R_123 Economy Model: Exercises

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1. Introduction

These exercises use the R_123 model, which is calibrated using a database derived from the R23 database developed for the World Bank. The extensions of the 123 model include the addition of factor demands, intermediate inputs, savings and investment, a range of government tax instruments and transfers; this model is an extension of Devarajan *et al.*, (1997). This implementation is designed as a platform for learning about CGE models, **not** as a tool for conducting (policy) experiments designed to influence policy choices. However, there is no *a priori* reason, if the dated were updated, why it could not be used in the same way as the World Bank's 123PRSP and R23 models[1]. This model (r_123) uses an aggregated version of the R23 database (see McDonald *et al.*, 2015) that has also had some of the transactions 'simplified' to be consistent with this training exercise. It will operate easily within the bounds of student/demo GAMS using the model r_123.gms.[2]

The exercises with this model do not involve changes to the model code. Rather the focus of attention is on checking the model is running correctly, after changing the country for which the model is calibrated and running simulations that emphasise adjustments to the default macroeconomic closure rules and factor market clearing conditions. We will look in detail at two sets of simulations. The first, examines the implications for Vietnam of reductions in trade taxes with and without tax replacement. The second, examines the implications of reductions in transfers, equivalent to aid, from the rest of world received by Ghana and the options for replacing those transfers by increasing domestic taxes. Considerations will be given to the implications of using different tax replacement instruments. Thus, both sets of experiments retain a focus on the trade accounts, and both address a major policy consideration for many countries.

Note that the experiments implemented here are far from exhaustive and are only a fraction of those that would be appropriate if seeking to develop evidence for policy decision making.

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1 For details on the R23 model see www.cgemod.org.uk. For details on the 123PRSP model see http://poverty.worldbank.org/files/12937_TKWeb_Chap_13_(Rev).pdf.

2 Earlier versions of this model used an aggregated version of the GTAP database. It was necessary to augment this database with IMF and World Bank data to relax serious limitations imposed by the GTAP database (see McDonald and Sonmez, 2004, for details). The R23 database was developed explicitly to relax constraints imposed in the development of the GTAP database.

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2. Set up for R_123 Model

READ THROUGH THIS SECTION BEFORE DOING ANYTHING MORE.

Setup

All the files you will need for this module are in the Practical CGE Library you created in module O1.

The first step is to get the correct files into a working directory. Do the following

1. Open GAMS Studio select `File>New Project` and add a new (sub) directory (`opmod2`) in the directory to give `C:\cgemod_training\opmod\opmod2`.
2. The Studio panels should appear automatically, and the Project Explorer and Editor panels should appear; note how the working directory's path is reported as `C:\cgemod_training\opmod\opmod2`. (See Figure 2.1.)
3. In Studio press `F6` and in the `Model Library Explorer` select the `Practical CGE Library` and then select the library file `opmod2` and choose `Load` (or double click of the name), which is SeqNr: 7.
4. The `r_123.gms` model will now be displayed in the editor window and be listed in the Project Explorer as being in the project `opmod2`.
5. Save this file as `r_123_**.gms`; where ** are wild cards, e.g., your initials.
6. You should note the files have been downloaded to the directory `C:\cgemod_training\opmod\opmod2`.
7. Review the model code and note the contents of each of the subsections.
8. Studio can now be used to work with the open economy model `r_123_**gms`.

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

The model (`r_123_**.gms`) is complete and linked to data for a country (actually the USA, but we will not be using the USA data during this course).

1. Make sure that the GAMS Configuration is set to automatically produce a reference file (`r_123_**.ref`) and stop after a limited number of errors (CErr).
2. Run the model with GDX creation.

