5\data\data.in7

	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



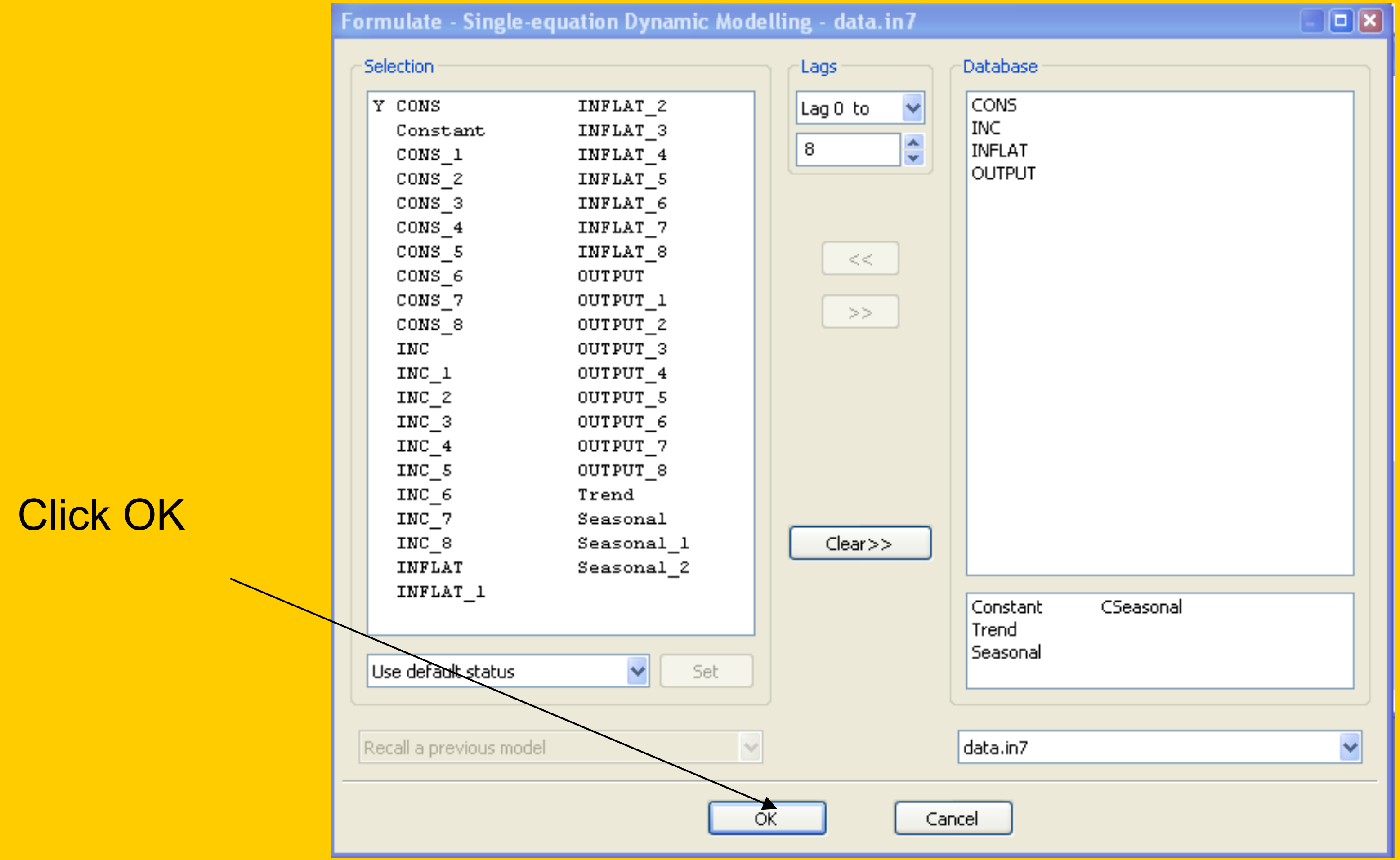
Select 2 years of data (8 lags)



