

Multi-Path General-to-Specific Modelling with OxMetrics

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Outline:

1. General-to-Specific (GETS) modelling:
 - Motivation, properties, advantages, disadvantages
2. The basics of OxMetrics 5:
 - Loading, editing and transforming data (logs, differencing), creating “special” series (cointegration relations, trends, etc.)
3. An overview of Autometrics:
 - Key concepts and characteristics
4. Single-equation modelling with Autometrics
 - Formulation, Advanced Autometrics settings, fixing variables, example (2007 Econometric Game, Q1)
5. Multiple-equation modelling with Autometrics
 - Formulation, fixing variables, example (2007 Econometric Game, Q2)

Common (in-sample) modelling strategies:

1. Select model that minimises information criterion
 2. Simple-to-general
 3. “1-shot” General
 4. Single-path GETS
- Multi-Path GETS: Combines 1 and 4 iteratively
 - Multi-Path GETS algorithms: Hoover and Perez (1999), PcGets (Hendry and Krolzig 2001, 2005), Autometrics (Doornik and Hendry 2007a, Doornik 2009), AutoSEARCH (Sucarrat and Escribano 2009, Sucarrat 2009)
 - Autometrics: A feature in OxMetrics that automates Multi-Path GETS

Autometrics automates GETS modelling of an OLS or IV estimable linear regression

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_K x_K + \epsilon$$

where the $\{\epsilon\}$ can be homoscedastic, heteroscedastic and/or autocorrelated

- NOTE: Only the case where $\{\epsilon\} \sim \text{IIN}(0, \sigma^2)$ has been extensively studied through Monte Carlo simulation (see in particular Hendry and Krolzig 2005, and Doornik 2009)
- Analytical analysis either not possible or yields limited insight

GETS modelling summarised:

1. Formulate a General Unrestricted Model (GUM)
2. Delete step-wise, along different paths, insignificant regressors at the chosen regressor significance level α (“target size”, optional), while checking a range of (optional) diagnostics at each deletion using a different (optional) significance level
3. If simplification results in more than one terminal model, then select the model with lowest value on the chosen information criterion (default: Schwartz), or their union (optional)

Main benefits of GETS modelling:

- Estimation and inference is conducted while controlling for the influence of other variables
- In simulations multi-path GETS compares favourably to other (in-sample) modelling strategies
- GETS modelling results in a parsimonious model that is particularly useful for scenario analysis (conditional forecasting, policy analysis, counterfactual analysis, etc.)

Main disadvantages of GETS modelling:

- Slight tendency to retain irrelevant variables (the more correlated the regressors, the higher the tendency)
- Finite sample behaviour can depend substantially on the properties of the data (regressor inter-correlation, homoscedastic vs. heteroscedastic errors, fat-tailed errors, etc.)

Define k_0 as the number of relevant variables in GUM, k_1 as the number of irrelevant variables in GUM (and so $k_0 + k_1 = K$ total number of variables in the GUM):

- \hat{k}_0/k_0 is the relevance proportion or “potency” (analogous to “power” in statistical hypothesis testing)
- \hat{k}_1/k_1 is the irrelevance proportion or “gauge” (analogous to “size” in statistical hypothesis testing)

Main statistical properties of Autometrics (default options):

- $E(\hat{k}_0/k_0) \rightarrow 1$ as the sample size goes to ∞
- $E(\hat{k}_1/k_1) \rightarrow \alpha$ as the sample size goes to ∞

Target size:

- User defined regressor significance level α . For example, if 5% is chosen, then the insignificant regressors at 5% are deleted

Diagnostic test p -value:

- The acceptable diagnostic test significance level. For example, if deleting an insignificant variable results in a diagnostic test p -value above the acceptable level, then the variable is re-included into the model

Branch:

- Suppose we choose a regressor significance level of 5%, and consider the following GUM:

Regressor	Coef.	<i>P</i> -value
x_1	2.851	0.35
x_2	0.343	0.00
x_3	1.069	0.07

The GUM contains TWO insignificant variables (x_1 and x_3) \Rightarrow TWO branches each made up of *paths*

