Practical Single Country Computable General Equilibrium (CGE) Modelling: Online Course

"All models are approximations. Essentially, all models are wrong, but some are useful"
(G Box)

Introduction

This course is an **advanced** course in practical computable general equilibrium (CGE) modelling for a single country 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 two different types of participants:

1. 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, take the Single Country or Global CGE model course.
2. 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 often take both the Single Country and Global CGE model course.
3. CGE modellers and model users - participants taking either or both the Single Country or Global CGE model courses as preparation for taking the Recursive Dynamic CGE Course.

The course is designed to provide training for those persons that have **completed** the Introduction to Practical CGE Modelling course (http://www.cgemod.org.uk/practical.html). This course assumes that you have completed the introductory course and does not provide

recaps. If you have **not** completed the introductory course, you will find there are substantial parts of this course that may be opaque and/or confusing.

PLEASE DO NOT COMPLAIN TO US ABOUT THIS DESIGN FEATURE.

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'.

But CGE models are approximations. Moreover, CGE models are numerical theoretical models that depend on deductive logic, in contrast to econometric models that employ inductive logic. Consequently, CGE models are, and never can be, forecasting models. Rather CGE models are designed to run experiments that can be used to better inform policy makers about the potential consequences of decisions. Hence CGE modellers are well advised to avoid over stating the precision of the results from CGE models.

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

The materials are organised in 4 modules with a total of 19 components, each of which requires approximately 4 to 6 hours of input from the participants. The final module of the course is a research project that requires about 12-18 hours of input. Thus, participants should allocate some 120-180 hours to complete the course.

The course assumes that the participants have completed the Introduction to Practical CGE course (http://www.cgemod.org.uk/practical.html) and 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 presumed that participants have completed the courses on 'GAMS and GAMS Studio' (http://www.cgemod.org.uk/gams_studio.html), 'Social Accounting Matrices (SAMs)' (http://www.cgemod.org.uk/int_sam.html) and 'Introduction to Practical CGE Modelling course' (http://www.cgemod.org.uk/practical.html). This course does **not** revisit the materials covered in those courses. Participants should expect the GAMS/GAMS Studio course to take 20-40 hours, SAM course to take 10-20 hours and Introduction to CGE course to take 160-240 hours. The methods used in this course require an understanding of the mechanics of GAMS and GAMS Studio, an understanding of accounting relationships in Social Accounting Matrices (SAMs) and an understanding of the basic principles of CGE modelling in GAMS.

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

Software

The course use GAMS and assumes that participants use GAMS Studio as the editor; the version of GAMS should be 49 or higher[1]. Participants need a licensed version of GAMS (https://www.gams.com/download/) with license for at least the Base Module and the PATH solver (the CONOPT solver is also advised but not essential). The demonstration license is **NOT** adequate for this course. Participants on the course need to make their own arrangements to access a licenced copy of the GAMS software.

The materials were developed in a MS Windows environment. While GAMS and Studio are also available in MacOS and LINUX variants, we cannot guarantee that all the techniques used are available in the Mac and LINUX environments.

It is assumed that participants have access to readers for pdf and mp4 files, and word processing and spreadsheet programmes (we use MS Office, but other programmes may be adequate).

This course does NOT use a GUI (Graphical User Interface) to access GAMS. Experience has demonstrated that the use of a GUI by participants on training programmes

[1] The current version of the course was last tested with GAMS 51.2 and Studio 1.22.2. Some of the details in the exercise documents may be not be correct for earlier versions of GAMS or Studio.

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 the potential that participants can, in the future, change behavioural relationships in CGE models.

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, especially the determinants of prices, 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.

CGE models, as are arguably all economic models, are underdetermined systems in the sense that there are more variables than equations. To bridge this gap CGE models require the specification of market clearing conditions, for all markets but most importantly for factor markets., and macroeconomic closure conditions. The macroeconomic closure conditions require that CGE modellers understand the implications of different macroeconomic closure assumptions and their relationships with different 'schools' of macroeconomic thought.

This course does not teach ***THE*** model. Rather our 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.

We do not advocate that `STAGE_t` should be used unchanged. It is designed as a 'standard' model that **SHOULD** be used to develop models suited to specific studies. We strongly 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 **NEVER** 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 single country 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 single country CGE models; and
v) identify, and present, the policy implications of simulations using single country 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 assume participants have completed the Introduction to Practical CGE course (http://www.cgemod.org.uk/practical.html).