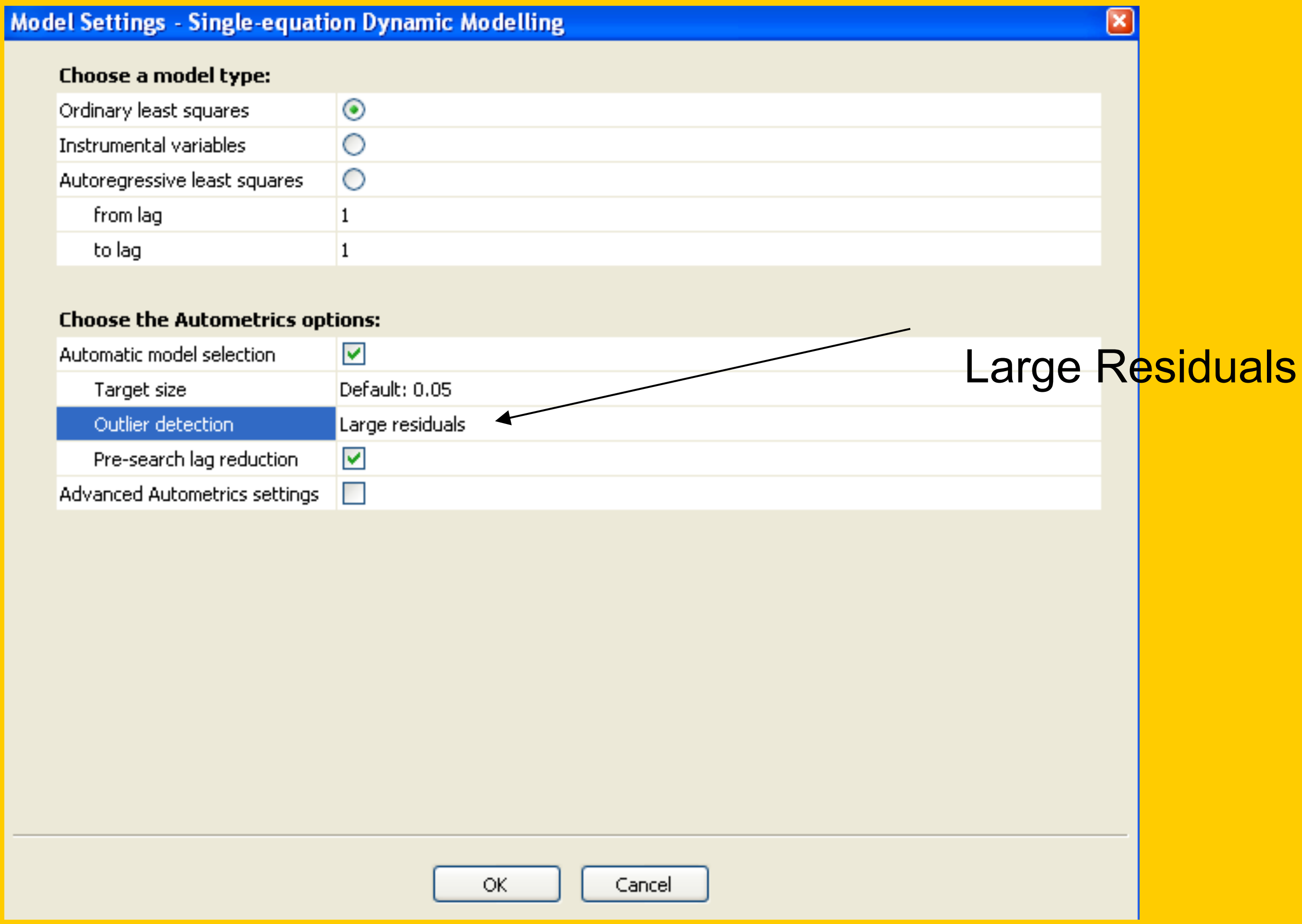
Modeling consumption

- 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

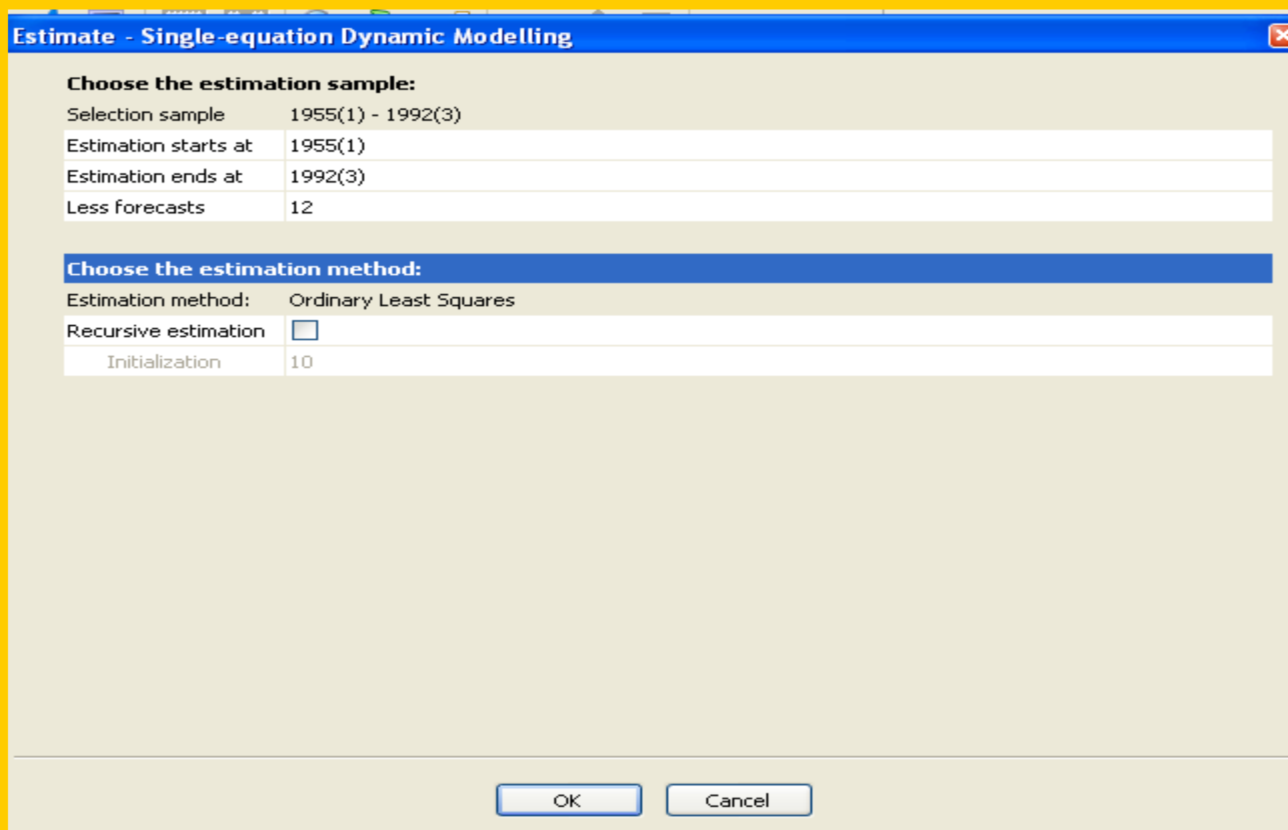


Model Setting

- 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



Autometrics yields an optimal model

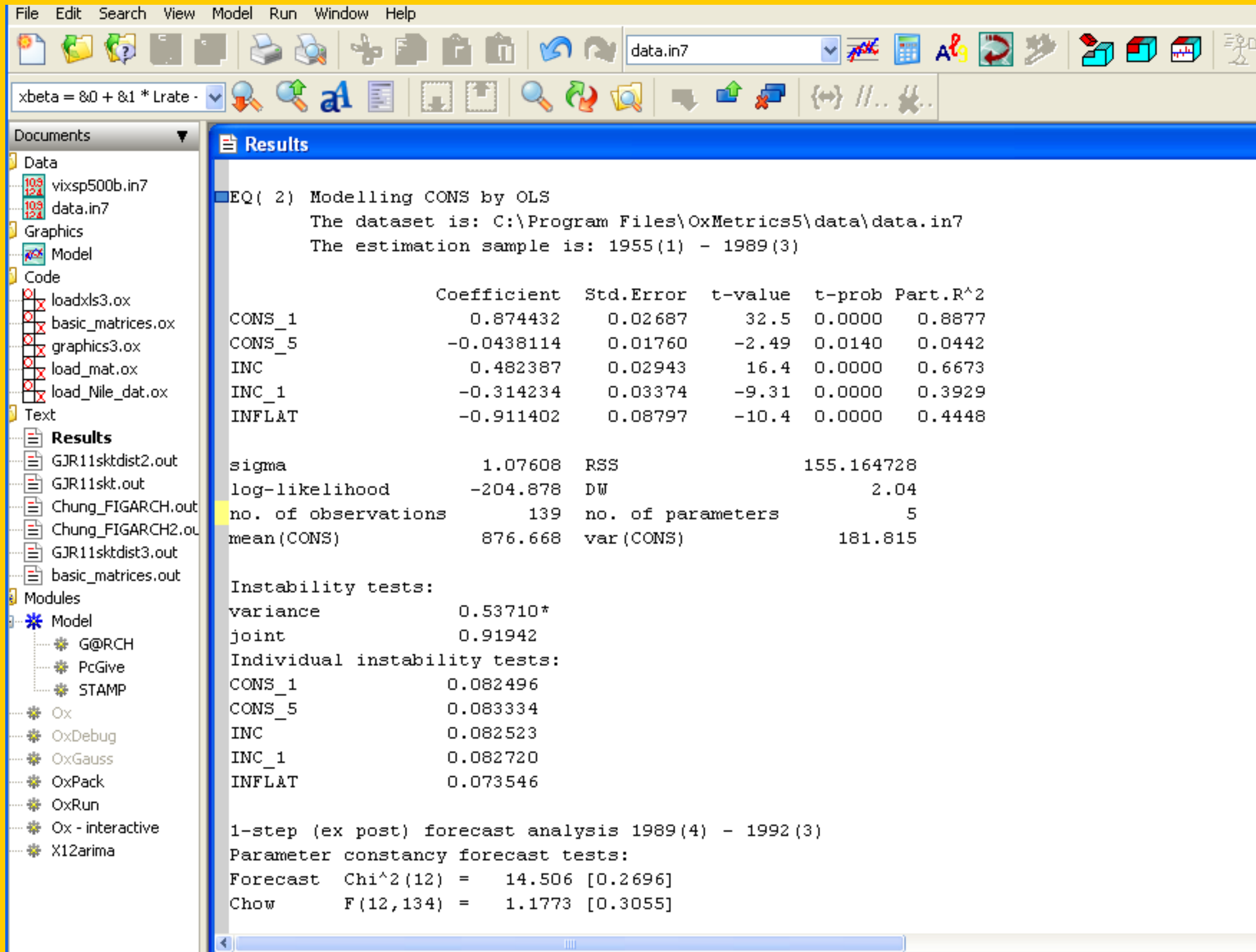
- In less than 1 minute, Autometrics generates the model with results of misspecification tests up front

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

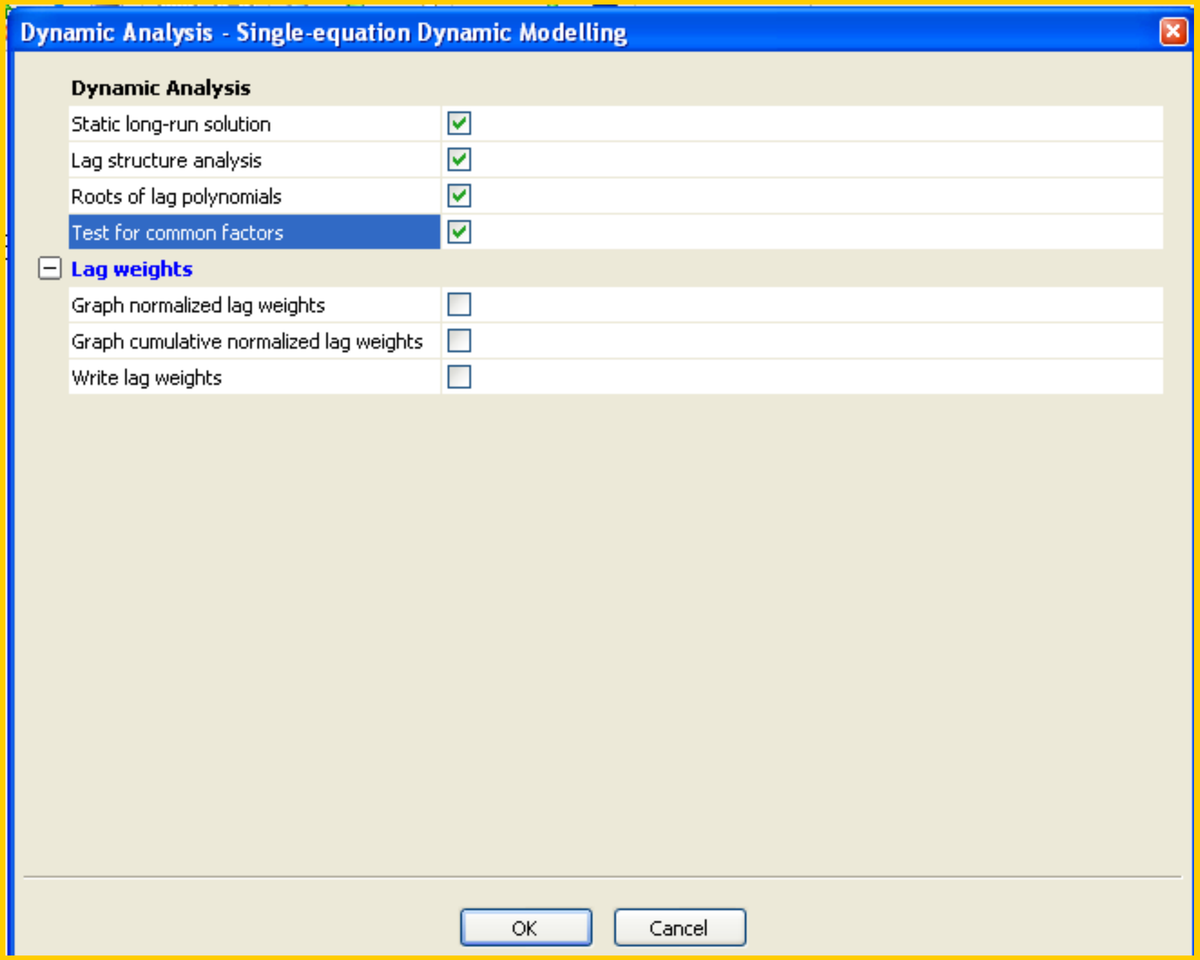
initial search space	2^40	final search space	2^11
no. estimated models	208	no. terminal models	4
test form	LR-F	target size	Default:0.05
outlier detection	0.025	presearch reduction	lags
backtesting	GUM0	tie-breaker	SC
diagnostics p-value	0.01	search effort	standard
time	0.85	Autometrics version	1.5