Path:

- A deletion sequence. For example if x_1 is deleted first and then x_3 before no regressors are significant at the chosen regressor significance level, then $\{x_1, x_3\}$ is a deletion path or sequence

Rounds:

- If simplification results in more than one terminal model, then Autometrics initiates a second round by forming a new GUM made up of the union of the terminal models
- Specification search terminates when either only one terminal model results, or when the GUM at round n equals the GUM at round $n - 1$. If this is the case, then a “Tiebreaker” (an information criterion) is used to select among the models

Backtesting:

- Parsimonious encompassing test. By default, this is a joint test of the final model against the initial GUM (“GUM 0”), that is, an F -test of whether the deleted regressors are jointly insignificant at

α

OxMetrics basics:

- Load data: File → Open, etc.
- Edit sample/dates: Edit → Change Sample
- Missing values (my recommendation): Set to “missing” by double-clicking the data cell in question
- Graph series: Model → Graphics (or click on the graphics button) → Actual series or All plot types
- Transform data (algebra feature):

Edit → Algebra (or click on the “Alg” button) → “Code”, e.g. `“DCOO = diff(COO,1);”` → Run (→ Done)

(NOTE: Case sensitivity in variable names!)

- Create special series (calculator feature): Model → Calculator (or click on the calculator button) → ...

- *Example.* Edit dates (2007 Econometric Game Case):

The screenshot shows the OxMetrics software interface. The main window displays a data table with columns: DATE, TEMP, COO, RAD, FRK, VAP, and CLD. The data spans from 196401 to 196610. A 'Change Sample' dialog box is open, showing the current database sample as '1 - 444 Undated'. The dialog box has fields for Frequency (Monthly), Days per week (5), Start Date (1964-1), and Sample Size (Observations: 0). The 'Action' dropdown is set to 'Add observations at the end'. The 'OK' and 'Cancel' buttons are at the bottom of the dialog box.

	DATE	TEMP	COO	RAD	FRK	VAP	CLD
1	196401	-.46813	319.57	160.1	565.67	284.02	576.78
2	196402	-.69308	-99.99	163.3	529.84	273.12	561.82
3	196403	1.7239	-99.99	169.28	485.5	316.9	554.76
4	196404	-.86419	-99.99	170.36	561.06	258.69	542.07
5	196405	-.81742	322.23	166.66			
6	196406	-.11888	321.89	174.27			
7	196407	-1.1069	320.44	174.27			
8	196408	-.79489	318.7	169.99			
9	196409	-.84677	316.7	170.48			
10	196410	-1.8906	316.87	169.42			
11	196411	1.68	317.68	167.74			
12	196412	-.26573	318.71	169.88			
13	196501	.67713	319.44	164.94			
14	196502	.14814	320.44	173.85			
15	196503	.90268	320.89	167.49			
16	196504	.014441	322.13	168.84			
17	196505	.63035	322.16	172.3			
18	196506	1.8855	321.87	169.88			
19	196507	-.85229	321.21	169.41			
20	196508	-.57024	318.87	166.6			
21	196509	.45379	317.81	169.38			
22	196510	-.90715	317.3	163.89			
23	196511	-.62274	318.87	169.44			
24	196512	-.32086	319.42	171.57			
25	196601	.3568	320.62	163.62			
26	196602	-.79059	321.59	168.87			
27	196603	2.5034	322.39	170.66			
28	196604	.28895	323.7	162.72	557.48	287.82	554.08
29	196605	.50448	324.07	163.78	523.04	298.36	566.47
30	196606	1.6865	323.75	170.41	564.71	321.53	565.45
31	196607	.28445	322.4	167.5	672.49	302.51	583.61
32	196608	-2.1055	320.97	170.17	735.03	248.43	570.47
33	196609	-1.9345	318.64	169.95	763.91	256.81	581.43
34	196610	.17696	318.1	169.04	610.38	295.64	574.52

DATE[1] 196401

- *Example.* Create a differenced series:

The screenshot shows the OxMetrics software interface. The main window displays a data table with columns: DATE, TEMP, COO, RAD, PRK, VAP, and CLD. The data is organized into a grid with rows numbered 1 to 10. The 'COO' column contains values ranging from -1.46813 to 1.7696. The 'TEMP' column contains values ranging from 319.57 to 318.87. The 'RAD' column contains values ranging from 160.1 to 166.66. The 'PRK' column contains values ranging from 565.67 to 561.39. The 'VAP' column contains values ranging from 284.02 to 298.11. The 'CLD' column contains values ranging from 576.78 to 581.44. The 'COO' column has a 'missing' value at row 1964(4).

