Global CGE Modelling Course: ANARRES_t Exercises Module G2

cgemod

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1. Introduction

These exercises continue an introduction to ANARRES_t. The exercises use a very aggregated database (4 commodities/activities, 4 factors and 3 regions), however the model code could be used for most aggregations[1] of the GTAP database that was structured to be consistent with the model (`anar_t`). The documentation for these exercises becomes progressively less prescriptive as you progress through them: it is assumed that (i) you will be becoming more independent and (ii) increasingly you will be adopting your own methods. During the course, however, we encourage you to stay close to our methods since it makes communication between us easier and avoids confusion if we need to provide more help. The exercises detailed in this part of the ANARRES_t programme cover the materials covered in module O12.

The next exercise (G2.1) is concerned with setting up and calibrating a version of ANARRES_t, i.e., setting up the model using a new database. The next three exercises are concerned with various dimensions of sensitivity analyses and extend the techniques developed in the Practical CGE Modelling Course. Exercise G2.2 introduces changes in the macroeconomic closure conditions and explores how different closures impact on the results. This is followed by introducing changes in the (factor) market clearing conditions and explores how different clearing conditions impact on the results (G2.3).[2] The final exercise (G2.4) in this part considers the sensitivity of the results to changes in the various elasticities used in the model: this issue is that most often known as sensitivity analyses, but we suggest that evaluating the impact of choices about macroeconomic closures and factor market clearing conditions is an important component of sensitivity analyses.[3]

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1 The limitations arise because of (i) many regions and accounts per region can render the model intractable due to, *inter alia*, solver issues and (ii) potential constraints imposed by the scaling of transactions across regions 'large' and 'small' causing problems with 'small' shares.

2 It is common practices to refer to macroeconomic closure and factor market clearing conditions under the collective title of closures. These courses distinguish between the two sets of conditions since macroeconomic closures conditions are essentially derived from macroeconomic considerations while factor market clearing conditions are microeconomic.

3 It is an implicit argument that too many analysts hold to rigid opinions about macroeconomic closure conditions, e.g., Keynesian, New Classical, etc., and therefore assert that only one set of macroeconomic closure conditions are valid. The approach here asserts that users should test the extent to which their macroeconomic 'world' view is a critical determinant of the results produced. The same argument can be extended to factor market clearing conditions.

The exercises for module Mod G2 use the same (highly) aggregated database as for Mod G1; all the techniques explored are scalable and there are no real benefits from using a larger database. Moreover, it has the benefit of making data handling and interpretation more tractable. The next set of exercises, those relating to module G3, will progress towards using a larger database, which allows the progressive development of the ability to interpret model results using ever more sophisticated analyses without needing to revisit the issues associated with the interpretation of the basic policy shocks. The data and model calibration, policy shocks, sensitivity analyses and save and restart facility will be used in exercise G3.1 – 'Interpreting Model Results I', and in exercise G3.2 – 'Interpreting Model Results II' – that also requires changes in the base data and policy shocks.

The final set of exercises, G4, are the course project. This uses an aggregation of the GTAP 8 database (we can only release 'out-of-date' copies GTAP data under GTAP's license conditions) that you determine, within limits, to examine your own choice of policy simulations. The project requires users to draw on lessons learned in previous exercises.

2. Ex G2.1 Model Setup and Calibration

There are several options to control features of the model. This exercise is an introduction to the control options and model set up features. It focuses on changes in elasticities. Elasticities can either be read from the GTAP database or can be assigned by the user.

This exercise is concerned with the processes that need to be completed when setting up and calibrating a global CGE model. The processes used by the ANARRES model are largely generic, i.e., would need to be undertaken for any global CGE model, although some are specific to the ANARRES model.

1. We will work in a new directory `C:\cgemod\anar_t\anar_t2`. (We could have used the same directory as used for module G1, but this option reduces the risk of overwriting and/or deleting files that you may wish to retain.)
2. In the directory `anar_t`, create a subdirectory `anar_t2`, `C:\cgemod\anar_t\anar_t2`.
3. Open GAMS Studio and select `File>New Project` , find the subdirectory `anar_t2` and create a new project – we suggest calling the project `anar_t2`.
4. In GAMS Studio press `F6` and in the Model Library Explorer then select the tab `Global CGE Course Library` and select and double click `anar_t2`, which is SeqNr: 02. This will add the files `anar_t.gms, anar_t_expt.gms, clean_anar.dat` and `anar_t_G2.zip` to your working directory. Unzip the file `anar_t_G2.zip` into the directory `C:\cgemod\anar_t\anar_t2`.
5. Rerun the base model, `anar_t.gms`, using `s=save` and then run the experiment file, `anar_t_expt.gms` using `r=save`, making sure they are configured to run with the same data as used for Ex G1.3 and G1.4. Our solution files for Ex G1.2/3/4, `4_expts\anar_t_expt_G1_2_sol.inc` and `1_2_Expt_data\data_anar_t_expt_G1_2_sol.xlsx`, will be in the working directory.

6. We want to modify the elasticities used by the model to conduct the FTA experiment used in exercises G1.2, G1.3 and G1.4.[1]
7. The percentage changes in imports by trade partners following a change in tariffs depend, in part, on the elasticity of substitution between imports and domestic goods and the elasticity of substitution between imports from different source regions. One option is to use elasticities reported in the GTAP database; alternatively, you the researcher, can assign the elasticities. In Excel, open the file, `data_4_4_3_anar_t_8_G1_1.xlsx` and review the tab "`controls`". The control for Armington elasticities, "`armelast`" = 1 and the control for the CET elasticities, "`cetelast`" = 1. This means the values for the elasticities are assigned in the Excel workbook; see the tabs "`comelastm`", "`comelastrm`", "`comelaste`", "`comelastre`".
8. You need to understand how the model assigns these elasticities; this is not straightforward since you need to know that you are looking for assignment statements that are set by the user through the model controls. (One cost of flexibility is that understanding how the process works does require learning about a model so that you can direct your searches.)
    a. Alternative 1: Search for `mod_cont` in the reference file and then step through the places in the model where `mod_cont` is referenced. The first case you are interested in is `cetelast`.
    b. Alternative 2: from the equation `CET(c,r)` in `anar_t.gms` the elasticity parameter is `rhot` and hence it can be deduced that by finding where `rhot` is assigned it is possible to work backwards, using the reference file, to how the elasticity is assigned. NB: you will need two searches from the reference file.

