A Single Country Computable General Equilibrium Modeling Course Exercises S2

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This document is subject to ongoing revisions. If you find any errors, please let us know so that we can correct them ASAP. If you have suggestions as to how the exercises can be improved, please send them to the email address above.

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Introduction

These exercises, for Module S2, continue using the STAGE_t CGE model with the same database as used for module S1. The core aim of these exercises is to develop your understanding of behavioural relationships in single country CGE models, while further developing your skills with GAMS, and preparing you for the interpreting model results exercises of module S3 and the course project of module S4.

There are seven exercises in this module. The first exercise involves an experiment that reduces factor use taxes, which impacts on the first order conditions in production and therefore impact on factor allocation decisions. This is followed by an exercise that considers alternative factor market clearing scenarios that also impact factor allocation decisions. These two exercises continue the process of analysing the sensitivity of model results to variations in the magnitude of shocks and different macroeconomic and factor market clearing conditions. Exercises S2:3 and S2:4 consider the analyses of the sensitivity of model results to changes in exogenous model parameters. Exercise S2:3 returns to the trade policy shock from module S1 to explore the impact of changes in the elasticities used in the trade functions, while exercise S2:4 explores the impact of changes in the elasticities used in the production functions when factor use taxes are shocked. The project, exercise S2:6, builds on these exercises.

Exercise S2:5 focuses on model setup and calibration by reviewing the options available when setting up a model to operate with a new database: you will need to make decisions about model setup and calibration for the course project in module S4. It is also the case that when configuring a model for a new database/country the modeler may be confronted with needing to modify the model's behavioural relationships. All too often the temptation is to 'adjust' the data to fit the model rather than modify the model to reflect the situation in the country being studied. Exercise S2:7 is designed to encourage you to recognise that modifying the model may not be a problem. You are presented with a revised database for South Africa wherein the second sales tax instrument, *TSS*, represents a specific commodity tax instrument, and therefore the *TSS* tax instrument in the model requires modification. The exercise instructions also provide suggestions for other changes in behaviour you might wish to undertake as training after the course.

The guidance for each exercise for this module is less comprehensive than for the exercises in module S1, i.e., it is assumed that you are becoming more independent. We will provide you with examples of the code for exercises based on how the tutor completed the exercise: these are one way the exercise may be completed.

NB: In places these guidance notes will be less than comprehensive. This derives from the fact that we are trying to make you read the code in the various files you are instructed to access. In these files you will find blocks of code that make complete or incomplete but have been commented out: these blocks of code are HINTS that can help you work out ways to code experiment files. Please note that there are many ways you might choose to code experiment files; the correct ones are those that work. However, we typically need to start various exercises from a specific starting point: typically, those starting points are examples of how we coded the experiments – all have "sol" in the title – although they are just one way of working.

All the codes required for Mod S2 are in the User Library established for Mod S1.

RESIST THE TEMPTATION TO EXPLORE THE CONTENTS OF THE LIBRARY; THAT WAY LIES CONFUSION. YOU GET TO SEE AND USE ALL THE FILES.

Ex S2:1 Factor Input Subsidies

> *Factor input subsidies are often suggested as instruments that governments could use to sponsor economic activities that they advocate. This exercise explores some of the implications of factor input subsidies. By so doing we are not advocating for or against factors subsidies/taxes: we are using this exercise solely as part of a process of learning how to formulate and interpret experiments.*

In this exercise, we will consider policies that directly affect the prices of factors used by activities in production, so called factor use/input taxes/subsidies. These taxes can be important because they directly enter the first order conditions that determine the mix of inputs used by activities.[1] Arguments asserting that factor input subsidies are required to ensure that domestic producers can compete internationally are common. In developed economies these arguments are often formulated with respect to agricultural activities[2], while in developing countries the arguments often relate to manufacturing activities and supporting the development of manufacturing capacity and sponsoring 'infant' industries. The analyses in this exercise do not develop support for arguments for, or against, the use of factor input subsidies; rather the aim is to analyse the issue and interpret simulation results.

The South Africa database for the exercises in modules S1 to S3 includes marked factor use subsidies (these subsidies were not so prominent in the base SAM for South Africa; they are *ad hoc* changes added for pedagogic reasons). This provides a context in which the withdrawal of factor use subsidies is an appealing basis for simulation exercises. This exercise will progressively remove factor use subsidies on all factors, on capital and labour individually for all activities. Then factor use subsidies on all factors will be removed for agriculture, manufacturing, and services. *A priori* it is expected that reducing subsidies, i.e., government expenditure, will increase government savings. In these simulations you will replicate the base closures used in the core model file, `stg_t.gms`, i.e., government savings will be flexible, but in the alternative closure settings government savings will be fixed and

1 Review the equations for *QVAFOC* and *FDFOC* in stg_t.gms.

2 The GTAP database uses data from the OECD to record domestic agricultural support policies as factor use subsidies. Nothing in this exercise should be interpreted as support for that method of accounting for domestic agricultural support

the saving in government expenditures on factor subsidies will be redistributed to households using two different mechanisms: multiplicative income tax changes and multiplicative GST rate changes. Many other closure alternatives are possible; the decision to limit the closure options to two is pedagogic not economic. The analysis of the results will emphasise the welfare implications for households and the competitiveness of domestic activities.

These exercises will use a new project directory `C:\cgemod\stg_t\stg_t_2`. The model stg_t.gms is unchanged as are the data used to calibrate the model; the reason for the new directory is to reduce the risk that the codes for previous exercises are distorted.

Setup

First you need to set up a new working directory and populate is from the User Library.

1. In the directory `stg_t,` create a subdirectory `stg_t_2`, `C:\cgemod\stg_t\stg_t_2.`
2. create a New Project with the name `stg_t_2`,
3. set the Working directory to `C:\cgemod\stg_t\stg_t_2`,
4. choose `File>Save,`
5. choose `File>New` in the working directory and `SAVE; new**.gms` will appear in the `stg_t_2` project.
6. In Studio press `F6` and in the Model Library Explorer select the `Single Country CGE Library` and then select the library file `stg_t_2_t` and choose `Load` (or double click of the name), which is SeqNr: 2.
7. The `stg_t.gms` model will now be displayed in the editor window and be listed in the project `stg_t_2`.
8. Open the directory `cgemod\stg_t\stg_t_2` and unzip the archive `stg_t_2.zip`.
9. You should note the files that have been downloaded to the directory `C:\cgemod\stg_t\stg_t_2`
10. Review the model code and note the contents of each of the subsections; note that there are nearly 2,000 lines of code so COMPILING the model (`Shift+F10`) to generate a reference file might help.
11. Change the file extension for `clean_stg_t.dat` file.