File Edit Search View Model Run Window Help
data.in7
xbeta = &0 + &1 * 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.ou
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
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



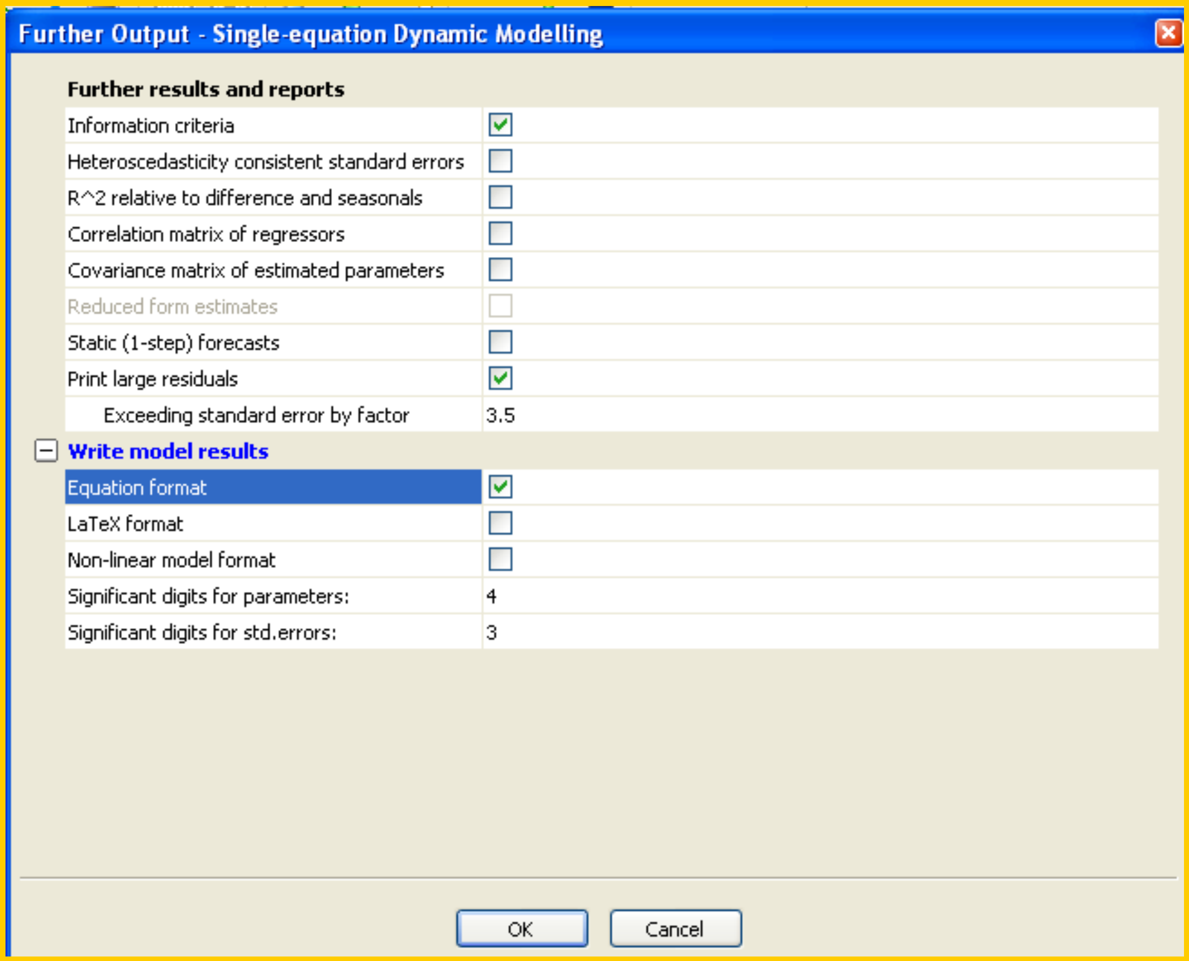
Output of dynamic analysis

```
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
```

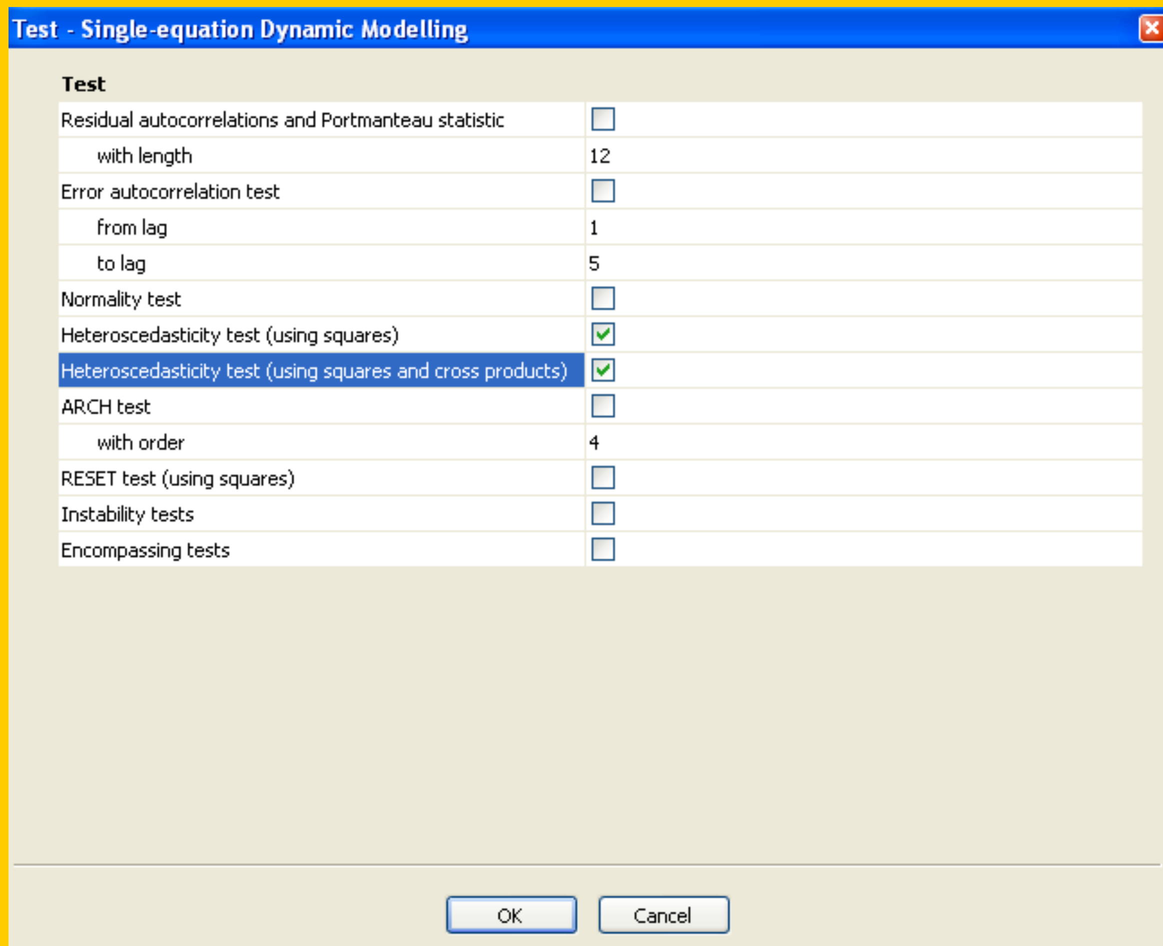
You can request information criteria and output in equation format



