Practical GE Modelling Course

	Size	Absorption Matrix 1 Producers	2 Investors	3 Household	4 Export*	5 Government	6 Stocks
	Size	← I →	← I →	← H →	← 1 →	← 1 →	← 1 →
Basic Flows domestic	↑ C ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Basic Flows imported	↑ C ↓	V1BAS	V2BAS	V3BAS		V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					
Production Tax	↑ 1 ↓	V1PTX					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported,

O = Number of Occupation Types

M = Number of Commodities used as Margins

H = 1: Number of Household Types

* Note: Export column is for domestic goods only.

Size	Make Matrix ← I →	Total
↑ C ↓	MAKE	= sales row totals
Total	=col total absorptn	

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

Centre of Policy Studies
Victoria University

contents.doc

Program **Participant List**	#program.doc *names.doc	**Preliminary**	**1**
First Simulation (Drought) **Introduction to GEMPACK**	#firstsim.doc firstsim.ppt firstsim.xls gempack.ppt	**First simulation**	**2**
ORANI-G document	ORANIG18.doc	**ORANI-G document**	**3**
ORANI-G slides	ORANIG18.ppt	**ORANI-G slides**	**4**
Database summary	version.doc datasum.doc	**ORANI-G database**	**5**
Hands on Computing with ORANI-G Part A	#HandsOnA.doc *HandsOnAans.doc	**Hands-on computing Part A**	**6**
Hands on Computing with ORANI-G Part B	HandsOnB.doc	**Hands-on computing Part B**	**7**
Real wage-cut simulation	#wagecut.doc wagecut.ppt wagehandout.pdf *wageans.doc	**Real wage simulation**	**8**
AnalyseGE exercise	newsclipdoc.pdf #ant.doc *antans.doc tarfsim.ppt tarfcut.xls	**AnalyseGE**	**9**
Adding new equations **Regional extension** **Condensation**	#neweq.doc neweq.ppt regional.ppt cond-org.doc condense.ppt	**Other topics**	**10**
Group projects **Group members** **Group results**	grouproj.doc *groups.doc *groupX.xls *allgroup.xls	**Group projects**	**11**
Installing/using the course software **Course evaluation**	softinst.doc questionnaire.doc	**GEMPACK & Course evaluation**	**12**

 # Different instructors copy

**To be handed out in class, or on disk*

Welcome to the Practical GE course !

Collect your course folder, course USB key and name badge. We ask that you wear the name badge during all course sessions.

Please choose a desk and set up your laptop.

Then prepare your PC for the course by completing the four computing tasks on the next page.

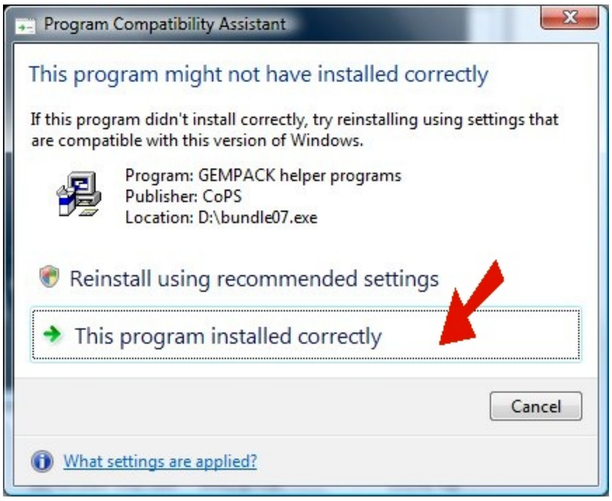
When everyone is ready, a short talk will be given describing the aims and scope of the course, and introducing the instructors. Then, we will ask each participant to stand up and introduce themself. You should tell everyone:

- your name, and where (what organization) you are from;
- a little about your background (economics degree? modelling experience?)
- why you are attending the course
- how you might use CGE modelling skills

Practical GE Modelling Course First Computing Tasks

Please run through these four quick tasks to make sure that you are using up to date software and the correct licence.

Task 1. Your computer should already have GEMPACK installed on it -- if so, go on to Task 2. If not please run the install program **gpei-11.4.003-install.exe** (or similar name) on the course USB key and follow the default installation prompts. Depending on how your computer is configured you may need Administrator rights to do the installation. If there is any problem, please ask one of the instructors to help you; or study the installation instructions at the end of the course folder. If you see a message similar to that below:

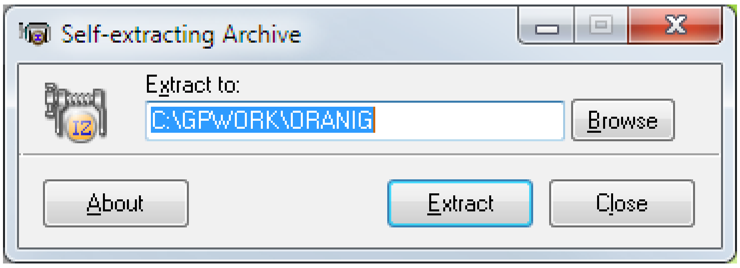


just click "This program installed correctly" as indicated above.

Task 2. By default the GEMPACK installation provides you with a 3 month expiring licence. You may have a permanent licence on your computer if GEMPACK is used in your organisation. The course USB key contains a Limited Executable-image GEMPACK licence which will expire in approximately 12 months. To use the course licence copy the file **licen.gem** on the course USB key, then paste it into your GEMPACK installation folder (usually C:\GP). You should replace the existing licence file. If you are not sure what to do please ask for help.

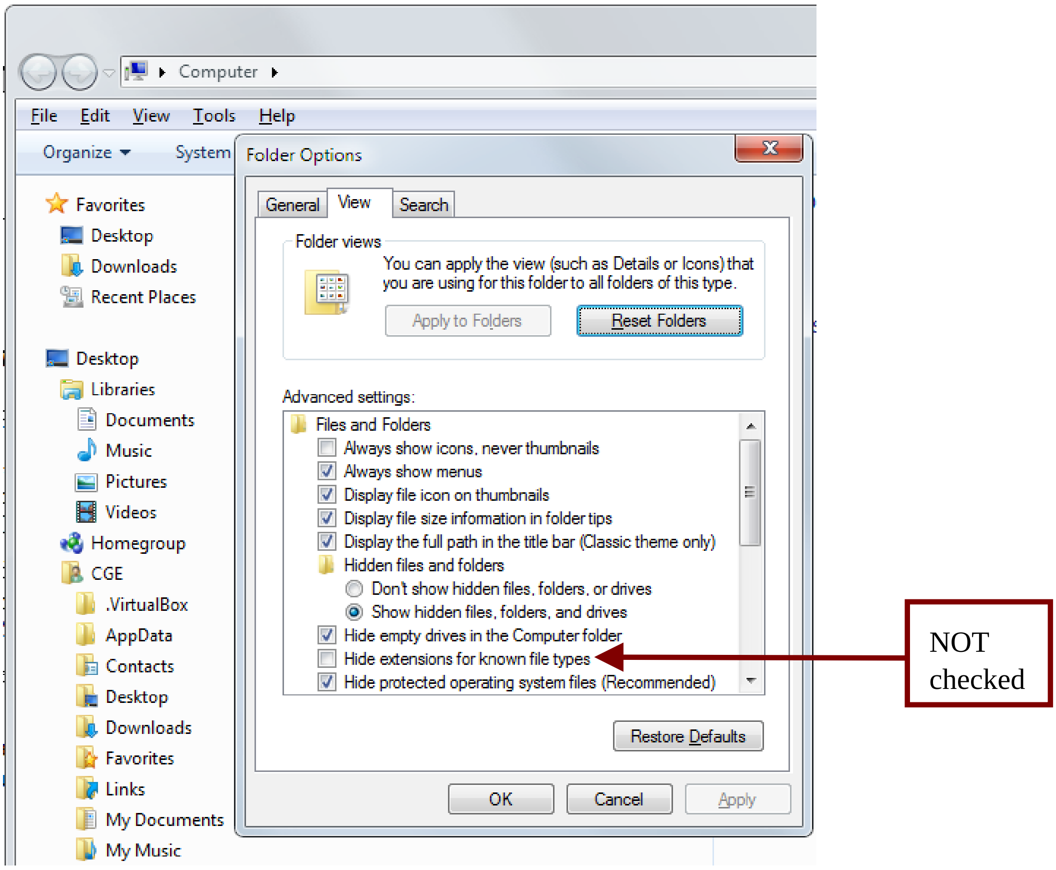
Tasks 3 and 5 are on the next page.

Task 3. Course Material Installation. All participants must install the course exercises from the course USB key. We have provided a small program to copy the course materials to the correct place on your C drive. Browse your course USB key, and double click on the file **exercises.exe**. Click Unzip to install the course material. (You should not change default location.)



[Alternative: E:\course\exercises.zip should be copied to C:\GPWORK\oranig\ and then unzipped in that directory.]

Task 4. Make sure that Windows Explorer is showing file extensions. Sometimes Windows Explorer hides file extensions, which is annoying. Prevent that by using the **Tools..Folder Options..View** dialog, as shown below. The option *Hide extensions for known file types* should **NOT** be checked.



If, after the course, you have any problems with the software please email support@gempack.com.

Good luck with the rest of the course!

Section 1

Preliminary

Program for Practical GE Modelling Course
Vienna 9-13 September 2019

Austrian Institute of Economic Research (WIFO), Arsenal Objekt 20, 1030 Vienna

Monday

9.00am–9.30am	**Course Welcome and Introduction**	
9.30am–10.30am	**The Broad Structure of a CGE model**	4: oranig.ppt (1-19)
10.30am-11.00am	**Morning Tea**	
11am–12.30pm	**Hands-On Computing with ORANI-G: First simulation**	2: FirstSim.doc 2: firstsim.xls
12.30pm–1.30pm	**Lunch**	
1.30pm–2.15pm	**Introduction to ORANI-G: Sets, Solution Method, the TAB file**	2: firstsim.ppt 4: oranig.ppt (20-40)
2.15pm–3.15pm	**Computing: Interrogating the Data**	6:HandsOnA.doc *HandsOnAans.doc
3.15pm–3.45pm	**Afternoon Tea**	
3.45pm–4.15pm	**Theory: Core Coefficients**	4: oranig.ppt (41-60)
4.15pm–6.00pm	**Computing: Interrogating the Data**	6: HandsOnA.doc 6: HandsOnB.doc

Tuesday

8.45am–9.45am	**Theory: Production Structure**	4: Oranig.ppt (61-83)
9.45am-11.30am	**Computing: Closure and Homogeneity**	7: HandsonB.doc
10.30am–10.50am	**Morning Tea (mid-session)**	
11.30–12.30am	**Overview of GEMPACK (including condensation)**	2: GEMPACK2.pptx
12.30–1.30pm	**Lunch**	
1.30–3.00pm	**Computing: Wage Cut Simulation**	8: Wagecut.doc
3.00–3.45pm	**Wage Cut Simulation: Analysis and Discussion**	8: Wagecut.ppt
3.45–4.15pm	**Afternoon tea**	
4.15–5.15pm	**Computing: Wage Cut Simulation: Industry Results**	8: Wagecut.doc
5.15-6.00pm	**Wage Cut Discussion (industry results)**	8: Wagecut.xls 8: Wagechart.xls *WageAns.doc

*To be handed out near end of lab.

Wednesday

8.45am–9.30am	**Theory: Output mix: Export/Local mix, Capital creation**	4: oranig.ppt (84-102)
9.30am–11.30am	**Computing: AnalyseGE & Tariff Simulation 1**	9: Ant.doc
10.30am–10.50am	**Morning Tea (mid-session)**	
11.30am-12.30pm	**Theory: Household Demands**	4: oranig.ppt (103-129)
12.30pm–1.30pm	**Lunch**	
1.30pm–2.30pm	**Theory: Other Final Demands, market clearing**	4: oranig.ppt (130-152)
2.30pm. – 4.30pm	**Computing: Tariff Simulation 2**	9: Ant.doc 9: Tarfcut.xls *AntAns.doc
3.20pm–3.45pm	**Afternoon Tea (mid session)**	
4.30pm–5.00pm	**Theory: Tariff simulation discussion**	9: tarfsim.ppt
5.00pm-6.00pm	**Computing: Adding Equations to Model**	10: NewEq.doc

Thursday

8.45am –9.45am	**Theory: Purchasers Prices and Macros**	10: neweq.ppt 4: oranig.ppt (153-168)
9.45am -11.45 am	**Theory: Investment, Labour Market, Closure**	4: oranig.ppt (169-207)
10.30am–10.50am	**Morning Tea (mid-session)**	
11.45am–12.45pm	**Theory: Regional Extension**	10: regional.ppt
12.45pm–1.45pm	**Lunch**	
1.45pm–2.00pm	**Official Photo**	
2.00pm–3.00pm	**Theory: Q&A session**	
3.00pm–3.30pm	**Group Projects: Allocation and Computing**	11: Grouproj.doc 11: Groups.doc
3.30pm–4.00pm	**Afternoon Tea**	
4.00pm–6.00pm	**Group Projects: Computing and Analysis**	11: Grouproj.doc 11: Groups.doc * group#xls.pdf

Friday

8.45am–10.30am	**Group Projects: Preparing Reports**
10.30am–10.50am	**Morning Tea**
10.50am–12.30pm	**Group Projects: Preparing Reports**
12.30pm-1.30pm	**Lunch**
1.30pm-3.30pm	**Presentation of Reports on Group Simulations: Groups 4-6**
3.30pm–4pm	**Course Wrap-up**
	Course will be finished by about 4.00pm

*To be handed out near end of lab.

Section 2

First simulation

Hands-on Computing with ORANI-G: First Simulation

This first session provides a rapid overview of the whole process of computing solutions for the ORANI-G model. You will be introduced to many files containing: model equations (TAB); model data (HAR); simulation details (CMF); and simulation results (SL4). All the different files and steps will be studied more carefully in later sessions -- ***do not worry if you do not understand everything straight away***. *We hope that you can work through to Section 3.6 during this session. Sections 3.7 and later are optional, or might be completed some other time.*

Most years, one or more regions of Australia suffer from low rainfall. However, during 2002 an unusually severe and widespread drought affected farmers all over Australia. Agricultural outputs fell sharply. We simulate the effects of such a drought using the ORANI-G model.

Questions are scattered through the instructions. Write down answers to the questions onto the instruction sheet.

1. Getting Started

1.1. Turning on the PC

Turn on your computer and wait for Windows to boot.

1.2. Starting WinGEM

If the WinGEM icon (resembling:) appears on your desktop, double-click on it to start WinGEM.

Otherwise, click on the ***Start*** button at the bottom left hand side of the screen. Choose ***All Programs*** then in the ***GEMPACK*** section select ***WinGEM***.

WinGEM is a Windows interface to GEMPACK. When it starts it shows a narrow menu across the top of the screen:

WinGEM - GEMPACK for Windows
File Simulation HA files Other tasks Programs Options Window Help

1.3. Setting the working directory

You will be working inside the WinGEM shell as much as possible. To see how GEMPACK for Windows is used, you will check the database used for the ORANI-G model and run a simulation.

On the PC,

- All the GEMPACK and Windows GEMPACK programs files are in the folder or directory called **C:\GP**. This directory is called the **GEMPACK directory**. You would not normally alter the programs and other files in the GEMPACK directory.[1]
- The directory called **C:\GPWork** contains various working directories, corresponding to different economic models.

You will be working (editing files, running simulations, looking at results) in the **working directory** of the ORANI-G model, **C:\GPWork\ORANIG.**

[1] The GEMPACK programs are installed from the GEMPACK CD onto your computer at home. You must add the name of the GEMPACK directory to your DOS path so your computer can find the GEMPACK programs when you need to run them.

When using WinGEM the first step is always to specify the location of the working directory. Choose:

File | Change both default directories

(By this notation we mean first click on ***File*** in the WinGEM menu. This will produce a drop-down menu. In the drop-down menu, click on the menu item

Change both default directories.)

In the file selection box that appears, choose drive **C:** then scroll down and *double*-click on the directory GPWORK. Next *double*-click on the subdirectory **ORANIG.** Check that the blue print above the directory box says C:\GPWORK\ORANIG**.** Click on the ***Ok*** button.

1.4. Viewing text files with TABmate

You'll often work with text files in GEMPACK, so you need a text editor. You could use a word processor but then you would always have to remember to save the file as a text or ASCII file. By default[2], WinGEM uses the TABmate editor which is part of GEMPACK.

To use TABmate to look at the TABLO Input file for the ORANI-G model, select in the WinGEM menu

File | Edit file...

The Open box should list several files associated with the ORANI-G model. You will briefly look at the TABLO Input file since it is the starting point for the ORANI-G model. It contains the equations of the model in a form very like algebra. Select the TABLO Input file to edit:[3]

ORANIG.TAB

(If this file does not appear in the Open box and you have to change directories to find it, you have not set your working directory correctly.)

Various colours appear on the screen for different parts of the TAB file; for example, TABLO Keywords are in BLACK, comments are in royal blue and so on[4]. The first page consists of a several comments (in blue) describing recent changes to the model.

Scroll down a page and you will see statements describing the two files used by this model:

- the input file BASEDATA containing input-out data and elasticities.
- the output (new) file SUMMARY which contains summary and checking data calculated from BASEDATA[5]

Place your cursor on the word BASEDATA and press the ***Gloss*** button (at top middle of the screen). If this gives a message saying "*no info available: run Check to generate*" at the bottom of the screen[6], click on the button marked ***TABLO Check*** (to left of *Gloss*) and then try ***Gloss*** again. This should show you all places in the TABLO Input file where the file BASEDATA is mentioned -- all the places where ini-

[2] WinGEM lets you choose your text editor, via the **Options | Change editor**... menu command. You could use your own preferred editor, or GEMEdit -- another editor supplied with WinGEM. GEMEdit is a simple black and white editor with a split-screen mode – allowing you to look at two files at once.

[3] There are many versions of the ORANI-G model. The three official versions are: ORANIG98, ORANIG01, and ORANIG (last 2 digits are release years).

[4] If this is not the case you can restore the default properties, (Select menu item Edit | Restore Default Properties) or you can change the screen properties by selecting Edit | Properties to set the font, the font size and various colours on the screen.

[5] BASEDATA and SUMMARY are 'logical' file names. When you run a simulation, you have to specify the name and location of corresponding actual files.

[6] If the message disappears too fast for you to read, click on the line at the bottom of the screen and the message will reappear.

tial data is read from file[7]. Click on the line number at the start of the Gloss line and TABmate will take you to that line[8].

A related feature is: if you hold the Alt key down, while moving the mouse over green words in the TAB file, you should see a short definition of each symbol.

Return to the top of the file (Ctrl and Home goes to the top of the file, Ctrl and End to the bottom of the file) and ***Search |Find |Search forward from top*** for the variable name **a1tot**. The first occurrences (in a comment) are not what we want, so do a Repeat Search ***(F3)*** until you find the line:

```
(all,i,IND)  a1tot(i)      # All input augmenting technical change #;
```

The "(all,i,IND)" means that a1tot is a vector variable with one value for each INDustry. Click on **a1tot** and press the ***Gloss*** button (at top middle of the screen). You can see that a1tot appears in 4 equations: the three demand equations E_x1_s, E_x1prim and E_x1oct and later on the long E_contGDPincE equation. Click on the red line number at left of equation E_x1_s and you should see:

```
Equation E_x1_s  # Demands for commodity composites #
 (all,c,COM)(all,i,IND)  x1_s(c,i) - [a1_s(c,i) + a1tot(i)] = x1tot(i);
```

Click on the = sign in the equation above and press the **Gloss** button to see a definition of each symbol that is used. The terms "(all,c,COM)(all,i,IND)" mean that Equation E_x1_s is actually a group or block of equations: there is one equation for each "commodity composite[9]" used by each industry. So if there were 37 commodities and 35 industries in the database there would be 1295 (=37*35) separate equations. Each of the variables x1_s, a1_s, a1tot and x1tot is a percentage change: if x1tot("OtherAgric") had value 5, that would mean that output of the OtherAgric industry would be 5% greater than in the initial equilibrium described by the input data in the BASEDATA file. The "a" variables a1_s and a1tot are technological change variables, normally exogenous (values fixed outside the model). Suppose output were fixed (x1tot=0), a shock of 10% to a1tot("OtherAgric") would mean that for each commodity c, the values of x1_s(c,"OtherAgric") must also increase 10% to keep the equation balanced. If you looked at the other equations where a1tot appears, you would find that a shock of 10% to a1tot("OtherAgric") would mean that 10% more of *all* inputs were needed to produce given OtherAgric output [note: positive a1tot implies technical *regress*].

Press ESC or spacebar to close the Gloss window.

Exit from TABmate in the usual Windows way by ***File | Exit.*** (There are usually alternatives in terms of keystrokes instead of the mouse action. For example you can use keystrokes ***Alt*** followed by ***F*** followed by ***X*** in order to exit.)

2. Data for the ORANI-G model

2.1. Viewing the data directly using VIEWHAR

The input-output data used during this course for the ORANI-G model is contained in the data file BASEDATA.HAR. This is a *binary* file used in GEMPACK programs - called a Header Array (HAR) file - so we cannot just look at it in a text editor. Instead we will look at BASEDATA.HAR using a special viewing program, ViewHAR. Select from the main WinGEM menu:

HA Files | View VIEWHAR

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[7] You can click on any variable, coefficient or set and press the Gloss button to display a list of every statement in the file mentioning that symbol. For a variable, say, the first of these statements will usually furnish a definition. The remainder show how the variable is used. Line numbers accompany each statement; you can click on these to jump to that location in the TAB file. If you press Gloss when the cursor is not on a variable, coefficient or set, you get a different list showing the definition of each variable, coefficient or set mentioned in the current statement.

[8] You can return to your original place as follows: At bottom left, the Location Indicator panel shows current line and column numbers. Click there and a window appears, listing lines that you jumped to or from. The most recently visited line appears at the top. You can click on any of these lines to jump there.

[9] An example of a "commodity composite" might be Coal used by the Iron industry. The Coal is potentially a mixture of local and imported coal, so we call it a "dom/imp composite".

The VIEWHAR window will appear. Click on

File | Open Header Array file

and open the file BASEDATA.HAR in directory ORANIG on drive C:

This will open the file BASEDATA.HAR and show its contents on the Contents screen[10].

Each of the rows corresponds to a different array of data on the file. Look at the column under the heading **Name** to see what these arrays are:

	Header	Type	Dimension	Coeff	Total	Name
1	COM	1C	37 length 12			Set COM commodities
2	IND	1C	35 length 12			Set IND industries
3	OCC	1C	8 length 12			Set OCC occupations
4	MAR	1C	4 length 12			Set MAR margin commodities
5	1BAS	RE	COM*SRC*IND	V1BAS	322581.9	Intermediate Basic
6	2BAS	RE	COM*SRC*IND	V2BAS	81887.98	Investment Basic

The first item, COM, is the list of commodities in this database. The array is of type 1C which means an array of strings. Double click on COM to see the commodity names.

To return to the Contents Screen, double-click on any cell [or click on ***Contents*** in the VIEWHAR menu].

Have a look at item 8, 4BAS, showing exports of each commodity. Double-click on the 4BAS row to look at the numbers. Values in this file are measured in million Australian dollars. Would you say Agriculture/Food exports were as large as Mining exports?

Double-click on any cell to return to the Contents Screen, then double-click on item 21 (header 1CAP), which shows the values of capital rentals in each industry. Note down below the following database value -- you will need to know it later:

- V1CAP("MeatDairy") =

Double-click on any cell to return to the Contents Screen, then double-click on item 7, 3BAS to see the numbers. The panel at the bottom of ViewHAR tells you that you are seeing household consumption, split according to commodity (COM) and SRC (domestic or imported). What is the single largest category of household expenditure?

ViewHAR for shares

ViewHAR can present numbers as shares. To see Row shares, look at the box in the top left hand corner beside the green and yellow bands. Click on the arrow beside this box and choose ***Row*** . You should see shares that add to 1 across each row. The shares show the proportion of domestically-produced or imported goods for household use of each commodity.

Try ***Col*** to calculate column shares, and ***Matrix.*** What share of household spending goes on *DrinksSmokes*?

Close VIEWHAR in the normal Windows way ***File | Exit.***

3. Simulating the short-run effect of a drought

In this section you will implement the ORANI-G model and use it to simulate the short-run effects of reduced productivity in Agriculture.

[10] BASEDATA.HAR is the actual file corresponding to the logical file BASEDATA mentioned in ORANIG.TAB.

3.1. Overview of the process

From the WinGEM menu at the top of the screen choose ***Simulation.*** In the drop-down menu the choices are

TABLO Implement
Compile & Link
TABmate Implement
Run TG Program
GEMSIM Solve
SAGEM Johansen Solve
GEMPIE Print
View Solution (ViewSOL)
AnalyseGE

The items from this menu you will be using in this simulation are

TABLO Implement
GEMSIM Solve
View Solution (ViewSOL)

TABLO, GEMSIM and ViewSOL are the names of programs which carry out the three steps of a simulation :

- Step 1 - Implement the model with TABLO
- Step 2 - Solve the equations of the model with GEMSIM
- Step 3 - View the results with ViewSOL

WinGEM will guide you through these steps and indicate what to do next.