12. Studio can now be used to work with the model `stg_t_**gms`.

This is the first step. Do not move on until you have successfully completed this sequence.

Exercise Experiments

In this exercise, we will consider reductions in factor use subsidies. Policy simulations will be run in two loops; the outer loop will select between different closures and the inner loop will control the changes in factor use subsidies. Results will be accessed using GAMS Studio.

1. These versions have been set up to run using the South African data used in Mod S1 and the experiment file and data from Exercise S1:5 (`stg_t_expt_1_5_sol.xlsx` and `stg_t_expt_1_5_sol.inc` together with different closures). (We are using our solution experiment file and experiment data workbook to ensure you are starting from files that are consistent with subsequent guidance.)
2. The model, `stg_t.gms`, should be open in GAMS Studio. Run the model using the `save` and `restart` method. Verify that the base model ran correctly.
3. Open the file experiment master file `stg_t_expt.gms` in a new project and run using `stg_t_expt_1_5_sol.inc` and `stg_t_expt_1_5_sol.xlsx` using `save` and `restart`. Verify that the experiments ran correctly. It is good practice to verify that the previous model variant and/or experiment is running correctly before making changes. **NB**: ensure the model and experiment main files are in different projects even though they are in the same directory.
4. Open the file `4_expt/sstg_t_expt_2_base.inc`; this is the experiment file that this exercise will start from and modify and extend. Rename the file as `stg_t_expt_2_1.inc`. This file will be called from the master experiment file `stg_t_expt.gms`.
5. Review the contents of the file `stg_t_expt_2_1.inc`. (Note you are still using the data from Exercise S1:5.)
6. Run the model, `stg_t.gms`, using the save and restart method.
7. Now run the mater experiment file, `stg_t_expt.gms`, with the experiment file, `stg_t_expt_2_1.inc` , using restart.

8. Verify that you ran all the experiments in `stg_t_expt_2_1.inc` (using save and restart) and access the results. Check that the intended experiments have been implemented.

Changing Factor Input Subsidies

In this part of the exercise, you will change the factor input subsidies using the preset closures in `stg_t_expt_2_1.inc`.

1. Open the file `4_expt/sstg_t_expt_2_base.inc`; this is the experiment file that this exercise will start from and modify and extend. Rename the file as `stg_t_expt_2_1.inc`. This file will be called from the master experiment file `stg_t_expt.gms`.
2. Review the contents of the file `stg_t_expt_2_1.inc`.
3. Open the Excel file `stg_t_expt_2_1.xlsx`. This has an extra worksheet – `fact_tax` – compared to the experiment workbooks for Mod S1. The values in this worksheet are all ONE: how does this impact on factor use tax rates in the file `stg_t_expt_2_1.inc` (It is the same as `stg_t_expt_1_5.xlsx` with the addition of one worksheet.)
4. You need to make the necessary changes to the Excel experiment data file and the experiment file, `stg_t_expt_2_1.inc`, so that
    a. factor input subsidies on the **capital** factors used by all activities are reduced in two stages;
    b. factor input subsidies on the **aggregate labour** factors used by all activities are reduced in two stages;
    c. factor input subsidies on the **unskilled labour** factors used by all activities are reduced in two stages;
    d. factor input subsidies on the **skilled labour** factors used by all activities are reduced in two stages;
    e. factor input subsidies on **all** factors used by **agricultural** activities are reduced in two stages;
    f. factor input subsidies on **all** factors used by **manufacturing** activities are reduced in two stages;

   g. factor input subsidies on **all** factors used by **service** activities are reduced in two stages.

5. Extend the set `sim` in `stg_t_expt_2_1.xlsx` so that it has elements for each of the experiments detailed in 2 above – there should be 17 elements. Remember to provide descriptions so you can remember what you intended to do.
6. Open the worksheet `fact_tax`. The table has row and column labels for a matrix of 'adjustments' to the factor tax rates. You need to fill the cells of this matrix. The changes in factor use taxes detailed above all assume that the base tax rates (you need to find the parameter for these base rates) are all the same as in the base, half the values in the base or zero. Hence all the values in the matrix could be 1, 0.5 or 0.0.
7. In the worksheet layout you need to extend the list of data that will be converted to GDX by the utility GDXXRW into the file `expt_in.gdx`. You need to add information in row 12:
   a. in the first column you need to tell GDXRRW the Data type (how is `fact_tax` declared?),
   b. in the second column you need to add the name (this can be the name of the parameter in the model although in some cases it could be different),
   c. in the third the data's location,
   d. in the fourth column the number of dimensions in the row, and
   e. in the fifth the number of dimensions in the columns. NB: In an Excel worksheet a matrix is present in two dimensions, but GAMS can record matrices with multiple rows and columns. An example of how GAMS can tabulate matrices with more than two dimensions will have been seen when using the TABLE option when viewing results in GDX files in ModO7. In this case you will have ONE dimension in the row and ONE dimension in the column.
8. In the experiment file `stg_t_expt_2_1.xlsx`, you need to tell GAMS to load the parameter `fact_tax` from the file `expt_in.gdx`. A `$GDXIN` set of instructions has been included in the template file, you need 'switch' it on and tell GDXIN which parameter to load.

9. In the experiment file `stg_t_expt_2_1.xlsx`, you need to assign values to the parameter `tfsim` and then add an instruction to implement the shocks in section 6 ("Shocks implemented").
10. Before solving the model, it is good practice to check that the changes you have made to the workbook are being read into GAMS. Somewhere in the experiment file code after loading the data and before the `LOOP` instruction you can add `$STOP`. Now if you run the experiment using F10 the resultant `*.lst` and `*.gdx` files will contain all the experiment data. You are likely to have made one of more mistakes; that is usual. Correct all the errors before going further.
11. Run the model and verify that the intended tax shocks have been implemented and the intended closure changes have been implemented. If the model does not solve you need to find out the causes and correct them. With practice you will soon find that the errors become clearer as you learn to read and understand the feedback provided by GAMS: there is no short cut to practice. **NB**: make sure you have run the core model with `save` and that you are running the experiment with `restart`.
12. Once the experiments are solved, use the results to answer the following questions. For each question you need to distinguish between the effects on the model variables of the three different closure settings – this is an important, but usually neglected, part of sensitivity analyses to macroeconomic closures.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on welfare, income and consumption expenditures for different households?
    c. Using the changes in prices to explain the causes for the observed impacts on households?
    d. What are the impacts on the volumes of domestic production, imports and exports?
    e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

Alternative Macroeconomic Closures

After the course you can enhance the previous exercise by extending the closure loop to include different macroeconomic closures.