While all too often CGE modellers regard data as a 'tedious distraction from the more important work of modelling' we strongly disagree.[1] We recommend continuous enhancement of your understanding of the potential for developing Social Accounting Matrices (SAMs) to better reflect economic systems.

The course is delivered from the cgemod website (www.cgemod.org.uk) and is not supported by a tutor.

However, if you find errors in the material and/or suggestions for improvements, we are grateful for feedback.

[1] The economic realities of different economies are different. You should regard SAMs that adopt the same account structure for commodities, activities, institutions, taxes and factor types for different economies with extreme scepticism.

Course Models

This course uses one 'standard' model, `stg_t`[1], which is, c 2010, a state-of-the-art CGE model designed for the analyses of a wide range of real-world policy issues. It is a 'standard' model in the sense that is provides an advanced basis for the further model development; not in the sense that is one size that fits all.

The STAGE_t model is a derivative of the smod_t model. It is organised in an identical way and uses (largely) common notation and coding techniques: it is however a step change from the smod_t.

1 `STAGE_t` is a development of the `STAGE_2` model first produced in the early 2000s. It has however been revised, customised, and further developed for this course.

Practical Single Country CGE (Online) Course

Module S1: STAGE_t: Theory and Coding

	Topic	Tasks	Exercises
S1:1	Intro to STAGE_t	Set up the course library	Ex S1:1 Set up the course library
S1:2	Tax Instrument in stg_t	Review stg_t and checking stg_t calibrates correctly	Ex S1:2 Review the Model stg_t
S1:3	Prices & accounting relationships: stg_t	Code trade liberalisation with simulations is Loop	Ex S1:3 Trade Policy: Ad Valorem Tariff Changes
S1:4	Production in stg_t	Using SETGLOBAL and post simulation analyses files	Ex S1:4 Accessing Model Results
S1:5	Final demand in stg_t	Using Save and Restart feature	Ex S1:5 Using Save and Restart
S1:6	Macroeconomic closures in stg_t	Code alternative macroeconomic closures; loop over sim, clos,	Ex S1:6 Trade Policy and Tax Replacement
S1:7	Exercise S1	Exploring implications of different tax replacement instruments	Ex S1:7 Exercise S1: Interpreting model results

Module S2: STAGE_t CGE Model: Tax Exercises

	Topic	Tasks	Exercises
S2:1	Price and Accounting Relationships	Setting up the model	Ex S2:0 Model Setup Ex S2:1 Factor Market Clearing
S2:2	Factor supply and demand	Factor input subsidies	Ex S2:1 Factor Input Subsidies
S2:3	Factor Market clearing	Factor input subsidies & factor market clearing	Ex S2:2 Factor Market Clearing
S2:4	Trade in STAGE_t & Sensitivity analyses 2	Trade and Sensitivity analyses	Ex S2:3 Trade Policy and Sensitivity Analysis
S2:5	Sensitivity analyses 2	Production and Sensitivity analyses	Ex S2:4 Factor Input Subsidies and Production Elasticities
S2:6	Additional options in STAGE_t	Adjusting model features	Ex S2:5 Model Setup & Calibration: Extra Options
S2:7	Changing model behaviour	Replacing an ad valorem tax with specific tax	Ex S2:6 Adding a Specific Tax Instrument
S2:8	Exercise S2	Factor subsidies and sensitivity analyses	Ex S2:7 Exercise S2 Sensitivity Analysis

Module S3: STAGE_t CGE Model: Factor Exercises

	Topic	Tasks	Exercises
S3:1	Analysing and reporting results	Appreciating the formulation, interpretation, and presentation of policy experiments	No exercises
S3:2	Interpreting model results (I)	Trade liberalisation by RSA	Interpreting trade liberalisation experiments for RSA (**Project S3.2**)
S3:3	Interpreting model results (II)	Changes in World prices	Interpreting world price experiments for RSA (**Project S3.3**)

Module S4: 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 has databases for 10 countries: you choose the country subject to minor constraints.

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 country. The final report will be a maximum of 10 pages.

	Topic	**Tasks**	**Exercises**
S4:1	STAGE_t project	The project aims are 1. set up and implement policy experiments in the stg_t CGE model; & 2. interpret the results of your policy experiments	There are seven elements to the project; 1. choose country and write-up the 'backstory' 2. Setup the model's Excel database 3. model recalibration and testing; 4. experiment programming; 5. policy experiments and interpretation; 6. sensitivity analyses; and 7. project report (**Project S4**)