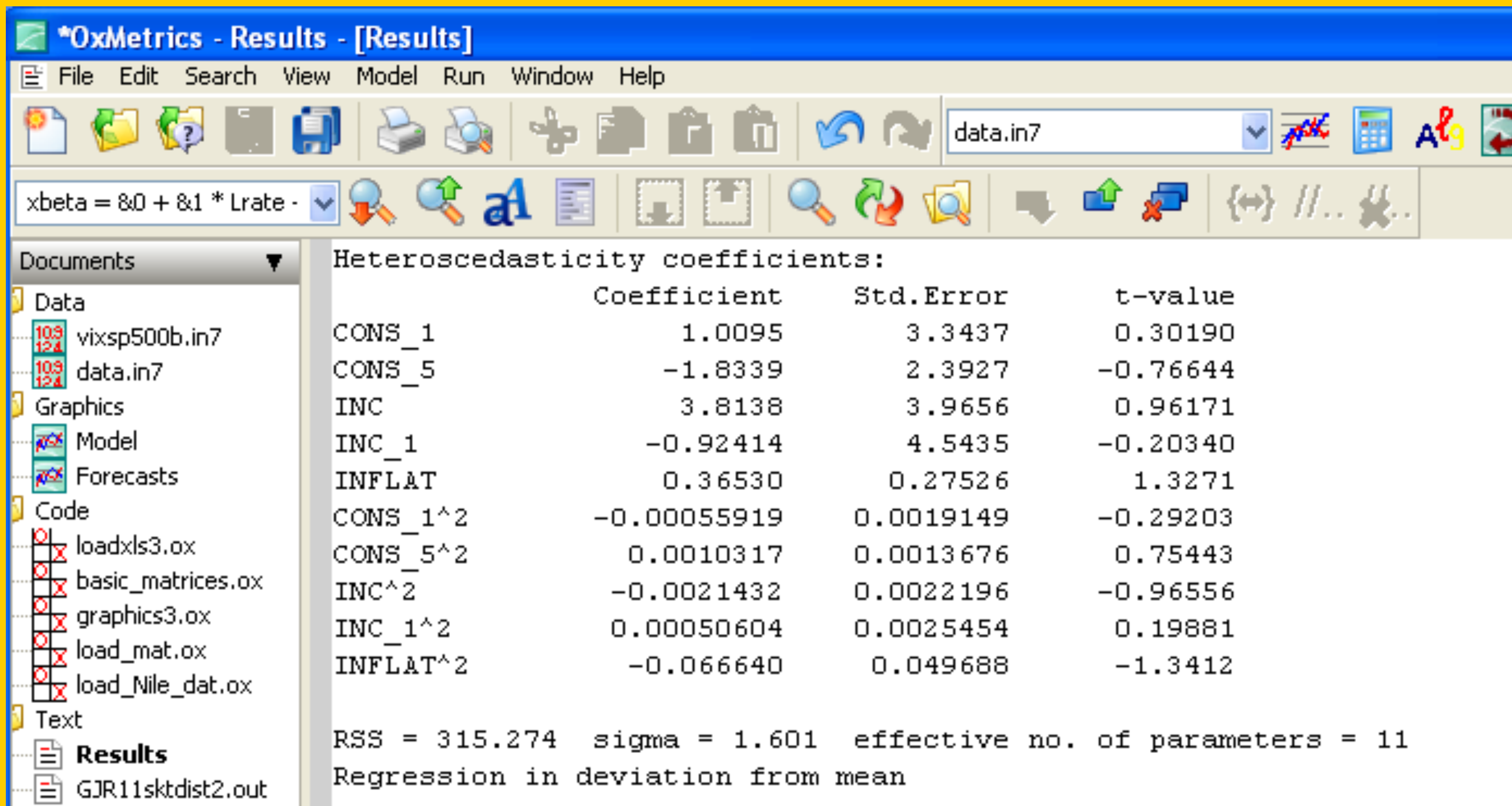
Information criteria and equation format

```
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



Heteroskedasticity tests for individual variables



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]
```

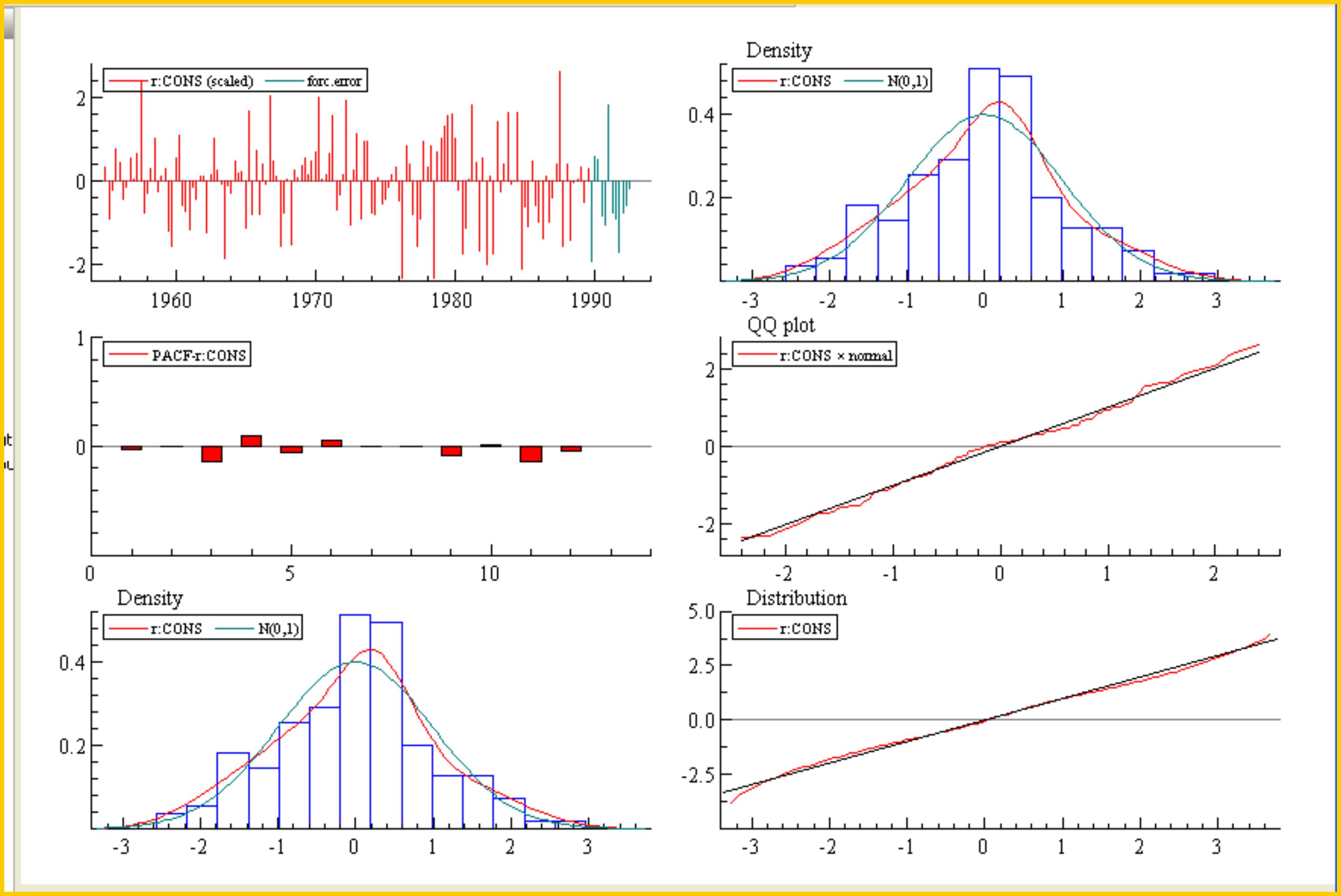
Robust Standard errors: White's, Newey-West, and Jacknifed