1. Different tax replacement instruments.
2. Fix government borrowing and change the transfers by government to households, with or without changes in the pattern of transfers.
3. Fix the real value (volume) of investment expenditure.
4. Fix the real value (volume) of government expenditure.
5. Fix the external balance.

In each instance you will need to remember that for each variable you fix you need to free another variable. The number of options is extensive and only limited by requiring some economic-theoretical justification and your 'creativity'.

Compare and explain the impacts of different macroeconomic closure mechanisms on the results from the model and the implications for different households.

Ex S2:2 Factor Input Subsidies and Factor Market Clearing

> *The presumption that all factors are fully employed and fully mobile is often regarded as 'unrealistic'. This exercise explores the possibility of imposing different assumptions about factor market clearing.*

In this exercise, we will use a simplified set of fact or use tax shocks together with two different sets of factor market clearing conditions – one 'long' run and one 'short' run - with two different tax replacement closures. The factor use tax shocks and the tax replacement closure will be taken from the previous exercise (Ex S2:1), so the focus will be on the factor market clearing conditions. All factor market clearing conditions, other than fully employed and fully mobile, require the imposition of additional constraints on the system, i.e., the model will optimise subject to one or more additional constraint.

The project directory created for module O8 (`C:\cgemod\stg_t\stg_t_2`) contains all the files needed for this exercise.

Short run Factor Market Clearing

In this exercise, we will consider the assumption that the factor market clears in the 'classic' 'short' run scenario, i.e., one, or more, factor is immobile as in the textbook example of short run analyses. The obvious factor is capital, but the database contains two types of capital, so the exercise could consider cases in which one or both capital factors are in fixed supply but immobile across activities. For the first application we will assume that both times of capital are activity specific, i.e., immobile. It will be left to you to experiment with situations in which one type of capital is immobile and make comparisons of the results.

Carry out the following activities.

1. Open the file `stg_t_expt_2_1_sol.inc` and rename the file as `stg_t_expt_2_2.inc`. This ensures you are starting from where we understand you have reached.
2. Set the experiment to run with one of the tax replacement instrument closures developed for Ex S2:1; using income taxes as the tax replacement instrument is possibly a good choice. (For now, using more than one alternative tax replacement closure will simply increase the potential for errors.)

3. Run the experiment and verify that the intended experiments have been implemented.
4. Starting with the closure file with your chosen tax replacement instrument. Save a copy of the file with a new name, e.g., `stg_t_cl_tyh_srun.inc`.
5. Open the workbook `stg_t_expt_2_1_sol.xlsx` and save it as `stg_t_expt_2_2.xlsx`. Extend the closure set to include your 'short' run closure file. Remember to remove the other closures from the set `clos` and the `clos_controls` worksheet in Excel.
6. Review and interpret the code for factor market clearing in the closure file, i.e.,

```
*# Basic Factor Market Closure

FSI.FX(insw,f)            = FSI0(insw,f) ;


WFDIST.FX(f,a)            = WFDIST0(f,a) ;
WF.LO(f)                  = -inf ;
WF.UP(f)                  = +inf ;
```

7. Note that factor supplies are fixed at the level of the institution. Note also that in GAMS the model will run for the last (sequential) condition imposed. This means that it is possible to set the factor market clearing conditions by modifying the conditions of the Basic Factor Market Closure further down closure file.
8. In the section '`activity specific capital for all activities`' add the following instructions

```
FD.FX(k,a)                = FD0(k,a) ;
WF.FX(k)                  = WF0(k) ;
WFDIST.LO(k,a)            = -inf ;
WFDIST.UP(k,a)            = +inf ;
```

9. Write brief notes, in the file, interpreting what you understand these changes will imply for the model.
10. In the experiment file `stg_t_expt_2_2.inc` add the new factor market clearing closure in the closure LOOP. You should have three closure files called provided you disconnected any extra closure files, i.e., the base closure, one tax replacement closure with full employment and one (same instrument) tax replacement closure with immobile capital.

11. Work out how many solutions you think should be carried out before running the experiment. Run the experiment and verify that the intended shocks and closure conditions have been imposed.
12. You may choose to solve the experiments first with just two closure settings - the base closure and one tax replacement closure with full employment – to verify that you have not made any mistakes. After that you can add the tax replacement closure with immobile capital.
13. Run the experiment and verify that the intended shocks and closure conditions have been imposed.

Interpretation

1. Use the results to answer the following questions, comparing the results and their interpretations across the different factor market clearing closures.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on welfare, income and consumption expenditures for different households?
    c. Using the changes in prices to explain the causes for the observed impacts on households?
    d. What are the impacts on the volumes of domestic production, imports and exports?
    e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

Write a short summary of the lessons you have learned from this exercise, noting how you could improve your coding and interpretations for future exercises.

Post course: Activity Inspired Factor Market Clearing

Presume, for some unspecified reason, that South Africa is required to reduce factor input subsidies, using the shocks from Ex S2:1. However, it is accepted that South Africa cannot increase the scale of production from the mining activity.

Using the files for the first part of this exercise do the following.

1. Generate a factor market clearing closure that fixes the capacity of the mining activity.

2. Run the experiment and verify that the intended shocks and closure conditions have been imposed.
3. Use the results to answer the following questions, comparing the results and their interpretations across the different factor market clearing closures.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on the welfare, income and consumption expenditures for different households?
    c. Using the changes in prices explain the causes for the observed impacts on households?
    d. What are the impacts on the volumes of domestic production, imports and exports?
    e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

Write a short summary of the lessons you have learned from this exercise, noting how you could improve your coding and interpretations for future exercises.

