Practical Computable General Equilibrium (CGE) Modelling: Online Course

Course Description

This course is an **introduction** to practical computable general equilibrium (CGE) modelling using the General Algebraic Modelling System (GAMS) software. The course is designed for individuals who want to develop the theoretical and technical skills required for CGE modelling. The course caters for three different types of participants:

1. Commissioners of CGE studies – participants who want a sufficient understanding of the strengths and weaknesses of and insights from CGE techniques so that they can commission studies and assess the quality of the outputs from CGE modellers and model users.
2. CGE model users – participants who want to be able to formulate and code appropriate policy experiments and interpret and **explain** the results from CGE based studies and only make 'small' changes to the model's behavioural equations. These participants will, typically, also take the Single Country or Global CGE model course.
3. CGE modellers - participants who want to be able to change and develop the behavioural equations in a model, i.e., generate a new model variant, and formulate and code appropriate policy experiments and interpret and **explain** the results from CGE based studies. These participants will, typically, also take the Single Country or Global CGE model course.

CGE models are **NOT** 'black' boxes': they are mathematical models and hence all model insights are ultimately deterministic. Given an understanding of general equilibrium (GE) microeconomics, and some macroeconomics, and the ability to read a simple programming language, all (well coded) CGE models transparent. GE systems may be complex, just as the world is complex; but an unwillingness to learn enough economics and a 'language' does not make a CGE model a 'black box'. Unfortunately, all too many CGE

practitioners fail to identify the insights derived from CGE models and do not **explain** the results, which encourages the claims that the models are 'black boxes'.

Participants need to have a well-developed background in economics, e.g., a masters, or higher, degree in economics or a closely related subject. The course emphasises an understanding of CGE databases, GAMS coding skills, the formulation of appropriate policy experiments and the interpretation of the results from simulation models, using a mix of video presentations, practical computer exercises and policy analysis exercises. This introductory course is a prerequisite for the Single Country and Global CGE Modelling courses that are offered by CGEMOD; it can also be taken as a standalone course.

The materials are organised in 6 modules with a total of 27 components, each of which requires approximately 3 to 5 hours of input from the participants. The seventh module of the course is a research project that requires about 12 hours of input. Thus, participants should allocate some 120 hours to complete the course.

The course assumes that the participants have an in-depth knowledge of microeconomic theory, especially general equilibrium theory, and an understanding of standard techniques of mathematical economics, especially those relating to differentiation and linear homogenous functions. It is assumed that participants have no prior computer programming experience, but that they do have basic computer skills associated with MS Excel.

The course presumes that participants have completed the pre-courses on 'GAMS and GAMS Studio' and 'Social Accounting Matrices (SAMs)': this course does **not** revisit the materials covered in the pre-courses. Participants should allow at least 2 weeks (part time) to complete the pre-course trainings. The methods used in this course require an understanding of the mechanics of GAMS and GAMS Studio, and an understanding of accounting relationships in Social Accounting Matrices (SAMs).

The course is delivered online from www.cgemod.org.uk\training .

This course does NOT use a GUI (Graphical User Interface) to access GAMS. Experience has demonstrated that the use of GUI's by participants on training programmes typically limits the development of the skills needed to be a good CGE modeller or user of CGE models, while encouraging the belief that CGE models are 'black boxes'. Basic GAMS

programming skills, and an understanding of economic theory, demonstrates that allegations that CGE models are 'black boxes' are false. The development of GAMS, or GEMPACK, programming skills greatly extends the ability of the user to exploit the power of CGE models, and, at the same time, opens up the potential that participants can, in the future, change behavioural relationships in CGE models.

Course Aims and Objectives

Course Aims

To provide a practical introduction to CGE modelling using GAMS so that participants can understand

i) databases used by CGE models;
ii) the properties of behavioural relationships used in CGE models;
iii) the formulation of appropriate CGE policy experiments; and
iv) the results generated by simple CGE models.