3.2. Step 1 - Implementing the ORANI-G model using TABLO.

As we saw previously, the TABLO Input file (which contains the theory of the ORANI-G model) is called **ORANIG.TAB**. Choose

Simulation | TABLO Implement

A window for TABLO will appear. Click the Options menu item at the top of this TABLO window and select "Run from STI file". Then click on the ***Select*** button to select the name of the STI file, ORANIG.STI. The STI (stored input) file contains some instructions which TABLO needs to implement the model. By "implement" we mean convert the TABLO Input file into binary computer files which are used by the simulation program GEMSIM in the next step. These files are referred to as Auxiliary files (or sometimes as the GEMSIM Statement and Table files) and in this case, are called ORANIG.GSS and ORANIG.GST[11].

Click on the ***Run*** button. TABLO runs in a DOS box[12] and when completed returns you to the TABLO window with the names of files it has created: the Information file ORANIG.INF and the Log file GPXX.LOG. Briefly look at both of these files by clicking the ***View*** buttons beside them.

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[11] Section 3.6 below gives an overview of the several files that are used at various stages.

[12] The TABLO DOS box might briefly appear as an icon on the Windows task bar which is normally at the bottom of the screen.

The Information file ORANIG.INF gives information about the TABLO Input file such as whether there are any syntax or semantic errors found by TABLO when it was checking the TABLO Input file. Error messages in the INF file are flagged by the characters '%%'. Search the file for %% to see if there are any errors (hopefully none).

Go to the top of the INF file and search for `INPUT CHECK SUMMARY` to see how many syntax errors and semantic problems there are (if any). Go to the end of the INF file to see what actions GEMSIM can carry out with the GEMSIM Statement and Table files produced in this run of `TABLO`.

Look briefly at the top of the LOG file. It should say the time and date when the log file was created. What GEMPACK Release was used? When you run TABLO in WinGEM, there is no output to the screen as it runs. Instead all, the screen output produced by TABLO goes to the LOG file. If there is some problem in running TABLO, consult both the LOG file and the INF file to find out what went wrong. Since this is a working model, no errors should occur provided you remember to run TABLO using the STI file ORANIG.STI.

When you have looked at these two files, close TABmate and click on the ***Go to GEMSIM*** button at the bottom of the TABLO window to go on to the next step in running a simulation: Step 2 - GEMSIM Solve.

3.3. Step 2 - Solve the equations of the model using GEMSIM.

The *Go To GEMSIM* button takes you to the GEMSIM window.

(Alternatively you can start this window by choosing *Simulation | GEMSIM Solve* from WinGEM's main menu.)

First ***Select*** a Command file called FIRSTSIM.CMF.

Look at this Command file in the text editor by clicking the ***Edit*** button. Command (or CMF) files are used to specify the details of a simulation. The main bits of information in this CMF file are:

- the model to use, in the line: auxiliary files = ORANIG;
- the solution method: Euler 3 4 5
- the actual file names, BASEDATA.HAR and SUMMARY.HAR, that correspond to the logical file names, BASEDATA and SUMMARY, which are mentioned in the TAB file. By default, the solution file is named after the CMF file -- so in this case the solution will be stored in file FIRSTSIM.SL4.
- the closure, or list of exogenous variables. The model can determine the value of most *but not all* variables. Some variables must be held fixed (or shocked) by the modeller. These are called *exogenous*. The choice of *which* variables are to be exogenous varies between simulations. In this simulation, industry capital stocks (variable x1cap) are held exogenous. The fixed capital stocks identify the simulation as short-run.
- the shocks are at the end of the file. In this simulation we shock the variable **a1tot** to increase by 10% for each of the agricultural industries, **BroadAcre** and **OtherAgric**. **a1tot** is a measure of overall technical efficiency -- the 10% means either that with inputs held constant output will be 10% less, or that 10% more inputs will be needed to produce the original output[13]. These shocks are used to simulate the main effect of the drought: agricultural productivity is reduced.

Use ***File | Exit*** to return from TABmate to the GEMSIM window.

Click on ***Run*** to run GEMSIM with the Command file FIRSTSIM.CMF. The simulation could take a few minutes to run. Do not touch the keyboard or mouse during this time. While you wait, study the overview of GEMPACK in Section 3.6 below.

---

[13] You can remind yourself how a1tot is used with the ORANIG.TAB file. From TABmate, use File..Open to re-open the TAB file, and search for (or Gloss on) a1tot.

Eventually, the *Accuracy Summary* window should appear [it is headed "via WinGEM: Whole simulation"]. You should see that nearly all the results are accurate to 5 or 6 significant figures[14]. The accuracy is indicated by two smiling faces (click on the key to see the range of facial expressions). Click OK to close the Accuracy Summary.

If there is an error, view the Log file.

If GEMSIM produces the Solution file, several new buttons will appear. There is no point in trying to look at the Solution file in the text editor because it is a binary file, not a text file. Instead, look at the Solution file using the Windows program ViewSOL, as described next.

3.4. Step 3 - View simulation results using ViewSOL

First click on the button ***Go to ViewSOL.*** The Contents screen shows the names of the variables. To see the values of a variable, double-click on its name. To return to the Contents screen, double-click on any number (or select ***Contents*** in the ViewSOL menu).

Start by double clicking on the first Contents row: **Macros** (Macros are scalar variables or variables with just one component.) You should see a list of macro variables and the value of their changes. You can click on the variable names -- a description will appear at the bottom of ViewSOL . Use the decimal places combo box at top right to set the number of decimal places to 2.

Most of the variables are percentage changes, but some (their names start with "del") are ordinary changes, measured in million-dollars. Values for exogenous variables are shown in red. Scroll down the list to find price indices (first letter "p"), nominal values (first letter "w"), and quantity indices (first letter "x"). Write down below what happened to:

- x4tot: aggregate exports
- x0gdpexp: real expenditure side GDP
- employ_i: aggregate employment
- x0cif_c: aggregate imports
- p4tot: export price index
- p3tot: consumer price index
- p1lab_io: average nominal wage
- p1lnd_i: average return to agricultural land

Double-click on any number to return to the Contents screen. Then scroll down till you find the variable x1tot (industry outputs). Double-click to view the numbers. Which non-agricultural industry was most affected?

Return to Contents and view results for:

- x4: exports
- x3: household use
- x1lab: employment
- regx1prim_i: state real GDP. Which state *gained*? Can you think why?

Note down below the following two results -- you will need them later.

- x1cap("MeatDairy") =
- p1cap("MeatDairy") =

---

[14] The Accuracy Summary gives separate estimates for Variables and for Data. Data will be more accurate than Variables. This is simply because most variables are %change. If some data has initial value X and increases by y% [accurate to 3 figures], the new value, X*[1+y/100], will be accurate to about 5 figures.

3.5. Other output files

The Summary file

Return to the GEMSIM window, that is, bring it to the front by clicking on it. Look at the data files used in this simulation by clicking on the button marked ***View Input/Output Files*** and view the output file *SUMMARY*. This SUMMARY.HAR file contains various useful tables and data summaries which are calculated only from the initial input data file BASEDATA.HAR[15].

Experienced modellers rely on a good knowledge of the main features of their database. To understand why some industries perform better than others in a simulation, we have to know the special characteristics of each sector. The SUMMARY file contains various data that have proved useful in the past. Some of the most useful are:

Header	Dimension	Coefficient	Name
SALE	COM*SRC*DEST	SALE	Sales aggregates
EMAC	EXPMAC	EXPGDP	Expenditure Aggregates
IMAC	INCMAC	INCGDP	Income Aggregates
TMAC	TAXMAC	TAX	Tax Aggregates
CSTM	IND*COSTCAT	COSTMAT	Cost Matrix
MKUP	COM*FLOWTYPE *SRC*SALECAT2	SALEMAT2	Basic, margin and tax components of purchasers values
MSHR	COM	IMPSHR	Share of imports in local market
SRSE	IND	SUPPLYELAST	Short-run supply elasticity
FACT	IND*FAC	FACTOR	Primary Factor Costs
1TOT	IND	V1TOT	Total industry cost plus tax
RV1P	IND*REG	REGV1PRIM	Factor bills

Use the SUMMARY file to answer the following questions:

- What is the share of exports in GDP? [Header EMAC, Col share]
- Intermediate inputs are ??% of the costs of the MeatDairy industry? [CSTM, row share]
- For which commodity do imports have the largest market share? [MSHR]
- Which two industries are most[16] labour intensive? [FACT, row share]
- Which two industries have highest short-run supply elasticity? [SRSE]
- Which region earns most from mining? [Header RV1P]

The Updated Data file

Return to the GEMSIM window (click it to bring it to front). Look at the data files used in this simulation by clicking on the button marked ***View Input/Output Files*** and view the updated file *BASEDATA*. This file (actual name FIRSTSIM.UPD) contains post-simulation values for the same data items as are contained in the input BASEDATA file, BASEDATA.HAR.Have a look at header 18, 1CAP.

Write down the new value for the MeatDairy industry in the "updated" column below:

	Initial	Updated	Percent Change
V1CAP("MeatDairy")			

[15] Thus, even though SUMMARY.HAR is recreated each time you run a simulation, its contents will not change -- unless the input BASEDATA file was changed. As an exception, the final 3 headers [FRNK, TPRS, and TAXV] do depend on the simulation.

[16] The little yellow (transpose) and green (sparse sorted) buttons at top left offer a quick way to answer “which is most” questions.

Write down the original value of V1CAP("MeatDairy") in the "initial" column above (you were asked to note this previously). Then write down the percentage change between Initial and Updated, using the formula[17]:

%change = 100*(Final - Initial)/Initial

The V1CAP vector contains values of capital rentals. Each value is the product of a price, P1CAP, and a quantity, X1CAP. The solution file contains values (you were asked to note these previously) for percent changes in these two variables. Write in these two values below.

	p1cap	x1cap
V1CAP("MeatDairy")		

Use the two variable results above to check that:

updated V1CAP = [original V1CAP]*[1+p1cap/100]*[1+x1cap/100]

How does GEMPACK know which price and quantity variables must be used to update V1CAP? That information comes from a line in the file ORANIG.TAB, which reads:

```
Update  (all,i,IND)   V1CAP(i) = p1cap(i)*x1cap(i);
```

This updated data file has the same headers as the original input file. In fact, it is possible to use the updated data as the starting point (or initial data) for a second simulation. We might do this if we wanted to find the effect of one shock *followed by* another shock. Updated data files are used in a similar way by recursive dynamic models, a type of multiperiod CGE model which solves one year a time. The simulation for year T produces an updated data file which is used as input by the simulation for year T+1.

[17] If you are too tired to do mental arithmetic, click the Programs menu item at the top of ViewHAR, then click on the Calculator icon which appears.

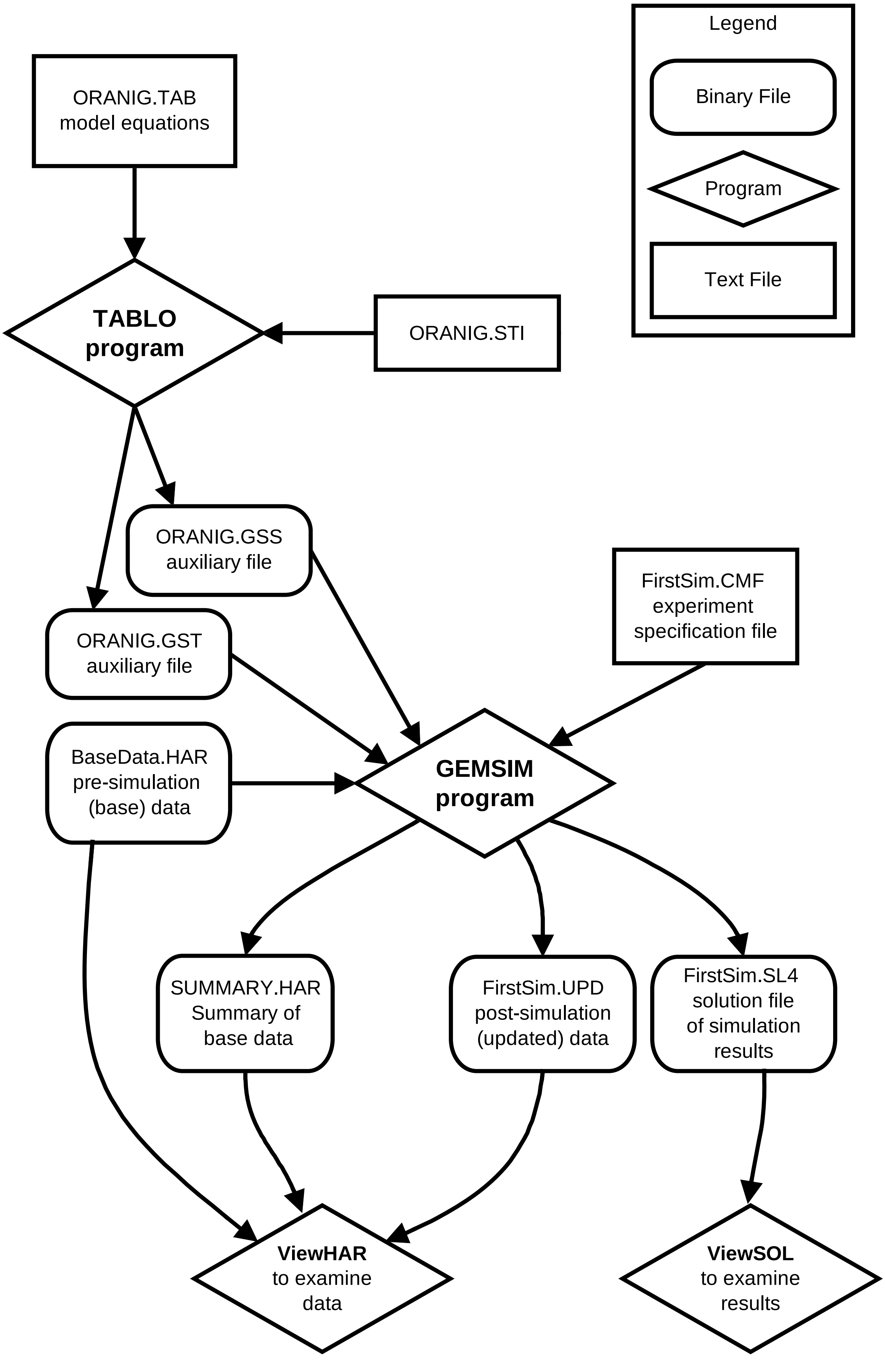


Figure 1: Stages in the GEMPACK process

3.6. Diagram of stages in the GEMPACK process

Figure 1 shows, in simplified form, the main stages in the process that you have just gone through. In the diagram:

- diamond- or lozenge-shaped boxes are GEMPACK programs, such as TABLO, GEMSIM, ViewHAR and ViewSOL.
- rectangles with rounded corners are binary (special format) files which can only be used by particular GEMPACK programs.
- rectangles with sharp corners are ordinary text files, which you could examine or modify with any text editor or word processor. You used the TABmate text editor to look at these files.

The process begins with the text file ORANIG.TAB which contains the equations of the model. The TABLO program translates the TAB file into two auxiliary GSS/GST files, which contain a computer-language representation of the model equations. Another small text input file, ORANIG.STI, specifies various TABLO options[18].

The two GSS/GST files are used by GEMSIM to solve the model [ie, run simulations]. GEMSIM requires two other input files:

- the data file BASEDATA.HAR, containing input-output data and behavioural parameters. This data file contains all necessary information about the initial equilibrium.
- experiment details from a text file FIRSTSIM.CMF, which specifies:
  (a) which variables are to be exogenous (ie, held constant or shocked);
  (b) shocks to some exogenous variables;
  (c) the solution method; and
  (d) the names of input and output files.

The GEMSIM simulation produces three output files:

- the FIRSTSIM.SL4 solution file shows percentage changes in variables from the initial equilibrium. SL4 solution files are in a special binary format: you can examine their contents with the ViewSOL program.
- the FIRSTSIM.UPD updated data file contains post-simulation values for the same data items as are contained in the input data file BASEDATA.HAR.
- the SUMMARY.HAR file contains various useful tables and data summaries which are calculated only from the *initial* input data file BASEDATA.HAR. The contents of the summary file do not depend on the experiment specified in the CMF file.

The files BASEDATA.HAR, FIRSTSIM.UPD, and SUMMARY.HAR are all Header Array files which you can examine using ViewHAR.

All the steps and files shown in Figure 1 are conveniently managed by the WinGEM interface program. However, it is possible to run the same programs without WinGEM by typing into a command prompt (DOS box). The traditional, command-line, method is still the only way to run GEMPACK on some other operating systems, such as UNIX.

The more expensive "source code" version of GEMPACK does not require GEMSIM. Instead TABLO (assisted by a Fortran compiler) produces a model-specific EXE file which runs the simulation. In Figure 1, GEMSIM would be replaced by a file ORANIG.EXE, which could solve the model faster than GEMSIM. For really big models (or huge databases) the source code version is necessary.

---

[18] Are you anxious to know what is in the STI file? It contains *condensation* instructions specifying *omissions, substitutions* and *backsolves*. Clear now? These interesting details are covered later in the week.

3.7. Changing the closure and shocks.

Several simulations can be carried out on the same model by changing the closure and/or the shocks as described in the Command file. Now you will make a new Command file in the text editor and then run another simulation using GEMSIM.

To change the command file FIRSTSIM.CMF, copy it to a new name FIRSTSIM2.CMF as follows:

In the main WinGEM menu, choose ***File | Edit...*** then open the file FIRSTSIM.CMF.

Click on ***File | Save As*** and save the file under the new name FIRSTSIM2.CMF.

Then use the text editor to modify this file, following the steps below.

In the original shortrun closure, the variable **realwage** (CPI-adjusted wage) was held fixed. Now instead we will hold fixed the nominal (un-adjusted) wage variable, **p1lab_io**.

Find the line:

```
            realwage ;        ! Average real wage
```

and alter it to read

```
   p1lab_io; ! realwage ; ! Average real wage
```

Don't forget the semicolon after p1lab_io. When GEMSIM reads the CMF file, an exclamation mark causes the rest of that line to be treated as a comment.

Exit from the editor after saving your changes.

Click on ***Simulation | Gemsim Solve*** and ***select*** Command file FIRSTSIM2.CMF.

Rerun program GEMSIM with command file FIRSTSIM2.CMF (similarly to Step 2 above).

Then look at the results (FIRSTSIM2.SL4) using ViewSOL. ViewSOL allows you to open several solution files at once. Open the solution from your previous simulation (FIRSTSIM.SL4). Compare the results for macro variables. Are the falls in employment and GDP greater or less with nominal (rather than real) wages fixed ? Explain.

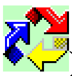
4. GEMPACK without WinGEM

In the examples above we ran the programs TABmate, ViewHAR, GEMSIM and ViewSOL from within WinGEM. However GEMPACK allows you to work in many other ways. You can run TABLO and GEMSIM from within the TABmate editor. Another Windows program, **RunGEM**, is good for running simulations when you are using a standard model which you do not want to change.

In the following set of examples we will use TABmate as editor, and from TABmate run TABLO and GEMSIM, then view results in ViewSOL. Then we run the simulation and view results in RunGEM.

4.1. Running TABLO from TABmate

In the previous examples we started TABmate from within the program WinGEM. Here we start it independently.

If the TABmate icon (resembling: ) appears on your desktop, double-click on it to start TABmate.

Otherwise, click on the ***Start*** button at the bottom left hand side of the screen. Choose ***All Programs*** then in the ***GEMPACK*** section select ***TABmate*** .

Click on the Open folder in the top left hand corner and select

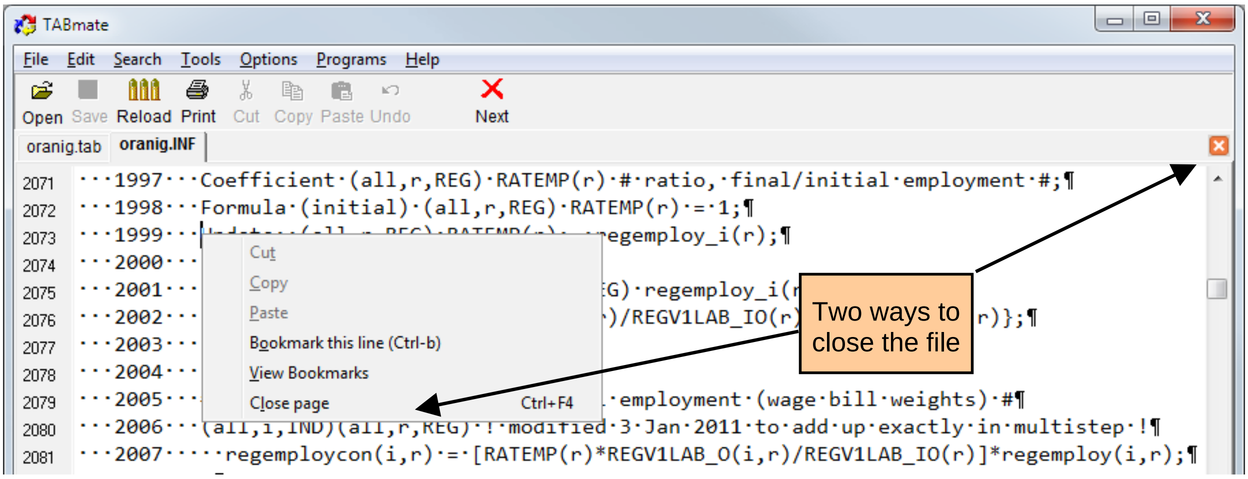
Files of Type : TABLO files (.tab)*

in the box at the bottom of the screen. Open the file C:\GPWork\ORANIG\ORANIG.TAB

To run TABLO to check for errors, select the button ***TABLO Check***. If there is an error, TABLO will point out where it is and you can edit the screen to fix it.

Try some of the other buttons to look at the Information (Inf) file and the Log file. When you have finished looking at these files, close them using one of these two methods:

- click the small ☒ icon at top right of the text window
- right-click on the text window, then select ***Close page***.



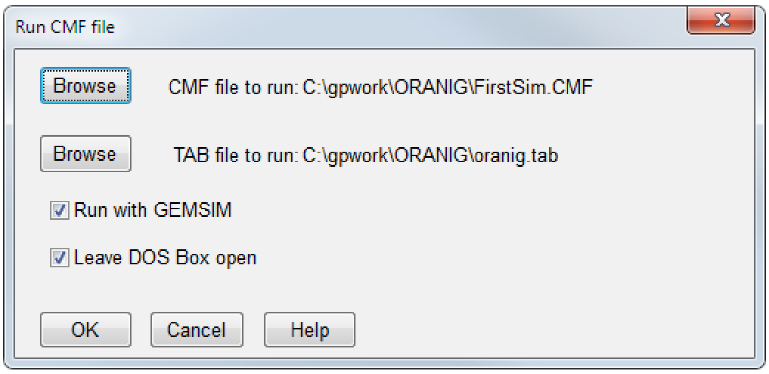
Alternatively, select ***File* | *Close***.

Return to the page containing ORANIG.TAB and select the ***TABLO STI*** button. A small window should appear asking if you want to run or edit the file ORANIG.STI. Click the ***Run*** button. This has the same effect as running TABLO from a STI in WinGEM. If no errors are found, it goes on to generate the code needed to actually run the model. It generates either FORTRAN code or GEMSIM code according to a setting in the STI file. In the course, we are using the Executable-Image version of GEMPACK which only allows you to write output for the program GEMSIM.

The names of the files created are ORANIG.GSS and ORANIG.GST. These files contain implementation of the model in the TABLO Input file ORANIG.TAB.

4.2. Running simulations from TABmate

Click the Run CMF button at the right of the upper TABmate toolbar. Then use the top Browse button to select FIRSTSIM.CMF (the simulation from earlier). Then click OK.

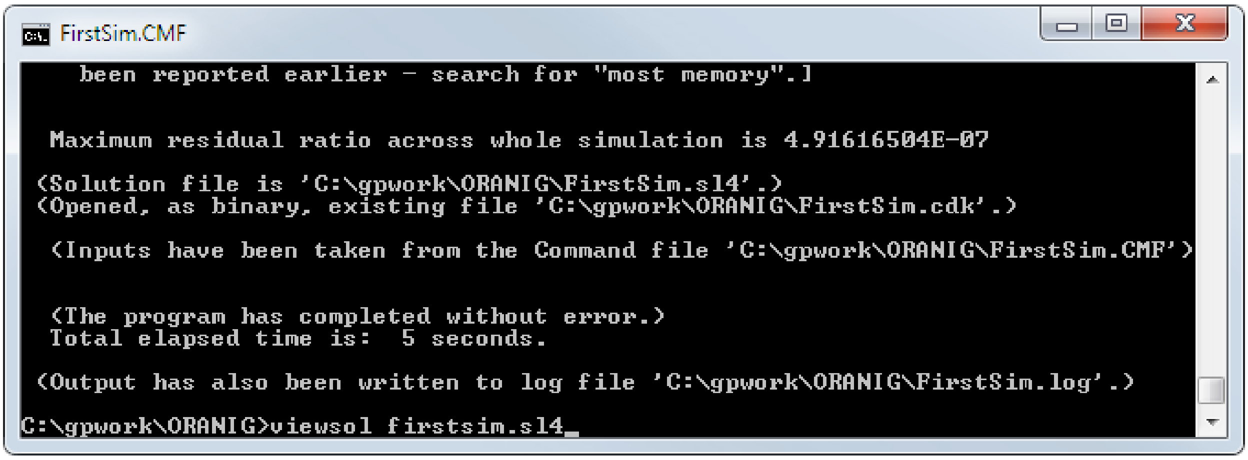


A "DOS Box" should appear with a stream of messages rushing past (see picture below). When it is finished, the last lines of the display should include the lines:

```
Solution file is 'C:\gpwork\ORANIG\FirstSim.sl4'.
The program has completed without error.
```

Click on the "DOS Box" and, as pictured below, type in (followed by Enter key):

```
Viewsol FirstSim.sl4
```



Viewsol should open and display the solution file FirstSim.sl4.