Ex S2:3 Trade Policy and Sensitivity Analysis

> *Parameter uncertainty is a feature of all CGE models; the models require a range of parameters for which empirical estimates are typically either unavailable or uncertain. In such circumstances it is incumbent on the analyst to demonstrate which of the results are 'sensitive' to the choice of parameter values*

In this exercise, we extend the trade policy and tax replacement exercise to include sensitivity analyses with respect to parameter values: how sensitive are the results to different elasticities of substitution/transformation between traded (imports and exports) and domestic goods? This exercise will start from Ex S1:5, i.e., trade policy and tax replacement. As usual we will limit the changes, so we will use the base and a tax replacement closure assuming all factors are fully employed and fully mobile and add the analyses of sensitivity to model parameters (elasticities). This will be done by adding a third loop to the experiment file.

It is not uncommon for CGE studies, especially those carried out by consultancy companies, to evaluate the impacts of **A** shock with **A** given set of macroeconomic closure and factor market clearing presumptions for **A** given set of elasticities. The possible explanations for this are straightforward: including, the client only wants a specific set of results (to justify a predetermined policy decision!!); and/or the consultant has sold a *forecast*[3] to the client (so alternative scenarios may confuse the client!!); and/or the consultant does not know any better; and/or the client will not pay for a better analysis; ……

It should be noted that the analyses before this exercise have included sensitivity analyses. The simulation loop has provided scope for assessing the sensitivity of outcomes to the magnitudes of the shocks, while the closure loop has provided scope for assessing the sensitivity of the results to presumptions about macroeconomic closures and factor marketer clearing conditions. Hence all this exercise is doing is adding another layer of sensitivity analysis.

[3] We repeatedly note that CGE models cannot be forecasting models, despite at least one 'authority' persistently asserting that CGE models are forecasting models.

There is, however, a complication. When changing elasticity values, we also need to re-calibrate the model because shift and share parameters in the CES functions depend on assumed elasticities. Consider the block of code in the box below.

```
* ## Parameters for Armington/CES functions

 rhoc(c)$(cx(c) AND cm(c))     = [1/ELASTC(c,"sigma")] - 1 ;

 delta(c)$(cd(c) AND cm(c))
                = {PM0(c)*QM0(c)**[rhoc(c)+1]}
                   /{PM0(c)*QM0(c)**[rhoc(c)+1]
                      + PD0(c)*QD0(c)**[rhoc(c)+1]} ;

 ac(c)$(cd(c) AND cm(c))
     QQ0(c)/{delta(c)*QM0(c)**[-rhoc(c)]
           +(1-delta(c))*QD0(c)**[-rhoc(c)]}**(-1/rhoc(c)) ;
```

The calibrated values of the parameter `delta` depend on the elasticity parameters `rhoc` and the shift parameters, `ac`, depend on the share parameters, `delta`, and the elasticity parameters, `rhoc`. Hence, any changes to the elasticity parameters imply the need to adjust the other parameters used in the CES/CET functions of the model. This is the process that will be added to the experiment file.

For this exercise we will revert to the files used for the trade shocks in ModO7, since it contains most of the files needed for this exercise but will work in a new directory to avoid overwriting previous files. Those extra files that you may, or may not, want can be copied from other projects,

Setup

We will continue to work in the directory `stg_t\stg_t_2`. This is one of the benefits of working with the directory structure used with `stg_t.gms` and two projects in one directory: we do not need to make changes to the core model while creating new experiment files by changing/extending existing experiment files. Also, by using the `save` and `restart` facility the based model does not need to be repeatedly solved. **BUT** there is a massive premium on making sure files are not overwritten and then 'lost'.

All the files needed for this exercise are in your working directory.

Sensitivity to Import Substitution Elasticities

In this exercise, we will consider changes in the elasticities of substitution for imports, i.e., `ELASTC(c,"sigma")`. The work can all be done in the files used for the experiments, i.e., those that restart from the work file created by `stg_t.gms`, and moreover the method we have been developing makes this the case. This first part will concentrate on a simple change in the experiment file.

Carry out the following tasks.

1. Make a copy of the file `1_2_Expt_data\stg_t_expt_1_5_sol.xlsx` and rename the file as `stg_t_expt_2_3.xlsx`.
2. Open the template experiment file `stg_t_expt_2_3.inc`. You will need to make some changes to the Excel workbook and the experiment file.
3. In the files `stg_t_expt_2_3.xlsx` and `stg_t_expt_2_3.inc` not that only two macroeconomic options are selected: the base closure plus one tax replacement closure with both presuming full employment and fully mobile factor clearing conditions.
4. In the file `stg_t_expt_2_3.xlsx` open the worksheet labelled sens_controls, which includes a template layout. We use the label `sens` for the controlling set for the sensitivity loop and the parameter `sens_cont` provides values for controlling the resetting of the model parameters. You should have two members of the set `sens` – `sen_base`, `sen_1` – and in the `sens_cont` parameter these should be numbered 1 and 2. HINT: follow the pattern used for closures and make sure you add some descriptive text to help you remember what the lables are meant to mean.
5. Save the file `stg_t_expt_2_3.inc` with a new name, e.g., your file `stg_t_expt_2_3_**.inc`. This step allows you to revert to the template without having to reload from the library.
6. Note that the file `stg_t_expt_2_3.inc` includes some code to get you started with adding the sensitivity loop – search for `LOOP(sens,`.
7. Now we need the code to reset an elasticity parameter. In the file `2_include/stg_t_parmcalib.inc` and search for `"rhoc"`. You need a copy of the block of code where `rhoc, delta and ac` are assigned. Make a

copy of this block of code and paste it into your file `stg_t_expt_2_3.inc` below the section label says `"* ## Parameters for Armington/CES functions";` there are 2 places for this.

