Practical Global Computable General Equilibrium (CGE) Modelling: Online Course

Introduction

This is a course in practical computable general equilibrium (CGE) global modelling using the General Algebraic Modelling System (GAMS) software with the Global Trade Analysis Project (GTAP) database. The course is designed for individuals who want to develop the theoretical and technical skills required to become users of modern CGE models and/or independent CGE modellers: 'users' are defined as those who want to use existing CGE models for the analysis economic policy options, while 'modellers' are defined as those who want to be develop the skills needed to modify CGE models and be 'users'. The course can also be used by persons who commission projects using CGE models and want to enhance their understanding.

The course emphasises an understanding of the theory of general equilibrium (GE), CGE databases, GAMS coding skills, CGE model coding skills, exponential functional forms, the formulation of appropriate policy experiments and the interpretation of the results from simulation models.

The course is delivered via an electronic learning environment – Moodle. The materials are organised in 10 modules each of which is scheduled for about one week. The course runs over 13 weeks, with a week's 'break' scheduled for week 7: this allows for one week's slippage for the first 5 modules and one week's slippage for the second 5 modules. Support is offered online during weeks 1 to 6 and 8 to 13 (see programme schedule below); by email and, where needed, VOIP/conference call. Participants should plan to allocate up to 20 hours per week to complete the course; little and often has produced better outcomes.

Participants need to have a well-developed background in economics, e.g., a masters, or higher, degree in economics or a closely related subject, with reasonably developed mathematical skills. The course assumes that the participants have in-depth knowledge of, at

least, intermediate microeconomic theory, especially general equilibrium theory, and a reasonable understanding of standard techniques of mathematical economics, especially those relating 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 uses a mix of video presentations (lectures and 'how to' videos), practical computer exercises and policy analyses exercises. The core software for the course is GAMS (www.gams.com), its editor GAMS Studio, and various GAMS utilities; you will need a GAMS license and short-term course licenses will be available. You will need MS Excel and MS Word, or another word processing package, an ability to play MP4 video files, and a reader for PDF files. The GAMS computer codes are platform independent for Windows, Mac OS and LINUX. The course codes were developed using Windows and some testing with Mac OS has been undertaken. Interfacing GAMS with Excel was developed using Windows and some testing with Mac OS has been undertaken; but we cannot guarantee that all the Excel techniques used are available with Mac OS. We do not use LINUX and have not tested the materials using LINUX.

A series of open-source courses are available from www.cgemod.org.uk/training.html). Some are introductions to Social Accounting Matrices and GAMS and GAMS Studio, which are precursors to our courses. Others are more specialist, e.g., 'Recursive Dynamic CGE Modelling for Dummies' and 'SAM Estimation'. These courses are self-directed and unsupported by a tutor.

Participants on this course will be given access to versions of the `STAGE_3` and `ANARRES_3` models. There are no plans to make `STAGE_3` or `ANARRES_3` open source; the distribution of `STAGE_3` and `ANARRES_3` models will be restricted to past participants of the single country and global CGE courses offered by cgemod. They will also be eligible for our 'Recursive Dynamic CGE Modelling Course' (www.cgemod.org.uk/rdyn_cge.html). This course will be offered for a small fee, but will be unsupported by a tutor since the length of the learning curve is indeterminate, and it will ONLY be available to past participants of either our Single Country or Global CGE Modelling courses.

Course Overview

CGE models are essentially systems of behavioural relationships expressed as non-linear and linear simultaneous equations that are derived from Walrasian microeconomics; hence they are firmly grounded in microeconomic theories and the concepts of constrained optimisation. The non-linear equations are almost invariably derived from linear homogenous equations that are linear in logarithms and use standard functional forms, e.g., Cobb-Douglas, Constant Elasticity of Substitution, etc. The databases for all CGE models can be expressed as Social Accounting Matrices (SAM) with satellite accounts; the data for all models used in cgemod courses are SAMs with satellite accounts. Once the principles are understood, SAMs provide a simple way to understand the data used in CGE models and identify the economic transactions that must be included in a CGE model.