4.3. Running simulations using RunGEM

If the RunGEM icon (resembling:) appears on your desktop, double-click on it to start RunGEM.

Otherwise, click on the ***Start*** button at the bottom left hand side of the screen. Choose ***All Programs*** then in the ***GEMPACK*** section select ***RunGEM***.

Click on ***RunGEM*** to start it running. [If this is the first time RunGEM has been used, you may be asked to select a model to work with. Click OK and select the model ORANIG.GSS in the directory C:\GPWork\ORANIG. RunGEM may also tell you that the default closure is missing. Just ignore this and click OK.]

The RunGEM screen has the appearance of a Tabbed notebook with separate pages. Click in turn on the pages labelled **Model/Data** **Closure** **Shocks** and so on to change from one page to another.

Below you will use RunGEM to repeat the FIRSTSIM simulation from earlier.

On the Model/Data page select the button ***Change Model*** and select the file created in TABmate **C:\GPWork\ORANIG\ORANIG.GSS**

In the box below place your cursor on the line

```
file BASEDATA = ...
```

and **right-click.** Select the menu line *Select or change file name* and select the file **C:\GPWork\ORANIG\BASEDATA.HAR** since this is the data file for the model ORANIG.

On the Closure page, click the Load Closure button and choose file ORANIGSR.CLS (which contains the usual shortrun closure for the ORANIG model):

On the Shocks page, first click the *Clear Shocks* button. Then, click on the arrow beside the box marked *Variable to Shock* and select the variable **a1tot**

In this simulation, you are to give shocks for industries BroadAcre and OtherAgric, which you specify in the *Elements to shock* box. Click on the down arrow on this box. You will be told that the Size and elements of the set IND are not known. [This is because they are read from the BASEDATA file). Click **Yes** to ask RunGEM to check the closure. After a few seconds you will be told that the closure is OK. Now return to the Shocks page and select variable a1tot as the *Variable to shock*. Then click again on the *Elements to shock* box. This time you will see the elements of the set IND.

Select the element “BroadAcre” and give it a shock of 10%. Add this shock to the shock list by selecting the ***Add to Shock List*** button. Next, from the *Elements to shock* box, select the element “Other Agric” and give it a shock of 10%. Add this shock also to the shock list by selecting the ***Add to Shock List*** button.

Look at the page Output Files (probably no changes are needed).

Then go to the Solve page. Change the solution method to Euler 3,4,5 steps. Add a few words to describe the simulation in *Verbal description* box. Then click on the **Solve** button to run the simulation. To see the results go to the Results page. These results should be the same as those calculated earlier using WinGEM and the Command file FIRSTSIM.CMF.

Exit from RunGEM as usual.

Drought Sim.

Purpose

- You were not expected to understand everything you did this morning (at this stage).

- Understanding the course will be easier now that you have had some "hands-on" experience with the model.

How do we implement a drought in the model?

Which industries affected?

"+" indicates more inputs now needed

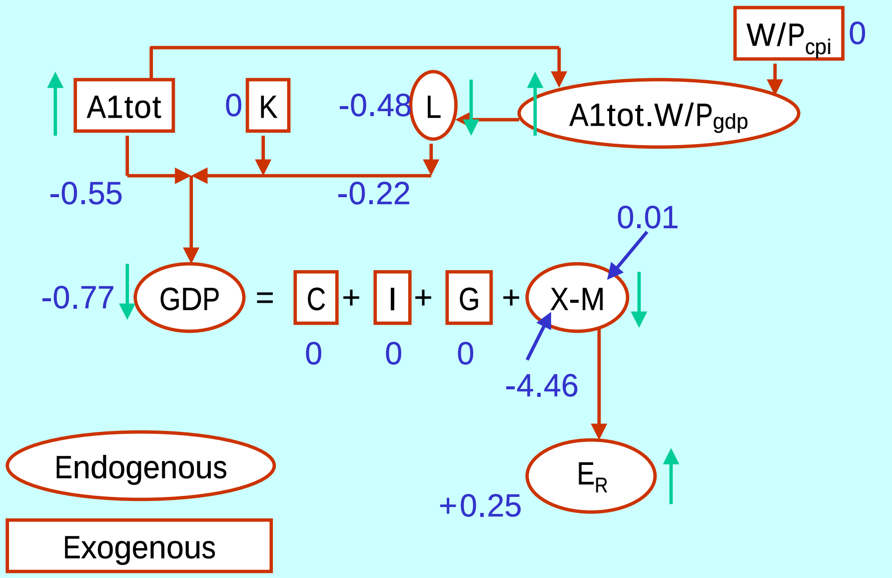
shock a1tot("broadacre") = +10
shock a1tot("otheragric") = +10

Productivity of all inputs to production

10% more inputs needed, to produce same level of output

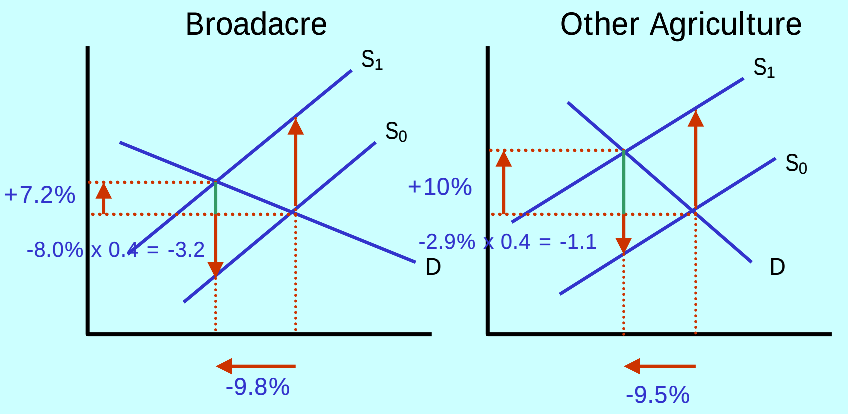
3

Macroeconomic effects



4

Industry effects



Other Agriculture - more elastic supply
(higher L share: 25% compared with 17% for Broadacre)

Broadacre - more elastic demand

More of the adjustment borne by fixed factors in Broadacre

5

Export Volumes

Increase in the costs of these industries drives up their export prices. Export demands are very elastic, hence:

Broadacre	**Wool/mutton exports**	**-11.2%**
	Grains/hay exports	**-24.1%**
	Beef cattle exports	**-0.4%**
Oth Agric	**Other agriculture**	**-54.2%**

MULTI PRODUCT

"NTRAD" - will explain later

6

Downstream industries

Broadacre and Other Agriculture also sell their output to other domestic industries, for use in current production.

<u>EG: MeatDairy</u> (manuf'g) . . . 58% of this industry's costs are inputs of <u>Wool/mutton, Beef cattle, Other agriculture</u>: causes its total intermediate input prices to rise by 6.6%.

The sector is also very trade exposed (34% of output exported, and export demand elasticity of -10)

MeatDairy's output contracts by 9.4% (8.2 percentage points of this due to lower exports)

Regional Results

Regional results generated by “top-down” model:

NSW	-0.47
VIC	-0.56
QLD	-0.68
SA	-0.83
WA	-0.32
TAS	-0.58
ACT	+0.22
NT	-0.35

Lots of Broadacre, OtherAg, MeatDairy

Little Broadacre, OtherAg, MeatDairy

C,I,G sectors: fixed nationally, not regionally

Macro	Variables	
capslack		Slack variable to allow fixing aggregate capital
contBOT	-0.7662	Contribution of BOT to real expenditure-side GDP (change)
delB	-0.0066	(Nominal balance of trade)/{nominal GDP} (change)
delV0tar_c	1.70	Aggregate tariff revenue (change)
delV0tax_csi	-43.73	Aggregate revenue from all indirect taxes (change)
delV1PTX_i		Ordinary change in all-industry production tax revenue (change)
delV1tax_csi	-41.70	Aggregate revenue from indirect taxes on intermediate (change)
delV2tax_csi	-0.90	Aggregate revenue from indirect taxes on investment (change)
delV3tax_cs	36.44	Aggregate revenue from indirect taxes on households (change)
delV4tax_c	-17.46	Aggregate revenue from indirect taxes on export (change)
delV5tax_cs		Aggregate revenue from indirect taxes on government (change)
employ_i	-0.4788	Aggregate employment: wage bill weights
f1lab_io	0.0000	Overall wage shifter
f1tax_csi		Uniform % change in powers of taxes on intermediate usa ..
f2tax_csi		Uniform % change in powers of taxes on investment
f2tot		Ratio, investment/consumption
f3tax_cs		Uniform % change in powers of taxes on household usage
f3tot	0.7134	Ratio, consumption/ GDP
f4p_ntrad		Upward demand shift, collective export aggregate
f4q_ntrad		Right demand shift, collective export aggregate
f4tax_ntrad		Uniform % change in powers of taxes on nontradtnl exp ..
f4tax_trad		Uniform % change in powers of taxes on tradtnl exports
f5tax_cs		Uniform % change in powers of taxes on government usage
f5tot		Overall shift term for government demands
f5tot2		Ratio between f5tot and x3tot
invslack	-2.7034	Investment slack variable for exogenizing aggregate inve ..
p0cif_c		Imports price index, C.I.F., local currency
p0gdpexp	0.2502	GDP price index, expenditure side
p0gne	0.1369	GNE price index
p0imp_c		Duty-paid imports price index, local currency
p0realdev	-0.2495	Real devaluation
p0toft	0.6628	Terms of trade
p1cap_i	-0.8047	Average capital rental
p1lab_io	0.1918	Average nominal wage
p1lnd_i	-5.7577	Average land rental
p1prim_i	-0.3275	Index of factor cost
p2tot_i	0.0111	Aggregate investment price index
p3tot	0.1918	Consumer price index
p4_ntrad	0.0390	Price, collective export aggregate
p4tot	0.6628	Exports price index, local currency
p5tot	0.0806	Government price index
p6tot	-18.2536	Inventories price index
phi		Exchange rate, local currency/$world
q		Number of households
realwage		Average real wage
utility	0.0000	Utility per household
w0cif_c	0.0134	C.I.F. local currency value of imports
w0gdpexp	-0.5179	Nominal GDP from expenditure side
w0gdpinc	-0.5179	Nominal GDP from income side
w0gne	0.1369	Nominal GNE
w0imp_c	0.0151	Value of imports plus duty
w0tax_csi	-0.0883	Aggregate revenue from all indirect taxes
w1cap_i	-0.8047	Aggregate payments to capital
w1lab_io	-0.2879	Aggregate payments to labour
w1lnd_i	-5.7577	Aggregate payments to land
w1oct_i	-0.1189	Aggregate "other cost" ticket payments
w1prim_i	-0.5741	Aggregate primary factor payments
w2tot_i	0.0111	Aggregate nominal investment
w3lux	0.0726	Total nominal supernumerary household expenditure

contGDPExp	
Consumpti	
Investmen	
Governme	
Stocks	
Exports	-0.7637
Imports	-0.0024

contGDPinc	
Land	
Labour	-0.2181
Capital	
IndTax	-0.0297
TechChan	-0.5183

w3tot	0.1918	Nominal total household consumption
w4tot	-3.8231	Local currency border value of exports
w5tot	0.0806	Aggregate nominal value of government demands
w6tot	-18.2536	Aggregate nominal value of inventories
x0cif_c	0.0134	Import volume index, C.I.F. weights
x0gdpexp	-0.7662	Real GDP from expenditure side
x0gdpinc	-0.7662	Decomposition of real GDP from income side
x0gne		Real GNE
x0imp_c	0.0151	Import volume index, duty-paid weights
x1cap_i		Aggregate capital stock, rental weights
x1lnd_i		Aggregate land stock, rental weights
x1prim_i	-0.2474	Aggregate effective primary factor use
x2tot_i		Aggregate real investment expenditure
x3tot		Real household consumption
x4_ntrad	-0.3897	Quantity, collective export aggregate
x4tot	-4.4564	Export volume index
x5tot		Aggregate real government demands
x6tot		Aggregate real inventories
x0gdpfac	-0.8352	Real GDP at factor cost (inputs) = x1prim_i

9 COM variables

	p0dom	p3_s	p4	x0com	x0dom	x0imp	x0loc	x3_s	x4
WoolMutton	10.0977	8.7146	7.7505	-8.5410	-4.8328		-4.8328	-3.4815	-11.1888
GrainsHay	4.0025	2.3647	2.7963	-11.1089	-0.8854	1.2104	-0.8635	-0.9806	-24.1042
BeefCattle	8.9421	7.9838	8.0471	-9.0218	-9.2659	5.8699	-9.2618	-3.2089	-0.3897
OtherAgric	9.9748	4.9570	8.1141	-9.4523	-4.5493	11.0301	-3.9090	-1.0295	-54.1852
ForestFish	0.0114	-0.0483	-0.0241	-0.0924	-0.1420	-0.1218	-0.1415	0.0530	0.2409
Mining	0.0316	0.0115	-0.0080	-0.0141	-0.1249	-0.0727	-0.1143	0.0267	0.0744
MeatDairy	2.9818	1.9567	2.7560	-9.4080	-1.8663	0.8112	-1.8048	-0.4047	-23.8035
OthFoodPro	0.6673	0.3078	0.5391	-1.2646	-0.3398	0.1372	-0.2730	-0.0550	-4.8224
DrinksSmoke	0.6557	0.4440	0.5435	-0.2092	-0.1932	0.5877	-0.1153	-0.0915	-0.3897
Textiles	0.6967	0.0700	0.5004	-1.5541	-1.1959	0.4842	-0.5003	0.0011	-2.8599
ClothingFtw	0.2392	-0.0794	0.1984	-0.4217	-0.1924	0.2693	-0.0107	0.0380	-1.9622
WoodProds	-0.0137	-0.0457	-0.0598	-0.0818	-0.0503	-0.0470	-0.0497	0.0647	-0.3897
PaperPrint	-0.1577	-0.1912	-0.1777	-0.2860	-0.2831	-0.3194	-0.2898	0.1447	-0.3897
Petrol_CoalP	-0.4382	-0.3709	-0.4161	-0.1455	-0.1248	-0.2491	-0.1439	0.2437	-0.3897
Chemicals	0.0061	-0.1721	-0.0298	-0.0700	-0.1307	-0.1548	-0.1398	0.1342	0.2990
RubberPlast	-0.1020	-0.1652	-0.1348	-0.4377	-0.4398	-0.3674	-0.4167	0.1304	-0.3897
NonMetlMinr	-0.0474	-0.1939	-0.0917	-0.0629	-0.0534	-0.0553	-0.0537	0.1462	-0.3897
BasicMetals	0.0086	-0.1189	-0.0064	-0.0092	-0.0496	-0.0553	-0.0504	0.1050	0.0537
FabMetalPrd	0.0037	-0.1358	-0.0215	-0.1455	-0.1344	-0.0855	-0.1271	0.1142	-0.3897
TransportEq	0.0128	-0.1266	-0.0234	-0.0381	-0.0712	0.0081	-0.0388	0.1419	0.2346
OthMachnEc	0.0500	-0.0993	-0.0246	-0.0228	-0.0860	0.0021	-0.0316	0.1224	0.2467
MiscManuf	0.0795	-0.1334	0.0372	-0.0143	0.0238	0.1425	0.0539	0.1129	-0.3897
ElecGasWat	-0.3768	-0.3765	-0.3768	-0.1092	-0.1088	-0.1088	-0.1088	0.2468	-0.3897
Construction	0.0676		0.0676	-0.0026	-0.0025	-0.1503	-0.0025	0.0397	-0.3897
Trade	-0.2853			-0.4728	-0.4728	-0.8669	-0.4728	0.0397	-0.3897
Repairs	-0.0960	-0.0960	-0.0960	-0.1068	-0.1062	-0.3315	-0.1067	0.0924	-0.3897
Hotel_Cafe	0.3693	0.3681		-0.1609	-0.1609	-0.1955	-0.1610	-0.1612	-0.3897
Transport	-0.3238	-0.2574	-0.3238	-0.2680	-0.9678	-0.2940	-0.8882	0.2641	3.2968
CommunicSr	-0.1751	-0.1648	-0.1751	-0.1598	-0.1485	-0.1426	-0.1481	0.1302	-0.3897
FinanceInsur	-0.0866	-0.0859	-0.0866	-0.1411	-0.1366	-0.1849	-0.1375	0.0868	-0.3897
OwnerDwelln	0.0726	0.0726		0.0000	0.0000		0.0000	0.0000	-0.3897
PropBusSrvc	-0.1238	-0.1226	-0.1238	-0.2548	-0.2512	-0.2997	-0.2525	0.1070	-0.3897
GovAdminDf	0.0587	0.0587	0.0587	-0.0270	-0.0255		-0.0255	0.0076	-0.3897
Education	0.1607	0.1541	0.1607	-0.0286	-0.0121	-0.0488	-0.0125	-0.0446	-0.3897
HealthComm	0.0965	0.0963	0.0965	-0.0266	-0.0262	-0.1193	-0.0264	-0.0130	-0.3897
CultuRecrea	0.1751	0.1681	0.1744	-0.0978	-0.0966	-0.0922	-0.0966	-0.0522	-0.3897
OtherService	0.0684	0.0681	0.0684	-0.0725	-0.0722	-0.3885	-0.1224	0.0025	-0.3897

9 IND variables

	employ	gret	p1cap	p1mat	p1prim	p1tot	p2tot	x1tot	x2tot
BroadAcre	-4.1670	-7.9635	-7.9840	1.2207	-6.6103	7.1772	-0.0222	-9.7621	-4.4698
OtherAgric	-1.5413	-2.8403	-2.8732	2.0720	-2.0968	9.9748	-0.0339	-9.4523	-0.9922
ForestFish	-0.1467	-0.0758	-0.1021	-0.0398	0.0796	0.0114	-0.0263	-0.0908	0.8580
Mining	-0.0577	0.0940	0.0762	-0.0759	0.1055	0.0314	-0.0178	-0.0146	0.9711
MeatDairy	-14.8065	-27.2783	-27.2841	6.5663	-11.3657	2.9625	-0.0079	-9.4222	-18.2223
OthFoodProc	-2.3132	-4.3825	-4.3898	1.7452	-1.9530	0.6641	-0.0076	-1.2505	-2.0325
DrinksSmoke	-0.5271	-0.8566	-0.8617	1.1278	-0.4622	0.6491	-0.0051	-0.2009	0.3372
Textiles	-2.7501	-5.2364	-5.2431	1.9297	-2.1998	0.6863	-0.0070	-1.5682	-2.6108
ClothingFtw	-0.5871	-0.9767	-0.9813	0.4242	-0.1553	0.2492	-0.0046	-0.4145	0.2569
WoodProds	-0.1232	-0.0468	-0.0550	-0.0729	0.1081	-0.0133	-0.0082	-0.0815	0.8773
PaperPrint	-0.5223	-0.8311	-0.8521	-0.0760	-0.2849	-0.1569	-0.0211	-0.2848	0.3542
Petrol_CoalP	-1.1658	-2.1029	-2.1306	-0.0305	-1.8523	-0.4311	-0.0283	-0.1419	-0.4971
Chemicals	-0.1452	-0.0803	-0.0989	-0.0068	0.0349	0.0064	-0.0186	-0.0669	0.8550
RubberPlast	-0.7464	-1.2595	-1.2984	0.0778	-0.4325	-0.0979	-0.0393	-0.4358	0.0678
NonMetlMinr	-0.1253	-0.0439	-0.0592	-0.1156	0.0656	-0.0466	-0.0153	-0.0624	0.8793
BasicMetals	-0.0161	0.1811	0.1596	-0.0591	0.1753	0.0104	-0.0214	-0.0078	1.0291
FabMetalPrd	-0.2199	-0.2267	-0.2483	-0.0318	0.0376	0.0040	-0.0217	-0.1430	0.7575
TransportEq	-0.0695	0.0663	0.0525	-0.0436	0.1283	0.0120	-0.0138	-0.0379	0.9526
OthMachnEc	-0.0161	0.1880	0.1595	-0.0426	0.1777	0.0454	-0.0284	-0.0091	1.0337
MiscManuf	-0.0010	0.2080	0.1897	0.0173	0.1911	0.0811	-0.0183	0.0075	1.0470
ElecGasWat	-0.4446	-0.6979	-0.6972	-0.1342	-0.4810	-0.3761	-0.0069	-0.1087	
Construction	0.0113	0.2504	0.2145	-0.0568	0.2032	0.0663	-0.0358	0.0057	
Trade	-0.8045	-1.4071	-1.4139	-0.1143	-0.4750	-0.2852	-0.0069	-0.4728	-0.0308
Repairs	-0.2595	-0.3237	-0.3275	-0.0830	-0.1157	-0.0960	-0.0038	-0.1061	0.6928
Hotel_Cafe	-0.2220	-0.2719	-0.2525	0.6422	0.0696	0.3693	0.0194	-0.1611	0.7273
Transport	-0.6040	-0.9961	-1.0149	-0.1595	-0.4832	-0.3228	-0.0190	-0.2675	0.2440
CommunicSr	-0.3639	-0.4919	-0.5360	-0.1152	-0.2194	-0.1730	-0.0444	-0.1588	0.5807
FinanceInsur	-0.3012	-0.4149	-0.4108	-0.0749	-0.1275	-0.0883	0.0041	-0.1420	
OwnerDwelln	-0.0240	0.0886	0.1438	-0.1266	0.1438	0.0726	0.0551	0.0000	
PropBusSrvc	-0.4265	-0.6777	-0.6610	-0.1150	-0.1438	-0.1238	0.0169	-0.2593	
GovAdminDf	-0.0298	0.1091	0.1321	-0.0296	0.1862	0.0587	0.0229	-0.0270	
Education	-0.0309	0.1122	0.1299	-0.0696	0.1873	0.1607	0.0177	-0.0286	
HealthComm	-0.0320	0.1272	0.1276	-0.0762	0.1810	0.0965	-0.0083	-0.0266	
CultuRecrea	-0.1669	-0.1496	-0.1423	0.2761	0.0533	0.1751	0.0073	-0.0978	0.8088
OtherService	-0.0854	-0.0061	0.0207	-0.0628	0.1658	0.0684	0.0206	-0.0725	0.9085

fandecomp((	LocalMarke	DomShare	Export	Total
WoolMutton	-2.0132	0.0000	-6.5277	-8.5409
GrainsHay	-0.4832	-0.0123	-10.6133	-11.1088
BeefCattle	-9.0067	-0.0042	-0.0107	-9.0216
OtherAgric	-3.5116	-0.5883	-5.3524	-9.4523
ForestFish	-0.1231	-0.0005	0.0312	-0.0924
Mining	-0.0508	-0.0047	0.0414	-0.0141
MeatDairy	-1.1839	-0.0408	-8.1834	-9.4080
OthFoodProc	-0.2166	-0.0531	-0.9949	-1.2646
DrinksSmoke	-0.1059	-0.0716	-0.0316	-0.2092
Textiles	-0.3912	-0.5473	-0.6156	-1.5541
ClothingFtw	-0.0093	-0.1582	-0.2542	-0.4217
WoodProds	-0.0451	-0.0005	-0.0362	-0.0818
PaperPrint	-0.2818	0.0065	-0.0107	-0.2860
Petrol_CoalF	-0.1327	0.0177	-0.0305	-0.1455
Chemicals	-0.1200	0.0078	0.0423	-0.0700
RubberPlast	-0.3989	-0.0222	-0.0166	-0.4377
NonMetlMinr	-0.0522	0.0002	-0.0109	-0.0629
BasicMetals	-0.0307	0.0005	0.0210	-0.0092
FabMetalPrd	-0.1216	-0.0070	-0.0168	-0.1455
TransportEq	-0.0346	-0.0289	0.0254	-0.0381
OthMachnEq	-0.0256	-0.0440	0.0469	-0.0228
MiscManuf	0.0490	-0.0274	-0.0359	-0.0143
ElecGasWat	-0.1087	0.0000	-0.0006	-0.1092
Construction	-0.0025	0.0000	-0.0001	-0.0026
Trade	-0.4728	0.0000		-0.4728
Repairs	-0.1064	0.0005	-0.0009	-0.1068
Hotel_Cafe	-0.1610	0.0001		-0.1609
Transport	-0.7421	-0.0669	0.5410	-0.2680
CommunicSr	-0.1411	-0.0003	-0.0183	-0.1598
FinanceInsur	-0.1351	0.0009	-0.0069	-0.1411
OwnerDwelln	0.0000	0.0000		0.0000
PropBusSrvc	-0.2459	0.0013	-0.0102	-0.2548
GovAdminDf	-0.0254	0.0000	-0.0017	-0.0270
Education	-0.0119	0.0004	-0.0171	-0.0286
HealthComm	-0.0263	0.0001	-0.0004	-0.0266
CultuRecrea	-0.0962	0.0000	-0.0016	-0.0978
OtherService	-0.1224	0.0502	-0.0003	-0.0725