8. Now we need to reset the elasticities for each element of `sens`. The first value is for the base, and therefore replicates the base elasticity values and the second is for sensitivity analyses. In this first case all we will do is change the import elasticity for one commodity – `cutil`.
9. Above the first assignment for `rhoc` add the line of code `ELASTC("cutil","sigma") = 2.0 ;`. This will replicate the base.
10. Above the second assignment for `rhoc` add the line of code `ELASTC("cutil","sigma") = 3.0 ;`. This will be the alternative elasticity value. Here we are making use of the fact that `ELASTC` is a parameter, and we are free to reassign it. While this is useful it does need care; it is easy to make a reassignment and then not realise that it is persisting.[4]
11. Run the experiments and verify that the intended shocks, closure, and elasticity values have been imposed.
12. Carry out a simple interpretation exercise to understand the implications of different elasticities. Here we are not assuming the new elasticity values are correct; the aim is to learn about the system. Use the following questions as guidance for your interpretation.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on welfare, income and consumption expenditures for different households?
    c. Using the changes in prices to explain the causes for the observed impacts on households?
    d. What are the impacts on the volumes of domestic production, imports and exports?
    e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

[4] Also remember that CES and CET functions are not defined for an elasticity value of ONE.

A copy of our solution file is in the working directory as `stg_t_expt_2_3_sol.inc`.

Sensitivity to Import Substitution Elasticities: Alternative Method

An alternative method for running sensitivity tests on the base elasticities can be achieved by multiplying the base elasticities by some adjustment factor. This is apparently appealing since it can be implemented with a need for fewer commands.

1. Save your experiment file `stg_t_expt_2_3_**.inc` with a new name.
2. In your new experiment file, you need to create a new experiment parameter - `sens_sim(sens,sim)` – that will be used to implement the multiplicative scaling of the base elasticities.
3. Now in section '2b Assign experiment parameters' assign `sens_sim(c,"base")` the value 1.0, and `sens_sim(c,"sen_1")` the value 0.5.
4. Now keeping one copy of the code for assigning `rhoc`, `delta` and `ac`, delete the two `IF (sens_cont(sens) = **` blocks of code.
5. Immediately before the code to reassign `rhoc` add

```
ELASTC(c,"sigma")  =  ELASTC(c,"sigma") * sens_sim(c,sens) ;
```

6. Run the experiments and verify that the intended shocks, closure, and elasticity values have been imposed.
7. Why did the experiment fail when entering the `sen_1` index for the `LOOP(sens)`?
8. Adjust the scaling factor for `sen_1` and rerun the experiments until they are solved.

Interpretation

1. Use the results to answer the following questions, comparing the results and their interpretations across the two macroeconomic closures and three different values for import substitution elasticities.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on welfare, income and consumption expenditures for different households?
    c. Using the changes in prices to explain the causes for the observed impacts on households?

d. What are the impacts on the volumes of domestic production, imports and exports?
e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

A copy of our solution file is in the working directory as `stg_t_expt_2_3b_sol.inc`.

Compound Elasticity Sensitivity Tests

Given that all CGE models involve complex interactions between different behavioural relationships it is often desirable to run sensitivity tests that involve changes in more than one set of elasticities. For trade studies an obvious pair of elasticities to consider are the import (CES) and export (CET) elasticities. The methods used above contain the basic code patterns that can be used for such compound sensitivity tests. Here the challenge is for you to create your own code using these basic code patterns.

This exercise will provide most of the coding you need for the project.

What are the lessons you should have learnt in this exercise?

1. Simple multiplicative changes to blocks of elasticities can present problems because CES and CET are undefined for some values. So, providing values from an Excel worksheet may be appropriate.
2. Using many elements in the set `sens` could allow for many different combinations of elasticity values. But is this a good way to present the results to help with comparisons?
3. Using IF statements to control the implementation of the sensitivity (`sens`) LOOP is practical. Might this option make it easier to explore the implications of changes in both sets of elasticities?

The challenge here is to create an experiment file and Excel worksheets that allow you to run sensitivity analyses across both import and export elasticities. Rather than provide detailed instructions we only provide a series of HINTS. (An example of how we did this will be provided later in the course. Note that our way is only one of several different ways that could be used to achieve the same outcome.)

HNITS

1. You will need a copy of the block of code from `stg_t_parmcalib.inc` where `rhot, gamma` and `at` are assigned.
2. The values in the parameter `ELASTC` used in the base model will persist unless they are overwritten.
3. Start simply and test your code with one change in elasticity for imports and exports.
4. You need to think about the process of interpretation (see a suggested block of simple questions below) since that is the objective of the exercise.
5. Think about how you want to present the results. **NB**: the dimensions in the results are controlled by the `$SETGLOBAL res_dimen`, so first you need to decide want dimensions you want in the results.
6. You will make mistakes, so spend time learning how to correct your mistakes (part of this process is learning how to interpret the feedback from GAMS).

Interpretation

1. Use the results to answer the following questions, comparing the results and their interpretations across the **two** macroeconomic closures and **eight** different values for trade function elasticities.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on welfare, income and consumption expenditures for different households?
    c. Using the changes in prices to explain the causes for the observed impacts on households?
    d. What are the impacts on the volumes of domestic production, imports and exports?
    e. Using the changes in prices explain the causes for the observed impacts on the volumes of domestic production, imports and exports?

Write a short summary of the lessons you have learned from this exercise, noting how you could improve your coding and interpretations for future exercises.

Ex S2:4 Factor Input Subsidies and Production Elasticities

> *Production systems in many CGE models are complex; often they are series of nested (CES) functions (or translog) functions. Thus, in contrast to the previous exercise there are multiple functions for which empirical estimates of elasticity parameters are typically unavailable.*

In this exercise, we revert to the factor use tax experiments and modify the experiment include file to accommodate changes in elasticities in the production system. As usual we will limit the changes, so we will use the base and a tax replacement closure assuming all factors are fully employed and fully mobile and extend the analyses of sensitivity to model parameters (elasticities). This experiment file can be built on the experiment file from Ex 2.3.

Sensitivity to Production Elasticities

For this exercise you should continue using the directory `stg_t_8`. In this exercise, we will consider changes in the elasticities of substitution in production using the trade policy shocks. First, rename the files from the previous exercise as `stg_t_expt_2_4.xlsx` and `stg_t_expt_2_4.inc`, but do not delete any of the codes.

There are three series of production elasticities: `ELASTX("sigmax",a)`, `ELASTX("sigmava",a)` and `ELASTF(ff,a)`. Choose one of these sets of elasticities to start with and then extend the experiment data file, e.g., `stg_t_expt_2_4.xlsx`, and experiment file, e.g., `stg_t_expt_2_4.inc`, to include sensitivity analyses with respect to the chosen set of base elasticities. HINT: switch off the sensitivity testing for the trade function elasticities in the experiment data file.

Run the experiments and verify that the intended shocks, closure and elasticity values have been imposed.