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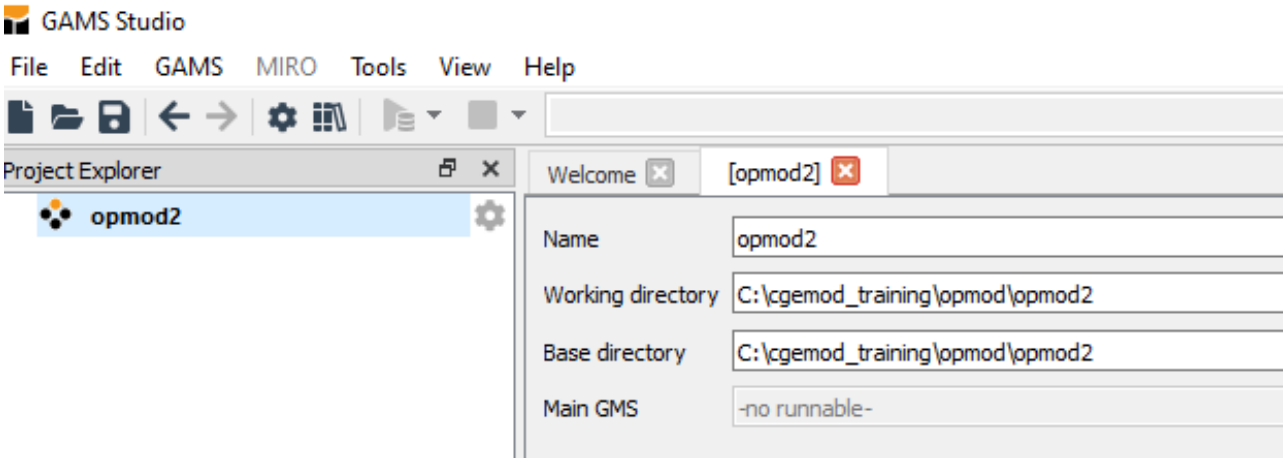
3. Check for a normal completion, e.g., does Walras equal zero, are all basic prices equal to one, etc.

Figure 2.1 New Project: opmod2



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3. Changing the Country and Checking the Model is 'Correct'

One great advantage of a modern set-based programming language is the ability to change the database without having to make changes to the model, if the new database has certain structural properties in common. In GAMS, the ability to control the operation of the model using dynamic sets and appropriate controls over the implementation of equations and calculations, means that a well-structured model may be used with many different databases/countries.[3] This set of exercises, and those done in the next parts of the course, will exploit this option. By so doing it is possible to let you explore economies with different structural characteristics.

But, when the database for a model is changed it is essential to first check that the model runs 'correctly' with the new database. This exercise goes through some of the steps used in the STAGE/ANARRES family of models to test that a model is running 'correctly' with a new database; there are other ways to carry out such tests and while some of these tests rely on features in GAMS, others depend on some of the code in the model.

Changing the Data

The `r_123.gms` model downloaded to directory `opmod2` was set up to run with data from the USA. However, the database for the r_123 model (for this course) has data for 36 countries.[4] The r_123 model can be run using data for any of those countries by changing three letters in one line of code in the model.

The course database is in the file `samR123.gdx`; all transactions are in millions of US dollars. The database is in the `opmod2` directory, so open the file `samR123.gdx` in GAMS Studio (it only has one symbol). Filter on the third index (the countries) and choose USA as the country, and then place the second index as the columns; this will let you see the structure of the USA SAM in the database. A brief period looking at the structure of the SAM for several countries will let you see the transactions between agents that are encompassed. Many of these you have seen previously but some you have not. Identify those you have not seen before and work out what they represent.

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3 This does not mean that the model is necessarily correct for a specific country. Ultimately, the model should reflect the realities of the country being studied.

4 The R23 database has a globally consistent SAM with full bilateral trade data and detailed transfers between countries for 204 countries. The full r_123 database has data for all 204 countries.

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In order to change the SAM read in by the model go to line 490 or search for '`Define SAM for this model`' (`Ctrl+G` opens a dialogue box in which you can enter the target line number). Two lines below you will see the formula

```
SAM(sac,sacp)    = SAMR(sac,sacp,"usa") ;
```

This indicates that the SAM for the model has two dimensions (`SAM(sac,sacp)`) and the database has three dimensions (`SAMR(sac,sacp,r)`). Use the reference file generated (`r_123_**.ref`) or search through the code for SAM and SAMR so that you understand where these parameters are declared and assigned.

You should end up seeking to find out the membership of the set *r* and the descriptions for it members. Find out the label for the country Vietnam. Once you have done this the data for the model can be changed

1. replace the label for the USA, in the formula that assigns the SAM for the model, with the label for Vietnam;
2. save the model as `r_123_vnm.gms`; and
3. rerun the model (`F10`).