SalesDecom	Interm	Invest	HouseH	Export	GovGE	Stocks	Margins	Total
WoolMutton	-1.9937		-0.0195	-6.5277				-8.5409
GrainsHay	-0.4631		-0.0325	-10.6133				-11.1088
BeefCattle	-8.9689		-0.0420	-0.0107				-9.0216
OtherAgric	-3.7452		-0.3547	-5.3524				-9.4523
ForestFish	-0.1459	0.0076	0.0147	0.0312				-0.0924
Mining	-0.0580	0.0021	0.0004	0.0414				-0.0141
MeatDairy	-1.0416		-0.1831	-8.1833				-9.4081
OthFoodPro	-0.2086		-0.0611	-0.9949				-1.2646
DrinksSmoke	-0.0314		-0.1462	-0.0316				-0.2092
Textiles	-0.8726	-0.0010	-0.0649	-0.6156				-1.5541
ClothingFtw	-0.0705		-0.0970	-0.2542				-0.4217
WoodProds	-0.0484	0.0006	0.0022	-0.0362				-0.0818
PaperPrint	-0.3034	0.0001	0.0280	-0.0107				-0.2860
Petrol_CoalP	-0.1768		0.0618	-0.0305				-0.1455
Chemicals	-0.1358		0.0236	0.0423				-0.0700
RubberPlast	-0.4395	0.0002	0.0182	-0.0166				-0.4377
NonMetlMinr	-0.0542		0.0023	-0.0109				-0.0629
BasicMetals	-0.0304		0.0003	0.0210				-0.0092
FabMetalPrd	-0.1340	0.0027	0.0027	-0.0168				-0.1455
TransportEq	-0.0602	-0.0134	0.0102	0.0254				-0.0381
OthMachnEq	-0.0425	-0.0351	0.0079	0.0469				-0.0228
MiscManuf	-0.0427	0.0345	0.0298	-0.0359				-0.0143
ElecGasWat	-0.1715		0.0628	-0.0006				-0.1092
Construction	-0.0055	0.0030		-0.0001				-0.0026
Trade	-0.0221	0.0000					-0.4507	-0.4728
Repairs	-0.1497		0.0438	-0.0009				-0.1068
Hotel_Cafe	-0.0498		-0.0919				-0.0191	-0.1609
Transport	-0.0453	-0.0001	0.0620	0.5410			-0.8256	-0.2680
CommunicSr	-0.1784		0.0369	-0.0183				-0.1598
FinanceInsur	-0.1457		0.0235	-0.0069			-0.0120	-0.1411
OwnerDwell			0.0000					0.0000
PropBusSrvc	-0.2488	-0.0009	0.0050	-0.0102				-0.2548
GovAdminDf	-0.0242	-0.0013	0.0001	-0.0017				-0.0270
Education	-0.0015		-0.0101	-0.0171				-0.0286
HealthComm	-0.0191		-0.0071	-0.0004				-0.0266
CultuRecrea	-0.0665	-0.0008	-0.0289	-0.0016				-0.0978
OtherService	-0.0733		0.0011	-0.0003				-0.0725

regx1tot(IND	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	-9.7621	-9.7621	-9.7621	-9.7621	-9.7621	-9.7621	-9.7621	-9.7621
OtherAgric	-9.4523	-9.4523	-9.4523	-9.4523	-9.4523	-9.4523	-9.4523	-9.4523
ForestFish	-0.0908	-0.0908	-0.0908	-0.0908	-0.0908	-0.0908	-0.0908	-0.0908
Mining	-0.0146	-0.0146	-0.0146	-0.0146	-0.0146	-0.0146	-0.0146	-0.0146
MeatDairy	-9.4222	-9.4222	-9.4222	-9.4222	-9.4222	-9.4222	-9.4222	-9.4222
OthFoodPro	-1.2505	-1.2505	-1.2505	-1.2505	-1.2505	-1.2505	-1.2505	-1.2505
DrinksSmok	-0.1679	-0.2208	-0.2586	-0.2545	-0.1413	-0.2470	0.0587	-0.0122
Textiles	-1.5682	-1.5682	-1.5682	-1.5682	-1.5682	-1.5682	-1.5682	-1.5682
ClothingFtw	-0.4145	-0.4145	-0.4145	-0.4145	-0.4145	-0.4145	-0.4145	-0.4145
WoodProds	-0.0815	-0.0815	-0.0815	-0.0815	-0.0815	-0.0815	-0.0815	-0.0815
PaperPrint	-0.2848	-0.2848	-0.2848	-0.2848	-0.2848	-0.2848	-0.2848	-0.2848
Petrol_CoalF	-0.1419	-0.1419	-0.1419	-0.1419	-0.1419	-0.1419	-0.1419	-0.1419
Chemicals	-0.0669	-0.0669	-0.0669	-0.0669	-0.0669	-0.0669	-0.0669	-0.0669
RubberPlast	-0.4358	-0.4358	-0.4358	-0.4358	-0.4358	-0.4358	-0.4358	-0.4358
NonMetlMinr	-0.0624	-0.0624	-0.0624	-0.0624	-0.0624	-0.0624	-0.0624	-0.0624
BasicMetals	-0.0078	-0.0078	-0.0078	-0.0078	-0.0078	-0.0078	-0.0078	-0.0078
FabMetalPrd	-0.1430	-0.1430	-0.1430	-0.1430	-0.1430	-0.1430	-0.1430	-0.1430
TransportEq	-0.0379	-0.0379	-0.0379	-0.0379	-0.0379	-0.0379	-0.0379	-0.0379
OthMachnEc	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091	-0.0091
MiscManuf	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
ElecGasWat	-0.0468	-0.1679	-0.2478	-0.1667	0.0028	-0.2245	0.3672	0.2097
Construction	0.0546	-0.0557	-0.1632	-0.1166	0.2308	-0.1241	0.4750	0.3646
Trade	-0.4244	-0.4791	-0.6118	-0.7918	-0.3629	-0.4873	0.3609	0.1738
Repairs	-0.0606	-0.1454	-0.2292	-0.2090	0.0031	-0.1899	0.4405	0.1876
Hotel_Cafe	-0.1186	-0.2012	-0.2788	-0.2239	-0.0604	-0.2546	0.2741	0.1311
Transport	-0.2675	-0.2675	-0.2675	-0.2675	-0.2675	-0.2675	-0.2675	-0.2675
CommunicSr	-0.1150	-0.1999	-0.2735	-0.2452	-0.0623	-0.2455	0.2535	0.1491
FinanceInsur	-0.0818	-0.1913	-0.2896	-0.2247	-0.0206	-0.2576	0.3316	0.2234
OwnerDwelln	0.0876	-0.0827	-0.2439	-0.1066	0.2054	-0.1990	0.8704	0.6071
PropBusSrvc	-0.2194	-0.3003	-0.3786	-0.3663	-0.1367	-0.3397	0.2066	0.0867
GovAdminDf	-0.0270	-0.0270	-0.0270	-0.0270	-0.0270	-0.0270	-0.0270	-0.0270
Education	-0.0159	-0.0406	-0.0638	-0.0443	0.0009	-0.0574	0.0928	0.0581
HealthComm	0.0074	-0.0591	-0.1189	-0.0652	0.0460	-0.1044	0.2979	0.1907
CultuRecrea	-0.0548	-0.1385	-0.2146	-0.1650	0.0014	-0.1895	0.3292	0.2131
OtherService	-0.0359	-0.1090	-0.1659	-0.1099	0.0020	-0.1547	0.2558	0.1738

regadvantag	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	-0.0186	0.0515	-0.0024	-0.1345	0.0156	0.0765	0.1392	-0.2151
OtherAgric	0.0266	-0.0328	-0.0194	-0.1087	0.0692	-0.0134	0.1318	0.0573
ForestFish	-0.0002	0.0000	0.0000	0.0001	-0.0001	0.0025	-0.0001	-0.0002
Mining	-0.0053	-0.0078	0.0021	-0.0032	0.0313	-0.0060	-0.0118	0.0226
MeatDairy	0.0140	-0.0110	-0.0336	0.0053	0.0185	-0.0370	0.0708	0.0688
OthFoodPro	0.0005	-0.0013	-0.0047	0.0034	0.0043	-0.0041	0.0108	0.0086
DrinksSmoke	0.0002	-0.0001	-0.0003	-0.0003	0.0002	-0.0002	0.0008	0.0004
Textiles	0.0012	-0.0066	0.0040	0.0032	0.0025	-0.0069	0.0058	0.0058
ClothingFtw	-0.0001	-0.0004	0.0001	0.0002	0.0004	0.0006	0.0005	0.0006
WoodProds	0.0000	0.0000	0.0003	-0.0001	-0.0002	0.0006	-0.0004	-0.0005
PaperPrint	0.0000	-0.0002	0.0002	0.0002	0.0002	-0.0005	0.0003	0.0005
Petrol_CoalP	0.0002	0.0002	0.0000	-0.0006	-0.0004	-0.0006	-0.0006	-0.0006
Chemicals	0.0004	0.0009	-0.0009	-0.0008	-0.0005	-0.0006	-0.0019	-0.0019
RubberPlast	0.0001	-0.0009	0.0005	-0.0001	0.0006	0.0008	0.0011	0.0011
NonMetlMinr	-0.0002	0.0001	0.0001	-0.0005	0.0004	0.0007	-0.0010	-0.0005
BasicMetals	0.0010	-0.0021	-0.0004	0.0007	0.0011	0.0034	-0.0033	0.0056
FabMetalPrd	-0.0001	0.0002	0.0002	-0.0001	0.0000	-0.0002	-0.0009	-0.0006
TransportEq	-0.0015	0.0024	-0.0009	0.0046	-0.0019	-0.0001	-0.0028	-0.0026
OthMachnEq	0.0007	0.0011	-0.0016	0.0006	-0.0011	-0.0020	-0.0026	-0.0037
MiscManuf	-0.0001	0.0002	0.0000	0.0001	0.0000	-0.0005	-0.0008	-0.0010
ElecGasWat	0.0022	-0.0022	-0.0052	-0.0021	0.0039	-0.0043	0.0182	0.0125
Construction	0.0033	-0.0046	-0.0105	-0.0080	0.0134	-0.0084	0.0398	0.0235
Trade	0.0042	-0.0008	-0.0143	-0.0319	0.0122	-0.0012	0.0785	0.0586
Repairs	0.0012	-0.0010	-0.0028	-0.0024	0.0021	-0.0019	0.0126	0.0060
Hotel_Cafe	0.0011	-0.0009	-0.0026	-0.0014	0.0017	-0.0020	0.0098	0.0053
Transport	-0.0001	0.0001	-0.0001	0.0001	0.0003	-0.0001	0.0006	-0.0002
CommunicSr	0.0013	-0.0012	-0.0033	-0.0025	0.0024	-0.0025	0.0137	0.0083
FinanceInsur	0.0043	-0.0033	-0.0100	-0.0056	0.0069	-0.0078	0.0331	0.0221
OwnerDwelln	0.0092	-0.0074	-0.0207	-0.0092	0.0120	-0.0169	0.0791	0.0405
PropBusSrvc	0.0034	-0.0036	-0.0100	-0.0087	0.0102	-0.0067	0.0382	0.0276
GovAdminDf	-0.0011	0.0016	-0.0025	-0.0001	-0.0048	-0.0002	0.0438	0.0041
Education	0.0014	-0.0009	-0.0016	-0.0011	-0.0003	-0.0018	0.0085	0.0024
HealthComm	0.0028	-0.0024	-0.0055	-0.0027	0.0031	-0.0050	0.0216	0.0117
CultuRecrea	0.0009	-0.0007	-0.0019	-0.0011	0.0012	-0.0015	0.0076	0.0042
OtherService	0.0010	-0.0008	-0.0018	-0.0008	0.0008	-0.0017	0.0076	0.0037

	regemploy_	regw1lab_i	regx1prim_i
NSW	-0.4265	-0.2355	-0.4746
VIC	-0.5326	-0.3419	-0.5627
QLD	-0.6332	-0.4426	-0.6767
SA	-0.5475	-0.3568	-0.8339
WA	-0.3530	-0.1619	-0.3243
TAS	-0.6052	-0.4146	-0.5771
ACT	0.0609	0.2528	0.2179
NT	-0.1029	0.0887	-0.3545

```
! First Simulation: Command file for ORANIG model: short-run closure

check-on-read elements = warn; ! very often needed
cpu=yes ; ! (Optional) Reports CPU times for various stages
log file = yes;  ! Optional
auxiliary files = oranig; ! needed by GEMSIM

! Solution method
method = euler ;
steps =   3 4 5;
!method = johansen; ! alternative to above

! Data and summary file
file basedata = basedata.har ;
updated file basedata = <cmf>.upd;
file summary  = summary.har;

! Closure

! Exogenous variables constraining real GDP from the supply side
exogenous  x1cap              ! all sectoral capital
         x1lnd              ! all sectoral agricultural land
         a1cap a1lab_o a1lnd
         a1prim a1tot a2tot  ! all technological change
         realwage ;          ! Average real wage

! Exogenous settings of real GDP from the expenditure side
exogenous  x3tot              ! real private consumption expenditure
         x2tot_i            ! real investment expenditure
         x5tot              ! real government expenditure on goods
         delx6 ;            ! real demands for inventories by commodity

! The demand curves of exports are fixed in both quantity and price axes
exogenous  f4p f4q              ! individual exports
         f4p_ntrad f4q_ntrad ; ! collective exports
! Exogenous foreign prices of imports ;
exogenous  pf0cif ;

! All tax rates are exogenous
exogenous  delPTXRATE f0tax_s  f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp
         f4tax_trad f4tax_ntrad f1oct ;

! distribution of government demands !
exogenous  f5 ;

! The nominal exchange rate is the numeraire
exogenous phi ;

! Number of households and their consumption preferences are exogenous
exogenous q a3_s ;

exogenous capslack; ! switch off aggregate capital constraint !

! Distribution of investment between industries
xSet EXOGINV  # 'exogenous' investment industries #
! (Utilities
 (ElecGasWater
  PropBusSrvc

xSubset EXOGINV is subset of IND;
xSet ENDOGINV # 'endogenous' investment industries # = IND - EXOGINV;
exogenous finv1(ENDOGINV); ! investment linked to profits
```

```
 ! Reduced productivity in Agriculture: DPSV shortrun closure
exogenous finv2(EXOGINV);  ! investment follows aggregate investment

! Exogenous variables for regional extension
exogenous    freg1 freg2 freg3 freg4 freg5 freg6;
exogenous    rsum1 rsum2 rsum3 rsum4 rsum5 rsum6;

rest endogenous ;

verbal description = Reduced productivity in Agriculture: DPSV shortrun closure;

shock  a1tot("BroadAcre")= 10;
shock  a1tot("OtherAgric")= 10;

→
```

An overview of GEMPACK

(General Equilibrium Modelling PACKage)

Centre of Policy Studies
Victoria University
Level 14, 300 Flinders St
Melbourne Victoria 3000

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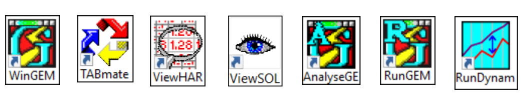
CoPS SINCE 1975

GEMPACK software system

What is it?

- GEMPACK is a suite of programs, developed at CoPS, which helps to create, solve and understand CGE models.
- A CGE model might consist of several million simultaneous non-linear equations – to solve such a model is a formidable challenge, requiring special tools.
- CoPS philosophy is that results must be understood and explained – so GEMPACK includes tools to visualize and analyse data and equations.



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CoPS

GEMPACK

- Designed for CGE modelling
- Allows modellers to concentrate more on economics and less on computing problems
- Makes modellers more productive
- Allows users to easily share models
- Provides a simple programming language which can be understood

History

- Development began in 1983 by Ken Pearson at La Trobe University
- Grew out the Impact Project and development of the ORANI from 1975
- First widely distributed release 4.2 available in 1990
- Release 12.0 available in September 2018

Different types of models

Single-country models

Australia, Brazil, China, Egypt, Finland, India, Indonesia, Ireland, Italy, Japan, Kazakhstan, Malaysia, Mongolia, New Zealand, Pakistan, Papua New Guinea, Philippines, Poland, South Africa, Spain, Venezuela, Vietnam, …

Multi-regional models

World trade models: GTAP

Sub-national regional models: VURM (8 states), TERM Australia (206 stat. areas) TERM China (35 provinces, 360 stat. areas)

Dynamic models

Recursive (time periods solved sequentially)

VU-National (MONASH), VURM (MMRF), USAGE-ITC, Dynamic GTAP, GTEM

Intertemporal (all time periods solved simultaneously)

ORANI-INT, Global meat market (CIE), OLG model (Wendner)

The TABLO programming language

The GEMPACK programming language is called TABLO.

Programs or models are saved in files with .tab extension (oranig.tab).

TAB files are processed by the GEMPACK program TABLO.EXE

TABLO **statements**

Statements in TABLO begin with a **keyword** and finish with a semi-colon **;**

```
Keyword ... ... ... ;
```

example:

labelling information

```
File BASEDATA # Input data file # ;
```

Keyword

rest of statement

end of statement

TABLO syntax

Statements

Begin with a keyword and end with a semi-colon ;

```
Keyword ... ... ... ;
```

Each statement type must follow a defined structure, see the manual.

Repeated statements

The keyword can be omitted if the previous statement on the file is of the same type.

Comments

`!Text between exclamation marks!` is ignored by GEMPACK.

Case

Not case sensitive (although case is often used: COEFFICIENTS, variables).

Strong comments

`![[! strong comment !]]!` can override normal comments

TABLO syntax

Labelling information

Some statements, SET, COEFFICIENT, VARIABLE, ASSERTION allow #labelling information# between hashes, up to 80 characters

Names

Names of coefficients, variables, sets, set elements, equations and files must begin with a letter and only contain `a-z`, `A-Z` , `0-9` , `_` , `@`.

`V1BAS, x0gdpinc`

Arguments

Arguments can be an index or a quoted set element

`V1TOT(i),  V1TOT("agriculture")`

or any index expression

Quantifiers

A quantifier is of the form (all, index, set). Quantifiers define the dimensions of coefficients, variables and equations.

`(all,c,COM)(all,s,SRC)(all,i,IND)`

TABLO syntax

Mathematical expressions

Used in equations, formulas, updates, assertions and other places

```
V1PUR(c,s,i) =
        V1BAS(c,s,i) + V1TAX(c,s,i) + sum{m,MAR,V1MAR(c,s,i,m)};
```

brackets: `(), {}, []`

operators: `+, -, *, /, ^, SUM, PROD, MAXS, MINS`

functions: `ABS, MAX, MIN, SQRT, EXP, LOGE, ID01, RANDOM, ...`

List of statement types

SET	SUBSET	COEFFICIENT	VARIABLE	FILE
READ	WRITE	FORMULA	EQUATION	UPDATE
ZERODIVIDE	DISPLAY	MAPPING	ASSERTION	TRANSFER
OMIT	SUBSTITUTE	BACKSOLVE	COMPLEMENTARITY	POSTSIM
LOOP	BREAK	CYCLE		

Statement examples

FILE – specifies file objects to read data from or write data to.

```
File  BASEDATA  # Input data file #;
 (new) SUMMARY  # Output for summary and checking data #;
```

keyword File omitted

SET – Defines a set. Elements can be read from file or given explicitly.

```
Set
 COM # Commodities# read elements from file BASEDATA header "COM";
 SRC # Source of commodities # (dom,imp);
 IND # Industries # read elements from file BASEDATA header "IND";
```

keyword Set omitted

SUBSET – declares subset relationship. Useful in formulas and equations.

```
Subset MAR is subset of COM;

Formula
 (all,n,NONMAR) MARSALES(n) = 0.0;
 (all,m,MAR)    MARSALES(m) = sum{c,COM, V4MAR(c,m) +
                              sum{s,SRC, V3MAR(c,s,m) + V5MAR(c,s,m) +
                               sum{i,IND, V1MAR(c,s,i,m) + V2MAR(c,s,i,m)}}};
```

size COM

formula for non-margin coms
formula for margin coms

Statement examples

COEFFICIENT – Declares a coefficient. Values read from file or assigned by formula.

quantifier list, dimensions are COM x SRC x IND

```
Coefficient  ! Basic flows of commodities (excluding margin demands)!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  # Intermediate basic flows #;

Coefficient
 (parameter)(all,i,IND) SIGMA1LAB(i) # CES substitution between skill types #;
```

READ – Assigns values read from file to a coefficient.

```
Read
 V1BAS from file BASEDATA header "1BAS";
 V2BAS from file BASEDATA header "2BAS";
 V3BAS from file BASEDATA header "3BAS";
```

WRITE – Writes values from a coefficient to a file.

```
Write PTXRATE to file SUMMARY header "PTXR";
```

Statement examples

FORMULA – Assigns values to coefficient on the left hand side.

```
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V1PUR(c,s,i)  = V1BAS(c,s,i) + V1TAX(c,s,i) + sum{m,MAR, V1MAR(c,s,i,m)};
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V2PUR(c,s,i)  = V2BAS(c,s,i) + V2TAX(c,s,i) + sum{m,MAR, V2MAR(c,s,i,m)};
```

quantifier list

ZERODIVIDE – replace undefined divide by zero by a default value

$\frac{x}{0}$ replaced with 0.5

```
Zerodivide default 0.5;
Formula
  (all,c,COM)(all,i,IND)      V2PUR_S(c,i)  = sum{s,SRC, V2PUR(c,s,i)};
  (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i) = V2PUR(c,s,i)/V2PUR_S(c,i);
Zerodivide off;
```

switch off replacement

possible divide by zero here

Statement examples

VARIABLE – defines variables, %-change or ordinary-change.

```
Variable  ! Variables used to update above flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)  x1(c,s,i)  # Intermediate basic demands #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  x2(c,s,i)  # Investment basic demands #;
 (all,c,COM)(all,s,SRC)             x3(c,s)    # Household basic demands #;
 (change) (all,c,COM)(all,s,SRC)    delx6(c,s) # Inventories demands #;
```

indicates delx6 is ordinary change

UPDATE – defines how variables update coefficient values.
WARNING: not a literal equation
CF = p*x is shorthand notation for CF := CF*(1 + p + x)

```
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i) = p0(c,s)*x1(c,s,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i) = p0(c,s)*x2(c,s,i);
 (all,c,COM)(all,s,SRC)             V3BAS(c,s)   = p0(c,s)*x3(c,s);
```

Statement examples

EQUATION – defines an equation, a linear relationship between variables.

equation name

```
Equation E_x1  # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  x1(c,s,i)-a1(c,s,i) = x1_s(c,i) -SIGMA1(c)*[p1(c,s,i) +a1(c,s,i) -p1_s(c,i)];
```

variables (underlined) appear in a linear way, always
CF1*v1 + CF2*v2 + ...
NEVER
CF1*v1^2*EXP(CF2*v2) + ...

ASSERTION – if evaluates to FALSE an error or warning is given

```
Assertion ! if below not true, program will stop with message !
 # DIFFIND = V1TOT-MAKE_C = tiny # (all,i,IND) ABS[DIFFIND(i)/V1TOT(i)] <0.001;
```

costs V1TOT(i) should equal output MAKE_C(i) for each industry i

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Statement examples

[more details on these statements later]

OMIT – gives a list of variables to be removed from the model
exogenous **variable** AND not shocked ⇒ **variable=0**
∴ can be removed from the model

```
Omit a1 a1oct a1mar a1_s a2 a2mar a2_s a3 a3mar a4mar a5mar;
Omit f1lab f1lab_o f1lab_i;
```

SUBSTITUTE – gives variable and equation to substitute out of model
variable is NOT on solution file

```
Substitute pq1 using E_pq1;
```

BACKSOLVE – gives variable and equation to substitute out of model
variable is on solution file

```
Backsolve p1 using E_p1;
Backsolve p1lab using E_p1lab;
```


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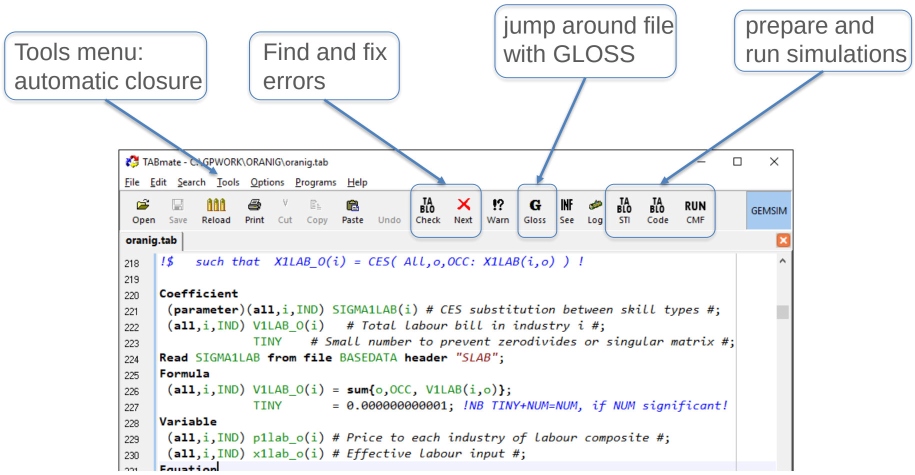
Tabmate text editor

The model TAB file is written with the TABmate editor.



Data

Data is saved in HAR files.

View and edit with **ViewHAR**

HAR (Header ARray) – each header contains an array of data

Example: **`basedata.har`**

Input data file **`basedata.har`** contains

Set definitions: COM, SRC, IND, OCC, MAR, ...