Course Objectives

On completion of the course the participants will have the ability to:

i) formulate and code appropriate policy experiments;
ii) modify simple behavioural relationships;
iii) interpret the results from simple CGE models; and
iv) identify and understand the strengths and limitations of CGE models.

Course Models

This course uses three models that have been developed to provide training in CGE theory and techniques. The first model (*clmod*) is a simple closed economy model that converts the simple GE model of textbook economics into a computable GE model; it is inspired by the Shoven and Whaley approach. The second model (*123*) is a variant of the model developed by Sherman Robinson and various collaborators to demonstrate the theoretical and empirical properties of the approach (following Armington) to the modelling of trade in CGE models. The third model (*smod_t*) is a simple single country CGE model consistent with the state-of-the-art CGE models in the late 1990s. The *smod_t* model brings together the behavioural

relationships used in the *clmod* and *123* models. All three models are organised in identical ways and use (largely) common notation and coding techniques.

The STAGE_t and ANARRES_t models, used in the Single country and global model courses, are elaborations of the *smod_t* model.

Pre-Course

Outline

Module B1: GAMS and GAMSIDE

	Topic	Tasks	Exercises
B1:1	Introduction to GAMS and GAMSIDE	Install and configure GAMS/GAMSIDE; Running a Model; Using a model library	Setting options; libraries; utilities; help; search
B1:2	A Transport Problem in GAMS	Understanding a GAMS programme; Reference files; Command line; Running an experiment	running programme; list & log files; ref files; gdx output
B1:3	Debugging a Transport Problem	Resolve syntax & execution errors; DiffText files	Debugging a model
B1:4	Extending a Transport Problem	Adding markets, plants & data	Adding accounts to a model

Readings:

Rosenthal, R.E., (1992). 'A GAMS TUTORIAL', in Brooke, A., Kendrick, D. and Meeraus, A., (1992). *GAMS: A User's Guide*, Scientific Press: San Francisco.

Module B2: Introduction to Social Accounting Matrices

	Topic	Tasks	Exercises
B2:1	What is a SAM?	Structure of a SAM; Contents of a SAM	Converting T-Accounts to a simple SAM
B2:2	Inter industry accounts in a SAM	Supply and Use tables; Input-Output tables	Interpreting the price system in a SAM
B2:3	Analysing a SAM	Interpreting a SAM	Row and column coefficients; interpreting SAMs
B2:4	SAM Multipliers	Income & Price multipliers; Interpreting multipliers	Multipliers; interpreting multipliers
B2:5	Satellite Accounts in a SAM	Adding satellite accounts	Interpreting satellite accounts

Readings:

Pyatt, G. and Round, J.I., (1977). 'Social Accounting Matrices for Development Planning', *Review of Income and Wealth*, 23(4), 339-364.

Stone, R., (1984). 'The Accounts of Society'. *Nobel Prize Memorial Lecture* (http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1984/stone-lecture.pdf)

Round, Jeffery (2003). Constructing SAMs for Development Policy Analysis: Lessons Learned and Challenges Ahead. Economic Systems Research 15 (2): 161-183.

Practical CGE (Online) Course

Module P1: A Simple Closed Economy CGE Model

	Topic	Tasks	Exercises
P1:1	Cobb Douglas Production and Utility Functions	Mathematics of CD functions	Primal & first order conditions; calibrating shift & share parameters
P1:2 & P1:3	Coding Production and Utility functions	Adding production & Utility functions	Coding a basic 2*2*2*2; testing a model
P1:4	Simple CGE experiments	Running experiments; interpreting results	Running experiments; interpreting results
P1:5	Policy Analysis	Impact of changes in the factor supply	Interpreting results

Readings:

Microeconomics theory textbook with detailed treatment of general equilibrium (unfortunately many 'modern' textbooks do not provide comprehensive developments of GE economics), e.g.,

Gravelle, H. and Rees, R., (2004). *Microeconomics*, 3rd edition. Prentice Hall: London. Chapter 12, pp 250 - 278.