This course does not teach ***THE*** model. Rather the courses are designed to aid the development of generic CGE skills. The models used by the course (see below) are designed so that participants can develop CGE skills using progressively more sophisticated models, by starting with the simplest CGE model and subsequently adding more complex behavioural relationships. All the models use the same range of behavioural relationships and functional forms with common notation, so the transition from simple to more complex models involves progressively learning techniques not starting afresh.

The final four modules use a sophisticated 'standard' global CGE model. It is, however, important to appreciate the meaning of 'standard'. We do not advocate that `ANARRES_t` should be used unchanged. Rather we advocate that ALL CGE models should be adjusted to fit the economic circumstances in a country as reflected in the data, i.e., SAM, and that the data should NOT be adjusted to fit a predetermined CGE model.

Course Aims and Objectives

Course Aims

To develop the CGE modelling skills of participants (using GAMS) so they

i) understand the behavioural relationships used in CGE models;
ii) understand the impact of different behavioural relationships used in CGE models;
iii) understand the calibration of the behavioural relationships in CGE models;
iv) can formulate appropriate CGE policy experiments; and
v) can interpret the results generated by global CGE models.

Course Objectives

On completion of the course the participants will be able:

i) formulate and code appropriate policy experiments;
ii) identify and understand the strengths and limitations of CGE models;
iii) make some modifications to behavioural relationships;
iv) interpret the results from global CGE models; and
v) identify, and present, the policy implications of simulations using global CGE models.

Pedagogic Method

The course emphasises the fact that CGE modelling is a practical skill that is best learnt-by-doing. However, it is recognised that developing the skills needed by CGE modellers and users can be daunting, because they require the development of

a) computer programming skills,
b) techniques needed to convert economic theories into computer equations,
c) an understanding of social accounts,
d) meaningful policy experiments, and
e) skills to analyse and interpret large numbers of results.

The pedagogic method adopted is inspired by the KISS – Keep It Simple 'Stupid' – principle, where 'stupid' is understood as saying that not keeping it simple is 'stupid'. Accordingly, the course progressively builds up the required economic theory, computer coding and policy experiment and analysis skills by starting with small and simple models before ending with an advanced, and scalable, CGE model.

Each module in the course builds on skills learnt in previous modules; it is important to complete each module. Each module has a work programme supported by detailed model documents, PowerPoint slides, PowerPoint videos, exercises, and computer code. For each module there are a series of exercises that are guided by detailed instructions: the exercises cover both computer coding exercises and policy experiments and interpretation. Most modules have an associated deliverable, which is typically based on the final exercise of the module.

The methods used in this course require a basic understanding of the mechanics of GAMS, and the programming editor GAMS Studio, and a basic understanding of Social Accounting Matrices (SAMs). Participants are strongly urged to complete, diligently, a series of open source pre course exercises before the course starts (see www.cgemod.org.uk/training.html for details). The pre-course materials also allow potential participants to make a more informed decision before committing to take the course. Two weeks before the course starts, registered participants are provided with two sets of exercises to complete BEFORE the start of the course: the first exercise is on GAMS and GAMS Studio and the second is on SAMs. They are not difficult but are designed to let you assess

your understanding of the pre course materials; participants who do not take the pre course materials seriously often struggle to keep pace with the course.

The course is delivered via an electronic learning environment – Moodle. Moodle provides an environment that allows the delivery of learning materials in a structured and organised manner, and an asynchronous forum in which participants can engage with other participants and with the course tutor. The course tutor is available, by email, to answer specific questions and provide help with problems: questions and requests for advice submitted between 0800 and 1600 UTC will typically be responded to by the end of the next working (Monday to Friday) day, i.e., by 1600 UTC. Most modules ask the participants to submit a deliverable; this allows the tutor to monitor progress and understanding, and to intervene if participants are not understanding concepts and techniques or having difficulties. Feedback is provided for each deliverable.