CGE database: basic flows, margin flows, primary factors, taxes, MAKE matrix, import taxes

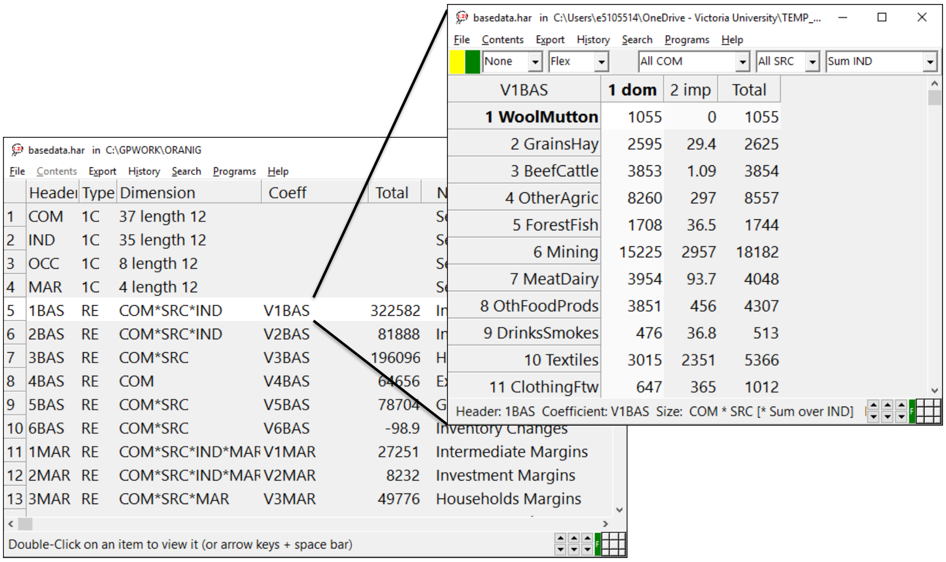
Parameters: elasticity parameters SIGMA1, SIGMA2, SIGMA3, SIGMAPRIM

Preparing data, GEMPACK programs can

Read in raw data from CSV files

Process and write out data to HAR files

Data, viewing with ViewHAR

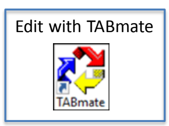


Command file (CMF) defines a simulation

Simulations
- start with the economy in equilibrium (initial solution)
- impose a shock (change) on the economy, a new equilibrium is found

GEMPACK reports the changes in moving from the initial to final values
- these changes are described by the **variables** in the model

Simulations are specified in Command Files (CMF files)
- Example: FirstSim.cmf



Command file statements begin with a keyword or phrase and finish with a semi-colon

```
Keyword/phrase ... ... ... ; ! comment
```

Exclamation mark begins a comment to the end of the line

Command file example

Example taken from FirstSim.cmf

model name (auxiliary files = <model name>;)

```
auxiliary files = oranig;
```

actual files

```
file basedata = basedata.har ;
```

solution method and number of steps

```
method = euler ;
steps =  3 4 5;
```

closure

```
exogenous  x1cap x1lnd a1cap a1lab_o a1lnd ... ;
rest endogenous ;
```

shocks

```
shock  a1tot("BroadAcre")= 10;
shock  a1tot("OtherAgric")= 10;
```

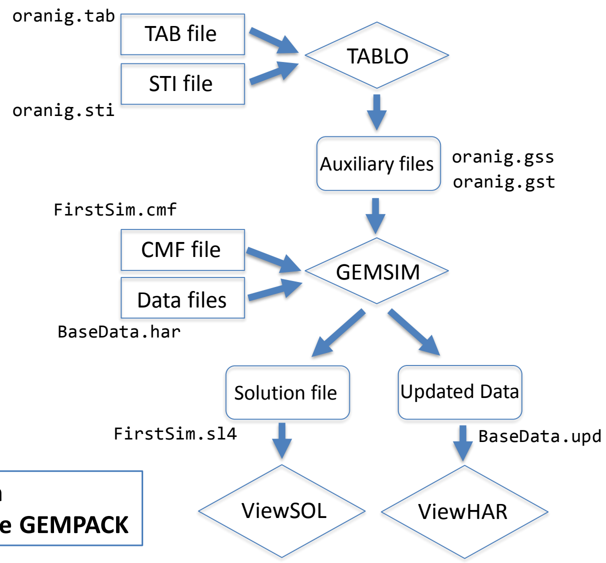
description

```
verbal description = Reduced productivity in Agriculture:
DPSV shortrun closure;
```


Implement with TABLO, simulation with GEMSIM

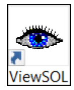
Implement model with TABLO

Run simulation with GEMSIM



Simulations with Executable-image GEMPACK

Solution file viewer – ViewSOL



The solution file is viewed with ViewSOL

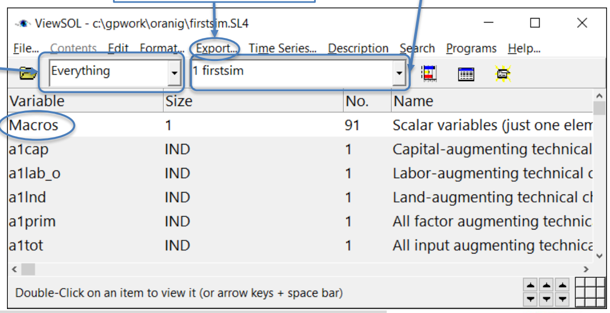
- Contains the %-change and ordinary-change variables
- Macro (scalar) variables are collected together: Macros on contents page
- Use the Filter box to display 3-dimensional variables
- Can't display 4 dimensional variables
- Can show multiple solutions

export to clipboard, paste into Excel

choose between open solution files

select item to filter with

Macros (scalars)



Variable	Size	No.	Name
Macros	1	91	Scalar variables (just one elem
a1cap	IND	1	Capital-augmenting technical
a1lab_o	IND	1	Labor-augmenting technical c
a1lnd	IND	1	Land-augmenting technical ch
a1prim	IND	1	All factor augmenting technic
a1tot	IND	1	All input augmenting technica

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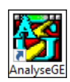
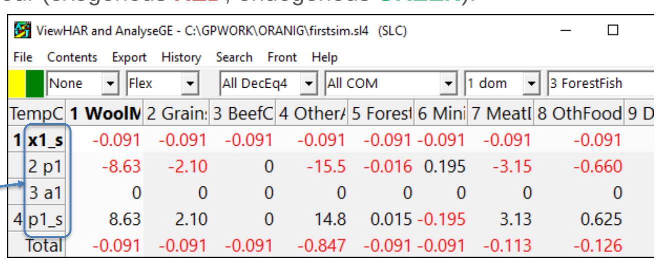
AnalyseGE: another way to view results



AnalyseGE displays simulation results of a while showing the TAB file.
Variables and Coefficients can be evaluated by clicking.
Values of any expression involving Coefficients and Variables can be displayed.
Equations can be displayed with contributions from each term (decomposition).
Closure indicated by colour (exogenous **RED**, endogenous **GREEN**).

Decomposing RHS of Equation E_x1



TempC	1 WoolM	2 Grain	3 BeefC	4 Other	5 Forest	6 Mini	7 MeatL	8 OthFood	9 D
1 x1_s	-0.091	-0.091	-0.091	-0.091	-0.091	-0.091	-0.091	-0.091	
2 p1	-8.63	-2.10	0	-15.5	-0.016	0.195	-3.15	-0.660	
3 a1	0	0	0	0	0	0	0	0	
4 p1_s	8.63	2.10	0	14.8	0.015	-0.195	3.13	0.625	
Total	-0.091	-0.091	-0.091	-0.847	-0.091	-0.091	-0.113	-0.126	

```
Equation E_x1  # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
 x1(c,s,i)-a1(c,s,i) = x1_s(c,i) -SIGMA1(c)*[p1(c,s,i) +a1(c,s,i) -p1_s(c,i)];
```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Programs and their function

Program	Used for	Associated file types
TABmate	Text editing. Shows errors in TAB files (TABLO Check)	TAB, CMF, LOG, STI
Tablo	Translates TAB file into GEMSIM aux. files or Fortran program	TAB, STI
GEMSIM	Performs simulations and data jobs	CMF, HAR SL4, UPD, LOG
ViewHAR	Displays and edits data files	HAR, UPD
ViewSOL	Displays solution files	SL4
AnalyseGE	Displays solution via TAB file and evaluating expressions	SL4, UPD
RunGEM	Runs simulations	Same as GEMSIM but with some renaming
WinGEM	Friendly interface for everything from implementation to sims	All of the above

Condensing the model

Basic idea:

Reduce model size → Use less memory
and
Speed up simulation

Three condensation actions

- **Omit** exogenous variables = 0 removed
- **Substitute** endogenous variable and equation substituted out
- **Backsolve** substitute, variable on solution file

Omit

Omitted variables must be exogenous and not shocked

Start with large variables

`Size a1mar = 10,360 = 37(COM) x 2(SRC) x 35(IND) x 4(MAR)`

`a1mar` **exogenous and NOT shocked** ⇒ `a1mar=0`

TABLO removes a1mar from the model

Substitute

Substitute

Endogenous variable AND matching equation

Dimensions of variable and equation must be the same

```
Variable  ! Powers of Commodity Taxes on Basic Flows !
(all,c,COM)(all,s,SRC)(all,i,IND) t1(c,s,i) # Power of tax on intermediate #;

                    Matching dimensions

Equation
E_t1  # Power of tax on sales to intermediate #
(all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;
```

Dim t1 = COM x SRC x IND = Dim E_t1

TABLO can substitute t1 using E_t1

Substitute

TABLO can substitute t1 using E_t1

```
Equation E_p1 # Purchasers prices - producers #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
                [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)]
                + sum{m,MAR, V1MAR(c,s,i,m)*[p0dom(m)+a1mar(c,s,i,m)]};


Equation E_p1 # Purchasers prices - producers #
(all,c,COM)(all,s,SRC)(all,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
            [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ f0tax_s(c) + f1tax_csi]
            + sum{m,MAR, V1MAR(c,s,i,m)*[p0dom(m)+a1mar(c,s,i,m)]};
```

After substitution of t1 using E_t1

1 less variable size COMxSRCxIND = 2590

1 less equation size COMxSRCxIND = 2590

Condensing ORANI-G

Backsolve

Backsolve is the same as Substitute but variable is made available in results

Condensation

- **TABLO** follows instructions in stored-input file **ORANIG.STI**
- Condensation statements can also be put in the TAB file (modern alternative)
- For size of variables and size of equations put

```
condensation information file = cond.txt;
```

in CMF file

Before condensation ORANIG has

310,041 variables (32,394 exog) and 272,647 equations.

After condensation

5824 variables (2732 exog) and 3092 equations, and a further 17,120 variables are backsolved for.

GEMPACK versions

Two versions available

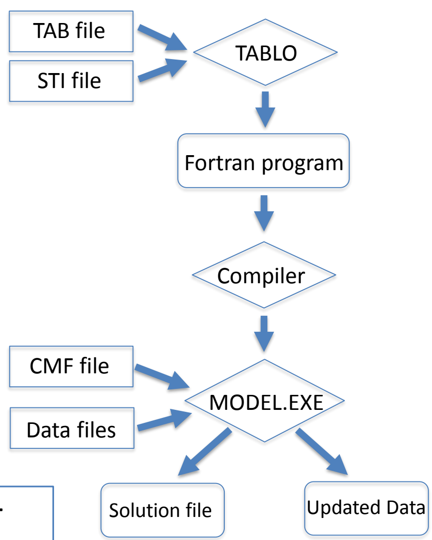
- Source-code GEMPACK
- Executable-image GEMPACK

Source-code GEMPACK

- TABLO generates a FORTRAN program
- FORTRAN compiler creates MODEL.EXE file

The MODEL.EXE

- replaces GEMSIM
- is faster for big models

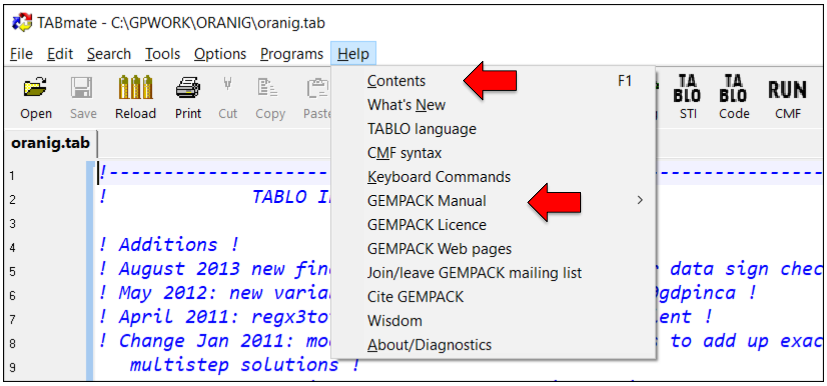


Simulations with Source-code GEMPACK

GEMPACK Manual and Help

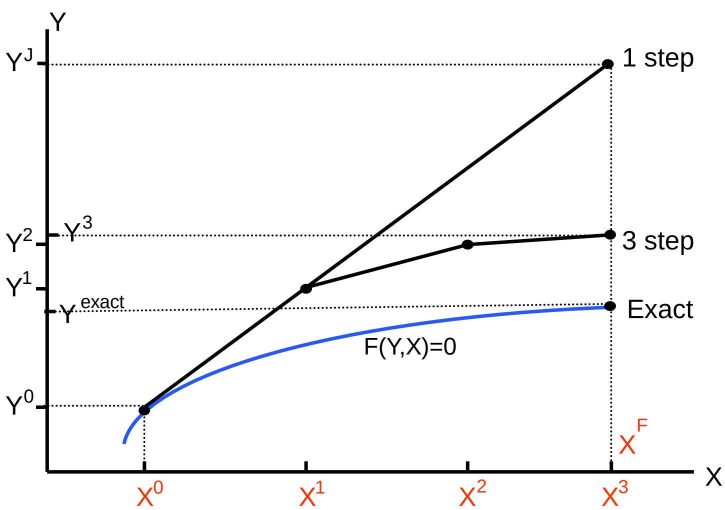
All GEMPACK programs have a Help menu.
Gives access to:

- Program specific Help manual
- GEMPACK reference Manual



Multistep solution

Y = vector of endogenous variables (Y determined by solving the model)
X = vector of exogenous variables (X values set outside model).



Extrapolation

Results shown are from `FirstSim.XAC` the extrapolation accuracy file.
Put this command in CMF file:

```
    extrapolation accuracy file = yes;
```

Solution method is Euler 3-step 4-step 5-step.

```
 ---> EXTRAPOLATION RESULTS.    (firstsim (drought) simulation)

 -->  Variable x4tot  Export volume index
 x4tot                  -4.52768      -4.50932      -4.49848      -4.45640     CX  3 L5

 -->  Variable regx4(COM,REG)  Exports by region
regx4(WoolMutton,NSW)    -11.5829      -11.4807      -11.4205      -11.1888     CX  3 L4
regx4(GrainsHay,NSW)     -25.0563      -24.8086      -24.6631      -24.1042     CX  3 L3
regx4(BeefCattle,NSW)   -0.283176     -0.310112     -0.326173     -0.389656     CX  2 L5
regx4(OtherAgric,NSW)    -58.0038      -56.9785      -56.3860      -54.1852     CX  2 L2
regx4(ForestFish,NSW)    0.352018      0.323573      0.306715      0.240855     CX  2 L4
regx4(Mining,NSW)        7.940237E-02  7.813712E-02  7.738585E-02  7.443985E-02 CX  3 L6
regx4(MeatDairy,NSW)     -24.0754      -24.0128      -23.9735      -23.8035     CX  3 L4
regx4(OthFoodProds,NSW)  -4.56241      -4.62893      -4.66835      -4.82240     CX  3 L4
regx4(DrinksSmokes,NSW) -0.283176     -0.310112     -0.326173     -0.389656     CX  2 L5
regx4(Textiles,NSW)      -2.79682      -2.81283      -2.82235      -2.85986     CX  4 L5
```

3-step | 4-step | 5-step | extrapolation

Conclusion

GEMPACK:

- solves very large systems of non-linear equations.
- equations are specified using a natural algebra-like notation.
- calculates accurate solutions of the economic model.
- has comprehensive documentation, the GEMPACK Manual.
- helps you visualize and explore code, data and results.
- AnalyseGE, the GEMPACK analyser, allows the user to view simulation results while looking at the model equations (helps understand results).
- solves recursive-dynamic and fully-intertemporal models.
- is continually improved, with prompt feedback given when problems are reported

Section 3

ORANI-G document

ORANI-G: A Generic Single-Country Computable General Equilibrium Model

Mark Horridge

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Abstract:The ORANI applied general equilibrium (AGE) model of the Australian economy has been widely used by academics and by economists in the government and private sectors. We describe a generic version of the model, ORANI-G, designed for expository purposes and for adaptation to other countries.

Our description of the model's equations and database is closely integrated with an explanation of how the model is solved using the GEMPACK system. The intention is to provide a convenient starting-point for those wishing to use or construct a similar AGE model. Computer files are available, which contain a complete model specification and database.

ORANI-G forms the basis of an annual modelling course, and has been adapted to build models of many countries, including Italy, Spain, South Africa, Brazil, Ireland, Taiwan, Kazakhstan, Kyrgyzstan, Pakistan, Sri Lanka, Fiji, South Korea, Denmark, Uganda, Vietnam, Thailand, Indonesia, Philippines and China.

Bibliographical Note: this document has its origin in the article"ORANI-F: A General Equilibrium Model of the Australian Economy", by J.M. Horridge, B.R. Parmenter and K.R. Pearson (all of the Centre of Policy Studies), which appeared in the journal Economic and Financial Computing (vol.3,no.2,Summer 1993). This original version can be found at http://www.copsmodels.com/archivep.htm#tpmh0139. Subsequently Horridge has progressively altered the article for teaching purposes, removing contributions by the other authors.

ORANI-G is designed to be freely used and adapted for various countries and purposes. The same is true of this document. You are welcome to use or alter all or parts of it to prepare documentation for your own ORANI-G based model. However, we ask that you make some attribution or acknowledgement if you do use the document in this way. You can cite the document as follows:
Horridge (2000), *ORANI-G: A General Equilibrium Model of the Australian Economy*, CoPS/IMPACT Working Paper Number OP-93, Centre of Policy Studies, Victoria University, downloadable from:
www.copsmodels.com/elecpapr/op-93.htm

Changes for the 2001 edition
This edition includes an expanded discussion of closures, changes reflecting advances in GEMPACK software; and a reorganized TAB file. The changes to the TAB file are designed to make it more readable, more modular, and easier to maintain. For example, instead of appearing in one huge list, most variables are declared immediately prior to the equations in which they appear (if desired, the software can produce a comprehensive list of variables, such as appears in Appendix K). Also, an attempt has been made to confine the effect of particular theoretical assumptions (such as the mechanism of a tax) to fewer (ideally, just one) equations. For example, update statements for tax flows and computations of aggregate tax revenue are now independent of whether tax variables are expressed as powers or as *ad valorem* rates. Again, the original version of ORANI used the assumptions of constant returns to scale and marginal cost pricing to eliminate quantity variables from the industry zero pure profits (ZPP) condition. Those assumptions are not embedded in the ZPP equation for ORANIG01.

Changes for the 2003 edition
This edition includes new variables: p1var (short-run variable cost price index); x0gne, p0gne and w0gne (absorption aggregates); xgdpfac (GDP at factor cost, easily decomposed into components due to each primary factor). New real income-side GDP variable x0gdpinc equals x0gdpexp and can be decomposed into primary factor, tech change and tax components. Some equations have been re-arranged to make them more friendly to AnalyseGE. For the same reason, many substitutions were converted to backsolves. Previously all parameters were positive except export demand elasticities and Frisch parameters: now these also may be positive without error. The ID01 function is used instead of TINY in some places. TINY and ID01 appear in a few more places to combat rare zero-divide problems.

Changes for the 2005 edition
The TAB file (but not the text) contains some new macro variables to assist in explaining results. The TAB file also contains an example of the “post-sim” calculations possible in Version 9 and later of GEMPACK.

Changes for the 2018 edition
Appendix A contains new material; examining the effects of changes in distribution parameters and in multi-input 'twists'.

Latest ORANI-G-related material will be found at:
http://www.copsmodels.com/oranig.htm

This document was produced in MS Word97. It is designed to be printed on A4 paper, and to be copied double-sided. In that case, even-numbered pages should appear on the left, and odd pages on the right, of each two-page spread. For printing, you might need to use some special fonts: the relevant files (with TTF extensions) should be included with the document file. Some other programs were used to produce diagrams: the Draw98 extension to Office97, MicroGrafx ABC FlowCharter 2.0, and Deneba Canvas7SE.

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1. Introduction

The ORANI applied general equilibrium (AGE) model of the Australian economy was first developed in the late 1970s as part of the government-sponsored IMPACT project[1]. The model has been widely used in Australia as a tool for practical policy analysis by academics, and by economists employed in government departments and in the private sector[2].

Initial versions of ORANI were static, with applications confined to comparative-static analysis. Later versions have contained dynamic elements, arising from stock/flow accumulation relations: between capital stocks and investment, and between foreign debt and trade deficits. Other extensions to the basic model have included systems of government accounts, and regional breakdowns of model results.

The version of ORANI described here, ORANI-G, resembles the original ORANI specification, and is designed both as an introduction to the ORANI methodology, and as a launching pad for developing new models. Indeed, it has already served as the basis for models of South Africa, Vietnam, Indonesia, South Korea, Thailand, the Philippines, Pakistan, Denmark, both Chinas and Fiji.

GEMPACK, a flexible system for solving AGE models, is used to formulate and solve ORANI-G (Harrison and Pearson, 1994). GEMPACK automates the process of translating the model specification into a model solution program. The GEMPACK user needs no programming skills. Instead, he/she creates a text file, listing the equations of the model. The syntax of this file resembles ordinary algebraic notation. The GEMPACK program TABLO then translates this text file into a model-specific program which solves the model.

The documentation in this volume is designed to serve as a template for researchers who may wish to use or construct a model like ORANI-G using the GEMPACK software. It consists of:

- an outline of the structure of the model and of the appropriate interpretations of the results of comparative-static and forecasting simulations;
- a description of the solution procedure;
- a brief description of the data, emphasising the general features of the data structure required for such a model;
- a complete description of the theoretical specification of the model framed around the TABLO Input file which implements the model in GEMPACK; and
- a guide to the GEMPACK system.

A set of computer files complements this document, which may downloaded—see Appendix B. The files contain the ORANI-G TABLO Input file and a 22-sector database. Some version of GEMPACK is required to solve the model. To order GEMPACK, see Appendix C.

[1] See: Powell, 1977; Dixon, Parmenter, Ryland and Sutton, 1977; Dixon, Parmenter, Sutton and Vincent (DPSV/Green Book), 1982.
[2] See: Parmenter and Meagher, 1985; Powell and Lawson, 1989, Powell, 1991; Vincent, 1989.

2. Model Structure and Interpretation of Results

ORANI-G has a theoretical structure which is typical of a static AGE model. It consists of equations describing, for some time period:

- producers' demands for produced inputs and primary factors;
- producers' supplies of commodities;
- demands for inputs to capital formation;
- household demands;
- export demands;
- government demands;
- the relationship of basic values to production costs and to purchasers' prices;
- market-clearing conditions for commodities and primary factors; and
- numerous macroeconomic variables and price indices.

Demand and supply equations for private-sector agents are derived from the solutions to the optimisation problems (cost minimisation, utility maximisation, etc.) which are assumed to underlie the behaviour of the agents in conventional neoclassical microeconomics. The agents are assumed to be price-takers, with producers operating in competitive markets which prevent the earning of pure profits.

2.1. A comparative-static interpretation of model results

Like the majority of AGE models, ORANI-G is designed for comparative-static simulations. Its equations and variables, which are described in detail in Section 4, all refer implicitly to the economy at some future time period.

This interpretation is illustrated by Figure 1, which graphs the values of some variable, say employment, against time. A is the level of employment in the base period (period 0) and B is the level which it would attain in T years time if some policy—say a tariff change—were *not* implemented. With the tariff change, employment would reach C, all other things being equal. In a comparative-static simulation, ORANI-G might generate the percentage change in employment 100(C-B)/B, showing how employment *in period T* would be affected by the tariff change alone.