Then extend the experiment data and experiment (code) files to include both two other sets of elasticities. HINT: do one at a time, checking after each that the intended shocks, closure and elasticity values have been imposed.

This is where having an INCLUDE file for recalibrating the parameters for the functions, e.g., `stg_t_sens_parmcalib.inc`, can/may help keep the experiment code file tractable.

The challenge here is to create an experiment file and Excel worksheets that allow you to run sensitivity analyses across different production elasticities. An example of how we did this will be provided later in the course. Note that our way is only one of several different ways that could be used to achieve the same outcome.

Interpretation

1. Use the results to answer the following questions, comparing the results and their interpretations across the two macroeconomic closures and the different values for the production function elasticities.
    a. What are the impacts on GDP and Absorption?
    b. What are the impacts on the volumes of domestic production, imports and exports?
    c. What are the impacts on the structure of domestic production?
    d. Using the changes in prices to explain the causes for the observed impacts on production?
    e. What are the impacts on factor prices and incomes?

Write a short summary of the lessons you have learned from this exercise, noting how you could improve your coding and interpretations for future exercises.

Ex S2:5 Model Setup & Calibration: Extra Options

This exercise introduces some of the options available to condition the model. Some of these options are covered in the User Guide, others are not. This session does not deal with changing the data/SAM used.

This exercise presumes that the reference file and the GDX dump file will be used intensively. The intention of this exercise is to develop your understanding so that the project for this course can be completed.

STAGE t Model Workbook: `stg_t_data.xlsx`

Open the model `stg_t.gms` in GAMS Studio, run it using F10 that will generate a reference file, `stg_t.ref`, and a `gdx` file, `stg_t.gdx`.

Layout Worksheet

Explore the layout worksheet and make sure you understand how the `GDXXRW` programme knows where to find information in the Excel workbook (for GAMS help search for 'GDXXRW').[5]

1. Data types: '`dset`' – domain set; '`set`' – other sets; '`par`' – parameter.
2. Location: use standard Excel notation on worksheet plus cell location in top left (reading continues until empty row and column encountered).
3. Row/Column ('`rdim`'/'`cdim`') Dimension: tables of 3 or more dimensions are presented in two dimensions by having multiple labels in either or both the rows and column. '`rdim`' identifies the number of labels in the rows, while '`cdim`' identifies the number of labels in the columns.

Sets Worksheet

This worksheet defines the sets and subsets used in the core model (`stg_t.gms`); while the members of the sets and subsets can be changed, indeed when working with data for a new country they would be expected to change. Explore this worksheet so that you understand the

[5] **NOTE**: GAMS is moving to use a new utility CONNECT for interacting with Excel. The CONNECT system will be platform independent and an alternative to GDXXRW. However, users are still working out the best ways to use CONNECT as a replacement for GDXXRW in applications similar to STAGE and ANARRES. cgemod will move to CONNECT at some point, but only when we deem our use of CONNECT is robust.

relationships between the 'master' set `sac`, its subsets, e.g., `c`, `a` and `f`, and the subsets of the subsets.

1. Use the reference file to explore where the sets are declared and where they are read into GAMS.
2. Verify that the values read into GAMS are those in the `sets` worksheet.

NB: GAMS orders the elements in sets accordance with the order in which they were first encountered in a programme. We ALWAYS load the set `sac` first; this means that the order of the elements in sac dictates the order of the elements in ALL subsets of `sac`, and subsets of subsets. Moreover, if ONE element appears in `sac` and in another set, say `xyz`, that is not a subset of `sac`, then the element from sac will be the first element in the set `xyz`.

Stab_sets Worksheet

This worksheet defines the sets used in the file (`stg_t_struct.inc`) and various files to report structural information about the model and results; the members of the sets should not be changed unless the files they are used in are extended and/or modified. Explore this worksheet and the code so that you understand how these sets and elements are used in the model.

Res_sets Worksheet

This worksheet defines the sets in various files used to generate analytical results; the members of the sets should not be changed unless the files they are used in are extended and/or modified. Explore this worksheet and the code so that you understand how these sets and elements are used in the model.

Nest_va Worksheet

This worksheet contains tuples/mapping sets that are used to control the arguments – natural and/or aggregate factors - that enter the *QVAPRODN* and *QVAFOC* equations. **HINT**: we use notation conventions when defining elements in these models.

Nest_fagg Worksheet

This worksheet contains tuples/mapping sets that are used to control the arguments – natural factors - that enter the *FDPRODN* and *FDFOC* equations. Does the model use any other tuples? If so, how are they assigned?

SAM Worksheet

The SAM records the transactions data observed in the study country for a given period. It is important that you understand how to read and interpret the information in SAM; it is amazing how many CGE modelers do not understand the information content of the SAMs used to calibrate their models.

1. Copy the SAM worksheet to new workbook (do NOT delete it from the model database)
2. Use Excel to calculate
    a. The column coefficients
    b. The row coefficients
3. Why are transactions for the accounts `tffcaunsk` and `tffcaskl` not visible in `stg_t.gdx`? Does this mean that the sets `tffcaunsk` and `tffcaskl` are not available in the model? Does this mean that there can be no factor use taxes on `fcaunsk` and `fcaskl`?

Factor Use Worksheet

This worksheet records the quantities of primary factors ($FD_{f,a}$) used by each activity. If this worksheet is empty will the model still run? Try it and see what happens. Use the reference file to work out why the model will run without factor use data.

Factor Institution Worksheet

This worksheet records the quantities of primary factors ($FSI_{insw,f}$) owned by each institution. If this worksheet is empty will the model still run? Try it and see what happens. Use the reference file to work out why the model will run without factor use data.

Controls Worksheet

This allows the use of parameters to condition the model setup.

1. `numerchk` - IF 1 then default, if NOT 1 then check on numeraire

2. `minaqxsh` –the minimum share of intermediates in cost for aqx
3. `samscal` - SAM scaling factor and initial value for autoscaling
4. `scaltarg` - target level for auto scaling
5. `scalprop`- proportion of NONzero elements that must be below the target level
6. `setpop`- If 1 then POP data used, If 2 then adult equivalent data used
7. `toldiffsam` - Tolerance on differences in base and solution SAM entries

Comelast Worksheet

The elasticities given are 'placeholders', i.e., the model requires a value to operate but those in the worksheet are unlikely to be 'right'. You need to customise this worksheet to the study you are conducting:

1. Find or generate elasticity estimates – typically very difficult.
2. Impose 'best guesses', in which case the following guidance may help
    a. Use a limited number of elasticities and avoid spurious accuracy, e.g., maximum of 2 decimal places – 0.25, 0.5, 0.75, 1.25, 1.5, etc.
    b. For each commodity decide if it should be elastic (> 1) or inelastic (< 1).
    c. Assign a value.
    d. Run sensitivity analyses.