Heteroscedasticity consistent standard errors

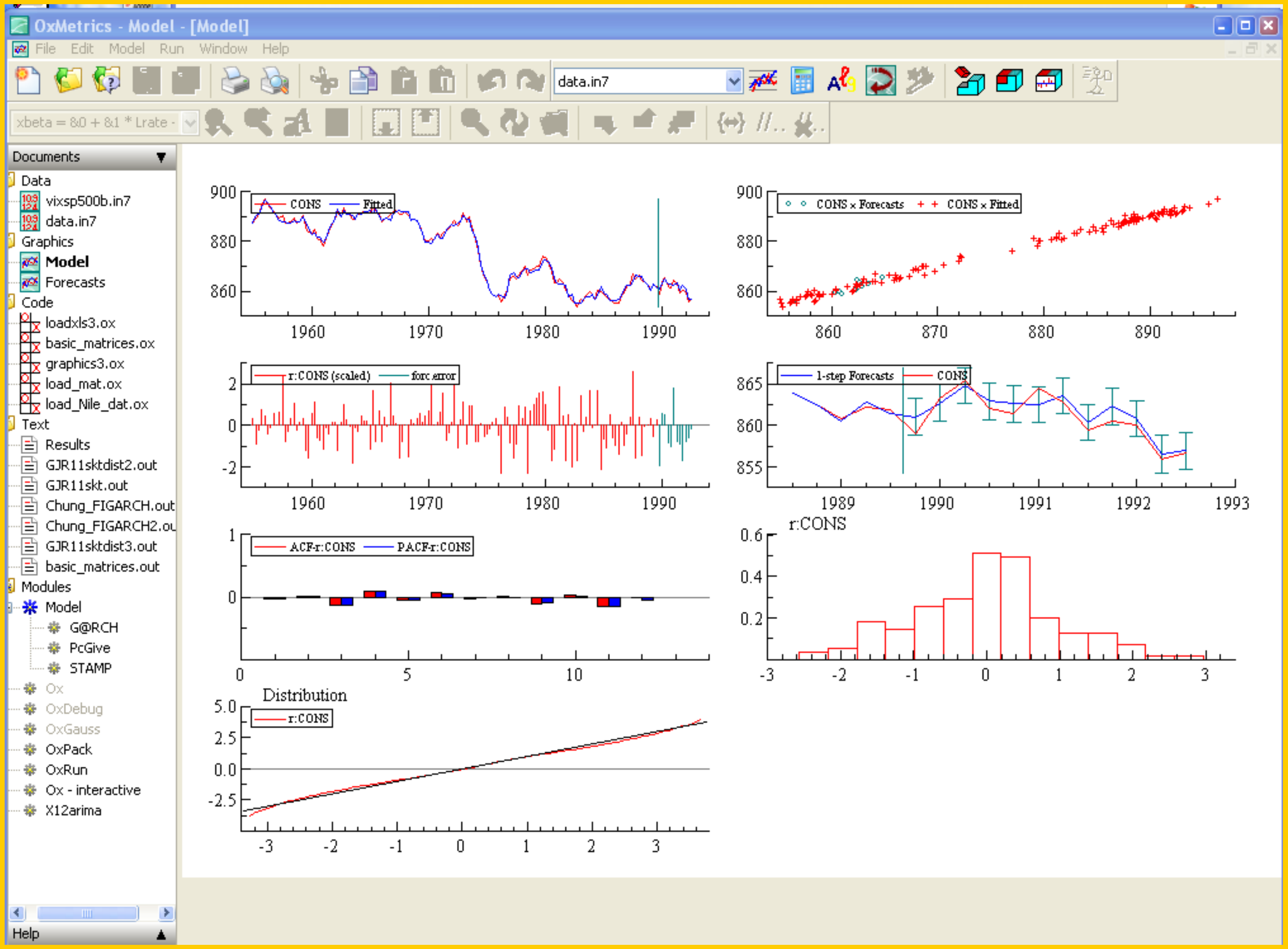
	Coefficients	SE	HACSE	HCSE	JHCSE
CONS_1	0.87443	0.026869	0.020131	0.024021	0.024825
CONS_5	-0.043811	0.017603	0.015224	0.017811	0.018201
INC	0.48239	0.029428	0.025429	0.026583	0.027186
INC_1	-0.31423	0.033742	0.026054	0.030809	0.031688
INFLAT	-0.91140	0.087969	0.071854	0.080678	0.084607