[1] For clarity: it is our opinion that the elasticities published by GTAP and used in the 'standard' GTAP model are inappropriate. First, the import elasticities are far too large; this is to reduce the magnitudes of the terms of trade produced because the model assumes that domestic and export goods are homogenous. Second, the assumptions that elasticities are invariant with respect to region requires the presumption that all economies are equally responsive to changes in relative prices; this is regarded as illogical. Third, when aggregating regions and section the GTAPAgg programme assumes that global value share weights should be used; it is argued that this assumption is illogical and simply reproduces the second issue above. (The resetting of the GTAP model to include regions specific indices on elasticities partially addresses these issues, but this change is not (yet) reflected in the GTAP database or GTAPAgg.

c. Alternative 3: you could search for `cetelast` in the file `anar_t_parmcalib.inc`, but this requires you knowing that this is a parameter calibration issue and that the element is called `cetelast`.

9. To verify that the user assigned Armington and CET elasticities are used, review the values for `rhoc, rhom, rhot, rhoe`. Verify that these values are consistent with the values in Excel.
10. Rather than using assigned elasticities, you can use the elasticity values that are aggregated from the GTAP database. In Studio open the file `anar_t.gdx` and review `ELASTMG(c,r)` and `ELASTRMG(c,r)` – these are the Armington elasticities aggregated from the GTAP database. (These data are also in the file `samg_4_4_3_anar_t_8.gdx`, see the parameters `esubd2` and `esubm2`).
11. The values for the elasticities for Armington CES over regions (see `ELASTRMG(c,r)`) are high[1]. One option is to scale them. In the file `data_4_4_3_anar_t_8_G1_1.xlsx` open the sheet "`controls`". Turn on the GTAP elasticities by setting `armelast = 2` and scale the GTAP elasticities by setting `armscal = 2`. And save as `data_4_4_3_anar_t_8_G2_1.xlsx`
12. Save the Excel file and rerun the model `anar_t.gms`, using the revised model data file, with `s=save` in the command line. Verify that the intended elasticity values have been loaded into the model and check the model has run correctly.
13. We will use the FTA trade simulations from exercise 11 to focus on changes in model setup and calibration.
14. Use `Open in a New Project` to open the file `anar_t_expt.gms`. Use the experiment file `anar_t_expt_G1_2_sol.inc` and the experiment data file `data_anar_t_expt_G1_2_sol(.xlsx)`.
15. Run the experiment file, `anar_t_expt.gms`, with `r=save` in the command line. Verify that the intended number of simulations have been run.
16. Compare the results with those reported for Africa as part of the Project G1.2.

Why do the results differ when we use GTAP elasticities?

[1] GTAP needs to use 'high' elasticities for imports because the demand for exports from region *s*(ource) to region *d*(estination) is solely driven by the demand for imports by *d* from *s*, i.e., region *s* does not respond to changes in the export price relative to the domestic price (GTAP does not include a CET relationship for exports). Without 'high' elasticities the GTAP model produces unacceptably large terms of trade effects.

3. Ex G2.2 Trade Policy and Macroeconomic Closures

This exercise introduces changes in the macroeconomic closure conditions and explores how different closures impact on the results. The settings for macroeconomic closures are often contentious because they reflect views about how macroeconomic relationships, which are (largely) exogenously determined, are reflected in a Walrasian CGE model. As such they open the possibility for disputes like those found in the macroeconomics literature between, inter alia, the monetarists, Keynesian, new-classical, neo-Keynesian etc., schools of thought. Models in the ANARRES and STAGE families adopt an agnostic approach to macroeconomic closures: 'closure conditions are a mathematic necessity, but users should be able to impose their own views about macroeconomic relationships'.

Sensitivity with Respect to the Macroeconomic Closures

The objective in this exercise (G2.2) is to run the model with a series of different macroeconomic closures. The objective is to run each experiment/simulation with multiple different macroeconomic closures and to collect the results in a series of GDX files. This will be done by running the macroeconomic closures in a loop.

To achieve the objective, it is necessary to change whether selected variables are defined as endogenous variables, i.e., variables solved by the model, or exogenous variables, i.e., variables that are fixed, when different solve statements are implemented. There are various ways this could be achieved in the code, but all require that four steps are completed:

1. set the `var.L` values equal to the initial values (this helps the solvers, which can be important with 'large' models);
2. free ALL variables that are involved in the closure files (this ensures that exogenous variables that are fixed in a previous set of macroeconomic closures can be endogenous variables in another closure);
3. define the settings for the next macroeconomic closure; and
4. assign elements to the set `clos` that will control the closure loop.

The method used in this course is designed with robustness as a key principle. Rather than making piecemeal changes to the individual variables, all the variables are reinitialized,

all variables in the closure files are made free and then selected variables are fixed for the next closure.

The discussion below will go through each of the key elements: System of LOOPS, Reinitialising Variables, Resetting Endogenous and Exogenous Variables and then develop a series of different macroeconomic closures. The closures reviewed will not be exhaustive, but rather are designed to illustrate some of the possibilities.

Loading and Checking the Model Files

This element of the exercise concentrates on setting up the version of the model that will be used for this series of exercises and testing that it is running correctly. We will be using the same models, `anar_t.gms` and `anar_t_expt.gms`, as for exercises G1.1, G1.2, G1.3 and G1.4. **All** the files are already in your working directory (`anar_t2`).

1. Open GAMS Studio and open `anar_t.gms`, in a new project, from the working directory `C:\cgemod\anar_t\anar_t2`.
2. Verify that the model runs correctly. And then run the model with `s=save` in the command line.
3. Open GAMS Studio and open `anar_t_expt.gms`, in a new project, from the working directory `C:\cgemod\anar_t\anar_t2`.
4. Open the experiment file `anar_t_expt_G1_2_sol.inc` and the experiment data file `data_anar_t_expt_G1_2_sol.xlsx`.
5. Assign these files as the experiment files in `anar_t_expt.gms`; add `r=save` to the command line and run the experiments.
6. Verify that the results are the same as those achieved with Exercise G1.

For exercises G1.2 to G1.4 the experiment file was written so that the macroeconomic closure and factor market clearing conditions were those set in the `anar_t.gms` file. These can be examined in the file `anar_t_cl_base.inc`.

We now need to extend the experiment file so that we can run the same experiments with multiple different macroeconomic closure and factor market clearing settings.

System of LOOPS

A system of LOOPS was encountered in the Practical CGE course with the `123` and `smod_t` models. The principles of the system used here are the same; the differences are those that make the system more general.

The simulations are implemented in the 'inner' LOOP, which is controlled by the set `simc(sim)`, where the use of `simc` allows the user to implement only a subset of the possible simulations, `sim`. The 'middle' LOOP, which will be controlled by the set `clos`, is where the different macroeconomic closures and factor market clearing options are implemented - factor market clearing options are explored in the next exercise (Ex 12.3). And finally, the 'outer' LOOP, which will be controlled by the set `elst`, is where the sensitivity of model results to variations in exogenous parameters are explored – sensitivity analyses with respect to exogenous parameters is explored in exercise Ex 12.4.