Actelast Worksheet

The elasticities given are 'placeholders', i.e., the model requires a value to operate but those in the worksheet are unlikely to be 'right'. You need to customise this worksheet to the study you are conducting:

1. Find or generate elasticity estimates – typically very difficult.
2. Impose 'best guesses', in which case the following guidance may help.
    a. Use a limited number of elasticities and avoid spurious accuracy, e.g., maximum of 2 decimal places – 0.25, 0.5, 0.75, 1.25, 1.5, etc.
    b. For each activity decide if it should be elastic (> 1) or inelastic (< 1).
    c. Assign a value.
    d. Run sensitivity analyses.

elastf Worksheet

The elasticities given are 'placeholders', i.e., the model requires a value to operate but those in the worksheet are unlikely to be 'right'. You need to customise this worksheet to the study you are conducting:

1. Find or generate elasticity estimates – typically very difficult.
2. Impose 'best guesses', in which case the following guidance may help.
    a. Use a limited number of elasticities and avoid spurious accuracy, e.g., maximum of 2 decimal places – 0.5, 0.75, 1.25, 1.5, etc.
    b. For each activity decide if it should be elastic (> 1) or inelastic (< 1).
    c. Assign a value.
    d. Run sensitivity analyses.

Hoelast and Frishcelast Worksheets

The elasticities given are 'placeholders', i.e., the model requires a value to operate but those in the worksheet are unlikely to be 'right'. You need to customise this worksheet to the study you are conducting:

1. Find or generate elasticity estimates – typically very difficult.
2. Impose 'best guesses' for the income elasticities of demand, in which case the following guidance may help.
    a. Use a limited number of elasticities and avoid spurious accuracy, e.g., maximum of 2 decimal places – 0.25, 0.5, 0.75, 1.25, 1.5, etc.
    b. For each commodity and household decide if the income elasticity should be elastic (> 1) or inelastic (< 1).
    c. Assign a value.
    d. Run sensitivity analyses.
3. Impose 'best guesses' for the Frisch parameters, in which case the following guidance may help.
    a. Use a limited number of elasticities and avoid spurious accuracy, e.g., maximum of 2 decimal places – -3.00, -2.50, -2.00, 1.50, etc. – but not greater than -1.00
    b. Rank each household on proportions of consumption likely to be subsistence or discretionary consumption – typically by income per

capita or by shares of food in household consumption expenditure. The more negative the Frisch parameter the greater will be subsistence consumption as a share to total consumption.

c. If the Frisch parameter for a household is -1.00 and all the income elasticities are 1, the LES utility function collapses to a Cobb Douglas function.
d. Assign a value.
e. Run sensitivity analyses.

NB: the income elasticities of demand in the worksheet are NOT those applied in the model. Check where these changes are introduced in the code and make sure you understand why.

STAGE_t Experiment Workbook: `stg_t_expt_**.xlsx`

Layout Worksheet

Explore the layout worksheet and make sure you understand how the `GDXXRW` programme knows where to find information in the Excel workbook.

exp_controls Worksheet

This allows the user to condition the analyses files that are run

1. `reslevel` - IF 1 then stg_int_reslevel runs; IF 0 then stg_int_reslevel does not run
2. `ressamg` -IF 1 then stg_int_ressamg runs; IF 0 then stg_int_ressamg does not run
3. `resmacro` - IF 1 then stg_int_resmacro runs; IF 0 then stg_int_resmacro does not run
4. `resstruct` - IF 1 then stg_int_resstruct runs; IF 0 then stg_int_resstruct does not run
5. `reswelf` - IF 1 then stg_int_reswelf runs; IF 0 then stg_int_reswelf does not run
6. `resindex` -IF 1 then stg_int_resindex runs; IF 0 then stg_int_resindex does not run
7. `restaxstr` -IF 1 then stg_int_restaxstr runs; IF 0 then stg_int_restaxstr does not run
8. `resperc` -IF 1 then stg_int_resperc runs; IF 0 then stg_int_resperc does not run

Exp_Sets Worksheet

This worksheet defines the sets and subsets used in experiments to control the experiments; these are relatively straightforward.

Clos_controls Worksheet

This worksheet defines the elements in the set `clos` and the data for the parameter `clos_cont`.

sens_controls Worksheet

This worksheet defines the elements in the set `sens` and the data for the parameter `sens_cont`.

Concluding Comments

It is **not** possible to automate all the steps UNLESS you restrict the discretion available to the individual user, e.g., control over subset membership, etc. The view adopted by the cgemod is that users should have options and that it is best that they make decisions during the set-up phase.[6] Two methods are available for setting up the workbook: (i) partially manual using macros in Excel and (ii) all manual using copy and paste in Excel. The former option has potential speed advantages when it works 'correctly', but when it goes wrong can be problematic. The latter is slower, and errors are more likely, but when it goes wrong can be easier to rectify. (We are working on ways to simplify the set-up process that will be robust.)

It is important to note that it will take a new user time to become comfortable with all the conventions, labels and techniques used when they confront a new model. The cgemod philosophy has been to try, as far as we can, to use common conventions, labels and techniques across the ANARRES, STAGE, R23 and SMOD families of models. This helps, BUT sometimes it proves necessary to change conventions, labels, and techniques in the light of trying to solve new challenges and we do not have the time to go back and change the conventions, labels and techniques used over the last 30+ years.

[6] The approach adopted by others is different. For instance, for the GTAP model, the aggregation process followed by GTAPAgg generates a default series of data files (mostly *.har files) that are assumed to be 'correct' values; thereafter if the user disagrees s/he must modify various files, e.g., cmfstart file. We argue that you must make positive decisions from the outset.