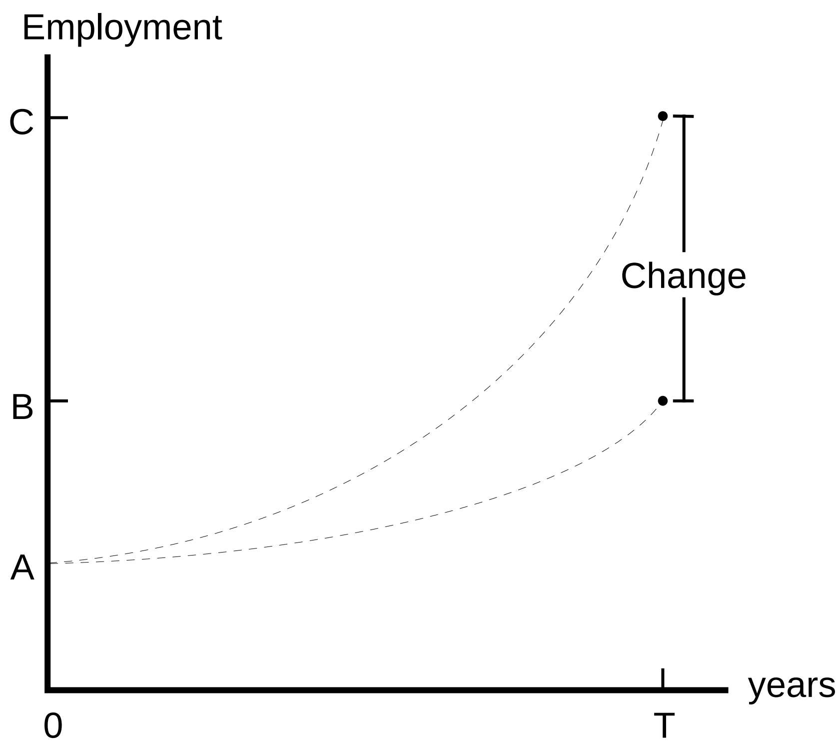

Figure 1. Comparative-static interpretation of results

Many comparative-static ORANI simulations have analysed the short-run effects of policy changes. For these simulations, capital stocks have usually been held at their pre-shock levels. Econometric evidence suggests that a short-run equilibrium will be reached in about two years, i.e., T=2 (Cooper, McLaren and Powell, 1985). Other simulations have adopted the long-run assumption that capital stocks will have adjusted to restore (exogenous) rates of return—this might take 10 or 20 years, i.e., T=10 or 20. In either case, only the choice of closure and the interpretation of results bear on the timing of changes: the model itself is atemporal. Consequently it tells us nothing of adjustment paths, shown as dotted lines in Figure 1.

There are also various dynamic versions of ORANI, to which this document refers only in passing. Results from the dynamic versions are also reported in percentage change form. Here, however, the changes compare two different instants in time. For example, in terms of Figure 1, results from a base forecast might refer to the change from A to B. Another set of results, incorporating the changed tariff, would refer to the change from A to C.

The dynamic versions of ORANI[3] generally incorporate investment-capital accumulation relations which explicitly mention the length of the period T. A more important practical difference between dynamic and comparative-static applications is that dynamic models require far more information about changes in exogenous variables. Comparative-static simulation of the change from B to C requires, in addition to the initial database, only the value of the exogenous tariff change. For a dynamic simulation we must specify changes in *all* exogenous variables. Thus we would need to forecast changes in foreign prices, in all sorts of tax rates, in technology and in tastes.

For these dynamic models, T is usually set to 1. A sequence of annual solutions are linked together, so that a complete forecast consists of a series of year-on-year changes for all of its many thousands of variables. By computing annual solutions, we are able to be fairly explicit about adjustment processes. The disadvantage, as mentioned above, is that the modeller is forced to postulate the future time-path of very many exogenous variables.

3. The Percentage-Change Approach to Model Solution

Many of the ORANI-G equations are non-linear—demands depend on price ratios, for example. However, following Johansen (1960), the model is solved by representing it as a series of linear equations relating percentage changes in model variables. This section explains how the linearised form can be used to generate exact solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions[4].

A typical AGE model can be represented in the levels as:

$$\mathbf{F}(\mathbf{Y},\mathbf{X}) = \mathbf{0}, \qquad (1)$$

where **Y** is a vector of endogenous variables, **X** is a vector of exogenous variables and **F** is a system of non-linear functions. The problem is to compute **Y**, given **X**. Normally we cannot write **Y** as an explicit function of **X**.

Several techniques have been devised for computing **Y**. The linearised approach starts by assuming that we already possess some solution to the system, $\{\mathbf{Y}^0,\mathbf{X}^0\}$, i.e.,

$$\mathbf{F}(\mathbf{Y}^0,\mathbf{X}^0) = \mathbf{0}. \qquad (2)$$

Normally the initial solution $\{\mathbf{Y}^0,\mathbf{X}^0\}$ is drawn from historical data—we assume that our equation system was true for some point in the past. With conventional assumptions about the form of the **F** function it will be true that for small changes **dY** and **dX**:

$$\mathbf{F}_\mathrm{Y}(\mathbf{Y},\mathbf{X})\mathbf{dY} + \mathbf{F}_\mathrm{X}(\mathbf{Y},\mathbf{X})\mathbf{dX} = \mathbf{0}, \qquad (3)$$

where $\mathbf{F}_\mathrm{Y}$ and $\mathbf{F}_\mathrm{X}$ are matrices of the derivatives of **F** with respect to **Y** and **X**, evaluated at $\{\mathbf{Y}^0,\mathbf{X}^0\}$. For reasons explained below, we find it more convenient to express **dY** and **dX** as small percentage changes **y** and **x**. Thus y and x, some typical elements of **y** and **x**, are given by:

$$y = 100dY/Y \quad \text{and} \quad x = 100dX/X. \qquad (4)$$

---

[3] ORANIG-RD, a dynamic version of ORANI-G, may be downloaded from the ORANI-G web page.

[4] For a detailed treatment of the linearised approach to AGE modelling, see the Black Book. Chapter 3 contains information about Euler's method and multistep computations.

Correspondingly, we define:

$$G_Y(\mathbf{Y},\mathbf{X}) = F_Y(\mathbf{Y},\mathbf{X})\hat{\mathbf{Y}} \quad \text{and} \quad G_X(\mathbf{Y},\mathbf{X}) = F_X(\mathbf{Y},\mathbf{X})\hat{\mathbf{X}}, \tag{5}$$

where $\hat{\mathbf{Y}}$ and $\hat{\mathbf{X}}$ are diagonal matrices. Hence the linearised system becomes:

$$\mathbf{G}_Y(\mathbf{Y},\mathbf{X})\mathbf{y} + \mathbf{G}_X(\mathbf{Y},\mathbf{X})\mathbf{x} = \mathbf{0}. \tag{6}$$

Such systems are easy for computers to solve, using standard techniques of linear algebra. But they are accurate only for small changes in **Y** and **X**. Otherwise, linearisation error may occur. The error is illustrated by Figure 2, which shows how some endogenous variable Y changes as an exogenous variable X moves from X^0 to X^F. The true, non-linear relation between X and Y is shown as a curve. The linear, or first-order, approximation:

$$y = -\, \mathbf{G}_Y(\mathbf{Y},\mathbf{X})^{-1}\mathbf{G}_X(\mathbf{Y},\mathbf{X})x \tag{7}$$

leads to the Johansen estimate Y^J—an approximation to the true answer, Y^{exact}.

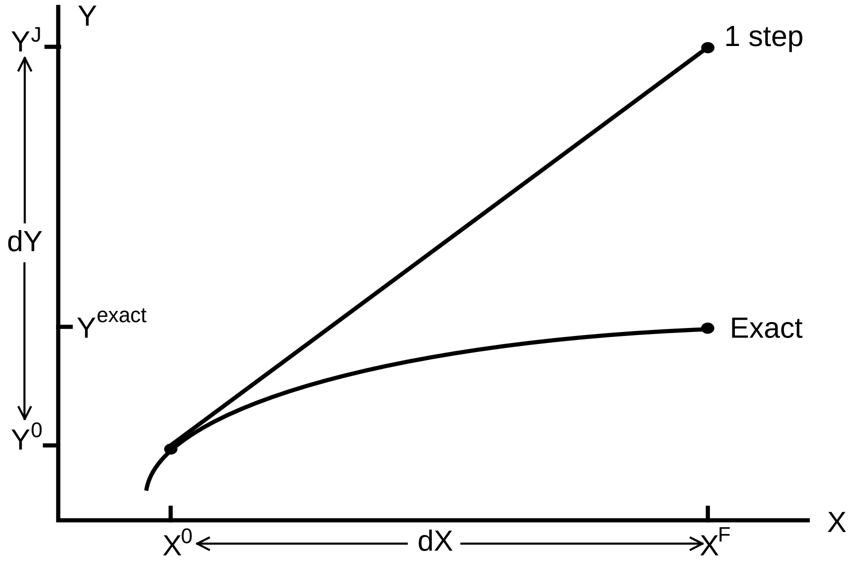

Figure 2. Linearisation error

Figure 2 suggests that, the larger is x, the greater is the proportional error in y. This observation leads to the idea of breaking large changes in X into a number of steps, as shown in Figure 3. For each sub-change in X, we use the linear approximation to derive the consequent sub-change in Y. Then, using the new values of X and Y, we recompute the coefficient matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$. The process is repeated for each step. If we use 3 steps (see Figure 3), the final value of Y, Y^3, is closer to Y^{exact} than was the Johansen estimate Y^J. We can show, in fact, that given sensible restrictions on the derivatives of $\mathbf{F}(\mathbf{Y},\mathbf{X})$, we can obtain a solution as accurate as we like by dividing the process into sufficiently many steps.

The technique illustrated in Figure 3, known as the Euler method, is the simplest of several related techniques of numerical integration—the process of using differential equations (change formulae) to move from one solution to another. GEMPACK offers the choice of several such techniques. Each requires the user to supply an initial solution $\{\mathbf{Y}^0,\mathbf{X}^0\}$, formulae for the derivative matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$, and the total percentage change in the exogenous variables, **x**. The levels functional form, $\mathbf{F}(\mathbf{Y},\mathbf{X})$, need not be specified, although it underlies $\mathbf{G}_Y$ and $\mathbf{G}_X$.

The accuracy of multistep solution techniques can be improved by extrapolation. Suppose the same experiment were repeated using 4-step, 8-step and 16-step Euler computations, yielding the following estimates for the total percentage change in some endogenous variable Y:

y(4-step) = 4.5%,
y(8-step) = 4.3% (0.2% less), and
y(16-step) = 4.2% (0.1% less).

Extrapolation suggests that the 32-step solution would be:

y(32-step) = 4.15% (0.05% less),

and that the exact solution would be:

y(∞-step) = 4.1%.

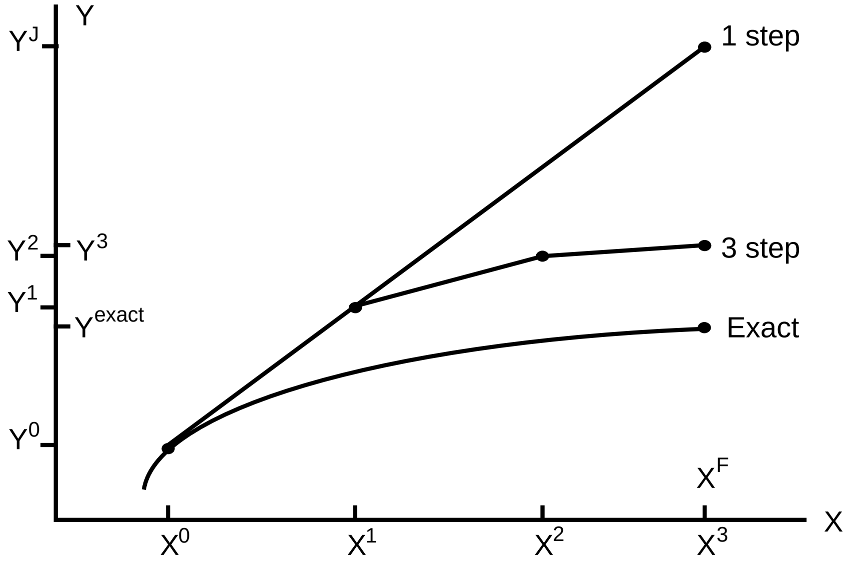

Figure 3. Multistep process to reduce linearisation error

The extrapolated result requires 28 (= 4+8+16) steps to compute but would normally be more accurate than that given by a single 28-step computation. Alternatively, extrapolation enables us to obtain given accuracy with fewer steps. As we noted above, each step of a multi-step solution requires: computation from data of the percentage-change derivative matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$; solution of the linear system (6); and use of that solution to update the data ($\mathbf{X}$,$\mathbf{Y}$).

In practice, for typical AGE models, it is unnecessary, during a multistep computation, to record values for every element in **X** and **Y**. Instead, we can define a set of *data coefficients* **V**, which are functions of **X** and **Y**, i.e., $\mathbf{V} = \mathbf{H}(\mathbf{X},\mathbf{Y})$. Most elements of **V** are simple cost or expenditure flows such as appear in input-output tables. $\mathbf{G}_Y$ and $\mathbf{G}_X$ turn out to be simple functions of **V**; often indeed identical to elements of **V**. After each small change, **V** is updated using the formula $\mathbf{v} = \mathbf{H}_Y(\mathbf{X},\mathbf{Y})\mathbf{y} + \mathbf{H}_X(\mathbf{X},\mathbf{Y})\mathbf{x}$. The advantages of storing **V**, rather than **X** and **Y**, are twofold:

- the expressions for $\mathbf{G}_Y$ and $\mathbf{G}_X$ in terms of **V** tend to be simple, often far simpler than the original **F** functions; and
- there are fewer elements in **V** than in **X** and **Y** (e.g., instead of storing prices and quantities separately, we store merely their products, the values of commodity or factor flows).

3.1. Levels and linearised systems compared: a small example

To illustrate the convenience of the linear approach[5], we consider a very small equation system: the CES input demand equations for a producer who makes output Z from N inputs X_k, k=1-N, with prices P_k. In the levels the equations are (see Appendix A):

$$X_k = Z\,\delta_k^{1/(\rho+1)}\left[\frac{P_k}{P_{ave}}\right]^{-1/(\rho+1)}, \qquad k=1,N \qquad (8)$$

$$\text{where}\quad P_{ave} = \left(\sum_{i=1}^{N} \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)}\right)^{(\rho+1)/\rho}. \qquad (9)$$

The δ_k and ρ are behavioural parameters. To solve the model in the levels, the values of the δ_k are normally found from historical flows data, $V_k=P_kX_k$, presumed consistent with the equation system and with some externally given value for ρ. This process is called calibration. To fix the X_k, it is usual to assign arbitrary values to the P_k, say 1. This merely sets convenient units for the X_k (base-period-dollars-worth). ρ is normally given by econometric estimates of the elasticity of substitution, σ (=1/(ρ+1)). With the P_k, X_k, Z and ρ known, the δ_k can be deduced.

In the solution phase of the levels model, δ_k and ρ are fixed at their calibrated values. The solution algorithm attempts to find P_k, X_k and Z consistent with the levels equations and with other exogenous

[5] For a comparison of the levels and linearised approaches to solving AGE models see Hertel, Horridge & Pearson (1992).

restrictions. Typically this will involve repeated evaluation of both (8) and (9)—corresponding to **F**(**Y**,**X**)—and of derivatives which come from these equations—corresponding to $\mathbf{F}_Y$ and $\mathbf{F}_X$.

The percentage-change approach is far simpler. Corresponding to (8) and (9), the linearised equations are (see Appendices A and E):

$$x_k = z - \sigma\left(p_k - p_{ave}\right), \qquad k=1,N \qquad (10)$$

and $$p_{ave} = \sum_{i=1}^{N} S_i p_i, \qquad \text{where the } S_i \text{ are cost shares, eg, } S_i = V_i \Big/ \sum_{k=1}^{N} V_k \qquad (11)$$

Since percentage changes have no units, the calibration phase—which amounts to an arbitrary choice of units—is not required. For the same reason the δ_k parameters do not appear. However, the flows data V_k again form the starting point. After each change they are updated by:

$$V_{k,new} = V_{k,old} + V_{k,old}(x_k + p_k)/100 \qquad (12)$$

GEMPACK is designed to make the linear solution process as easy as possible. The user specifies the linear equations (10) and (11) and the update formulae (12) in the TABLO language—which resembles algebraic notation. Then GEMPACK repeatedly:

- evaluates $\mathbf{G}_Y$ and $\mathbf{G}_X$ at given values of **V**;
- solves the linear system to find **y**, taking advantage of the sparsity of $\mathbf{G}_Y$ and $\mathbf{G}_X$; and
- updates the data coefficients **V**.

The housekeeping details of multistep and extrapolated solutions are hidden from the user.

Apart from its simplicity, the linearised approach has three further advantages.

- It allows free choice of which variables are to be exogenous or endogenous. Many levels algorithms do not allow this flexibility.
- To reduce AGE models to manageable size, it is often necessary to use model equations to substitute out matrix variables of large dimensions. In a linear system, we can always make any variable the subject of any equation in which it appears. Hence, substitution is a simple mechanical process. In fact, because GEMPACK performs this routine algebra for the user, the model can be specified in terms of its original behavioural equations, rather than in a reduced form. This reduces the potential for error and makes model equations easier to check.
- Perhaps most importantly, the linearized equations help us understand simulation results. We can easily see the contribution of (the change in) each RHS variable to the LHS of each equation. For example, in the CES price index equation:

  $$p_{ave} = \sum_{i=1}^{N} S_i p_i$$

  we can identify the contribution of each individual price p_i to the index p_{ave}. The GEMPACK program AnalyseGE automates this task.

3.2. The initial solution

Our discussion of the solution procedure has so far assumed that we possess an initial solution of the model—$\{\mathbf{Y}^0,\mathbf{X}^0\}$ or the equivalent $\mathbf{V}^0$—and that results show percentage deviations from this initial state.

In practice, the ORANI database does not, like B in Figure 1, show the expected state of the economy at a future date. Instead the most recently available historical data, A, are used. At best, these refer to the present-day economy. Note that, for the atemporal static model, A provides a solution for period T. In the static model, setting all exogenous variables at their base-period levels would leave all the endogenous variables at their base-period levels. Nevertheless, A may not be an empirically plausible control state for the economy at period T and the question therefore arises: are estimates of the B-to-C percentage changes much affected by starting from A rather than B? For example, would the percentage effects of a tariff cut inflicted in 1994 differ much from those caused by a 2005 cut? Probably not. First, balanced growth, i.e., a proportional enlargement of the model database, just scales equation coefficients equally; it does not affect ORANI results. Second, compositional changes, which do alter percentage-change effects, happen quite slowly. So for short- and medium-run simulations A is a reasonable proxy for B, (Dixon, Parmenter and Rimmer, 1986).[6]

4. The Equations of ORANI-G

In this section we provide a formal description of the linear form of the model. Our description is organised around the TABLO file which implements the model in GEMPACK. We present the complete text of the TABLO Input file divided into a sequence of excerpts and supplemented by tables, figures and explanatory text.

The TABLO language in which the file is written is essentially conventional algebra, with names for variables and coefficients chosen to be suggestive of their economic interpretations. Some practice is required for readers to become familiar with the TABLO notation but it is no more complex than alternative means of setting out the model—the notation employed in DPSV (1982), for example. Acquiring the familiarity allows ready access to the GEMPACK programs used to conduct simulations with the model and to convert the results to human-readable form. Both the input and the output of these programs employ the TABLO notation. Moreover, familiarity with the TABLO format is essential for users who may wish to make modifications to the model's structure.

Another compelling reason for using the TABLO Input file to document the model is that it ensures that our description is complete and accurate: complete because the only other data needed by the GEMPACK solution process is numerical (the model's database and the exogenous inputs to particular simulations); and accurate because GEMPACK is nothing more than an equation solving system, incorporating no economic assumptions of its own.

We continue this section with a short introduction to the TABLO language—other details may be picked up later, as they are encountered. Then we describe the input-output database which underlies the model. This structures our subsequent presentation.

4.1. The TABLO language

The TABLO model description defines the percentage-change equations of the model. For example, the CES demand equations, (10) and (11), would appear as:

```
Equation E_x # input demands #
 (all, f, FAC)  x(f) = z - SIGMA*[p(f) - p_f];
Equation E_p_f # input cost index #
 V_F*p_f = sum{f,FAC, V(f)*p(f)};
```

The first word, 'Equation', is a keyword which defines the statement type. Then follows the identifier for the equation, which must be unique. The descriptive text between '#' symbols is optional—it appears in certain report files. The expression '(all, f, FAC)' signifies that the equation is a matrix equation, containing one scalar equation for each element of the set FAC.[7]

Within the equation, the convention is followed of using lower-case letters for the percentage-change variables (x, z, p and p_f), and upper case for the coefficients (SIGMA, V and V_F). Since GEMPACK ignores case, this practice assists only the human reader. An implication is that we cannot use the same sequence of characters, distinguished only by case, to define a variable and a coefficient. The '(f)' suffix indicates that variables and coefficients are vectors, with elements corresponding to the set FAC. A semicolon signals the end of the TABLO statement.

---

[6] We claim here that, for example, the estimate that a reduction in the textile tariff would reduce textile employment 5 years hence by, say, 7%, is not too sensitive to the fact that our simulation started from today's database rather than a database representing the economy in 5 years time. Nevertheless, the social implications of a 7% employment loss depend closely on whether textile employment is projected to grow in the absence of any tariff cut. To examine this question we need a forecasting model. If the base forecast scenario had textile employment grow annually by 1.5%, the 7% reduction could be absorbed without actually firing any textile workers.

[7] For equation E_x we could have written: (all, j, FAC) x(j) = z - SIGMA*[p(j) - p_f], without affecting simulation results. Our convention that the index, (f), be the same as the initial letter of the set it ranges over, aids comprehension but is not enforced by GEMPACK. By contrast, GAMS (a competing software package) enforces consistent usage of set indices by rigidly connecting indices with the corresponding sets.

To facilitate portability between computing environments, the TABLO character set is quite restricted—only alphanumerics and a few punctuation marks may be used. The use of Greek letters and subscripts is precluded, and the asterisk, '∗', must replace the multiplication symbol '×'.

Sets, coefficients and variables must be explicitly declared, *via* statements such as:

```
Set FAC # inputs # (capital, labour, energy);
Coefficient
 (all,f,FAC) V(f) # cost of inputs #;
           V_F    # total cost #;
         SIGMA    # substitution elasticity #;
Variable
 (all,f,FAC) p(f) # price of inputs  #;
 (all,f,FAC) x(f) # demand for inputs  #;
             z    # output #;
           p_f    # input cost index #;
```

As the last two statements in the 'Coefficient' block and the last three in the 'Variable' block illustrate, initial keywords (such as 'Coefficient' and 'Variable') may be omitted if the previous statement was of the same type.

Coefficients must be assigned values, either by reading from file:

```
Read V from file FLOWDATA;
Read SIGMA from file PARAMS;
```

or in terms of other coefficients, using formulae:

```
Formula V_F = sum{f, FAC, V(f)};  ! used in cost index equation !
```

The right hand side of the last statement employs the TABLO summation notation, equivalent to the Σ notation used in standard algebra. It defines the sum over an index f running over the set FAC of the input-cost coefficients, V(f). The statement also contains a comment, i.e., the text between exclamation marks (!). TABLO ignores comments.

Some of the coefficients will be updated during multistep computations. This requires the inclusion of statements such as:

```
Update (all,f,FAC) V(f) = x(f)*p(f);
```

which is the default update statement, causing V(f) to be increased after each step by [x(f) + p(f)]%, where x(f) and p(f) are the percentage changes computed at the previous step.

The sample statements listed above introduce most of the types of statement required for the model. But since all sets, variables and coefficients must be defined before they are used, and since coefficients must be assigned values before appearing in equations, it is necessary for the order of the TABLO statements to be almost the reverse of the order in which they appear above. The ORANI-G TABLO Input file is ordered as follows:

- definition of sets;
- declarations of variables;
- declarations of often-used coefficients which are read from files, with associated Read and Update statements;
- declarations of other often-used coefficients which are computed from the data, using associated Formulae; and
- groups of topically-related equations, with some of the groups including statements defining coefficients which are used only within that group.

4.2. The model's data base

Figure 4 is a schematic representation of the model's input-output database. It reveals the basic structure of the model. The column headings in the main part of the figure (an absorption matrix) identify the following demanders:

(1) domestic producers divided into I industries;
(2) investors divided into I industries;
(3) a single representative household;
(4) an aggregate foreign purchaser of exports;

(5) government demands; and
(6) changes in inventories.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = Number of Commodities
I = Number of Industries

S = 2: Domestic,Imported,
O = Number of Occupation Types

M = Number of Commodities used as Margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

Figure 4. The ORANI-G Flows Database

The entries in each column show the structure of the purchases made by the agents identified in the column heading. Each of the C commodity types identified in the model can be obtained locally or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export column. M of the domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes are payable on the purchases. As well as intermediate inputs, current production requires inputs of three categories of primary factors: labour (divided into O occupations), fixed capital, and agricultural land. Production taxes include output taxes or subsidies that are not user-specific. The 'other costs' category covers various miscellaneous taxes on firms, such as municipal taxes or charges.

Each cell in the illustrative absorption matrix in Figure 4 contains the name of the corresponding data matrix. For example, V2MAR is a 4-dimensional array showing the cost of M margins services on the flows of C goods, both domestically produced and imported (S), to I investors.

In principle, each industry is capable of producing any of the C commodity types. The MAKE matrix at the bottom of Figure 4 shows the value of output of each commodity by each industry. Finally, tariffs on imports are assumed to be levied at rates which vary by commodity but not by user. The revenue obtained is represented by the tariff vector V0TAR.

4.3. Dimensions of the model

Excerpt 1 of the TABLO Input file begins by defining logical names for input and output files. Initial data are stored in the BASEDATA input file. The SUMMARY output file is used to store summary and diagnostic information. Note that BASEDATA and SUMMARY are *logical* names. The actual locations of these files (disk, folder, filename) are chosen by the model user.