Checking the Model

There are SEVEN checks **all** of which need to be passed. These checks, in the order they should be done are:

1. Check the data in the model are the intended data.
   This can only be done by comparing values in the `SAM` (NOT SAMR) reported in the file `r_123_vnm.gdx` with the SAM for Vietnam in the file `samR123.gdx`. You should only need to check a few values. The values will differ by a factor of 10,000. Why this is the case is explained below in the sub section 'Scaling the database'.
2. Check that the value for `VAR WALRAS` is zero.
   This check can be done from the `lst` file or `r_123_vnm.gdx`. In the list file search for '`Var Walras`' or use the index for `SolVAR`. In `r_123_vnm.gdx` search for '`Walras`'. If `WALRAS` does not equal zero, then the model fails Walras's law and some transactions are not accounted. (If `WALRAS.L < 10E-10`, that is close enough to zero.)
3. Check that the basic prices are equal to one.

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This check can be done from the `lst` file or `r_123_vnm.gdx`. In the list file search for '`Var PE`' or use the index for SolVAR. In `r_123_vnm.gdx` search for '`PE`'. (do this for `PD` and `PM` also). If values are not one, then the standard price normalisation rule has not been applied correctly.

4. Check that all entries in `ASAM1CHK` are equal to zero

   This checks for differences between the Macro SAM from the database for the model and the macro SAM calculated from the values of the calibrated parameters and variables. They should be identical and therefore all entries in `ASAM1CHK` equal to zero. (As elsewhere, very small differences/values (< $10E^{-10}$) are not important.)

5. Check that all entries in `ASAM2CHK` are equal to one

   This checks the ratio of the entries in the macro SAM calculated from the values of the calibrated parameters and the macro SAM calculated from the values of the parameters and variables in the model. They should be identical and therefore all entries in `ASAM2CHK` should be equal to one.

6. Check the `LHS` values. Search from the beginning for the first string `LHS` in the `lst` file; then search from the cursor for the string '***'

   In the output, GAMS reports the equations after all equations are organised so that all endogenous terms are on the RHS and hence the `LHS` should equal zero or a known exogenous value. Those that do not satisfy that condition are marked with '***'. In the `lst` file GAMS reports the values of the `LHS`: the search for `LHS` finds the first such entry, and second search finds the equations with incorrect `LHS` values.

7. Numéraire check: if the numéraire is doubled then all prices should double and quantities remain the same, hence all values should double. Only do this test after the others have been passed.

   Double the numeraire by changing the line '`PQD.FX = PQD0 ;`' to '`PQD.FX = PQD0 * 2 ;`' and re run the model. If the Exchange Rate (`ER`) is fixed it is also necessary to double the exchange rate. Check that `WALRAS` is equal to zero and the values in `ASAM2CHK` are all identical and all numéraire entries equal to two.

8. Reset the numeraire statement to '`PQD.FX = PQD0 ;`' and restore `ER.FX =ER0` if you changed that in the numéraire check.

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Only after these checks have been passed should you move on to using the model with the new database. Otherwise you risk spending many hours analysing results that are WRONG.

Scaling the Database

Over the last 25 years GAMS and the solvers it uses have become capable of solving bigger and bigger models and models that are increasing 'badly' scaled. Nevertheless, it is good practice to help the algorithms. One of the ways to do this is to scale the data to reduce the maximum size of the transactions. There is however a tradeoff; all transactions must be scaled by the same factor so as the bigger values are reduced in scale so are the smaller values. Hence deciding on the scaling factor is not always simple and there is no absolute rule.

The r_123 model has a manually set scaling factor. The code is

```
samscal     = 10000 ;
```

It is found on line 476, or search for `samscal`.

You will find that the scaling factor that works best, i.e., for which GAMS found the solution most quickly, varies with the data. Experiment with different values for `samscal`, although it is easiest to only work with powers of 10.

Applications

The applications with this model are the deliverables for Mod04. Once you have the model setup correctly and fully tested you can move onto the deliverable applications.

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Appendix

Countries in the R_123 database are:

afg	Afghanistan	ken	Kenya
aus	Australia	lka	Sri Lanka
ben	Benin	mar	Morocco
bfa	Burkina Faso	mex	Mexico
bra	Brazil	moz	Mozambique
bwa	Botswana	mwi	Malawi
chl	Chile	nld	Netherlands
chn	China	pak	Pakistan
cmr	Cameroon	phl	Philippines
deu	Germany	pry	Paraguay
egy	Egypt	rus	Russian Federation
eth	Ethiopia	sen	Senegal
fra	France	swe	Sweden
gha	Ghana	tur	Turkey
grd	Grenada	uga	Uganda
hun	Hungary	usa	United States
ind	India	vnm	Vietnam
kaz	Kazakhstan	zmb	Zambia

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