Nicholson, W., (1998). *Microeconomic Theory: Basic Principles and Extensions*, 7th Edition. Dryden Press: Fort Worth. Chapter 16, pp 459 – 500.

Shoven, J.B. and Whalley, J., (1984). 'Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey', *Journal of Economic Literature*, Vol 22, pp 1007-1051.

Module P2: A Closed Economy CGE Models

	Topic	Tasks	Exercises
P2:1	Adding Government, Investment & Intermediate inputs	Coding taxes, investment & intermediate inputs; testing a model	Coding an extended 2*2*2*2; testing the model
P2:2	Tax experiments in a closed economy	Coding tax policy experiments	Tax experiments; interpreting results
P2:3	Using LOOPS in GAMS	Running experiments in LOOPS	Experiments in loops; interpreting results
P2:4	Tax experiments and factor market clearing	Coding compound experiments with different macro closures	Coding and interpreting compound experiments
P2:5	Interpreting results	Collecting experiment results	Interpreting results
P2:6	Policy Analysis	Direct vv indirect taxes and alternative macro closure	Interpreting results

Readings:

Microeconomics theory textbook with detailed treatment of general equilibrium (unfortunately many 'modern' textbooks do not provide comprehensive developments of GE economics), e.g.,

Gravelle, H. and Rees, R., (2004). *Microeconomics*, 3rd edition. Prentice Hall: London. Chapter 12, pp 250 - 278.

Nicholson, W., (1998). *Microeconomic Theory: Basic Principles and Extensions*, 7th Edition. Dryden Press: Fort Worth. Chapter 16, pp 459 – 500.

Shoven, J.B. and Whalley, J., (1984). 'Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey', *Journal of Economic Literature*, Vol 22, pp 1007-1051.

Module P3: 1*2*3 (Open Economy) CGE Model

	Topic	Tasks	Exercises
P3:1	CES and CET Functions	Primal & first order conditions;	Simple maths using CES
P3:2	The Basic 1*2*3 model	CES/CET functions in a simple CGE model with trade	Review 1*2*3 model
P3:3	Coding Trade with Imperfect substitution	Coding trade equations; calibrating CES/CET parameters; testing a model; running experiments	Coding import and export equations
P3:4	Understanding CES and CET functions	Role of elasticities in CES/CET functions; Offer curves and 'Dutch' disease	Change world price of imports; sensitivity to CES elasticity. Change trade balance; sensitivity to CES elasticity
P3:5	Understanding CES and CET functions	Role of trade shares in CES/CET functions; Offer curves	Changes to the world price of imports and change trade shares; sensitivity to CES elasticity

Readings:

Armington, P.S., (1969). 'A Theory of Demand for Products Distinguished by Place of Production', *IMF Staff Papers*, Vol 16, pp 159-178.

Benjamin, N., Devarajan, S. and Weiner, R., (1989), 'The 'Dutch' disease in a developing country: Oil reserves in Cameroon,' *Journal of Development Economics,* 30(1): 71–92.

Devarajan, S., Lewis, J.D. and Robinson, S., (1990). 'Policy Lessons from Trade-Focused, Two-Sector Models', *Journal of Policy Modeling*, Vol 12, pp 625-657.

Sen, A.K., (1963). 'Neo-classical and Neo-Keynesian Theories of Distribution', *Economic Record*, Vol 39, pp 53-64.

Module O4: 1*2*3 (Open Economy) CGE Model

	Topic	Tasks	Exercises
P4:1	An extended 1*2*3 Model	Adding government, investment, intermediate inputs and transfers from ROW to the simple 1*2*3 model	Review code with government, investment, intermediate inputs and transfers from ROW
P4:2	Changing country database	Assign a SAM for a different country in the model	Check that the model with new data is properly configured
P4:3a	Analysis of trade policy change	Use Vietnam data/SAM	Develop and implement an experiment file for policy analysis
P4:3b	Analysis of aid reduction	Use Ghana data/SAM	Develop and implement an experiment file for policy analysis

Readings:

Devarajan, S., Lewis, J.D. and Robinson, S., (1990). 'Policy Lessons from Trade-Focused, Two-Sector Models', *Journal of Policy Modeling*, Vol 12, pp 625-657.