The rest of Excerpt 1 defines sets: lists of descriptors for the components of vector variables. Set names appear in upper-case characters. For example, the first Set statement is to be read as defining a set named 'COM' which contains commodity descriptors. The elements of COM (a list of commodity names) are read from the input file (this allows the model to use databases with different numbers of sectors). By contrast the two elements of the set SRC—dom and imp—are listed explicitly.

```
! Excerpt 1 of TABLO input file: !
! Files and sets !

File  BASEDATA  # Input data file #;
 (new) SUMMARY  # Output for summary and checking data #;

Set                                                                    !Index!
 COM # Commodities# read elements from file BASEDATA header "COM";       ! c !
 SRC # Source of commodities # (dom,imp);                                ! s !
 IND # Industries # read elements from file BASEDATA header "IND";       ! i !
 OCC # Occupations # read elements from file BASEDATA header "OCC";      ! o !
 MAR # Margin commodities # read elements from file BASEDATA header "MAR";! m !
Subset MAR is subset of COM;
Set NONMAR   # Non-margin commodities # = COM - MAR;                     ! n !
```

The commodity, industry, and occupational classifications of the Australian version of ORANI-G described here are aggregates of the classifications used in the original version of ORANI, which had over 100 industries and commodities, and 8 labour occupations.

The industry classification differs slightly from the commodity classification. Both are listed in Table 1. In this aggregated version of the model, multiproduction is confined to the first two industries, which produce the first three commodities. Each of the remaining industries produces a unique commodity. Labour is disaggregated into skill-based occupational categories described by the set OCC.

The central column of Table 1 lists the elements of the set COM which are read from file. GEMPACK uses the element names to label the rows and columns of results and data tables. The element names cannot be more than 12 letters long, nor contain spaces. The IND elements are the same as elements 2-23 of COM.

Elements of the set MAR are margins commodities, i.e., they are required to facilitate the flows of other commodities from producers (or importers) to users. Hence, the costs of margins services, together with indirect taxes, account for differences between *basic* prices (received by producers or importers) and *purchasers'* prices (paid by users).

TABLO does not prevent elements of two sets from sharing the same name; nor, in such a case, does it automatically infer any connection between the corresponding elements. The Subset statement which follows the definition of the set MAR is required for TABLO to realize that the two elements of MAR, Trade and Transport, are the same as the 18th and 19th elements of the set COM.

The statement for NONMAR defines that set as a complement. That is, NONMAR consists of all those elements of COM which are not in MAR. In this case TABLO is able to deduce that NONMAR must be a subset of COM.

Table 1 Commodity and Industry Classification

	Commodity Description	Elements of Set COM		Industry Description
1	Cereals	Cereals	1	Broadacre rural
2	Broadacre rural	AgBroadacre	2	Intensive rural
3	Intensive rural	AgIntensive		
4	Mining, export	MiningExport	3	Mining, export
5	Mining, other	MiningOther	4	Mining, other
6	Food & fibre, export	FoodFibre	5	Food & fibre, export
7	Food, other	FoodOther	6	Food, other
8	Textiles, clothing & footwear	TCF	7	Textiles, clothing & footwear
9	Wood related products	WoodProds	8	Wood related products
10	Chemicals & oil products	ChemProds	9	Chemicals & oil products
11	Non-metallic mineral products	NonMetal	10	Non-metallic mineral products
12	Metal products	MetalProds	11	Metal products
13	Transport equipment	TrnspEquip	12	Transport equipment
14	Other machinery	OthMachnry	13	Other machinery
15	Other manufacturing	OthManufact	14	Other manufacturing
16	Utilities	Utilities	15	Utilities
17	Construction	Construction	16	Construction
18	Retail & wholesale trade	**Trade** (margin)	17	Retail & wholesale trade
19	Transport	**Transport** (margin)	18	Transport
20	Banking & finance	Finance	19	Banking & finance
21	Ownership of dwellings	Dwellings	20	Ownership of dwellings
22	Public services	PublicServcs	21	Public services
23	Private services	PrivatServcs	22	Private services

4.4. The ORANI-G naming system

The TABLO Input file defines a multitude of variables and coefficients that are used in the model's equations. It can be difficult to remember the names of all these variables and coefficients[8]. Fortunately, their names follow a pattern. Although GEMPACK does not require that names conform to any pattern, we find that systematic naming reduces the burden on (human) memory. As far as possible, names for variables and coefficients conform to a system in which each name consists of 2 or more parts, as follows:

first, a letter or letters indicating the type of variable, for example,

a	technical change
del	ordinary (rather than percentage) change
f	shift variable
H	indexing parameter
p	price, local currency
pf	price, foreign currency
S	input share
SIGMA	elasticity of substitution
t	tax
V	levels value, local currency
w	percentage-change value, local currency
x	input quantity;

second, one of the digits 0 to 6 indicating user, that is,

[8] GEMPACK's TABmate editor offers some comfort to the forgetful. With the TABLO Input file open in TABmate, you may click on any variable or coefficient name, then click the Gloss button. A list will appear, starting with a description of that variable and then showing all statements in the TABLO Input file where it is used.

1	current production
2	investment
3	consumption
4	export
5	government
6	inventories
0	all users, or user distinction irrelevant;

third (optional), three or more letters giving further information, for example,

bas	(often omitted) basic—not including margins or taxes
cap	capital
cif	imports at border prices
imp	imports (duty paid)
lab	labour
lnd	land
lux	linear expenditure system (supernumerary part)
mar	margins
oct	other cost tickets
prim	all primary factors (land, labour or capital)
pur	at purchasers' prices
sub	linear expenditure system (subsistence part)
tar	tariffs
tax	indirect taxes
tot	total or average over all inputs for some user;

fourth (optional), an underscore character, indicating that this variable is an aggregate or average, with subsequent letters showing over which sets the underlying variable has been summed or averaged, for example,

_c	over COM (commodities),
_s	over SRC (dom + imp),
_i	over IND (industries),
_io	over IND and OCC (skills).

Although GEMPACK does not distinguish between upper and lower case, we use:

lower case for variable names and set indices;
upper case for set and coefficient names; and
initial letter upper case for TABLO keywords.

4.5. Core data coefficients and related variables

The next excerpts of the TABLO file contains statements indicating data to be read from file. The data items defined in these statements appear as coefficients in the model's equations. The statements define coefficient names (which all appear in upper-case characters), the locations from which the data are to be read, variable names (in lower-case), and formulae for the data updates which are necessary in computing multi-step solutions to the model (see Section 3).

4.5.1. Basic flows

The excerpts group the data according to the rows of Figure 4. Thus, Excerpt 2 begins by defining coefficients representing the basic commodity flows corresponding to row 1 (direct flows) of the figure, i.e., the flow matrices V1BAS, V2BAS, and so on. Preceding the coefficient names are their dimensions, indicated using the "all" qualifier and the sets defined in Excerpt 1. For example, the first 'Coefficient' statement defines a data item V1BAS(c,s,i) which is the basic value (indicated by 'BAS') of a flow of intermediate inputs (indicated by '1') of commodity c from source s to user industry i. The first 'Read' statement indicates that this data item is stored on file BASEDATA with header '1BAS'. (A GEMPACK data file consists of a number of data items such as arrays of real numbers. Each data item is identified by a unique key or 'header').

Each of these flows is the product of a price and a quantity. The excerpt goes on to define these variables. Unless otherwise stated, all variables are percentage changes—to indicate this, their names appear in lower-case letters. Preceding the names of the variables are their dimensions, indicated using the sets defined in Excerpt 1. For example, the first variable statement defines a matrix variable x1 (indexed by commodity, source, and using industry) the elements of which are percentage changes in the direct demands by producers for source-specific intermediate inputs. This is the quantity variable corresponding to V1BAS.

```
! Excerpt 2 of TABLO input file: !
! Data coefficients and variables relating to basic commodity flows !

Coefficient  ! Basic flows of commodities (excluding margin demands)!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  # Intermediate basic flows #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  # Investment basic flows #;
 (all,c,COM)(all,s,SRC)             V3BAS(c,s)    # Household basic flows #;
 (all,c,COM)                        V4BAS(c)      # Export basic flows #;
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    # Government basic flows #;
 (all,c,COM)(all,s,SRC)             V6BAS(c,s)    # Inventories basic flows #;
Read
 V1BAS from file BASEDATA header "1BAS";
 V2BAS from file BASEDATA header "2BAS";
 V3BAS from file BASEDATA header "3BAS";
 V4BAS from file BASEDATA header "4BAS";
 V5BAS from file BASEDATA header "5BAS";
 V6BAS from file BASEDATA header "6BAS";
Variable  ! Variables used to update above flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)  x1(c,s,i)  # Intermediate basic demands #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  x2(c,s,i)  # Investment basic demands #;
 (all,c,COM)(all,s,SRC)             x3(c,s)    # Household basic demands #;
 (all,c,COM)                        x4(c)      # Export basic demands #;
 (all,c,COM)(all,s,SRC)             x5(c,s)    # Government basic demands #;
 (change) (all,c,COM)(all,s,SRC)    delx6(c,s) # Inventories demands #;
 (all,c,COM)(all,s,SRC)             p0(c,s)    # Basic prices for local users #;
 (all,c,COM)                        pe(c)      # Basic price of exportables #;
 (change)(all,c,COM)(all,s,SRC)  delV6(c,s)    # Value of inventories #;
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  = p0(c,s)*x1(c,s,i);
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  = p0(c,s)*x2(c,s,i);
 (all,c,COM)(all,s,SRC)             V3BAS(c,s)    = p0(c,s)*x3(c,s);
 (all,c,COM)                        V4BAS(c)      = pe(c)*x4(c);
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    = p0(c,s)*x5(c,s);
 (change)(all,c,COM)(all,s,SRC)     V6BAS(c,s)    = delV6(c,s);
```

The last in the group of quantity variables, delx6, is preceded by the 'Change' qualifier to indicate that it is an ordinary (rather than percentage) change. Changes in inventories may be either positive or negative. Our multistep solution procedure requires that large changes be broken into a sequence of small changes. However, no sequence of small *percentage* changes allows a number to change sign—at least one change must exceed -100%. Thus, for variables that may, in the levels, change sign, we prefer to use ordinary changes. The names of ordinary change variables often start with the letters "del".

Next come two price variables. A matrix variable p0 (indexed by commodity and source), shows percentage changes in the basic prices which are common to all local users. These basic prices do not include the cost of margins and taxes. Exports have their own basic prices, pe. Potentially, the pe could be different from the domestic part of p0[9].

Finally, the variable delV6 is used in the update statements which appear next.
The first 'Update' statement indicates that the flow V1BAS(c,s,i) should be updated using the default update formula, which is used for a data item which is a product of two (or more) of the model's variables. For an item of the form V = PX, the formula for the updated value V^U is:

$$V^U = V^0 + \Delta(PX) = V^0 + X^0\Delta P + P^0\Delta X$$

[9] Exports (V4BAS) are valued with price vector pe. Unless we activate the optional CET transformation between goods destined for export and those for local use, the pe are identical to the domestic part of p0. See Excerpt 13.

$$= V^0 + P^0X^0\left(\frac{\Delta P}{P^0} + \frac{\Delta X}{X^0}\right) = V^0 + V^0\left(\frac{p}{100} + \frac{x}{100}\right) \qquad (13)$$

where V^0, P^0 and X^0 are the pre-update values, and p and x are the percentage changes of the variables P and X. For the data item V1BAS(c,s,i) the relevant percentage-change variables are p0(c,s) (the basic-value price of commodity c from source s) and x1(c,s,i) (the demand by user industry i for intermediate inputs of commodity c from source s).

Not all of the model's data items are amenable to update *via* default Updates. For example, the inventories flows, V6BAS, might change sign, and so must not be updated with percentage change variables. In such a case, the Update statement must contain an explicit formula for the ordinary change in the data item: this is indicated by the word 'Change' in parentheses. For V6BAS we represent the change by an ordinary-change variable, delV6. The Update formula (13) then becomes simply:

$$V^U = V^0 + \Delta V. \qquad (14)$$

An equation defining the delV6 variable appears later on.

4.5.2. Margin flows

The coefficients and variables of Excerpt 3 are associated with row 2 (margins) of Figure 4, i.e., the flow matrices V1MAR, V2MAR, and so on. These are the quantities of retail and wholesale services or transport needed to deliver each basic flow to the user. For example V3MAR(c,s,m) is the value of margin type m used to deliver commodity type c from source s to households (user 3). The model assumes that margin services are domestically produced and are valued at basic prices—represented by the variable p0dom, which (we shall see later) is simply a synonym for the domestic part of the basic price matrix, p0 [i.e., p0dom(c) = p0(c,"dom")].

```
! Excerpt 3 of TABLO input file: !
! Data coefficients and variables relating to margin flows !

Coefficient
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                   V1MAR(c,s,i,m)  # Intermediate margins #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                   V2MAR(c,s,i,m)  # Investment margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)  V3MAR(c,s,m)    # Households margins #;
 (all,c,COM)(all,m,MAR)             V4MAR(c,m)      # Export margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)  V5MAR(c,s,m)    # Government margins #;
Read
 V1MAR from file BASEDATA header "1MAR";
 V2MAR from file BASEDATA header "2MAR";
 V3MAR from file BASEDATA header "3MAR";
 V4MAR from file BASEDATA header "4MAR";
 V5MAR from file BASEDATA header "5MAR";
Variable ! Variables used to update above flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  x1mar(c,s,i,m)# Intermediate margin demand #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  x2mar(c,s,i,m)# Investment margin demands #;
 (all,c,COM)(all,s,SRC)(all,m,MAR) x3mar(c,s,m)  # Household margin demands #;
 (all,c,COM)(all,m,MAR)            x4mar(c,m)    # Export margin demands #;
 (all,c,COM)(all,s,SRC)(all,m,MAR) x5mar(c,s,m)  # Government margin demands #;
 (all,c,COM)           p0dom(c) # Basic price of domestic goods = p0(c,"dom") #;
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  V1MAR(c,s,i,m)  = p0dom(m)*x1mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                                  V2MAR(c,s,i,m)  = p0dom(m)*x2mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR) V3MAR(c,s,m)    = p0dom(m)*x3mar(c,s,m);
 (all,c,COM)(all,m,MAR)            V4MAR(c,m)      = p0dom(m)*x4mar(c,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR) V5MAR(c,s,m)    = p0dom(m)*x5mar(c,s,m);
```

4.5.3. User-specific commodity taxes

Excerpt 4 contains coefficients and variables associated with row 3 (commodity taxes) of Figure 4, i.e., the flow matrices V1TAX, V2TAX, and so on. These all have the same dimensions as the corresponding basic flows.

```
! Excerpt 4 of TABLO input file: !
! Data coefficients and variables relating to commodity taxes !

Coefficient  ! Taxes on Basic Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1TAX(c,s,i) # Taxes on intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2TAX(c,s,i) # Taxes on investment #;
 (all,c,COM)(all,s,SRC)             V3TAX(c,s)   # Taxes on households #;
 (all,c,COM)                        V4TAX(c)     # Taxes on export #;
 (all,c,COM)(all,s,SRC)             V5TAX(c,s)   # Taxes on government #;
Read
 V1TAX from file BASEDATA header "1TAX";
 V2TAX from file BASEDATA header "2TAX";
 V3TAX from file BASEDATA header "3TAX";
 V4TAX from file BASEDATA header "4TAX";
 V5TAX from file BASEDATA header "5TAX";
Variable
 (change)(all,c,COM)(all,s,SRC)(all,i,IND) delV1TAX(c,s,i) # Interm tax rev #;
 (change)(all,c,COM)(all,s,SRC)(all,i,IND) delV2TAX(c,s,i) # Invest tax rev #;
 (change)(all,c,COM)(all,s,SRC)            delV3TAX(c,s)   # H'hold tax rev #;
 (change)(all,c,COM)                       delV4TAX(c)     # Export tax rev #;
 (change)(all,c,COM)(all,s,SRC)            delV5TAX(c,s)   # Govmnt tax rev #;
Update
 (change)(all,c,COM)(all,s,SRC)(all,i,IND)  V1TAX(c,s,i) = delV1TAX(c,s,i);
 (change)(all,c,COM)(all,s,SRC)(all,i,IND)  V2TAX(c,s,i) = delV2TAX(c,s,i);
 (change)(all,c,COM)(all,s,SRC)             V3TAX(c,s)   = delV3TAX(c,s);
 (change)(all,c,COM)                        V4TAX(c)     = delV4TAX(c);
 (change)(all,c,COM)(all,s,SRC)             V5TAX(c,s)   = delV5TAX(c,s);
```

ORANI-G treats commodity taxes in great detail—the tax levied on each basic flow is separately identified. Published input-output tables are usually less detailed—so to construct the initial model database we enforce plausible assumptions: e.g., that all intermediate usage of, say, Coal, is taxed at the same rate. However, the disaggregated data structure still allows us to simulate the effects of commodity-and-user-specific tax changes, such as an increased tax on Coal used by the Iron industry.

The tax flows are updated by corresponding ordinary change variables: equations determining these appear later on.

4.5.4. Factor payments and other flows data

Excerpt 5 of the TABLO Input file corresponds to the remaining rows of Figure 4. There are coefficient matrices for payments to labour, capital, and land, and 2 sorts of production tax. Then are listed the corresponding price and quantity variables. For the production tax V1PTX, the corresponding ordinary change variable delV1PTX is used in a Change Update statement: an equation determining this variable appears later. The other flow coefficients in this group are simply the products of prices and quantities. Hence, they can be updated *via* default Update statements.

Excerpt 5 also defines the import duty vector V0TAR. Treatment of the last item in the flows database, the multiproduction matrix MAKE, showing output of commodities by each industry, is deferred to a later section.

```
! Excerpt 5 of TABLO input file: !
! Data coefficients for primary-factor flows, other industry costs, and tariffs!

Coefficient
 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  # Wage bill matrix #;
 (all,i,IND)             V1CAP(i)    # Capital rentals #;
 (all,i,IND)             V1LND(i)    # Land rentals #;
 (all,i,IND)             V1PTX(i)    # Production tax #;
 (all,i,IND)             V1OCT(i)    # Other cost tickets #;
Read
 V1LAB from file BASEDATA header "1LAB";
 V1CAP from file BASEDATA header "1CAP";
 V1LND from file BASEDATA header "1LND";
 V1PTX from file BASEDATA header "1PTX";
 V1OCT from file BASEDATA header "1OCT";
Variable
 (all,i,IND)(all,o,OCC)   x1lab(i,o)  # Employment by industry and occupation #;
 (all,i,IND)(all,o,OCC)   p1lab(i,o)  # Wages by industry and occupation #;
 (all,i,IND)  x1cap(i)        # Current capital stock #;
 (all,i,IND)  p1cap(i)        # Rental price of capital #;
 (all,i,IND)  x1lnd(i)        # Use of land #;
 (all,i,IND)  p1lnd(i)        # Rental price of land #;
 (change)(all,i,IND) delV1PTX(i) # Ordinary change in production tax revenue #;
 (all,i,IND)  x1oct(i)        # Demand for "other cost" tickets #;
 (all,i,IND)  p1oct(i)        # Price of "other cost" tickets #;
Update
 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  = p1lab(i,o)*x1lab(i,o);
 (all,i,IND)             V1CAP(i)    = p1cap(i)*x1cap(i);
 (all,i,IND)             V1LND(i)    = p1lnd(i)*x1lnd(i);
(change)(all,i,IND)      V1PTX(i)    = delV1PTX(i);
 (all,i,IND)             V1OCT(i)    = p1oct(i)*x1oct(i);

! Data coefficients relating to import duties !
Coefficient (all,c,COM) V0TAR(c)  # Tariff revenue #;
Read V0TAR from file BASEDATA header "0TAR";
Variable (all,c,COM) (change) delV0TAR(c) # Ordinary change in tariff revenue #;
Update (change)  (all,c,COM) V0TAR(c) = delV0TAR(c);
```

4.5.5. Purchasers' values

Excerpt 6 defines the values at purchasers' prices of the commodity flows identified in Figure 4. These aggregates will be used in several different equation blocks. The definitions use the TABLO summation notation, explained in Section 4.1. For example, the first formula in Excerpt 6 contains the term:

```
sum{m,MAR, V1MAR(c,s,i,m) }
```

This defines the sum, over an index m running over the set of margins commodities (MAR), of the input-output data flows V1MAR(c,s,i,m). This sum is the total value of margins commodities required to facilitate the flow of intermediate inputs of commodity c from source s to user industry i. Adding this sum to the basic value of the intermediate-input flow and the associated indirect tax, gives the purchaser's-price value of the flow.

Next are defined purchasers' price variables, which include basic, margin and tax components. Equations to determine these variables appear in Excerpt 22 below.

```
! Excerpt 6 of TABLO input file: !
! Coefficients and variables for purchaser's prices (basic + margins + taxes) !

Coefficient ! Flows at purchasers prices !
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1PUR(c,s,i)  # Intermediate purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2PUR(c,s,i)  # Investment purch. value #;
 (all,c,COM)(all,s,SRC)             V3PUR(c,s)    # Households purch. value #;
 (all,c,COM)                        V4PUR(c)      # Export purch. value #;
 (all,c,COM)(all,s,SRC)             V5PUR(c,s)    # Government purch. value #;
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V1PUR(c,s,i)  = V1BAS(c,s,i) + V1TAX(c,s,i) + sum{m,MAR, V1MAR(c,s,i,m)};
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V2PUR(c,s,i)  = V2BAS(c,s,i) + V2TAX(c,s,i) + sum{m,MAR, V2MAR(c,s,i,m)};
 (all,c,COM)(all,s,SRC)
   V3PUR(c,s)    = V3BAS(c,s)   + V3TAX(c,s)   + sum{m,MAR, V3MAR(c,s,m)};
 (all,c,COM)
   V4PUR(c)      = V4BAS(c)     + V4TAX(c)     + sum{m,MAR, V4MAR(c,m)};
 (all,c,COM)(all,s,SRC)
   V5PUR(c,s)    = V5BAS(c,s)   + V5TAX(c,s)   + sum{m,MAR, V5MAR(c,s,m)};
Variable ! Purchasers prices !
 (all,c,COM)(all,s,SRC)(all,i,IND) p1(c,s,i)# Purchaser's price, intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND) p2(c,s,i)# Purchaser's price, investment #;
 (all,c,COM)(all,s,SRC)            p3(c,s)  # Purchaser's price, household #;
 (all,c,COM)                       p4(c)    # Purchaser's price, exports,loc$ #;
 (all,c,COM)(all,s,SRC)            p5(c,s)  # Purchaser's price, government #;
```

4.6. The equation system

The rest of the TABLO Input file is an algebraic specification of the linear form of the model, with the equations organised into a number of blocks. Each Equation statement begins with a name and (optionally) a description. For ORANI-G, the equation name normally consists of the characters E_ followed by the name of the left-hand-side variable. Except where indicated, the variables are percentage changes. Variables are in lower-case characters and coefficients in upper case. Variables and coefficients are defined as the need arises. Readers who have followed the TABLO file so far should have no difficulty in reading the equations in the TABLO notation. We provide some commentary on the theory underlying each of the equation blocks.

4.7. Structure of production

ORANI-G allows each industry to produce several commodities, using as inputs domestic and imported commodities, labour of several types, land, and capital. In addition, commodities destined for export are distinguished from those for local use. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions, illustrated by the nesting shown in Figure 5. For example, the assumption of *input-output separability* implies that the generalised production function for some industry:

$$\text{F(inputs,outputs)} = 0 \tag{15}$$

may be written as:

$$\text{G(inputs)} = \text{X1TOT} = \text{H(outputs)} \tag{16}$$

where X1TOT is an index of industry activity. Assumptions of this type reduce the number of estimated parameters required by the model. Figure 5 shows that the H function in (16) is derived from two nested CET (constant elasticity of transformation) aggregation functions, while the G function is broken into a sequence of nests. At the top level, commodity composites, a primary-factor composite and 'other costs' are combined using a Leontief production function. Consequently, they are all demanded in direct proportion to X1TOT. Each commodity composite is a CES (constant elasticity of substitution) function of a domestic good and the imported equivalent. The primary-factor composite is a CES aggregate of land, capital and composite labour. Composite labour is a CES aggregate of occupational labour types. Although all industries share this common production structure, input proportions and behavioural parameters may vary between industries.

The nested structure is mirrored in the TABLO equations—each nest requiring 2 sets of equations. We begin at the bottom of Figure 5 and work upwards.