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 CGE training programmes limits the development of the skills needed to be a good CGE 'modeller' or 'user' of CGE models, while encouraging the fallacy 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 the potential that participants can, in the future, change behavioural relationships in CGE models.

Course Models

This course uses five 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 microeconomics into a computable GE model; it is inspired by the Shoven and Whaley approach and is used in modules O1 and O2 – we allow 3 weeks for these two modules. The second model (`123`) is a variant of a 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 and is used in modules O3 and O4. 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 and is used in module O5 and O6. The `smod_t` model brings together the behavioural relationships used in the `clmod` and `123` models. The fourth model, `anar_t`[1], is a state-of-the-art global CGE model designed for the analyses of a wide range of real-world policy issues and an advanced basis for the further model development; it is used in modules O7 and O10.

All four models are organised in identical ways and use (largely) common notation and coding techniques: different models allow the progressive development of skills.

In our experience most participants who complete the global course have relatively little difficulty in transitioning to our single country model, `STAGE`, because they use the same common notation and coding techniques.

[1] `ANARRES_t` is a development of the `GLOBE_2` model first produced in the early 2000s. It has however been revised, customised, and further developed for this course. `ANARRES_t` is only available to participants of this course and the companion Single Country CGE course.

Timetable

Online courses are run in two cycles – September to December and January/February to April – with recruitment for each course limited to c12 participants. This course will be offered in cycles 1 and 2.

The timetables, with dates, for courses are available at www.cgemod.org.uk/ttable.html

Week	Module	Topic
1	ModO1	Basic Closed Economy Model
2	ModO1/O2	Basic/Closed Economy Model
3	ModO2	Closed Economy Model
4	ModO3	Basic 123 Model
5	ModO4	123 Model
6	ModO5	Simple Open Economy Model
7	Break	
8	ModO6	SMOD_t: nested trade functions
9	ModO7	ANARRES_t Model: Theory
10	ModO8	ANARRES_t Model: Tax Exercises
11	ModO9	ANARRES_t Model: Other Exercises
12	ModO10	Project
13		On-going support

Course Fees

The course fees and conditions are detailed at www.cgemod.org.uk/fees.html

Discounts are offered for participants from developing countries ('Low-income economies' and 'Lower-middle-income economies' as classified by the World Bank) and students. The fees for academics, students and not-for-profit organisations are also discounted.

A limited number of scholarships are available to students from developing countries. Applications for a scholarship must be made at the time of registration; applications must be accompanied by a case for being awarded the scholarship that is not longer than one-side of A4/US letter: a case for an award must be academic and not an ability to pay (the host institutions of students are funded to provide teaching/training). Applicants must be registered at a degree awarding institution, correspond from an academic email address, and provide confirmation of their status from an academic advisor. Applications that do NOT meet all these conditions will not be considered or responded to.

Registration

Registration is online at www.cgemod.org.uk/regist.html

Further Information and registration

For further information please contact Dr Scott McDonald

Email: scott@cgemod.org.uk

Pre-Course

Module P1: GAMS and GAMS Studio

	Topic	Tasks	Exercises
P1:1	Introduction to GAMS and GAMS Studio	Install and configure GAMS/GAMS Studio; Running a Model; Using a model library	Setting options; libraries; utilities; help; search
P1:2	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
P1:3	Debugging a Transport Problem	Resolve syntax & execution errors	Debugging a model
P1:4	Extending a Transport Problem	Adding markets, plants & data	Adding accounts to a model

Module P2: Introduction to Social Accounting Matrices

	Topic	Tasks	Exercises
P2:1	What is a SAM?	Structure of a SAM; Contents of a SAM	Converting T-Accounts to a simple SAM
P2:2	Inter industry accounts in a SAM	Supply and Use tables; Input-Output tables	Interpreting the price system in a SAM
P2:3	Analysing a SAM	Interpreting a SAM	Row and column coefficients; interpreting SAMs
P2:4	SAM Multipliers	Income & Price multipliers; Interpreting multipliers	Multipliers; interpreting multipliers
P2:5	Satellite Accounts in a SAM	Adding satellite accounts	Interpreting satellite accounts