An 'Algebra - EG_2007_data_01.xls' dialog box is open, showing the following code:

```
// Enter Algebra code here, for example:
Ly = log(y); Dly = diff(Ly, 1);

1 DCOO = diff(COO, 1);
```

The dialog box also includes a 'Functions' list with 'log(VAR);' and a 'Database' list with 'DATE', 'TEMP', 'COO', 'RAD', 'PRK', 'VAP', and 'CLD'. The 'Run' button is highlighted.

The status bar at the bottom shows 'COO[1964(4)]' and 'missing'.

Autometrics is a multi-path GETS modelling feature in OxMetrics:

- The objective of Autometrics is to automate Multi-Path GETS specification search of a *data coherent, General Unrestricted Model* (GUM) in the form of a linear OLS/IV estimable regression (or regressions)
- Default definition of data-coherency: Stable parameters and Gaussian, serially uncorrelated, homoscedastic errors. NOTE: These assumptions can be relaxed through the “Advanced Autometrics settings”, and if the GUM fails one or several diagnostic checks Autometrics proceeds anyway
- GUM: A general model (advice: Not too general!) that includes the variables and lags that are believed to possibly have an impact
- Further reading: Doornik and Hendry (2007a, pp. 70-77), Hendry and Krolzig (2001) (Autometrics is an evolution of PcGets)

Single-equation estimation. *Example*: 2007 Econometric Game, Question 1

- A “rough” GUM:

$$\Delta COO_t = b_0 + b_1 \Delta COO_{t-1} + b_2 \Delta COO_{t-2} + \sum_{j=1}^{11} c_j d_{j,t} + e_t \quad (1)$$

- Formulating a model: (Model →) PcGive → Category: “Models for time series data” → Model class: “Single-equation dynamic modelling using PcGive” (→ Options) → “Formulate”
- Some estimation options (→ Options):
 - White (1980) standard errors: Tick “Heteroscedasticity consistent standard errors”
 - Newey and West (1987) standard errors: Tick “Heteroscedasticity consistent standard errors” *and* “HACSE”
 - Selected diagnostic tests: Tick “Test summary”

- Formulate a model: (Model \rightarrow) PcGive \rightarrow Category: “Models for time series data” \rightarrow Model class: “Single-equation dynamic modelling using PcGive” \rightarrow “Formulate”

The screenshot displays the OxMetrics software interface. The main window shows a data table with columns: DATE, TEMP, COO, RAD, PER, VAP, CLD, and DCOO. The data is organized into rows, with some values marked as 'missing'. A dialog box titled 'PcGive - Models for time-series data' is open in the foreground, showing the 'Formulate...' button selected. The dialog also displays the 'Module' as 'PcGive', the 'Category' as 'Models for time-series data', and the 'Model class' as 'Single-equation Dynamic Modelling using PcGive'. The 'Formulate...' button is highlighted, indicating the next step in the process.