	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

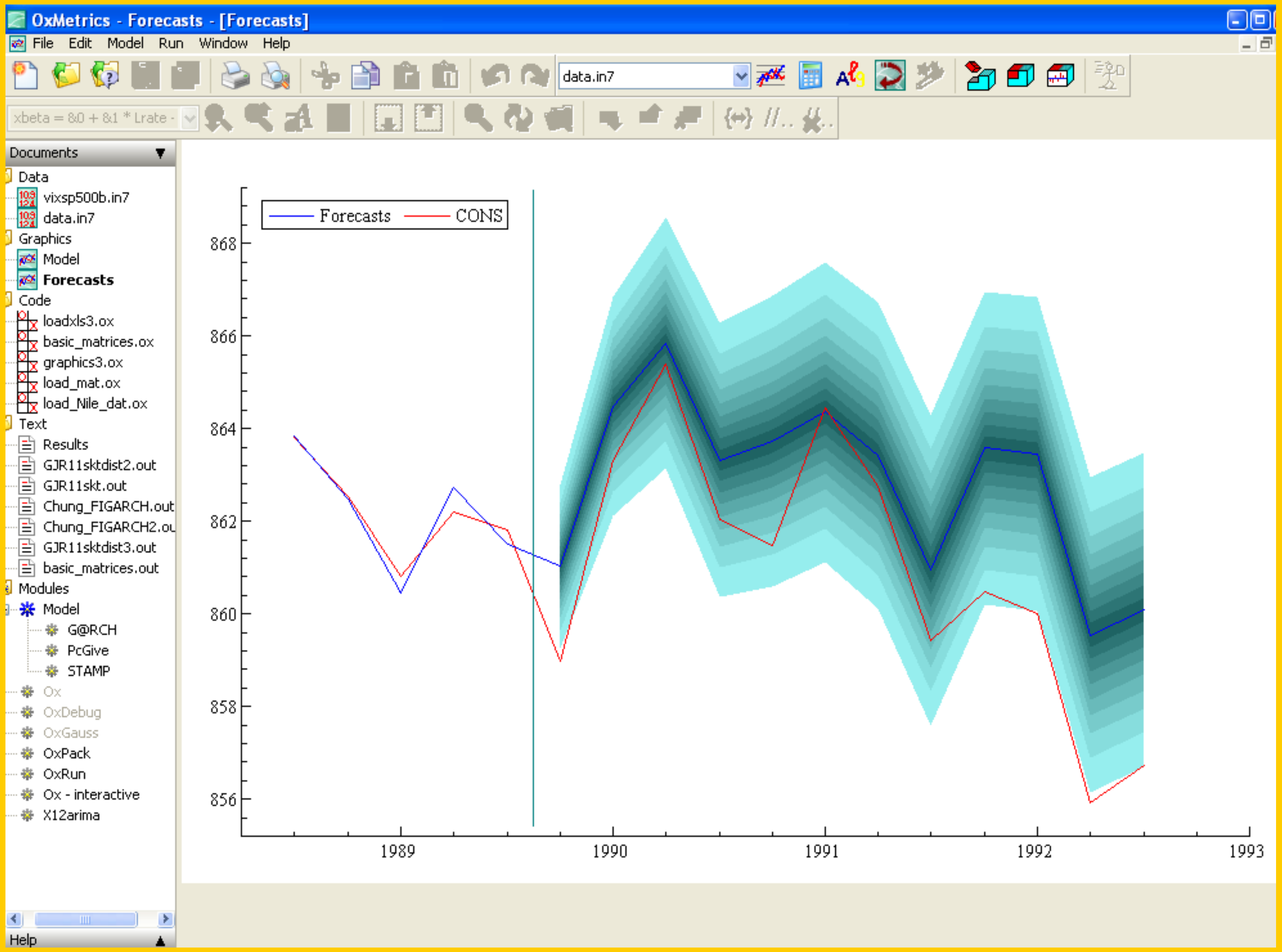
Graphical Residual Analysis



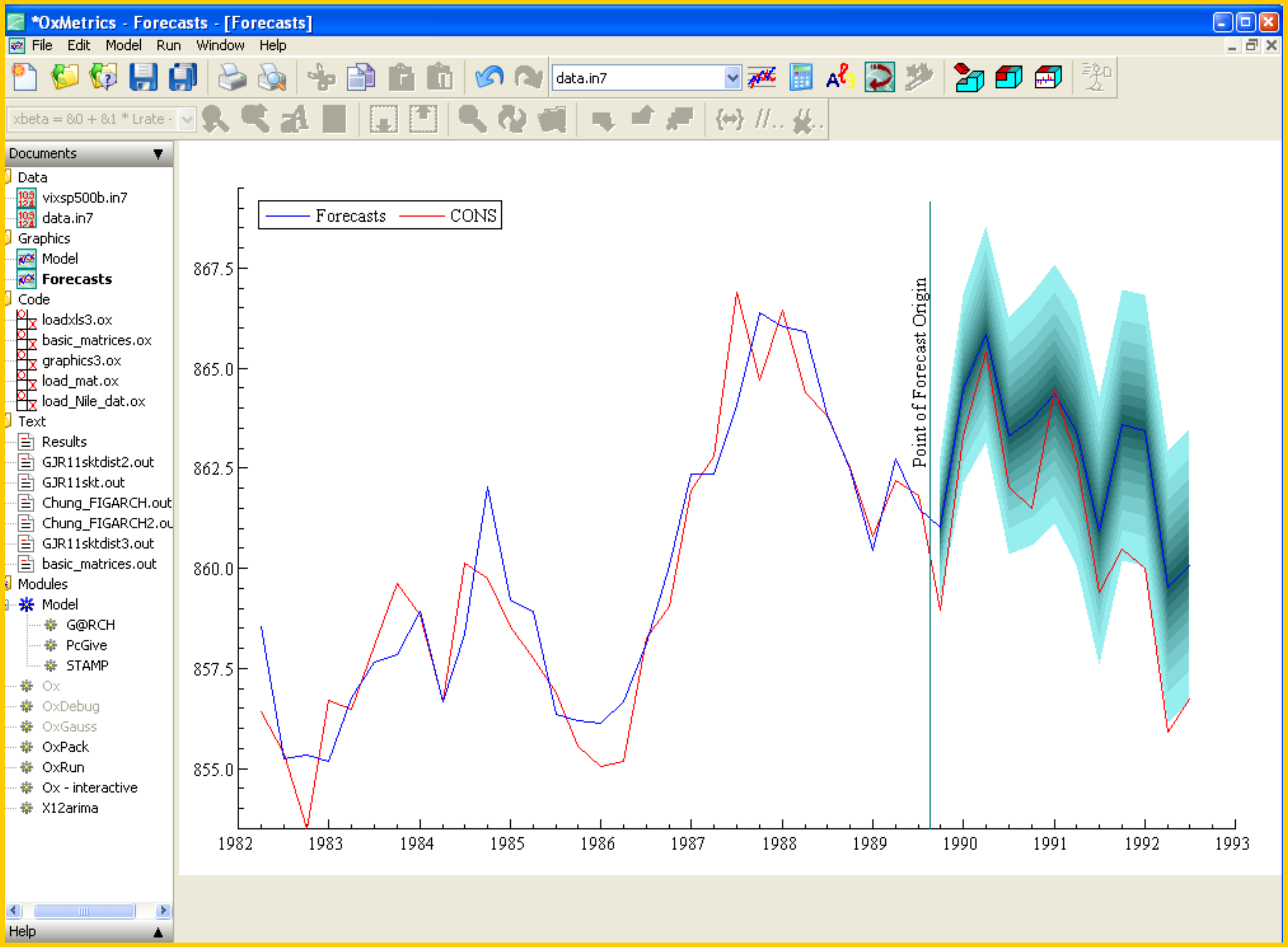
Model Graphics can be paneled



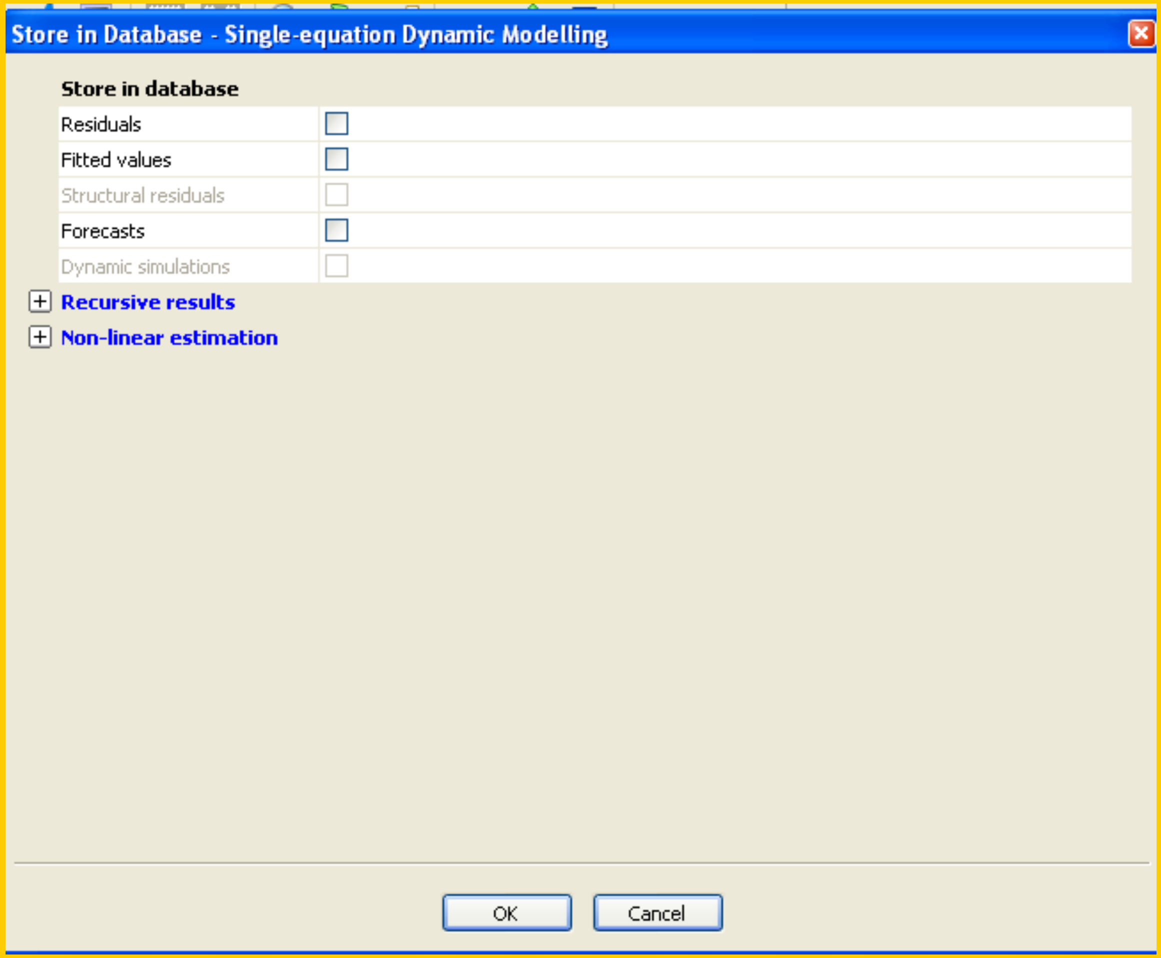
Out-of-Sample Forecasting (Or Generated Individually)