Practical Single Country CGE (Online) Course

Module O1: A Simple Closed Economy CGE Model

	Topic	Tasks	Exercises
O1:1	Cobb Douglas Production and Utility Functions	Mathematics of CD functions	Primal & first order conditions; calibrating shift & share parameters
O1:2 & O1:3	Coding Production and Utility functions	Adding production & Utility functions	Coding a basic 2*2*2*2; testing a model
O1:4	Simple CGE experiments	Running experiments; interpreting results	Running experiments; interpreting results
O1:5	Policy Analysis	Impact of changes in the factor supply	Interpreting results

Module O2: A Closed Economy CGE Models

	Topic	Tasks	Exercises
O2:1	Adding Government, Investment & Intermediate inputs	Coding taxes, investment & intermediate inputs; testing a model	Coding an extended 2*2*2*2; testing the model
O2:2	Tax experiments in a closed economy	Coding tax policy experiments	Tax experiments; interpreting results
O2:3	Using LOOPS in GAMS	Running experiments in LOOPS	Experiments in loops; interpreting results
O2:4	Tax experiments and factor market clearing	Coding compound experiments with different macro closures	Coding and interpreting compound experiments
O2:5	Collecting and interpreting results	Collecting results from experiments	Collecting and interpreting results
O2:6	Policy Analysis	Direct vv indirect taxes and alternative macro closure	Interpreting results

Module O3: 1*2*3 (Open Economy) CGE Model

	Topic	Tasks	Exercises
O3:1	CES and CET Functions	Primal & first order conditions;	Simple maths using CES
O3:2	The Basic 1*2*3 model	CES/CET functions in a simple CGE model with trade	Review 1*2*3 model
O3:3	Coding Trade with Imperfect substitution	Coding trade equations; calibrating CES/CET parameters; testing a model; running experiments	Coding import and export equations
O3:4	Understanding CES and CET functions 1	Role of elasticities in CES/CET functions;	Change world price of imports; sensitivity to CES elasticity
O3:5	Understanding CES and CET functions 2	Dutch disease	Change trade balance; sensitivity to CES elasticity
O3:6	Understanding CES and CET functions 3	Role of trade shares in CES/CET functions; Offer curves	Changes to the world prices sensitivity to CES elasticity

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

	Topic	Tasks	Exercises
O4:1	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
O4:2	Changing country database	Assign a SAM for a different country in the model	Check that the model with new data is properly configured
O4:3	Analysis of trade policy change	Use Vietnam data/SAM	Develop and implement an experiment file for policy analysis
O4:4	Analysis of aid reduction	Use Ghana data/SAM	Develop and implement an experiment file for policy analysis

Module O5: A Simple CGE Model

	Topic	Tasks	Exercises
O5:1	Introduction to SMOD	Model code & structure; data inputs & outputs; testing a model	Setting up and testing a simple CGE model
O5.2	Production functions	Coding a CES production function	
O5.3	Utility function	Coding a LES utility function	
O5:4	Trade policy experiments 1	Coding policy experiments; interpreting model results	Coding and interpreting compound experiments
O5:5	Trade policy experiments 2	Coding macroeconomic closures; interpreting model results	Coding and interpreting results
O5:6	Trade policy experiments 3	Coding factor market clearing; interpreting model results	Coding and interpreting results
O5:7	Trade policy experiments 4	Sensitivity analyses	Interpreting results from sensitivity analyses

Module O6: Nested CES Functions (smod_t): Theory and Coding

	Topic	Tasks	Exercises
O6:1	Introduction to Regular Nested CES functions	Review the theory	None
O6:2	Prices and accounting relationships	Understand the relationship between data in the SAM and nested prices in the model.	Calculating nested prices & accounting matrices (Deliverable O6.1)
O6.3	Nested CES Functions	Adding a CES and CET nests for trade	Ex 6.2: Nested Trade Functions
06.4	Trade policies	Trade policies with multiple trade partners	Ex 6.3 Factor Market Clearing