Extend the experiment file code to include a system of three LOOPS

1. Open the file `anar_t_expt_G1_2_sol.inc` and save it as `anar_t_expt_G2_2_***.inc`
2. Immediately above the sim LOOP command add two additional LOOP commands – `LOOP(elst,` and then `LOOP(clos,`
3. Then after the termination of the sim LOOP - `) ;` - at the end of the file add commands to close the closure and elasticity LOOPS. (See Figure G2.2.1)
4. It is now necessary to declare and assign the sets `clos` and `elst` that will control the LOOPS. They are already declared but will need assigning.
5. Open the workbook `data_anar_t_expt_G1_2_sol.xlsx`, and save it with a name that links it to this exercise, e.g., `data_anar_t_expt_G2_2_***.xlsx`.
6. Go to the worksheet `simset` and add columns for the sets `clos` (3 columns – `clos` in `col G`, parameter value in `col H`, and description in `col I`) and `elst` (two columns - `elst` in `col L`, description in `col M`). Call the first element in the column for `clos` `clbase` and the first element in the column for `elst` `elstbase`. Add `'1'` as the first element in the column for '`parameter value`' (the role of the parameter value will be explained below). (see Figure G2.2.2)
7. The layout worksheet now needs to be extended so `GDXRRW` knows where to find the information. Add three rows (see Figure G2.2.3).

```
a. dset      clos      simsets!G5     1
b. dset      elst      simsets!K5     1
c. par       closure   simsets!G5     1
```

8. Return to the file `anar_t_expt.gms` . Change the text associated with `res_dimen` from `sim` to `elst,clos,sim`.
9. Make sure that a `trade` folder is included in the results folder, i.e., `6_results\trade`.
10. Rerun the experiment with `r=save` in the command line.
11. Examine the results files in `6_results\trade`. You will find that two additional dimensions have been added to each of the results parameters, but each dimension only has a single member.
12. Explore the files `5_analysis\anar_t_resparm.inc`, `5_analysis\anar_t_resassign.inc`, and, say, `5_analysis\anar_t_resperc.inc`. Work out how the system for declaring, assigning and using variable results has been modified to extend the range of information recorded.

Figure G2.2.1 Code for Model Experiment `anar_t_expt_G2_2_***.inc`

```
* ------- 4. Running the experiments -------------------------------------
* ------- 4a. elst loop begins -------------------------------------------
LOOP(elst,
* ------- 4b. clos loop begins -------------------------------------------
LOOP(clos,
* ------- 4c. sim loop begins --------------------------------------------
LOOP(simc(sim),
* ------- 4d. Implementing sim shocks ------------------------------------
……..
* ------- 5. Solve statement ---------------------------------------------
 OPTION DECIMALS = 6 ;
 Options limrow=100,limcol=0;
Solve anar_t Using MCP ;
* ------- 6. Storing results ---------------------------------------------
* Assigning levels results to the result parameters for all variables
$INCLUDE anar_t_resassign.inc
* ------- 7a. Terminating sim loop ---------------------------------------
```

```
 ) ;
* ------- 7b. Terminating clos loop ---------------------------------------
 ) ;
* ------- 7c. Terminating elst loop ---------------------------------------
 ) ;
.....
```

Figure G2.2.2 Worksheet 'simset' in `data_anar_t_expt_G2_2_sol.xlsx`

	G	H	I	J	K	L
	Closures set				**Elasticities set**	
	clos	**Parameter value**	**(description)**		**elst**	**(description)**
	clbase	1	Base closure		elstbase	base elasticities
	cl_tax_tyh	2	Tax replacement tyh			
	cl_tyh_investfx	3	Tax replace tyh invest FX			
	cl_tyh_investfx_ERfx	4	ER fx Tax replace tyh invest FX			

Figure G2.2.3 Worksheet 'layout' in `data_anar_t_expt_G2_2_sol.xlsx`

	A	B	C	D	E	F	G
1	**LAYOUT**						
2							
3	**Data Type**	**Name**	**Location**	**Row dimen**	**Column din**	**Total dimension**	
4				rdim	cdim	dim	
5							
6	dset	sim	simsets!A5	1			
7	dset	simc	simsets!D5	1			
8	dset	clos	simsets!G5	1			
9	dset	elst	simsets!K5	1			
10	par	closure	simsets!G5	1			
11	dset	rerfx	clsets!A5	1			
12	dset	rsavfx	clsets!D5	1			
13	dset	rinvshfx	clsets!G5	1			
14	dset	riadjfx	clsets!J5	1			
15	dset	rkapgfx	clsets!M5	1			
16	dset	rluen	clsets!P5	1			
17	dset	rfta	expsets!A5	1			
18	dset	wfta	expsets!D5	1			
19	dset	rcons	res_controls!A7	1			
20	par	res_cont	res_controls!A7	1			
21							

Implementing Macroeconomic Closure Changes

Extending the experiment file to include a system of LOOPS requires several steps: first, the experiment file needs extending to include code for a system of LOOPS

The extract from the file anar_t_expt_G2_2_sol_2.inc, see Figure G2.2.1, illustrates the elements of the experiment INCLUDE file that will be critical to the next three exercises (G2.2, G2.3 and G2.4).

Reinitialising Variables

You will be working with the file anar_t_expt_G2_2_***.inc. This will be the file you will be modifying and extending for these exercises.

This exercise concentrates on the use of the closure LOOP; for now, the elasticity sensitivity LOOP – controlled by the set elst – will be ignored (see exercise 12.4 for this LOOP). The first series of instructions encountered when GAMS steps into the closure LOOP, i.e., for each member of the set clos, will be an INCLUDE file anar_t_varinit2.inc, which reinitializes the variables to their base values, and the second will be and anar_t_reset.inc, which resets all the variables that are fixed in the previous closure (see Figure G2.2.4). This code needs to be added to the experiment file anar_t_expt_G2_2_***.inc.

Figure G2.2.4 Code ANARRES Experiment File anar_t_expt_G2_2.inc

```
* ------- 4b. clos loop begins ----------------------------------------
LOOP(clos,
* First set *.L values back initial values for looping over diff closures
$INCLUDE anar_t_varinit2.inc
* Second, free all variables that are involved in any closure rule
$INCLUDE anar_t_reset.inc
* Third, select closure include files
.....
```

An extract of the code in anar_t_varinit2.inc is provided in Figure G2.2.5. The code simply resets the values of all variables in the model to those in the base, i.e., the level values, ***.L(**), are all set equal to the base values, ***0(**), from the parameter calibration file.[1]

[1] This step is potentially important, especially with large models, since GAMS always starts the next experiment with the solutions from the previous experiment. After many simulations the difference between the base and solution values for variables my be large. Resetting the values makes it easier for the solvers.