Ex S2:6 Project S2.1 Sensitivity Analysis

> *Sensitivity analyses are typically presumed requirements for all CGE analyses. While consultants may choose not to report the results of sensitivity analyses, they would be unwise not to carry out such analyses: a good/informed client is likely to ask about the results from sensitivity analyses. In an academic context, editors and referees will typically require some commentary on the results of sensitivity analysis.*

For this exercise you have substantial discretion, i.e., this exercise is not only about the techniques used in sensitivity analysis but also about your ability to formulate a series of policy shocks and a range of sensitivity analyses.

Carry out the following.

1. Select an appropriate tax policy shock.
2. Select an appropriate range of macroeconomic closure and factor market clearing conditions.
3. Select an appropriate range of elasticities that a subjected to sensitivity analyses.

Project S2:1

Compile your results and comments in a Word document with a maximum of, say, 2,500 words, excluding tables and figures but an absolute maximum of 10 sides – using small print is cheating!!!. The reasons for the limits are to encourage you to identify the important results and concentrate the report on the important implications of the results.

An example of how we might have done this project is available on the course page for Mod S2.

Ex S2:7 Adding a Specific Tax Instrument

This exercise introduces a specific tax instrument, i.e., a tax instrument levied on the quantity of commodities consumed. The exercise will involve modifying the code for an ad valorem tax instrument (TSS) into the code for a specific tax instrument.

This exercise is optional but should be undertaken.

Taxes are one of the key policy instruments available to policy makers. Accordingly, it can be argued that the tax instruments in a model application for country X should reflect the tax regime in operation in country X. Moreover, a CGE model may be used to evaluate changes in the tax regime in a country, e.g., a shift from a GST to a VAT based system, where VAT was not in the country's previous tax regime and hence may not be included in the CGE model currently in use. In these, and other, situations it may be necessary to modify the CGE model to include different tax regimes. This exercise explores one such possibility.

The task is to convert *TSS* from a tax based on *ad valorem* transactions to a tax based on specific, i.e., volume, transactions. Later you may want a model with both *ad valorem* and specific taxes.

Introducing a Specific Commodity Tax Instrument

Most of this exercise concentrates on modifying the core model file, `stg_t.gms`. But this exercise involves making changes to the behavioural relationships in the core model, using a new model data file, it is appropriate to work in a new directory.

1. In the directory `stg_t_8`, create a subdirectory `specif`, `C:\cgemod\stg_t\stg_t_2\specif`.
2. Open GAMS Studio and select `File>New Project`.
3. Find and select the sub directory `C:\cgemod\stg_t\stg_t_2\specif`, and then in the File name box name the project `specif.gsp` and `Save`.
4. This will establish the project `specif` in GAMS Studio. Use the project's cog wheel to display the project name, working directory and base directory.

5. In Studio press `F6` and in the Model Library Explorer then select the tab `Single CGE Course Library` and select and double click `stg_t_8_7`, which is SeqNr: 05.
6. The `stg_t.gms` model will now be displayed in the editor window. This is the same model as used in Mod O7 and O8.
7. The ZIP file (`stg_t_08.zip`) needs to be unzipped into the project's working directory.
8. Studio can now be used to work with the `stg_t` model.
9. Save the file `stg_t.gms` as `stg_t_8_7.gms`. Make sure the new model file runs correctly and carry out all the standard checks.
10. In the file `stg_t_8_7.gms` change the Excel data file loaded by the programme to `stg_t_data_sam_8_7.xlsx`. Verify that the model runs with the new data file.
11. Open the files `stg_t_parmcalib.inc, stg_t_varinit.inc` and `stg_t_samchk.inc`. You will need to make changes in these files as well as the core model file `stg_t_8_7.gms`.
12. In the model `stg_t_8_7.gms`. identify every equation that includes the variable `TSS`. Each of these equations, and any parameters associated with them, will need changing.
13. Now put your computer aside and work with pen and paper. You need to work out the following.
    a. The revised price definitions for `PQD` and any other price definitions that use `TSS`.
    b. The method for calibrating the base rate of `TSS` as a specific tax as opposed to an *ad valorem* tax instrument.
    c. It can help to do some numerical calculations for one commodity so that you know the expected values of the various components.
    d. HINT: Examine the code for TEX.
14. Once you have worked out the mathematics you can start to modify the model. The suggested sequence in which to make the changes is:

   a. Change the model equations. **HINT 1**: it may be wise to comment out the existing equations and then add the new equations. **HINT 2**: a list of all arguments in the equations that have been reassigned may be useful.
   b. Make sure that **every** reference to `TSS` and associated equations, including documentation, is revised, and made consistent. **NB**: documenting your models is important since you soon forget the precise details and reasons behind changes.
   c. Start with, say, the revised variables and work back from the equations to ensure the initial values, i.e., `**0`, and initialization of variables, i.e., `**.L`, are declared and assigned correctly.
   d. Then do the same for all associated parameters.
   e. Now revise the code in the SAM checking files, i.e., `stg_t_samchk.inc`.
15. Assume you will have made mistakes, i.e., that you will need to debug the revised model.
16. When debugging note that in the GAMS Configuration you set the value for '`cerr = x`', where `x` is an integer (we use 5 to 10). This stops the programme after `x` compilation errors; you may choose to change `x` but note a large number will not be helpful. It is also helpful to make use of the `$stop` command. Given the changes you have made, one way forward is to stop the model after the data are loaded and checked, then after the parameter calibration for `TSS`, and after the variable initialisation file, and after the first SAM Check. After each '`$stop`' check that the values for the various components are those expected.
17. After passing all the checks, remove all `$stop` commands and run the model `stg_t__8_7.gms`.
18. If the model fails to solve, and you should be surprised if it does solve correctly, use the reference file, the `gdx` file and the `log` file to track back through the model to find your errors. Expect the model to fail.
19. When the model solves, carry out all the standard checks to ensure a valid solution.
20. If it does not pass all the standard checks you need to go back into the code and correct the problem.

21. Once the model has passed all the standard checks for a valid solution, carry out a series of simple experiments and verify that the model produces valid solutions that generate results that are consistent with expectations. The experiments should include changes in `TSS` and the use of different tax replacement instruments.

The challenge here is to modify the behavioural relationships in the model, including changes in the Excel data file, and create an experiment file that tests your model changes. An example of how we did this will be provided at the end of the course. Note that our way is only one of several different ways that could be used to achieve the same outcome.