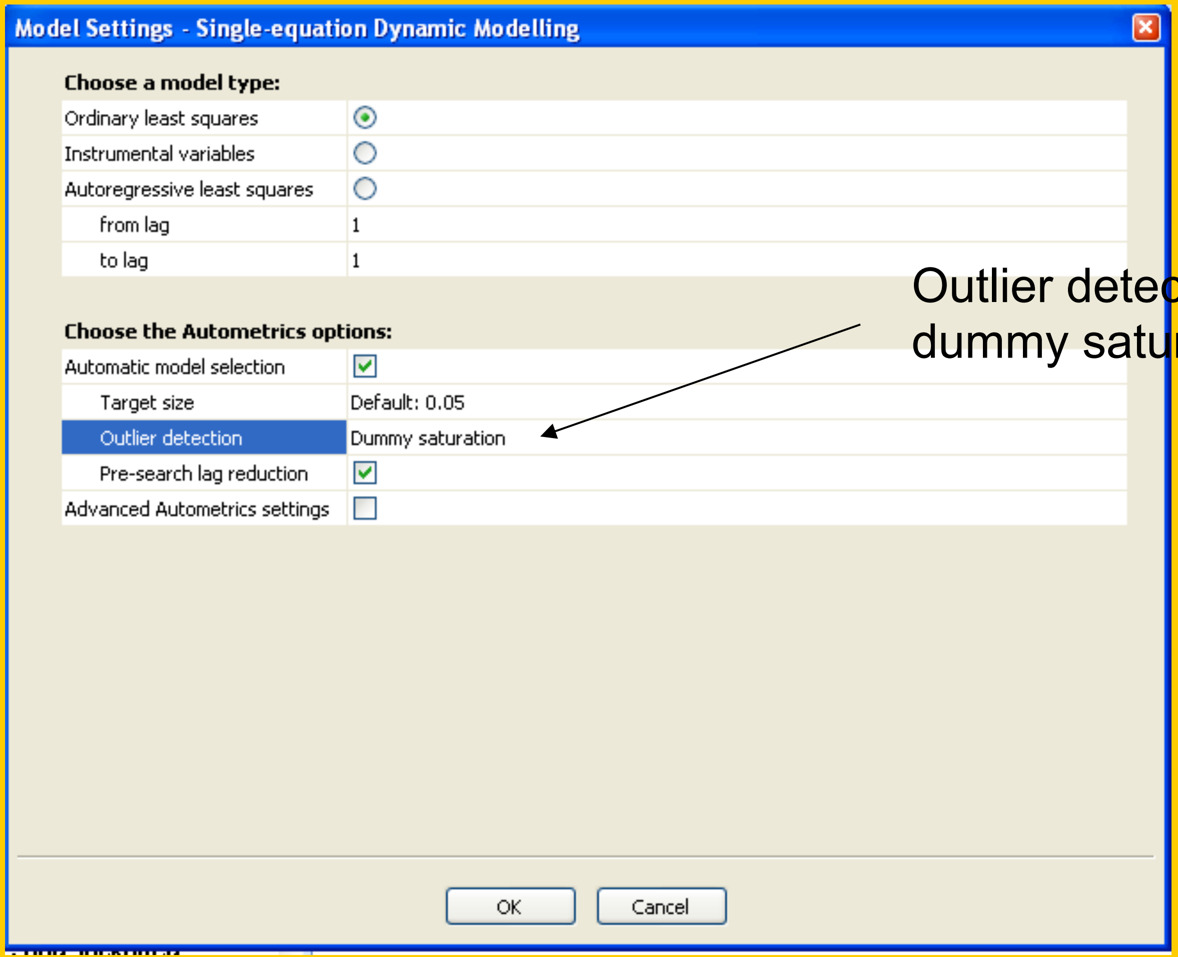
Or Customized to your needs



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

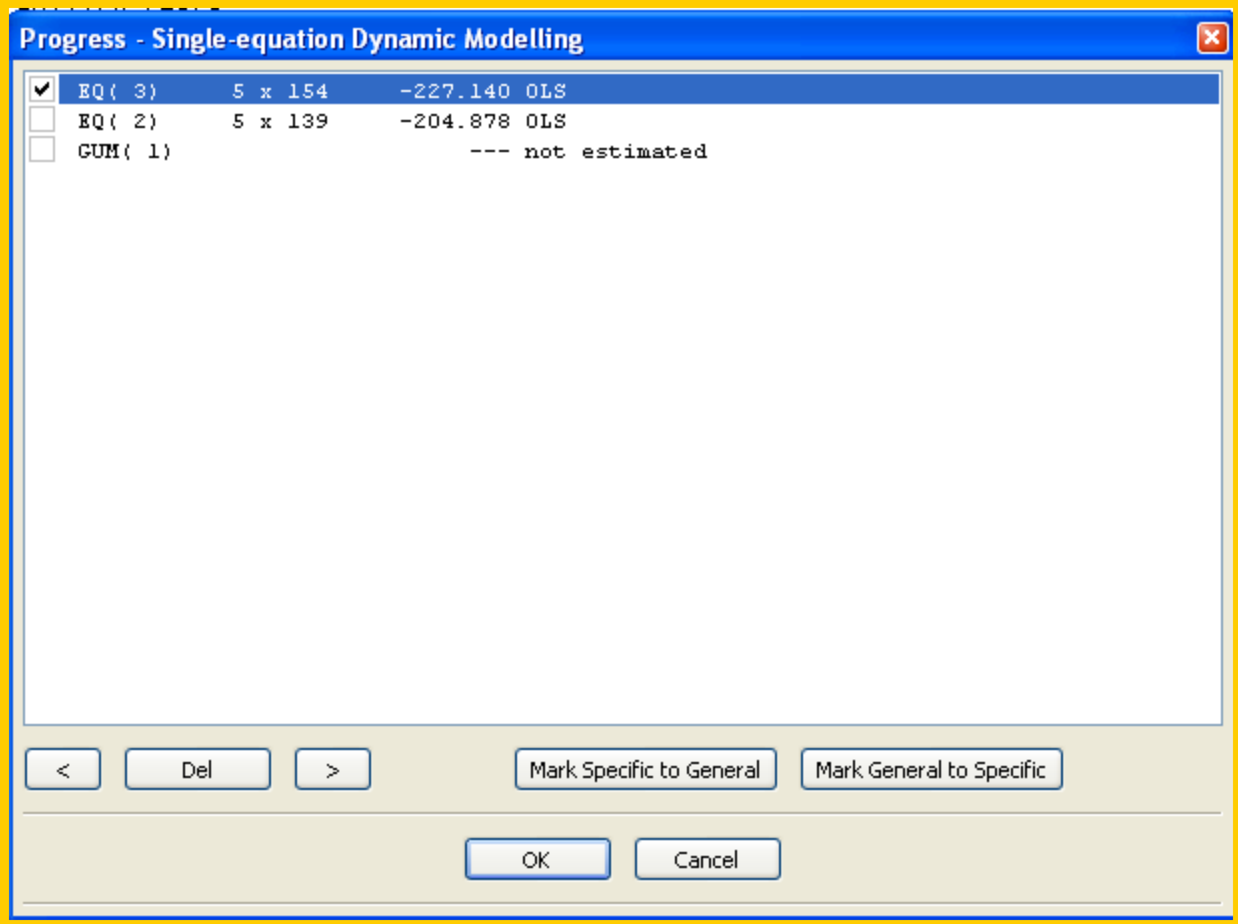
- Opting for dummy saturation will automatically reveal additive outliers in the data.

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^2
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

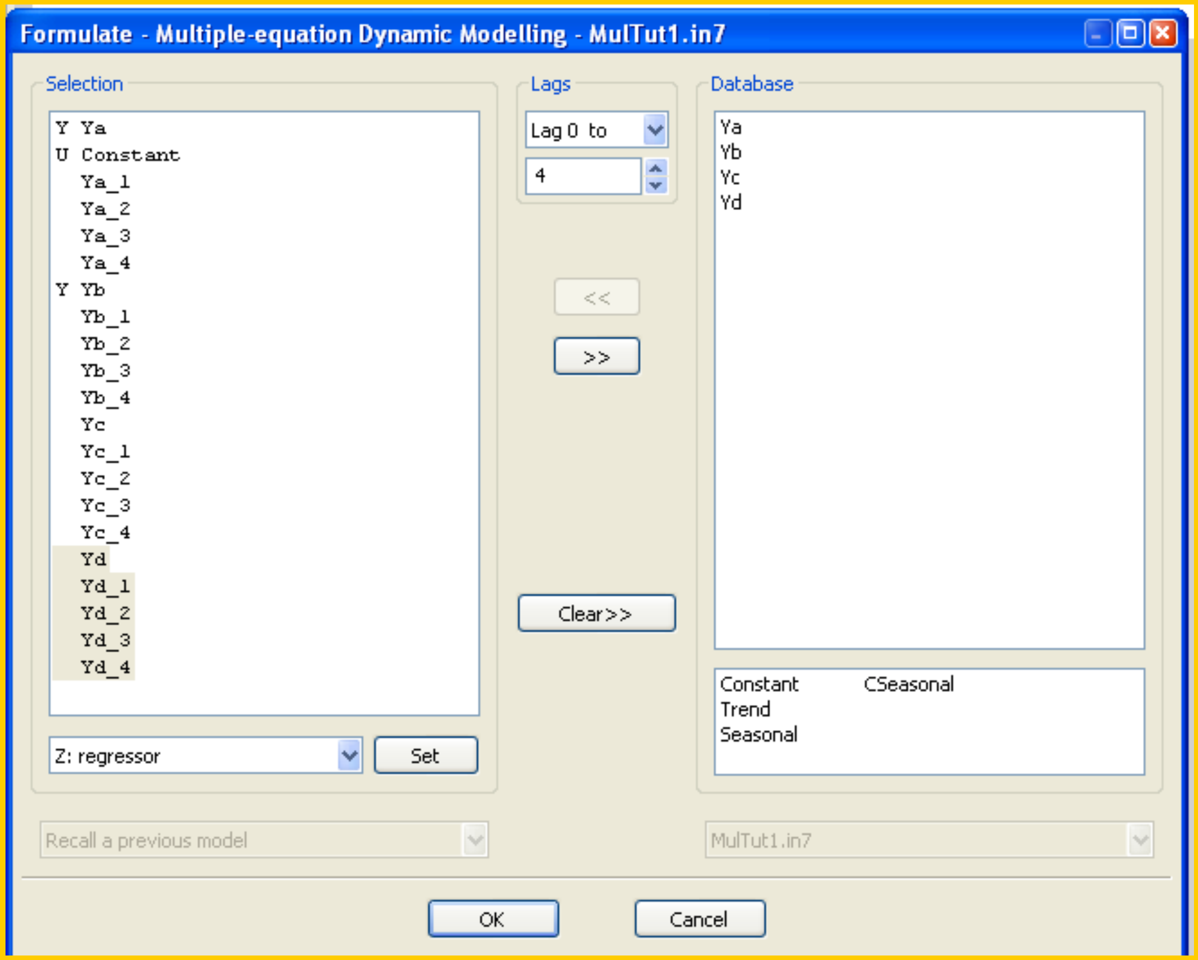
Comparative Model Analysis (progress)