	DATE	TEMP	COO	RAD	PER	VAP	CLD	DCOO
1964 (1)	196401	-.46813	319.57	160.1	565.67	284.02	576.78	missing
1964 (2)	196402	-.63308	missing	163.3	529.84	273.12	561.82	missing
1964 (3)	196403	1.7299	missing	169.28	485.5	316.9	554.76	missing
1964 (4)	196404	-.86419	missing	170.36	561.06	258.69	542.07	missing
1964 (5)	196405	-.81742	322.23	166.66	561.39	273.32	569.55	missing
1964 (6)	196406	-.11808	321.89	174.27	567.33	298.11	581.44	-.34
1964 (7)	196407	-1.1069	320.44	174.27	671.11	272.72	579.34	-1.45
1964 (8)	196408	-.79489	318.7	169.39	771.53	270.75	563.82	-1.74
1964 (9)	196409	-.84677	316.7	170.48	768.29	277.99	579.39	-2
1964 (10)	196410	-1.8906	316.87	169.42	659.14	262.62	590.88	.17
1964 (11)	196411	1.68	317.68	167.74	596.23	328.01	578.7	.81
1964 (12)	196412	-.26573	318					
1965 (1)	196501	-.67713	319					
1965 (2)	196502	1.4814	320					
1965 (3)	196503	.90268	320					
1965 (4)	196504	.014441	322					
1965 (5)	196505	.63035	322					
1965 (6)	196506	1.8855	321					
1965 (7)	196507	-.85229	321					
1965 (8)	196508	-.57024	318					
1965 (9)	196509	-.45379	317					
1965 (10)	196510	-.90715	31					
1965 (11)	196511	-.62274	318					
1965 (12)	196512	-.92086	319					
1966 (1)	196601	.3568	320					
1966 (2)	196602	-.79059	321					
1966 (3)	196603	2.5034	322					
1966 (4)	196604	.28895	32					
1966 (5)	196605	.50448	324					
1966 (6)	196606	1.6865	323					
1966 (7)	196607	.28445	32					
1966 (8)	196608	-2.1055	320					
1966 (9)	196609	-1.9345	318.64	169.95	762.91	256.82	581.43	-1.73
1966 (10)	196610	-.17696	318.1	169.04	610.38	295.64	574.52	-.54

Model DCOO[1964(1)] missing

- Estimation options (→ Options):

Options - Single-equation Dynamic Modelling

Maximization Settings

Maximum number of iterations	1000
Write results for every	0
Write in compact form	<input type="checkbox"/>

Convergence

Strong convergence tolerance	.0001
Weak convergence tolerance	.005

Default

Reset default	<input type="checkbox"/>
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☒ **Additional output to be printed after estimation**

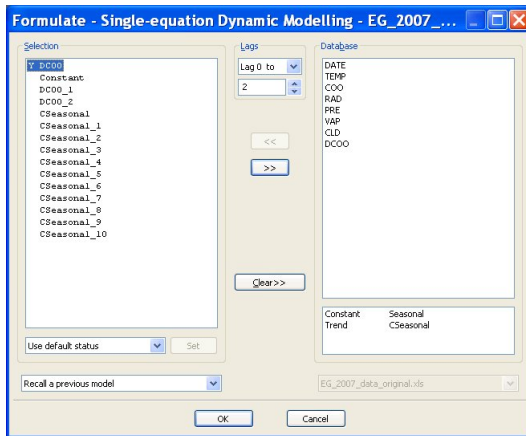
Correlation matrix of regressors	<input type="checkbox"/>
Heteroscedasticity consistent standard errors	<input type="checkbox"/>
HACSE (default is HCSE if selected)	<input type="checkbox"/>
Information criteria	<input type="checkbox"/>
Instability tests (single equation only)	<input type="checkbox"/>
R ² relative to difference and seasonals (single equation only)	<input type="checkbox"/>
Covariance matrix of estimated parameters	<input type="checkbox"/>
Test Summary	<input type="checkbox"/>
Static long-run solution	<input type="checkbox"/>
Equation format	<input type="checkbox"/>
Cointegration test	<input type="checkbox"/>

☒ **Further options**

Cointegration test: with Max test	<input type="checkbox"/>
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OK Cancel

- Specify model ($\dots \rightarrow$ Formulate):



- “Seasonal”, “CSeasonal”: Seasonal dummies and centred seasonal dummies, respectively
- Estimate with default options: Ok \rightarrow Ok \rightarrow Ok

Single-equation GETS modelling with Autometrics. *Example: 2007 Econometric Game, Question 1*

- Recall the “rough” GUM:

$$\Delta COO_t = b_0 + b_1 \Delta COO_{t-1} + b_2 \Delta COO_{t-2} + \sum_{j=1}^{11} c_j d_{j,t} + e_t$$