The file anar_t_varinit2.inc differs from the file anar_t_varinit.inc only in the exclusive use of the ***0(**) values rather than a mix of formulae derived from the equations. This is because the file anar_t_varinit.inc serves two purposes: (i) to initialise the variables and (ii) to verify the parameter calibration process. The second purpose is not used here (the use of formulae derived from the equations may not correctly initialise ALL the variables).

Figure G2.2.5 Code from ANARRES Model File anar_t_varinit2.inc

```
* -------------- anar_t variable RE initialisation ----------------------
$ontext
When RE initialising variables so that they are reset to their base values
the ***.L values are set equal to the ***0 values.
An alternative version of this file ***_varinit.inc defines the initial
values using formulae based on the equations with some base (***0) values.
$offtext
* #### Exchange Rate Block
 ER.L(r)             = ER0(r) ;
* ######## TRADE BLOCK
* #### Exports Block
 PER.L(c,w,r)        = PER0(c,w,r) ;
 PE.L(c,r)           = PE0(c,r) ;
 PWE.L(c,w,r)        = PWE0(c,w,r) ;
 PD.L(c,r)           = PD0(c,r) ;
 QER.L(c,w,r)        = QER0(c,w,r) ;
.....
```

Resetting Endogenous and Exogenous Variables

The second series of instructions encountered when GAMS steps into the closure LOOP, i.e., for each member of the set clos, are in the INCLUDE file are_t_reset.inc (see Figure G2.2.4).

An extract of the code in anar_t_reset.inc is provided in Figure G2.2.6. The code makes all variables that can be fixed in the macroeconomic closures (and factor market clearing conditions) FREE VARIABLES, i.e., bounded between minus and plus infinity. The extract of code illustrates the mechanics of freeing variables (see the GAMS documentation on the attributes of variables).

Figure G2.2.6 Code from ANARRES Model File `anar_t_reset.inc`

```
* -------------- anar_t reset closure variables ------------------------
$ontext
 If closure rules are to be changed when running experiments in LOOPS
 it is necessary to first free all variables that are involved in ANY
 closure rule or the equation variable count will be lost.
$offtext
*## FOREIGN EXCHANGE MARKET CLOSURE
 ERPI.LO                    = -inf ;  ERPI.UP                    = +inf ;
 ER.LO("glo")               = -inf ;  ER.UP("glo")               = +inf ;
 ER.LO(rgn)                 = -inf ;  ER.UP(rgn)                 = +inf ;
 KAPWOR.LO(rgn)             = -inf ;  KAPWOR.UP(rgn)             = +inf ;
……..
```

The model has now been reset to a point at which there are no effecting macroeconomic closures so that 'new' macroeconomic closures can be defined for each member of `clos`.

Macroeconomic Closures

The closure `LOOP` operates in conjunction with `IF` statements to select `INCLUDE` files that contain different selections of exogenous variables consistent with different macroeconomic closure conditions.[1] In this file no 'closure include files' are selected. We will modify the model so that the experiments are now run with a different closure file.

1. Open the file `anar_t_cl_base.inc`.
5. Compare the contents of `anar_t_cl_base.inc` and `anar_t_cl_balm.inc`. (Hint: use the comparison software.)
6. Open the file `data_anar_t_expt_G2_2_****.xlsx` and go to the worksheet `simsets`.
7. Make sure the file `data_anar_t_expt_G2_2_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
8. Add the element `clos01` to the set `clos`, give it the parameter value of 1 and add a description. Save the workbook.
9. Make notes on the differences so that you know what to look for in the results.

[1] This method allows the user select which macroeconomic closures are run from Excel.

10. Below the text “Third, select closure include files” add the following three lines of code

```
IF(closure(clos) = 1,
$INCLUDE anar_t_cl_balm.inc
) ;
```

11. The resulting code should look like the code in Figure 12.2.7.
12. In the file `anar_t.gms` comment out the code `$INCLUDE anar_t_expt_G2_1_sol.inc` AND add the code `$INCLUDE anar_t_expt_G2_2_***.inc` to section 17
13. Run the model.
14. Verify that the new closure conditions have been imposed. (Hint: Check that a variable that was fixed in `anar_t_cl_base.inc` and flexible in `anar_t_cl_balm.inc` does change.)

Figure G2.2.7 IF and INCLUDE files for closure

```
…….
* Third, select closure include files
IF(Closure(clos) = 1,
$INCLUDE anar_t_cl_balm.inc
 ) ;
……….
```

This stage of the exercise will have successfully changed the closure run in the experiment phase (`anar_t_cl_balm.inc`) from the one run in the calibration phase (`anar_t_cl_base.inc`).

You should devote time to understanding the differences in logic between the ‘base’ and ‘balm’ (balanced macroeconomic) closures.

Tax Replacement

The previous exercise concentrated on the mechanics of changing the macroeconomic closure file used by the model. This exercise, and the next two, focus on adjusting the economic settings in closure files. The alternative settings that could be imposed are a small subset of those that could be chosen.

In this exercise the emphasis is on replacing the tax revenues that may be 'lost' when import duties are reduced; this is often regarded as a standard formulation in comparative static models because it avoids results that can include one possible source of 'manna from heaven', e.g., unrequited government borrowings. For this exercise the decision will be to use direct income tax rates (*TYH*) as the tax replacement instruments, although in due course you should explore the impact of different tax replacement instruments.

We will modify the model so that the experiments are now done with two different closure settings.

1. Open the file `data_anar_t_expt_G2_2_****.xlsx` and go to the worksheet `simsets`.
2. Add the element `clos02` to the set `clos`, give it the parameter value of 2 and add a description. Save the workbook (see Figure G2.2.8).
3. Make sure the file `data_anar_t_expt_G2_2_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
4. Now go to the file `anar_t_expt_G2_2_***.inc` and go to the point in the file immediately after the parenthesis and semi colon that controls the inclusion of the closure file `anar_t_cl_balm.inc`. and add the following three lines of code

   ……

   ```
   IF(closure(clos) = 2,
   $INCLUDE anar_t_cl_repl_tyh.inc
   ) ;
   ```

   …….
5. Making changes to the code in the file `anar_t_cl_balm.inc.`, will change the closure settings. Go to the file `anar_t_cl_balm.inc` and save the file as `anar_t_cl_repl_tyh.inc`.
6. First, switch **off** the code that fixes income tax rates in all regions, i.e., `TYHADJ.FX(r) = TYHADJ0(r);` : this will allow the income tax rates to vary multiplicatively.
7. Then, switch **on** the code that fixes government borrowings (the internal balance), i.e., `KAPGOV.FX(r) = KAPGOV0(r);` : this will fix the levels of government borrowing equal to the levels in the base period –values other than KAPGOV0(r) could have been chosen.