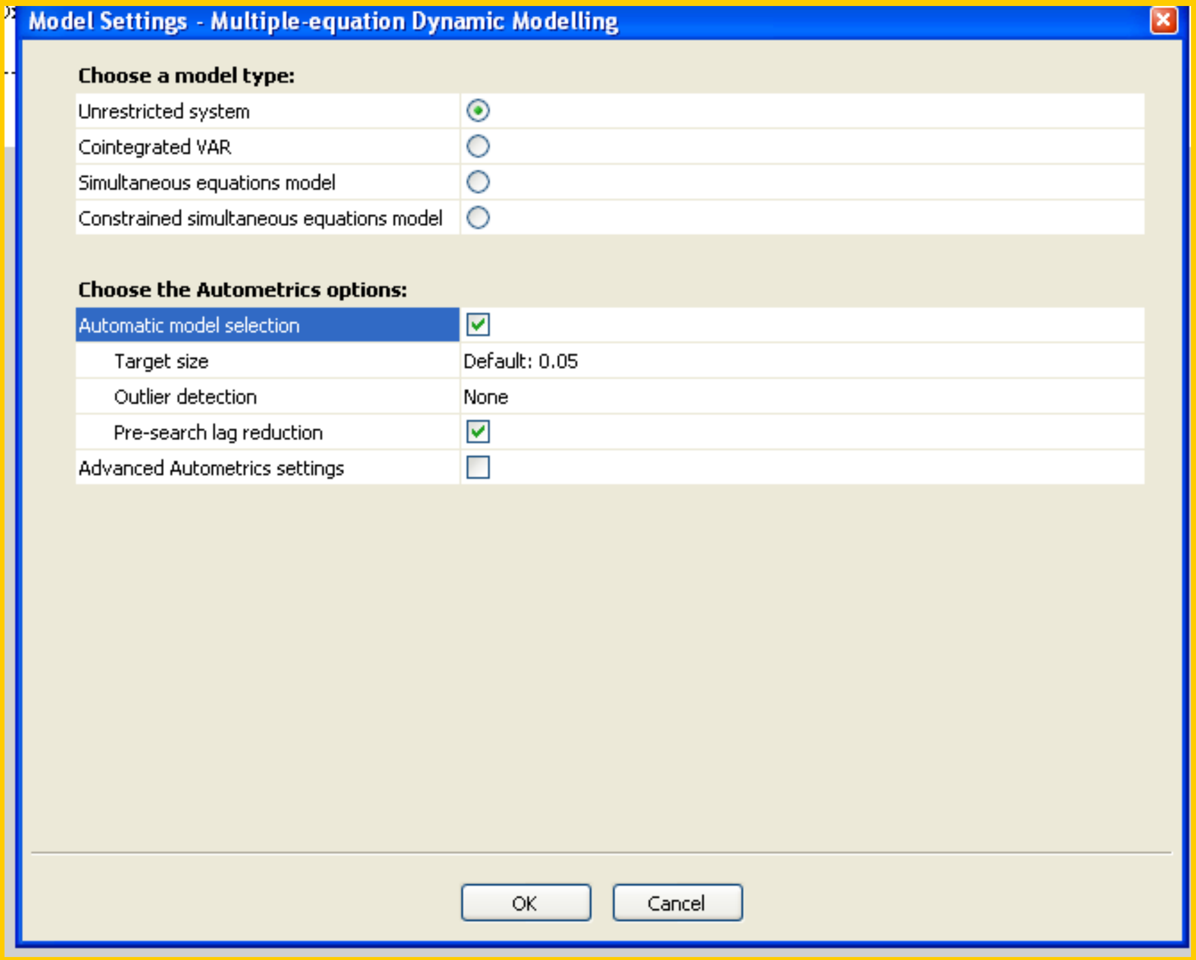
Autometrics can also model multivariate models

- 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

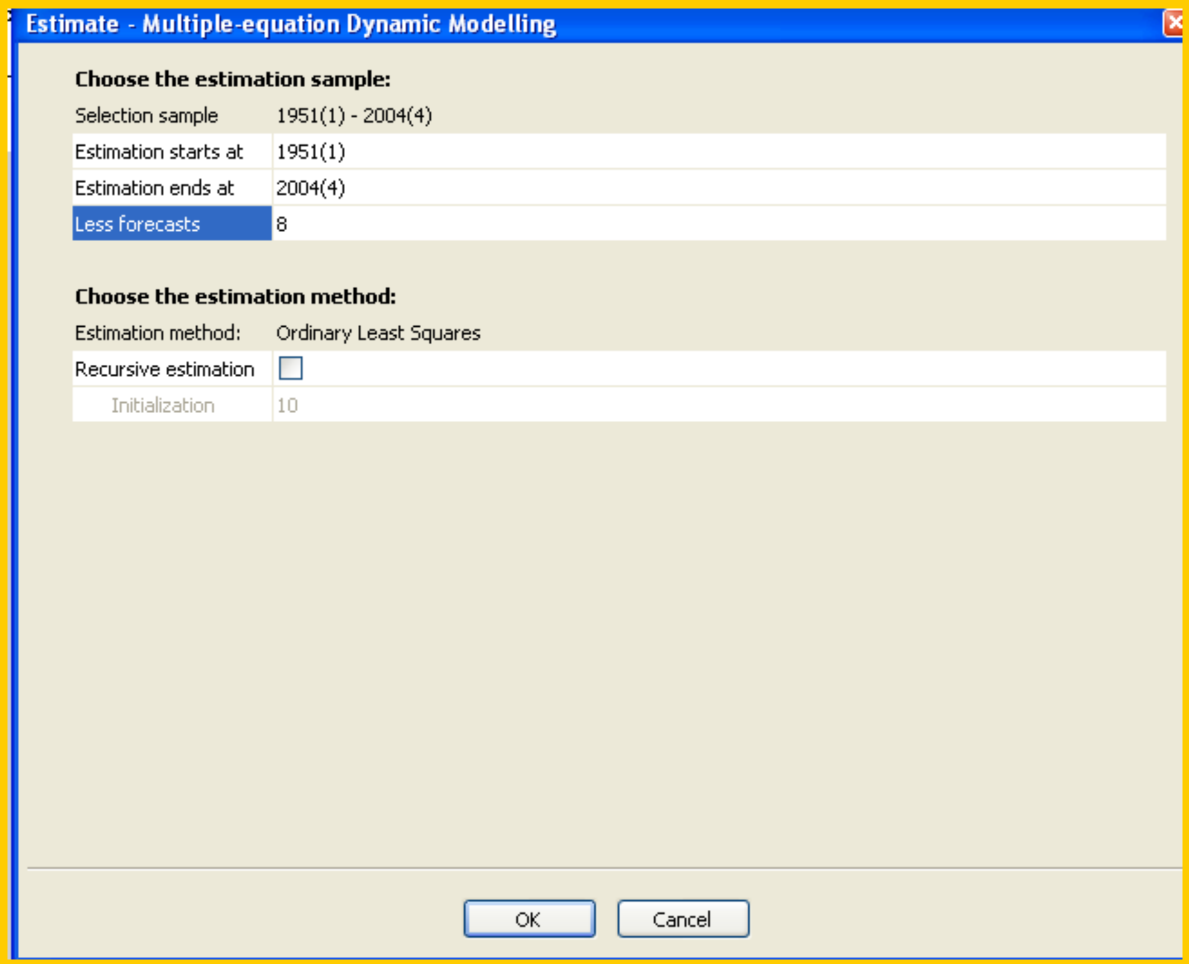
An Unrestricted Vector Autoregression



Check the Autometrics selection



Define the estimation sample



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
```

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]
```

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-nm)    Max test (T-nm)
   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