Armington, P.S., (1969). 'A Theory of Demand for Products Distinguished by Place of Production', *IMF Staff Papers*, Vol 16, pp 159-178.

Sen, A.K., (1963). 'Neo-classical and Neo-Keynesian Theories of Distribution', *Economic Record*, Vol 39, pp 53-64.

de Melo, Jaime and Robinson, Sherman (1989). Product Differentiation and the Treatment of Foreign Trade in Computable General Equilibrium Models of Small Economies. Journal of International Economics 27 (1-2): 47-67.

Module P5: A Simple CGE Model

	Topic	Tasks	Exercises
P5:1	Linear Expenditure System	The Stone-Geary utility function and the LES	Understanding calibration of LES functions
P5:2	Introduction to smod_t	Model code & structure; data inputs & outputs; testing a model	Setting up and testing a simple CGE model
P5:3	Trade policy experiments	Coding policy experiments; interpreting model results	1. Coding compound experiments 2. Sensitivity to elasticities 3. Coding macroeconomic closures 4. Coding factor market clearing 5. Systematic sensitivity analyses
P5:4	Trade policy	Coding and interpreting results	Coding and interpreting results

Readings:

Pyatt, G., (1987). 'A SAM Approach to Modeling', *Journal of Policy Modeling*, Vol 10, pp 327-352.

Dahl, H., Devarajan, S. and van Wijnbergen, S., (1994). 'Revenue-Neutral Tariff Reform: Theory and an Application to Cameroon', *Economic Studies Quarterly*, Vol 45, pp 213-226.

Robinson, S., Yunez-Naude, A., Hinojosa-Ojeda, R., Lewis, J.D. and Devarajan, S., (1999). 'From Stylised to Applied Models: Building Multisector CGE Models for Policy Analysis', *North America Journal of Economics and Finance*, Vol 10, pp 5-38

Module P6: Introduction to Nested Functions

	Topic	Tasks	Exercises
P6:1	Introduction to nested function	Introduction to nested functions	None
P6:2	Two-Level nest	Code two-level production nest	Coding smod_t2 and running a standard trade policy experiment
P6:3	Three-Level nest	Code three-level production nest	Coding smod_t3 and running a standard trade policy experiment Coding a generalised smod_t3 and running a standard trade policy experiment

Readings:

Perroni, C. and Rutherford, T., (1995).' Regular flexibility of nested CES functions', *European Economic Review* 39 (1995) 335-343

Course Project

The objectives of the project are to develop your ability to (i) set up and implement policy experiments in a small CGE model; and (ii) interpret the results of your policy experiments. There are five elements to the project; model recalibration, experiment programming, policy experiments and interpretation, sensitivity analyses and project report.

The available data are SAMs for (approx.) 15 countries, each of which has 12 commodities and activities, 5 factors, 7 taxes, 3 domestic institutions and 1 (one) rest of the world account.

Your remit is that of an economic consultant who has been employed to analyse policy issues that are relevant and current to your chosen country. You will be required to identify the policy issue, code the policy experiments, interpret and write up the results and conduct sensitivity analyses. The final report will be a maximum of 10 pages including tables and graphs.

	Topic	Tasks	Exercises
O6:1	SMOD Project	The project aims are 1. set up and implement policy experiments in a small CGE model; and 2. interpret the results of your policy experiments.	There are five elements to the project; 1. model recalibration; 2. experiment programming; 3. policy experiments and interpretation; 4. sensitivity analyses; and 5. project report