8. Run the model.
9. Verify that the new closure conditions have been imposed. (**HINT**: Check that a variable that was fixed in `anar_t_cl_balm.inc` and flexible in `anar_t_cl_repl_tyh.inc` does change.)
10. Compare how the changes in the closure setting changes the results for variables (prices and quantities) in the solutions. (**HINT**: the results for the base and tax replacement closures will be found in all the GDX files that store the results.)
11. How do these closure differences impact on the welfare gains from the policy change in different regions?

You have now completed your first closure change in a way that allows you to easily compare the differences in the results. As such you have also completed basic sensitivity analyses i.e., you have evaluated how sensitivity the results are to changes in exogenously imposed constraints.

Figure G2.2.8 Worksheet 'simset' in `data_anar_t_expt_12_2_***.xlsx`

G	H	I
Closures set		
clos	**Parameter value**	**(description)**
clbase	1	Base closure
cl_tax_tyh	2	Tax replacement tyh

'Keynesian' Investment Closure

The closures implemented so far assume that the volume of investment (the value share of GDP is fixed but the price of investment commodities are endogenously determined) is determined by the value of savings in the economies. In orthodox presentations of Keynesian economics, a common, if simplistic, assumption is that savings adjust to provide the funds required to make investments consistent with the expectations of entrepreneurs. For this exercise it will be assumed that the volumes of investment are exogenously determined and that savings rates adjust to clear the investment savings account. We will maintain the tax replacement decision that direct income tax rates (*TYH*) acts as tax replacement instruments.

We will modify the model so that the experiments are now run with **three** different closure settings.

1. Open the file `data_anar_t_expt_G2_2_****.xlsx` and go to the worksheet `simsets`.
1. Add the element `clos03` to the set `clos`, give it the parameter value of 3 and add a description. Save the workbook.
2. Make sure the file `data_anar_t_expt_G2_2_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
4. Now go to the file `anar_t_expt_G2_2_***.inc` and go to the point in the file immediately after the parenthesis and semi colon that controls the inclusion of the closure file `anar_t_cl_repl_tyh.inc`. and add the following three lines of code

```
IF(closure(clos) = 3,
$INCLUDE anar_t_cl_invest_repl_tyh.inc
.....
 ) ;
```

5. Now go to the file `anar_t_cl_repl_tyh.inc` and save the file as `anar_t_cl_invest_repl_tyh.inc`.
4. Now modify the file `anar_t_cl_invest_repl_tyh.inc`, so that the scaling factor for the volume of investment is fixed (`IADJ.FX(r)`) and the investment share (`INVESTSH(r)`) is variable.
5. Run the model.
6. Verify that the new closure conditions have been imposed. (**HINT**: Check that a variable that was fixed in `anar_t_cl_repl_tyh.inc` and flexible in `anar_t_cl_invest_repl_tyh.inc` does change.)
7. Compare how the changes in the closure setting changes the results for variables (prices and quantities) in the solutions. (**HINT**: the results for the base, tax replacement and Keynesian closures will be found in all the GDX files that store the results.)
8. How do these closure differences impact on the welfare gains from the policy change in different regions?

You have now completed your second closure change in a way that allows you to easily compare the differences in the results.

4. Ex G2.3 Trade Policy and Factor Market Clearing

This set of exercise introduces changes in the factor market clearing conditions and explores how different settings impact on the results. The settings for the factor market clearing conditions can be contentious because they reflect different views/beliefs about how factor markets operate. As such they open the possibility for disputes, especially if there is any assumption of surplus labour/unemployment. Models in the ANARRES and STAGE families adopt an agnostic approach to factor market clearing conditions: the conditions are a mathematic necessity, but users should be able to impose their own views about factor market relationships.

Loading and Checking the Model Files

This element of the exercise concentrates on setting up the version of the model that will be used for this series of exercises and testing that it is running correctly.

1. We continue to work in the same project directory for this exercise `C:\cgemod\anar_t\anar_t2`, but it will be convenient to send the results to a new directory, say `6_results\factor`, which you will need to create and change the `$SETGLOBAL` instruction.
2. All the files needed for this exercise will already be in the project directory `C:\cgemod\anar_t\anar_t2`. This is OK because we will continue to use the same SAM database.
3. Open the file `anar_t.gms` and run the model with `s=save` in the command line.
4. Open the file `anar_t_expt.gms`. This should be in a different project, as before.
5. Run the model `anar_t_expt.gms` with `r=save` in the command line and using the data file `data_anar_t_expt_G2_2_sol.xlsx` and the experiment file `anar_t_expt_G2_2_sol.inc` (these are our versions of the files you created as part of Exercise G2.2; they are used to ensure that you start working from code and a set of experiments that are known and certain, which makes it much easier to provide help if you need it). Also, turn on the line of code `$INCLUDE anar_t_anal.inc`.
6. Verify that the experiments ran correctly.

For previous exercises the experiment file was written so that the macroeconomic closures were changed but the factor market clearing conditions were fixed. For these exercises we will replace the macroeconomic closure files with files that change the factor market clearing conditions with files with consistent macroeconomic closure conditions.

Sensitivity with Respect to the Factor Market Clearing Conditions

The objective in this element of the exercise is to run the model with a series of different factor market clearing conditions. The objective is to run each experiment/simulation with multiple different factor market clearing conditions and to collect the results in a series of GDX files. This will be done by running the factor market clearing conditions in a loop.

The method is identical to the method used for macroeconomic closures: all that is different are the elements of the closure file that are changed. First, all the variables are reinitialized, second, all variables in the closure files are made free and third, selected variables are fixed for the next closure.