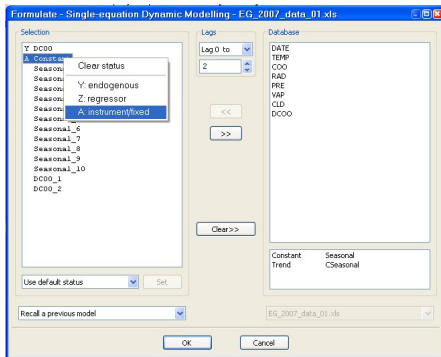
- The specific model proposed by Autometrics using the default options:

$$\Delta COO_t = b_0 + b_1 \Delta COO_{t-1} + \sum_{j=1}^3 c_j d_{j,t} + \sum_{j=5}^{11} c_j d_{j,t} + e_t$$

- Level representation:


$$COO_t = b_0 + (1 + b_1) COO_{t-1} + b_1 COO_{t-2} + \sum_{j=1}^3 c_j d_{j,t} + \sum_{j=5}^{11} c_j d_{j,t} + e_t$$

- Specify model:



USEFUL FEATURE: Fixing regressors (that is, preventing Autometrics from deleting them). Select the regressors to fix → Right-click mouse → A: instrument/fixed. NOTE: Do the same thing to define instruments if IV is used instead of OLS

- GETS modelling with Autometrics: Tick “Automatic model selection”

Model Settings - Single-equation Dynamic Modelling 

Choose a model type:

Ordinary least squares	<input checked="" type="radio"/>
Instrumental variables	<input type="radio"/>
Autoregressive least squares	<input type="radio"/>
from lag	1
to lag	1

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 checked="" type="checkbox"/>

- Main Autometrics options:

- Target size: Regressor and backtesting significance level

- Outlier detection: Neutralises large residuals in the GUM by means of impulse dummies

- Pre-search lag reduction: Speeds up simplification; GENERAL ADVICE: Turn off!

- Advanced Autometrics settings: Tick if default settings are unsatisfactory

- Advanced Autometrics settings:

Autometrics Settings - Single-equation Dynamic Modelling

☐ Search settings

Outlier detection	None
Pre-search lag reduction	<input type="checkbox"/>
Pre-search variable reduction	<input type="checkbox"/>
Search effort	1
Backtesting	GUM 0
Tie-breaker	SC
Print level	Default output
Target size	Default: 0.05
User determined p-value	.05
Diagnostic test p-value	.01
Standard errors	Default
GIVE: first do reduced form	<input checked="" type="checkbox"/>

☒ Block identification when there are too many parameters

☐ Diagnostic test set

Use default	<input checked="" type="checkbox"/>
Normality test	<input checked="" type="checkbox"/>
Heteroscedasticity test (using squares)	<input checked="" type="checkbox"/>
Heteroscedasticity test (using squares and cross products)	<input type="checkbox"/>
Chow test	<input checked="" type="checkbox"/>
RESET test (using squares)	<input type="checkbox"/>
Error autocorrelation test	<input checked="" type="checkbox"/>
Portmanteau statistic	<input type="checkbox"/>
ARCH test	<input checked="" type="checkbox"/>

☐ Diagnostic test arguments

Use default	<input checked="" type="checkbox"/>
Chow-test sample split (%)	70
Error autocorrelation to lag	2
Portmanteau lag length	10
ARCH test to lag	2

OK Cancel

- Selected advanced Autometrics settings:
 - Backtesting: “None” may be preferable if the final model does not encompass the initial GUM. “GUM0” is the initial GUM, which generally does not correspond to the “Current GUM”
 - Tiebreaker: The information criterion used to select between terminal models. SC (Schwartz) and min(k) (the model with the least regressors) are the most conservative
 - Diagnostic test p -value: The acceptable diagnostic test significance level. If deleting an insignificant variable results in a diagnostic test p -value above the acceptable level, then the variable is re-included into the model
 - Standard errors: Ordinary (“Default”), White (1980) (“HCSE”) and Newey and West (1987) (“HACSE”)
 - Heteroscedasticity tests: White (1980)