Programme Module O11: ANARRES_t: Theory and Coding

	Topic	Tasks	Exercises
O11:1	Intro to anar_t	Understanding the structure of the anar_t model	Ex 11.1: Run model setup and check solution
O11:2	Trade in anar_t	The modelling of trade relationships in a global model	No exercises
O11:3	FTA Exercise	Code trade liberalization simulations; results in GDX with Studio.	Ex 11.3: Trade Policy - OECD and Africa form an FTA
O11:4	Production and Demand in anar_t	The modelling of production and demand relationships in a global model.	Ex 11.4: Model Results in GDX
O11.5	Loading anar_t data	Using $SETGLOBAL	Ex 11.5: Load data and check calibration
O11:6	Prices, Taxes and Accounting in anar_t	The modelling of price and tax relationships in a global model	Ex 11.6: Calculating trade prices for a region **Deliverable O11**

Programme Module O12: ANARRES_t Model Exercises

	Topic	Tasks	Exercises
O12:1	Introduction to the anar_t Database	Understanding the structure of the database	No exercises
O12:2	Configuring the anar_t Model	Understanding the structure of, and data used in, anar_t; use of model control	Ex 12.2: Model setup and calibration
O12:3	Macroeconomic Closure Conditions	Code alternative macroeconomic closures; loop over sim and clos	Ex 12:3: Trade policy and macroeconomic closures
O12:4	Factor Market Clearing Conditions	Code alternative factor market clearing conditions; loop over sim and clos	Ex 12.4: Trade policy and factor market specification
O12:5	Sensitivity Analyses	Analysing an Africa OECD FTA	Ex 12.5: Sensitivity analyses
O12:6	Analysis of FTA Results	Coding sims and clos for FTA analysis described in the deliverable.	Deliverable O12

Programme Module O13: Interpreting ANARRES_t Model Results

	Topic	Tasks	Exercises
	Topic	**Tasks**	**Exercises**
O13:1	Analysing and Reporting Results	Appreciating the formulation, interpretation, and presentation of policy experiments	No exercises
O13:2	Interpreting Model Results (I)	Analysing an OECD Africa free trade agreement (FTA)	Ex 13.2: Interpreting Model Results I: Trade Policy **Deliverable O13.2** (in the Exercise document)
O13:3	Interpreting Model Results (II)	Analysing efficiency gains in a global context	Ex 13.3: Interpreting Model Results II: Competitiveness Shocks **Deliverable O13.3** (in the Exercise document)

Module O14: Course Project

The objectives of the project are to develop your ability to (i) set up and implement policy experiments in a 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 database provided is a variant of the GTAP 9 database: you choose the aggregation subject to minor constraints.[1]

This part of the course not only synthesizes the coding skills you have developed in the previous exercises, but also helps develop your ability to set up a database for a model. The emphasis is on interpreting results, particularly in the context of the structure of the economy. The policy simulations, closure assumptions and sensitivity analysis conducted are not prescribed. Instead, you must design the simulation to answer a policy question.

You are an economic consultant hired to analyse policy issues that are relevant and current to your chosen aggregation. The final report will be a maximum of 10 pages.

	Topic	Tasks	Exercises
O14:1	anar_t Project Proposal	Develop your project proposal which includes the backstory, aggregation and experiments	Ex 14.1: Backstory and proposal **Deliverable O14.1:** Project proposal
O14:2	anar_t Project Data	Aggregate the course database to a specification appropriate for your policy question	Generate the project database
O14:3	anar_t Project Model	Run the anar_t model with your aggregation	Set up the project model's database
O14:4	anar_t Project Analysis	Set up and implement policy experiments in the anar_t model; interpret the results of your policy experiments	Run the anar_t model with your policy experiments. **Deliverable O14.4:** Project Report (in the Course Project document)

[1] These include a requirement that participants who work in the same team must choose different aggregations, and a range of aggregations must be covered (preferences will be accepted on a first come first chosen basis).