Implementing Factor Market Clearing Changes

The base closure file (`anar_t_cl_base.inc`) contains a block of text that provides guidance on the various options for setting factor market clearing conditions. This block of code is reproduced below

```
*######## Alternative Factor Market Clearing Condition

This code allows for configuring various factor market clearing options.
For these examples the presumption is that the 'Base Factor Market
Clearing' settings are overwritten below. The term 'Base Factor Market
Clearing' does not imply any presumption that an assumption that 'all
factors are mobile and fully employed' is either correct or appropriate
(see the User Guide for more details).

     The method used here is to code in changes to the clearing conditions
in which 'all factors are mobile and fully employed'. When changing factor
market closure rules be careful to count how many conditions you relax,
i.e., unfix, and how many you fix.

     The instructions below assume that the user will make the changes in
factor market clearing conditions by over writing the conditions for all
factors to be mobile and full employed.

     SHORT RUN CONDITIONS - TO MAKE A FACTOR ACTIVITY SPECIFIC AND FIXED

      i)     Fix FD.FX("factor",a,"reg") AND WF.FX("factor",a,"reg")

      ii)    Fix WF.FX(ff,r)$fag(ff)

      iii)   Unfix WFDIST.FX("factor",a,"reg")
```

```
      iv)   FS.FX("factor","reg") is redundant BUT leave FIXED
     SURPLUS LABOUR CONDITIONS - TO ALLOW FOR A FACTOR IN SURPLUS SUPPLY
      i)  Unfix FS.FX("factor",r)
      ii) Fix WF.FX("factor",r) AND FS.LO("factor",r) and FS.UP("factor",r)
     TO CONTROL FACTOR USE BY ACTIVITY
        Adapt the SHORT RUN conditons, e.g., to FIX ALL factors in ONE
       activitiy in ONE region
      i)   Fix FD.FX(f,"activ","reg") AND WF.FX(f,"activ","reg")
      ii)  UNFIX WFDIST(f,"activ","reg")
      iii) Factor supplies are fixed and adjust through other activities
STANDARD BLOCK of conditions for factor "fact" is
     FS.FX("fact",r)              = FS0("fact",r) ;
     WFDIST.FX("fact",a,r)        = WFDIST0("fact",a,r) ;
     WF.LO("fact",r)              = -inf ;
     WF.UP("fact",r)              = +inf ;
     WFDIST.FX("fact","aserv",r)  = WFDIST0("fact","aserv",r) ;
     FD.FX("fact",a,r)            = FD0("fact",a,r) ;
     WF.FX("fact",r)              = WF0("fact",r) ;
     FS.LO("fact",r)              = -inf ;
     FS.UP("fact",r)              = +inf ;
*#########################
```

There are three sections that describe the process for short run, surplus labour and activity specific factor market clearing conditions. This is not exhaustive but covers the options often used and provides the basis for further alternatives. The illustrations, and all other options, ultimately depend upon making changes using equations selected out of the NINE equations listed in the 'STANDARD BLOCK'

For this course we will develop three different factor market clearing arrangements based on the descriptions in the extract of code above. We will keep things simple by using the experiment file from Ex G2.2 and the balanced macroeconomic (*balm*) closure for `clos1` in the set `clos`.

The first task is to set up a basic experiment file.

1. Open the experiment file `anar_t_expt_G2_2_sol.inc` and delete the code that implements closure settings other than those for the balanced macroeconomic closure, i.e., `anar_t_cl_balm.inc`

2. Open the experiment data file `data_anar_t_expt_G2_2_sol.xlsx` and delete the elements in the closure set other than that for the base closure.
3. Run the experiment with `r=save` in the command line.
4. Verify that the output reports the standard FTA policy experiments with only the base closure.

Short run

This factor market clearing condition variation replicates a simple short run factor market clearing case where capital is immobile but fully employed, i.e., capital cannot be reallocated between activities within regions. This is in the spirit of the short run scenario used in standard microeconomics, except it applies to all activities simultaneously.

We will start from the experiment file for G2.2 and then modify the model closure so that the experiments are now run with **two** different factor market clearing conditions but leave all the macroeconomic closures unchanged.

1. Open the workbook `data_anar_t_expt_G2_2_sol.xlsx`, and save it with a name that links it to this exercise, e.g., `data_anar_t_expt_G2_3_****.xlsx`
2. Add the element `clos02` to the set `clos`, give it the parameter value of 2 and add the description 'short run'. Save the workbook.
3. Open the experiment file `anar_t_expt_G2_2_sol.inc` and save it as `anar_t_expt_G2_3_***.inc`. and is identified as the experiment file in the file `anar_t_expt.gms`.
4. Make sure the file `data_anar_t_expt_G2_3_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
5. Run `anar_t_expt.gms` and verify that the programme runs, and the expected results are achieved.
6. In the file `anar_t_expt_G2_3_***.inc`., go to the section where the closure loop begins, `LOOP(clos` and add the following three lines of code

```
IF(closure(clos) = 2,
$INCLUDE anar_t_cl_short.inc
) ;
```

7. Now go to the file `anar_t_cl_balm.inc` and save the file as `anar_t_cl_short.inc`.

8. In the file `anar_t_cl_short.inc` go to the point in the file immediately after the block that describes 'Alternative Factor Market Clearing Conditions' (immediately before the section 'Technology Closures for Factor Market') and add the following block of code

```
* Short run closure activity specific K all activities & regions
    FD.FX(k,a,r)          = FD0(k,a,r) ;
    WFDIST.LO(k,a,r)      = -inf ;
    WFDIST.UP(k,a,r)      = +inf ;
   * Fix AVERAGE wage (WF) so all adjustment via WFDIST
    WF.FX(k,r)            = WF0(k,r) ;
   * factor market clearing for k is redundant
    FS.FX(k,r)            = FS0(k,r) ;
   *  FS.LO(k,rgn)         = -inf ;
   *  FS.UP(k,rgn)         = +inf ;
```

9. Spend some time working out what this code does. [**HINTS**: (i) if a parameter is reassigned later in the code the later value holds, and (ii) the properties of variables can be changed by fixing them or unfixing them.]
10. Run the model, with the experiment file `anar_t_expt_G2_3_***.inc` and the analysis file turned on.
11. Verify that the new closure conditions have been imposed. (**HINT**: Check that a variable that was fixed in `anar_t_cl_short.inc` and flexible in `anar_t_cl_balm.inc` does change.)
12. Compare how the changes in the closure setting change the results for variables (prices and quantities) in the solutions. (**HINT**: the results for the base and short run closures will be found in all the GDX files that store the results.)
13. How do these factor market clearing differences impact on the welfare gains from the policy change in different regions?

You have now completed your first factor market clearing change in a way that allows you to easily compare the differences in the results.

Surplus Labour

This factor market clearing condition variation imposes the assumption that there is surplus unskilled labour in all three regions in the model. It is like the ideas in the Lewis dual

economy models – the MP_L of labour is zero: as such it is a very simple way to model 'unemployment' although the meaning 'unemployment' in this context is somewhat opaque. We prefer the label surplus labour.

We will start with the previous experiment so that the experiments are now run with **two** different factor market clearing conditions.