- “Recursive estimation”: Slows down the computations (slightly), but it enables some very useful recursive stability analysis features
- Specific model proposed by Autometrics:

```

EQ( 2) Modelling DCOO by OLS
|
|   The dataset is: C:\Documents and Settings\sucarrat\Mis documentos\files\teaching
|   The estimation sample is: 1964(8) - 2000(12)
|
|   Coefficient   Std. Error   t-value   t-prob   Part.R^2
|   -----
|   DCOO_1        -0.213999    0.04512   -4.74    0.0000   0.0503
|   Seasonal      -0.199927    0.05880   -3.40    0.0007   0.0265
|   Seasonal_1    -0.507123    0.05851   -8.67    0.0000   0.1502
|   Seasonal_2    -0.451573    0.06034   -7.48    0.0000   0.1165
|   Seasonal_4    -0.707806    0.05885   -12.0    0.0000   0.2540
|   Seasonal_5    -1.94870    0.06413   -30.4    0.0000   0.6848
|   Seasonal_6    -3.02784    0.09527   -31.8    0.0000   0.7038
|   Seasonal_7    -3.77271    0.1275    -29.6    0.0000   0.6733
|   Seasonal_8    -3.69728    0.1505    -24.6    0.0000   0.5868
|   Seasonal_9    -1.89487    0.1424    -13.3    0.0000   0.2941
|   Seasonal_10   -0.176490    0.07692   -2.29    0.0222   0.0122
|   Constant      1.50663     0.06042    24.9    0.0000   0.5940
|
|   sigma         0.286776    RSS          34.9520821
|   R^2           0.946555    F(11,425) =   684.3 [0.000]**
|   log-likelihood -68.1549    DW           2.05
|   no. of observations 437    no. of parameters 12
|   mean(DCOO)       0.112334    var(DCOO)     1.49654
|
|   AR 1-7 test:    F(7,418) =   1.0154 [0.4196]
|   ARCH 1-7 test:  F(7,411) =   0.78778 [0.5979]
|   Normality test: Chi^2(2) =   2.5460 [0.2800]
|   Hetero test:    F(12,412) =   0.85756 [0.5908]
|   Hetero-X test:  F(22,402) =   1.2915 [0.1715]
|   RESET test:     F(1,424) = 0.00067988 [0.9792]

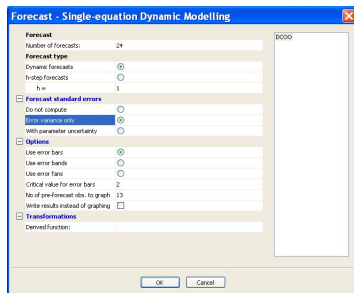
```

Some further diagnostic tests:

- Residuals graphs: Model \rightarrow Test \rightarrow Graphical analysis $\rightarrow \dots$
- User specified residuals tests: Model \rightarrow Test \rightarrow Test $\rightarrow \dots$
- Recursive graphics (VERY useful!): Model \rightarrow Test \rightarrow Recursive graphics $\rightarrow \dots$

Single equation dynamic forecasting:

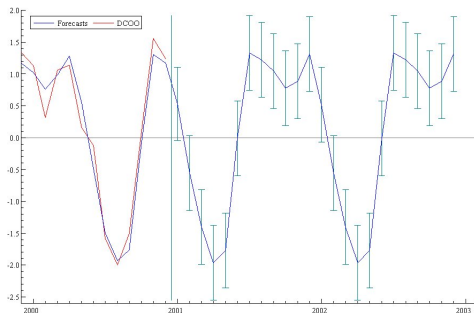
- The parsimonious model suggested to us by Autometrics contains lags and deterministic terms only, so we may readily generate dynamic forecasts beyond 2000(12)
- Forecasting DCOO dynamically 24 months beyond 2000(12):
Model → Test → Forecast and then



yields (graph on next slide)

Single equation dynamic forecasting (cont.):

- Out-of-sample forecasts of DCOO from 2001(1)-2002(12):