1. In the workbook `data_anar_t_expt_G2_3_***.xlsx`, add the element `clos03` to the set `clos`, give it the parameter value of 3 and add the description 'surplus unskilled labour'. Save the workbook.
2. Make sure the file `data_anar_t_expt_G2_3_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
3. Go to the file `anar_t_expt_G2_3_***.inc` and go to the point in the file immediately after the instructions for the second closure add the following three lines of code
   - `IF(closure(clos) = 3,`
   - `$INCLUDE anar_t_cl_surp.inc`
   - `) ;`
4. Go to the file `anar_t_cl_short.inc` and save the file as `anar_t_cl_surp.inc`.
5. In the file `anar_t_cl_surp.inc` comment out the code that imposed the short run closure.
6. In the file `anar_t_cl_surp.inc` add the following block of code after the code for the short run closure

```
* Surplus labour closure - ONE factor and ALL regions
* First cancel previous settings
  FD.LO(k,a,r)          = -inf ;
  FD.UP(k,a,r)          = +inf ;
* Then setup new settings
  WF.FX("fUskil",r)       = WF0("fUskil",r) ;
  FS.LO("fUskil",r)       = -inf ;
  FS.UP("fUskil",r)       = +inf ;;
```

7. Note how it is necessary to relax the constraint imposed by the short run closure, i.e., `FD.FX(k,a,r)`. This is a special case required ONLY because of the constraints

imposed for the previous closure; the next example does not need a similar step. **THERE IS NO SIMPLE WAY TO DEVELOP AN INTUITIVE EXPLANATION FOR SUCH SPECIAL CASES WITHOUT SUBSTANTIAL ADDITIONAL CODING: WE JUDGE THIS METHOD NO TRICKIER THAN USING ADDITIONAL CODE.**

8. Spend some time working out what this code does. [**HINTS**: (i) why is the supply of unskilled labour made a free variable, and (ii) why is the wage rate fixed?]
9. Run the model.
10. Verify that the new closure conditions have been imposed. (**HINT**: Check that a variable that was fixed in `anar_t_cl_surp.inc` and flexible in `anar_t_cl_short.inc` does change.)
11. Compare how the changes in the closure setting change the results for variables (prices and quantities) in the solutions.
12. How do these factor market clearing differences impact on the welfare gains from the policy change in different regions?

You have now completed your second factor market clearing change in a way that allows you to easily compare the differences in the results.

Activity specific factor market clearing

This factor market clearing condition variation considers a situation where the modeler has reason to believe that an activity in a region cannot change its output during the solution period. This is illustrated for the case where it is assumed that the mining sector in Africa cannot changes it capacity; in some cases, this may a reasonable assumption because mines have long time horizons to introduce new capacity or output may be constrained, e.g., Botswana's production of diamonds is constrained by the de Beers cartel.

We will start from the previous experiment so that the experiments are now run with **three** different factor market clearing conditions.

1. In the workbook `data_anar_t_expt_G2_3_***.xlsx`, add the element `clos04` to the set `clos`, give it the parameter value of 4 and add the description 'fixed for mining in Africa'. Save the workbook.

2. Make sure the file `data_anar_t_expt_G2_3_****.xlsx` is identified as the experiment data file in the file `anar_t_expt.gms`.
3. Go to the file `anar_t_expt_G2_3_***.inc` and go to the point in the file immediately after the instructions for the third closure add the following three lines of code

```
IF(closure(clos) = 4,
$INCLUDE anar_t_cl_mining.inc
) ;
```

4. Go to the file `anar_t_cl_surp.inc` and save the file as `anar_t_cl_mining.inc`.
5. In the file `anar_t_cl_mining.inc` comment out the code that imposed the surplus labour closure.
6. In the file `anar_t_cl_mining.inc` add the following block of code after the code for the short run closure

```
* Fixed factor demand for Mining in Africa
*NB. FD.LO(f,a,r) and FD.UP(f,a,r) must be cut free above
FD.FX(f,"anres","afr")          = FD0(f,"anres","afr") ;
WFDIST.LO(f,"anres","afr")      = -inf ;
WFDIST.UP(f,"anres","afr")      = +inf ;
*factor market supply for f is already fixed above (it does no harm to repeat)
* FS.FX(f,"afr")            = FS0(f,"afr") ;
```

7. You will now have blocks of code for 4 different factor market clearing options that you can easily reuse.
8. Spend some time working out what this code does. [**HINTS**: (i) why is the demand of factors fixed, (ii) how do the wage rates adjust, and (iii) why is it not necessary to fix `FS(f,"afr")`?]
9. Run the model.
10. Verify that the new closure conditions have been imposed. (**HINT**: Check that a variable that was fixed in `anar_t_cl_mining.inc` and flexible in `anar_t_cl_unemp.inc` does change.)
11. Compare how the changes in the closure setting change the results for variables (prices and quantities) in the solutions.
12. Does this setting fix the output of mining activity in Africa?

13. How do these factor market clearing differences impact on the welfare gains from the policy change in different regions?

You have now completed your fourth factor market clearing change in a way that allows you to easily compare the differences in the results.

Examples of the different closure files are included in the directory `3_close` with the names `anar_t_cl_short_sol.inc`, `anar_t_cl_surp_sol.inc` and `anar_t_cl_mining_sol.inc`. The file `anar_t_expt_G2_3_sol.inc` illustrates the complete experiment file.

5. Ex G2.4 Sensitivity Analyses

This set of exercise introduces sensitivity analyses with respect to changes in the elasticities that control the behavioural functions. In most cases changes in the elasticities impact upon the magnitudes of the results but not the signs, although changes between elasticity and inelasticity elasticities can cause sign changes. The approach adopted here concentrates on the mechanics and uses a simple multiplicative method for changing the elasticities.

The sensitivity analyses explored in this exercise (G2.4) concentrate on sensitivity to elasticity settings; the analyses are deliberately kept relatively straightforward and potential important nuances are deliberately avoided. This is because the coding requirements are potentially difficult to understand, so keeping things relatively straightforward is a good first step.

Before looking at the mechanics of sensitivity testing with elasticity values it will be useful to review how the functions that use elasticities are calibrated. The code extract in Figure G2.4.1 is for calibrating the parameters of the CES functions that control the aggregation of imports *c* from regions *w* by region *r*. Review this code to refresh your memory about its interpretation.

Figure G2.4.1 Parameter Calibration Code for Trade (CES Imports)

```
rhom(c,r)          = ((1/mod_elastrm(c,r)) - 1) ;
deltar(w,c,r)$cmrl(w,c,r)
                  = (PMR0(w,c,r)*QMR0(w,c,r)**(1+rhom(c,r)) )
                     /SUM(wp$cmrl(wp,c,r), PMR0(wp,c,r)*QMR0(wp,c,r)
                      **(1+rhom(c,r)) ) ;
 acr(c,r)$QML0(c,r)    = QML0(c,r)/SUM(wp$cmrl(wp,c,r),
                              deltar(wp,c,r)*QMR0(wp,c,r)
                                   **(-rhom(c,r)) )**(-1/rhom(c,r)) ;
```

Notice that the value of the elasticity parameter (`rhom`) depends on the elasticity (`mod_elastrm`). Then given the value of the elasticity parameter (`rhom`) the share parameter (`deltar`) can be calibrated using `rhom` and the initial values for the prices (`PMR0`) and quantities (`QMR0`) of imports. Finally, the shift parameter can be derived using `rhom, deltar` and initial values for quantities. Hence, if the elasticity value changes so

must the share and shift parameters, i.e., the shift and share parameters are functions of elasticity.

This has an important implication. Sensitivity analyses with respect to elasticity values require that the parameters for the function that use each elasticity must be recalculated for each different elasticity.

For this exercise there will be little or no coding for you to undertake; this is because the coding could take a long time and therefore could delay you from moving on to more interesting aspects of the course.

Loading and Checking the Model Files

This element of the exercise concentrates on setting up the version of the model that will be used for this exercise and testing that it is running correctly.

1. We continue to work in the same project directory for this exercise `C:\cgemod\anar_t\anar_t2`, but it will be convenient to send the results to a new directory, say `6_results\sensit`, which you will need to create and change the `$SETGLOBAL` instruction.
2. All the files required are already in your working directory.
3. Open the file `anar_t.gms` and run the model with `s=save` in the command line.
4. Open the file `anar_t_expt.gms`. This should be in a different project, as before.
5. Run the model `anar_t_expt.gms` with `r=save` in the command line and using the data file `data_anar_t_expt_G2_3_sol.xlsx` and the experiment file `anar_t_expt_G2_3_sol.inc` (these are our versions of the files you created as part of Exercise G2.3; it is used to ensure that you start working from code and a set of experiments that are known and certain, which makes it much easier to provide help if you need it). Also, turn on the line of code `$INCLUDE anar_t_anal.inc`.
6. Verify that the experiments ran correctly.
7. The file `data_4_4_3_glb_t_8_G2_1.xlsx` will be used in this exercise to be sure we all start from the same code with updates to the controls done in the previous exercise. Open the file `1_1_model_data\data_4_4_3_anar_t_8_G2_1.xlsx` and explore the data. Verify that the **GTAP** Armington elasticities are used and scaled.

8. In anar_t.gms change the $SETGLOBAL assignment so the data file data_4_4_3_anar_t_8_G2_1.xlsx is read into the model
9. Run the model anar_t_.gms with s=save in the command line.
10. Verify that the model ran correctly by carrying out the standard checks.

The experiment file is set up to run two simulations (base and sim03) and two closures (tax replacement - anar_t_cl_repl_tyh.inc - and surplus labour - anar_t_cl_surp.inc). You have worked with these variants before, so they should be familiar to you. For this exercise the third LOOP (elst) in the experiment file will be implemented – there will be 11 elements in the elst loop.

Sensitivity to Elasticities of Substitution, Transformation and Production

We will use experiment and data files prepared for this exercise.

1. Open the experiment file, anar_t_expt.gms.
2. In the experiment programme file set the experiment file to anar_t_expt_G2_4_sol.inc. This is a version of the experiment files used before, but with some additional code for the sensitivity analyses with respect to elasticities. (This version is used to ensure that you start working from code and a set of experiments that are known and certain).
3. Set the experiment data file to data_anar_t_expt_G2_4_sol.xlsx. Note that there is a new worksheet – elst_sens - this provides data used for the sensitivity analyses. Also note the membership of the set elst.
4. Review the content of the file anar_t_expt_G2_4_sol.inc and find the point in the file where the LOOP(elst, starts. The code reported below should be seen.

```
*------- 4a. elst loop begins ----------------------
LOOP(elst,
$ontext
An INCLUDE file is used to reparametise behavioural
functions for different elasticity values. In this version the
following functions are recalibrated CES and CET functions for trade
CES functions for production
$offtext
*### CES, CET functions for anar_t
$INCLUDE anar_t_elast_sens.inc
```

5. Note how the code INCLUDES a file `anar_t_elast_sens.inc` . Open the file `anar_t_elast_sens.inc` and spend some time working out what this code does. [**HINT**: compare the code in this include file with the `anar_t_parmcalib.inc` file.]
6. Review the code extract from `anar_t_elast_sens.inc` that is reported below. Note several important features:
    a. The base elasticities - `mod_elastre(*,*)` - are modified using scaling factors in `elst_sens(*,*)`;
    b. note the roles of the various parameters `sens_elast**(**,r,elst)` (what do they do?).
    c. the code is careful to avoid any of the elasticities being equal to ONE (Why?)
    d. the parameter calibrations depend on the value of the parameter `rhoe`;
    e. the parameters for the functions are NOT indexed on `elst` (Why?)
7. Scaling elasticities relative to those in database

```
sens_elastre(c,r,elst)   = mod_elastre(c,r) * elst_sens(elst,"cet_re") ;
* Avoiding elasticities equal to ONE
sens_elastre(c,r,elst)$(sens_elastre(c,r,elst) GT 0.85 and
                  sens_elastre(c,r,elst) LE 1.00) = 0.85 ;
sens_elastre(c,r,elst)$(sens_elastre(c,r,elst) GT 1.00 and
              sens_elastre(c,r,elst) LT 1.15) = 1.15 ;
* Setting CET parameters for EXPORTS by trade partner
rhoe(c,r)          = ((1/sens_elastre(c,r,elst)) + 1) ;
gammar(c,w,r)$(cer(c,w,r) AND rgn(r))
      = (PER0(c,w,r)*QER0(c,w,r)**(1-rhoe(c,r)) ) /
      SUM(wp$cer(c,wp,r), PER0(c,wp,r)*QER0(c,wp,r)**(1-rhoe(c,r)) );
atr(c,r)$(QE0(c,r) AND rgn(r))
      = QE0(c,r)/SUM(w, gammar(c,w,r)*QER0(c,w,r)
              **(rhoe(c,r)) )**(1/(rhoe(c,r))) ;
```

8. Run the model.
9. Open the file `anar_t_expt.gdx` and review the values of the parameters `sens_elast**(**,r,elst)`. Are these values those that you expected?
10. Verify that the changes in the elasticities have been implemented.
11. Compare how the changes in the elasticities change the results for variables (prices and quantities) in the solutions.

Future Considerations

The method used here to conduct sensitivity analyses via equiproportionate changes in the values of the base elasticities is relatively simple/crude. It serves to illustrate the mechanics and to provide a simple and useful starting point. However, with experience it is likely that you would want to develop a more sophisticated method that facilitates a more selective range of changes in the elasticities.