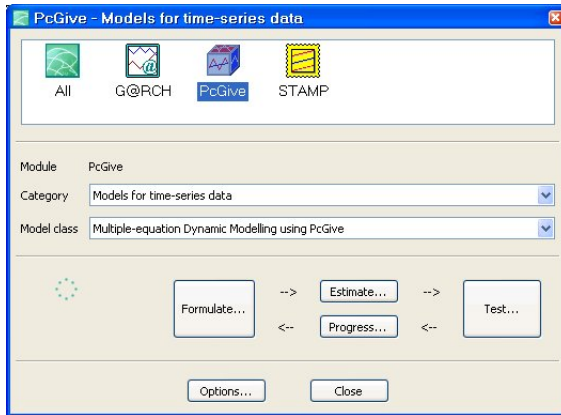


- In order to generate forecasts of the *level* of COO, recall that any variable y_T satisfies $y_T = y_0 + \sum_{t=1}^T \Delta y_t$. In other words, tick “Write results instead of graphing” and use Algebra or Calculator (Model \rightarrow Calculator) to obtain the forecasts of the levels COO

Multiple-equation modelling with Autometrics (two approaches):

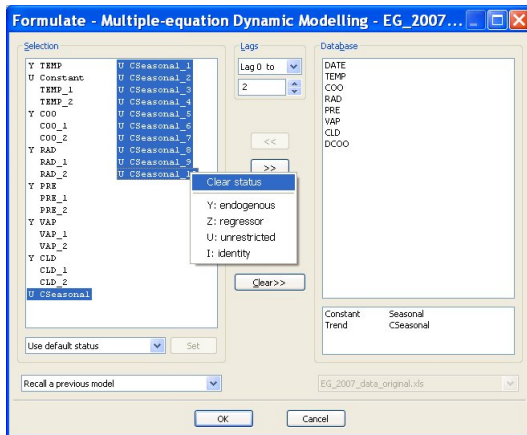
1. Seemingly Unrelated Regression (SUR) using OLS/IV, that is, single-equation GETS modelling of each equation separately (requires stationarity of regressors)
2. Simultaneous variable deletion (or non-deletion) across equations using vector diagnostic tests but estimation still by OLS (does not require stationarity of regressors), see Doornik and Hendry (2007b, pp. 29-31). (NOTE: IV estimation not available with this strategy)
 - Model type: “Unrestricted system” (system of URFs), see Doornik and Hendry (2007b, chapter 3)

Formulate a system: (Model \rightarrow) PcGive \rightarrow Category: “Models for time series data” \rightarrow Model class: “Multiple-equation dynamic modelling using PcGive” \rightarrow “Formulate”



Multiple-equation modelling with Autometrics using second approach. *Example: 2007 Econometric Game, Question 2*

- My GUM: A six-dimensional VAR(2) of $y_t = (TEMP_t, COO_t, RAD_t, PRE_t, VAP_t, CLD_t)$, with a constant and 11 centered seasonals in each of the six equations:



- Fixing variables (that is, restricting Autometrics to keep them) now differs:
 - ◇ Fixing VAR-lags is not possible, only the exogenous regressors can be fixed
 - ◇ Select the exogenous regressors to fix → Right-click mouse → U: Unrestricted
 - ◇ To unfix exogenous regressors, select the regressors to unfix → Right-click mouse → Clear status
- Lag-deletion is undertaken across equations. For example, $TEMP_1$ is either deleted from all six equations or from none, etc.

Results with default settings:

- NOTE: Autometrics simplifies even though the GUM does not pass all diagnostic checks
- Four variables are removed from all of the equations: The second lag of TEMP, VAP and CLD, and CSeasonal_10

Other type of analysis:

- Cointegration analysis (applied on the Unrestricted system, *not* on the simplified model): Model \rightarrow Test \rightarrow Dynamic Analysis and Cointegration Tests \rightarrow ...

See Doornik and Hendry (2007b, chapter 4)

References:

- Doornik, J. (2009). Autometrics. In J. L. Castle and N. Shephard (Eds.), *The Methodology and Practice of Econometrics: A Festschrift in Honour of David F. Hendry*. Oxford: Oxford University Press.
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