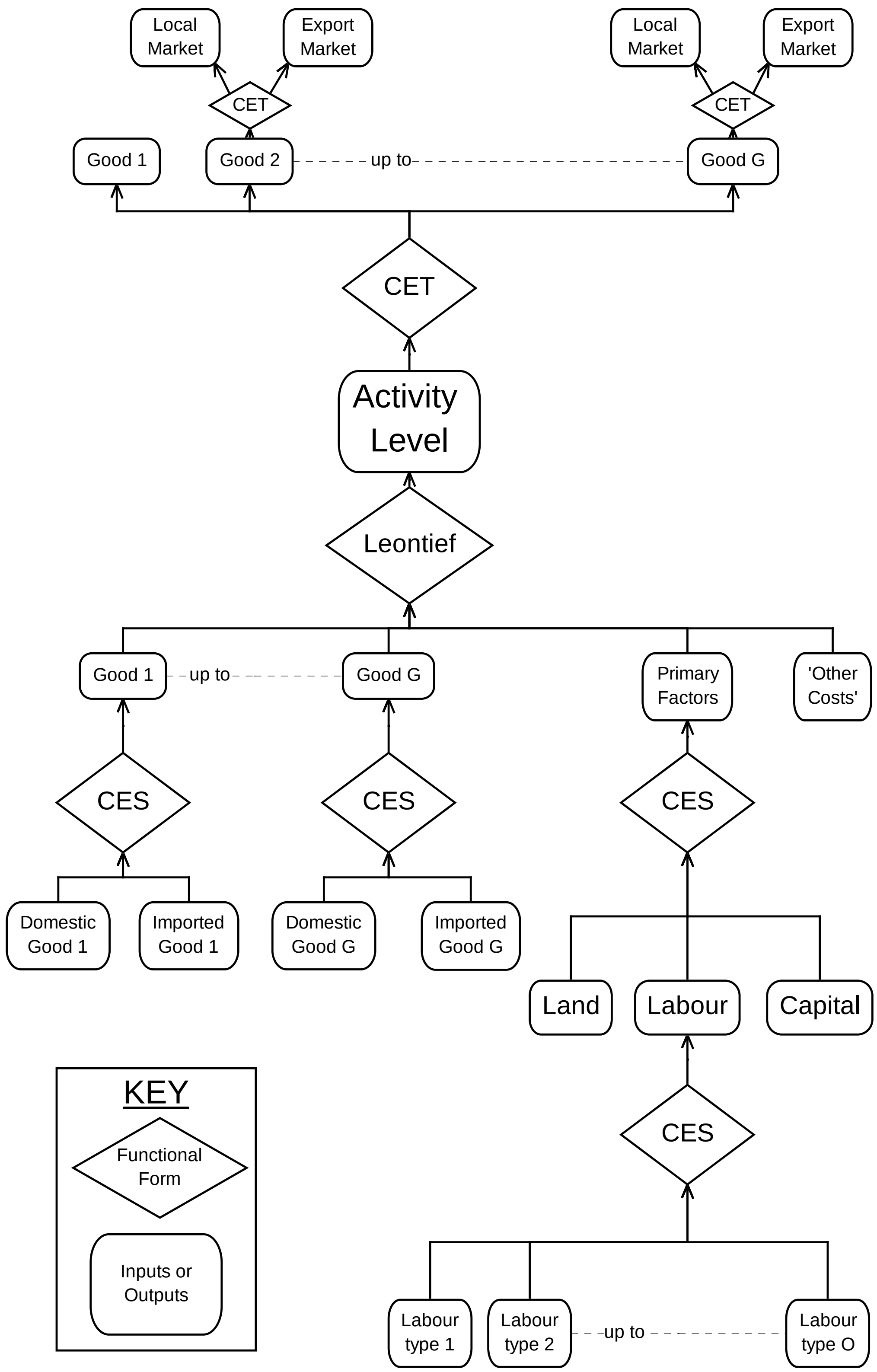

Figure 5. Structure of Production

4.8. Demands for primary factors

Excerpt 7 shows the equations determining the occupational composition of labour demand in each industry. For each industry i, the equations are derived from the following optimisation problem:

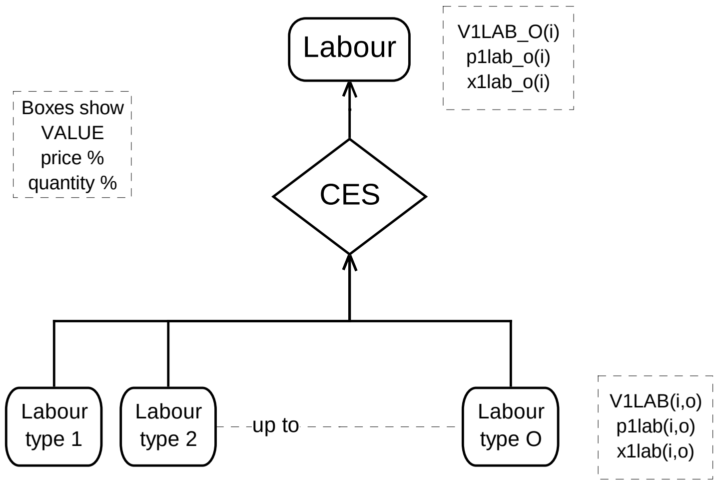

Figure 6. Demand for different types of labour

Choose inputs of occupation-specific labour,

X1LAB(i,o),

to minimize total labour cost,

Sum{o,OCC, P1LAB(i,o)∗X1LAB(i,o)},

where

X1LAB_O(i) = CES[All,o,OCC: X1LAB(i,o)],

regarding as exogenous to the problem

P1LAB(i,o) and X1LAB_O(i).

Note that the problem is formulated in the levels of the variables. Hence, we have written the variable names in upper case. The notation CES[ ] represents a CES function defined over the set of variables enclosed in the square brackets.

```
! Excerpt 7 of TABLO input file: !
! Occupational composition of labour demand !

Coefficient
 (parameter)(all,i,IND) SIGMA1LAB(i) # CES substitution between skill types #;
 (all,i,IND) V1LAB_O(i)   # Total labour bill in industry i #;
             TINY    # Small number to prevent zerodivides or singular matrix #;
Read SIGMA1LAB from file BASEDATA header "SLAB";
Formula
 (all,i,IND) V1LAB_O(i) = sum{o,OCC, V1LAB(i,o)};
             TINY       = 0.000000000001;
Variable
 (all,i,IND) p1lab_o(i) # Price to each industry of labour composite #;
 (all,i,IND) x1lab_o(i) # Effective labour input #;
Equation
 E_x1lab   # Demand for labour by industry and skill group #
  (all,i,IND)(all,o,OCC)
   x1lab(i,o) = x1lab_o(i) - SIGMA1LAB(i)*[p1lab(i,o) - p1lab_o(i)];
 E_p1lab_o # Price to each industry of labour composite #
  (all,i,IND) [TINY+V1LAB_O(i)]*p1lab_o(i) = sum{o,OCC, V1LAB(i,o)*p1lab(i,o)};
```

The solution of this problem, in percentage-change form, is given by equations E_x1lab and E_p1lab_o (see Appendix A for derivation). The first of the equations indicates that demand for labour type o is proportional to overall labour demand, X1LAB_O, and to a price term. In change form, the price term is composed of an elasticity of substitution, SIGMA1LAB(i), multiplied by the percentage change in a price ratio [p1lab(i,o)-p1lab_o(i)] representing the wage of occupation o relative to the average wage for labour in industry i. Changes in the relative prices of the occupations induce substitution in favour of relatively cheapening occupations. The percentage change in the average wage, p1lab_o(i), is given by the second of the equations. This could be rewritten:

p1lab_o(i) = sum{o,OCC, S1LAB(i,o)∗p1lab(i,o)},

if S1LAB(i,o) were the value share of occupation o in the total wage bill of industry i. In other words, p1lab_o(i) is a Divisia index of the p1lab(i,o).

It is worth noting that if the individual equations of E_x1lab were multiplied by corresponding elements of S1LAB(i,o), and then summed together, all price terms would disappear, giving:

x1lab_o(i) = sum{o,OCC, S1LAB(i,o)∗x1lab(i,o)}.

This is the percentage-change form of the CES aggregation function for labour.

For an industry which does not use labour (housing services is a common example), V1LAB(i,o) would contain only zeros so that p1lab_o(i) would be undefined. To prevent this, we add the coefficient TINY (set to some very small number) to the left hand side of equation E_p1lab_o. With V1LAB_O(i) zero, equation E_p1lab_o becomes:

p1lab_o(i) = 0.

The same procedure is used extensively in later equations.

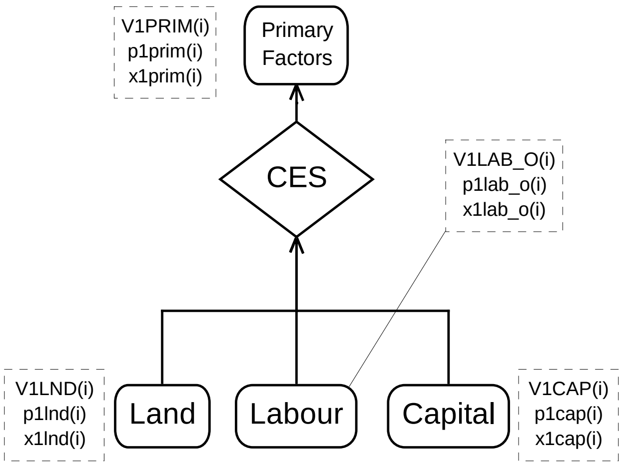

Figure 7. Primary Factor Demand

Excerpt 8 contains equations determing the composition of demand for primary factors. Their derivation follows a pattern similar to that underlying the previous nest. In this case, total primary factor costs are minimised subject to the production function:

$$\mathrm{X1PRIM(i)} = \mathrm{CES}\left[\frac{\mathrm{X1LAB\_O(i)}}{\mathrm{A1LAB\_O(i)}}, \frac{\mathrm{X1CAP(i)}}{\mathrm{A1CAP(i)}}, \frac{\mathrm{X1LND(i)}}{\mathrm{A1LND(i)}}\right].$$

Because we may wish to introduce factor-saving technical changes, we include explicitly the coefficients A1LAB_O(i), A1CAP(i), and A1LND(i).

The solution to this problem, in percentage-change form, is given by equations E_x1lab_o, E_x1cap and E_x1lnd, and E_p1prim. Ignoring the technical-change terms, we see that demand for each factor is proportional to overall factor demand, X1PRIM, and to a price term. In change form the price term is an elasticity of substitution, SIGMA1PRIM(i), multiplied by the percentage change in a price ratio representing the cost of an effective unit of the factor relative to the overall, effective cost of primary factor inputs to industry i. Changes in the relative prices of the primary factors induce substitution in favour of relatively cheapening factors. The percentage change in the average effective cost, p1prim(i), given by equation E_p1prim, is again a cost-weighted Divisia index of individual prices and technical changes.

```
! Excerpt 8 of TABLO input file: !
! Primary factor proportions !

Coefficient
(parameter)(all,i,IND) SIGMA1PRIM(i) # CES substitution, primary factors #;
Read SIGMA1PRIM from file BASEDATA header "P028";
Coefficient (all,i,IND) V1PRIM(i) # Total factor input to industry i#;
Formula     (all,i,IND) V1PRIM(i) = V1LAB_O(i)+ V1CAP(i) + V1LND(i);
Variable
 (all,i,IND) p1prim(i)  # Effective price of primary factor composite #;
 (all,i,IND) x1prim(i)  # Primary factor composite #;
 (all,i,IND) a1lab_o(i) # Labor-augmenting technical change #;
 (all,i,IND) a1cap(i)   # Capital-augmenting technical change #;
 (all,i,IND) a1lnd(i)   # Land-augmenting technical change #;
(change)(all,i,IND) delV1PRIM(i)# Ordinary change in cost of primary factors #;

Equation
 E_x1lab_o  # Industry demands for effective labour #
  (all,i,IND)  x1lab_o(i) - a1lab_o(i) =
   x1prim(i) - SIGMA1PRIM(i)*[p1lab_o(i) + a1lab_o(i) - p1prim(i)];

 E_p1cap  # Industry demands for capital #
  (all,i,IND)  x1cap(i) - a1cap(i) =
   x1prim(i) - SIGMA1PRIM(i)*[p1cap(i) + a1cap(i) - p1prim(i)];

 E_p1lnd  # Industry demands for land #
  (all,i,IND)  x1lnd(i) - a1lnd(i) =
   x1prim(i) - SIGMA1PRIM(i)*[p1lnd(i) + a1lnd(i) - p1prim(i)];

 E_p1prim  # Effective price term for factor demand equations #
  (all,i,IND)  V1PRIM(i)*p1prim(i) = V1LAB_O(i)*[p1lab_o(i) + a1lab_o(i)]
    + V1CAP(i)*[p1cap(i) + a1cap(i)] + V1LND(i)*[p1lnd(i) + a1lnd(i)];

 E_delV1PRIM  # Ordinary change in total cost of primary factors #
  (all,i,IND) 100*delV1PRIM(i) = V1CAP(i)  * [p1cap(i) + x1cap(i)]
                               +  V1LND(i)  * [p1lnd(i) + x1lnd(i)]
                    + sum{o,OCC, V1LAB(i,o)* [p1lab(i,o) + x1lab(i,o)]};
```

Appendix A contains a formal derivation of CES demand equations with technical-change terms. The technical-change terms appear in a predictable pattern. Imagine that the percentage-change equations lacked these terms, as in the previous, occupational-demand, block. We could add them in by:

replacing each quantity (x) variable by (x-a);

replacing each price (p) variable by (p+a); and

rearranging terms.

The last equation defines DelV1PRIM, the ordinary change in total cost of primary factors to each industry. This variable is used later in computing industries' total production costs.

4.9. Sourcing of intermediate inputs

We adopt the Armington (1969; 1970) assumption that imports are imperfect substitutes for domestic supplies. Excerpt 9 shows equations determining the import/domestic composition of intermediate commodity demands. They follow a pattern similar to the previous nest. Here, the total cost of imported and domestic good i are minimised subject to the production function:

$$\text{X1\_S(c,i)} = \text{CES}\left[\text{All,s,SRC:} \frac{\text{X1(c,s,i)}}{\text{A1(c,s,i)}}\right], \qquad (17)$$

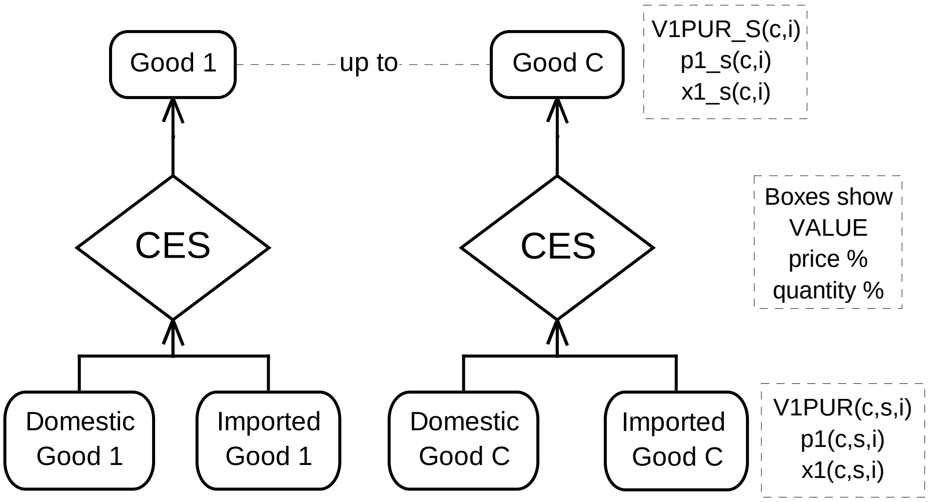

Figure 8. Intermediate input sourcing decision

Commodity demand from each source is proportional to demand for the composite, X1_S(c,i), and to a price term. The change form of the price term is an elasticity of substitution, SIGMA1(i), multiplied by the percentage change in a price ratio representing the effective price from the source relative to the effective cost of the import/domestic composite. Lowering of a source-specific price, relative to the average, induces substitution in favour of that source. The percentage change in the average effective cost, p1_s(i), is again a cost-weighted Divisia index of individual prices and technical changes.

```
! Excerpt 9 of TABLO input file: !
! Import/domestic composition of intermediate demands !

Variable
 (all,c,COM)(all,s,SRC)(all,i,IND) a1(c,s,i) # Intermediate basic tech change #;
 (all,c,COM)(all,i,IND) x1_s(c,i)    # Intermediate use of imp/dom composite #;
 (all,c,COM)(all,i,IND) p1_s(c,i)    # Price, intermediate imp/dom composite #;
 (all,i,IND)            p1mat(i)     # Intermediate cost price index #;
 (all,i,IND)            p1var(i)     # Short-run variable cost price index #;
Coefficient
 (parameter)(all,c,COM) SIGMA1(c)    # Armington elasticities: intermediate #;
 (all,c,COM)(all,i,IND) V1PUR_S(c,i) # Dom+imp intermediate purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i) # Intermediate source shares #;
 (all,i,IND)            V1MAT(i)     # Total intermediate cost for industry i #;
 (all,i,IND)            V1VAR(i)     # Short-run variable cost for industry i #;
Read SIGMA1 from file BASEDATA header "1ARM";
Zerodivide default 0.5;
Formula
 (all,c,COM)(all,i,IND)            V1PUR_S(c,i) = sum{s,SRC, V1PUR(c,s,i)};
 (all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i)    = V1PUR(c,s,i) / V1PUR_S(c,i);
 (all,i,IND)                       V1MAT(i)     = sum{c,COM, V1PUR_S(c,i)};
 (all,i,IND)                       V1VAR(i)     = V1MAT(i) + V1LAB_O(i);
Zerodivide off;

Equation E_x1  # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  x1(c,s,i)-a1(c,s,i) = x1_s(c,i) -SIGMA1(c)*[p1(c,s,i) +a1(c,s,i) -p1_s(c,i)];

Equation E_p1_s  # Effective price of commodity composite #
 (all,c,COM)(all,i,IND)
  p1_s(c,i) = sum{s,SRC, S1(c,s,i)*[p1(c,s,i) + a1(c,s,i)]};

Equation E_p1mat  # Intermediate cost price index #
 (all,i,IND)
  p1mat(i) = sum{c,COM, sum{s,SRC, (V1PUR(c,s,i)/ID01[V1MAT(i)])*p1(c,s,i)}};
```

```
Equation E_p1var  # Short-run variable cost price index #
 (all,i,IND)
  p1var(i) = [1/V1VAR(i)]*[V1MAT(i)*p1mat(i) + V1LAB_O(i)*p1lab_o(i)];
```

Following the pattern established for factor demands, we could have written Equation E_p1_s as:

V1PUR_S(c,i)∗p1_s(c,i)=Sum{s,SRC,V1PUR(c,s,i)∗[p1(c,s,i)+a1(c,s,i)]};

where V1PUR_S(c,i) is the sum over domestic and imported of V1PUR(c,s,i). However, this equation would have left p1_s(c,i) undefined when V1PUR_S(c,i) is zero—not all industries use all commodities. In computing the share:

S1(c,s,i) =V1PUR(c,s,i)/V1PUR_S(c,i),

(see again Excerpt 9) we used the Zerodivide statement to instruct GEMPACK to set import and domestic shares (arbitrarily) to 0.5 in such cases. This device avoids a numerical error in computing, without any other substantive consequence.

The last 2 equations defines 2 variables used to explain results. P1mat is an industry-specific index of the price of intermediate inputs[10]. P1var is an index of short-run variable cost: it includes the cost of all industry inputs except capital and land (which are fixed in the short-run). Changes in p1var correspond to vertical shifts in shortrun industry supply schedules. Equations for both p1mat and p1var are written with no coefficient on the LHS—this facilitates the use of GEMPACK's AnalyseGE tool. AnalyseGE is able to 'decompose' the RHS of these equations to show the contribution of each individual price change to the total change in p1mat or p1var.

4.10. Top production nest

Excerpt 10 covers the topmost input-demand nest of Figure 5. Commodity composites, the primary-factor composite and 'other costs' are combined using a Leontief production function, given by:

$$\mathrm{X1TOT(i)} = \frac{1}{\mathrm{A1TOT(i)}} \times \mathrm{MIN}\left[\mathrm{All,c,COM:}\ \frac{\mathrm{X1\_S(c,i)}}{\mathrm{A1\_S(c,i)}}, \frac{\mathrm{X1PRIM(i)}}{\mathrm{A1PRIM(i)}}, \frac{\mathrm{X1OCT(i)}}{\mathrm{A1OCT(i)}}\right]. \qquad (18)$$

Consequently, each of these three categories of inputs identified at the top level is demanded in direct proportion to X1TOT(i).

The Leontief production function is equivalent to a CES production function with the substitution elasticity set to zero. Hence, the demand equations resemble those derived from the CES case but lack price (substitution) terms. The a1tot(i) are Hicks-neutral technical-change terms, affecting all inputs equally.

```
! Excerpt 10 of TABLO input file: !
! Top nest of industry input demands !
Variable
 (all,i,IND)  x1tot(i)        # Activity level or value-added #;
 (all,i,IND)  a1prim(i)       # All factor augmenting technical change #;
 (all,i,IND)  a1tot(i)        # All input augmenting technical change #;
 (all,i,IND)  p1tot(i)        # Average input/output price #;
 (all,i,IND)  a1oct(i)        # "Other cost" ticket augmenting techncal change#;
 (all,c,COM)(all,i,IND) a1_s(c,i) # Tech change, int'mdiate imp/dom composite #;

Equation E_x1_s  # Demands for commodity composites #
 (all,c,COM)(all,i,IND)  x1_s(c,i) - [a1_s(c,i) + a1tot(i)] = x1tot(i);

Equation E_x1prim  # Demands for primary factor composite #
 (all,i,IND)  x1prim(i) - [a1prim(i) + a1tot(i)] = x1tot(i);

Equation E_x1oct  # Demands for other cost tickets #
 (all,i,IND)  x1oct(i) - [a1oct(i) + a1tot(i)] = x1tot(i);
```

[10] Equation E_p1mat uses the ID01 function built-in to GEMPACK: another way of avoiding divide-by-zero problems. If x=0, ID01(x)=1; otherwise ID01(x)=x.

4.11. Industry costs and production taxes

Excerpt 11 computes levels and changes in the total cost of production both excluding (V1CST) and including (V1TOT) an ad valorem production tax, V1PTX. The equations are arranged to facilitate changing the base of the production tax. For example, a comment line underneath equation E_delV1PTX shows how a value-added tax might be implemented: by making V1PRIM (rather than V1CST) the tax base.

```
! Excerpt 11 of TABLO input file: !
! Output cost inclusive of production tax !

Coefficient
 (all,i,IND)  V1CST(i)    # Total cost of industry i #;
 (all,i,IND)  V1TOT(i)    # Total industry cost plus tax #;
 (all,i,IND) PTXRATE(i)   # Rate of production tax #;
Formula
 (all,i,IND)  V1CST(i)    = V1PRIM(i) + V1OCT(i) + V1MAT(i);
 (all,i,IND)  V1TOT(i)    = V1CST(i) + V1PTX(i);
 (all,i,IND)  PTXRATE(i)  = V1PTX(i)/V1CST(i); !VAT: V1PTX/V1PRIM !
Write PTXRATE to file SUMMARY header "PTXR";
Variable
 (change)(all,i,IND) delV1CST(i)   # Change in ex-tax cost of production #;
 (change)(all,i,IND) delV1TOT(i)   # Change in tax-inc cost of production #;
 (change)(all,i,IND) delPTXRATE(i) # Change in rate of production tax #;

Equation
 E_delV1CST  (all,i,IND) delV1CST(i) = delV1PRIM(i) +
  sum{c,COM,sum{s,SRC,  0.01*V1PUR(c,s,i)*[p1(c,s,i) + x1(c,s,i)]}}
                     +  0.01*V1OCT(i)    *[p1oct(i)  + x1oct(i)];

 E_delV1PTX  (all,i,IND) delV1PTX(i) =
                       PTXRATE(i)*delV1CST(i)  + V1CST(i) * delPTXRATE(i);
 ! VAT alternative:    PTXRATE(i)*delV1PRIM(i) + V1PRIM(i)* delPTXRATE(i); !

 E_delV1TOT  (all,i,IND) delV1TOT(i) = delV1CST(i) + delV1PTX(i);

 E_p1tot     (all,i,IND) V1TOT(i)*[p1tot(i) + x1tot(i)] = 100*delV1TOT(i);

Variable (all,i,IND) p1cst(i) # Index of production costs (for AnalyseGE) #;
Equation E_p1cst  (all,i,IND) p1cst(i) =  [1/V1CST(i)]*[
  sum{c,COM,sum{s,SRC,  V1PUR(c,s,i)*p1(c,s,i)}}
                     +  V1OCT(i)    *p1oct(i)
                     +  V1CAP(i)    *p1cap(i)
                     +  V1LND(i)    *p1lnd(i)
          + sum{o,OCC, V1LAB(i,o)  *p1lab(i,o)}];
```

The penultimate equation defines p1tot(i) as the percentage change in the unit cost of production for industry i. Given the constant returns to scale which characterise the model's production technology, p1tot is also the percentage change in marginal cost. We enforce the competitive *Zero Pure Profits* condition (price = marginal cost) by assuming that the p1tot are also equal to the average price received by each industry.

Under constant returns to scale, we could combine equations listed previously to deduce:

$$p1tot(i) = \sum S_k p_k \quad + \text{tax and technical change terms}$$

where S_k and p_k are respectively the share of input k in total cost, and the percent change in its price.

The final equation defines another variable used to explain results. P1cst is an index of production costs which can be decomposed using AnalyseGE to show the contribution of individual price changes to the total change in input costs. This index ignores the effects of technical change.

4.12. From industry outputs to commodity ouputs

ORANI-G allows for each industry to produce a mixture of all the commodities. For each industry, the mix varies, according to the relative prices of commodities[11]. The first two equations of Excerpt 12 determine the commodity composition of industry output—the final nest of Figure 5. Here, the total revenue from all outputs is *maximised* subject to the production function:

$$X1TOT(i) = CET[\ All,c,COM: Q1(c,i)]. \quad (19)$$

The CET (constant elasticity of transformation) aggregation function is identical to CES, except that the transformation parameter in the CET function has the opposite sign to the substitution parameter in the CES function. In equation E_q1, an increase in a commodity price, relative to the average, induces transformation in favour of that output. The symbol, p1tot, defined in E_x1tot as average unit revenue, is the same as that used in the previous equation group to refer to the effective price of a unit of activity. This confirms our interpretation of equation E_p1tot as a *Zero Pure Profits* condition.

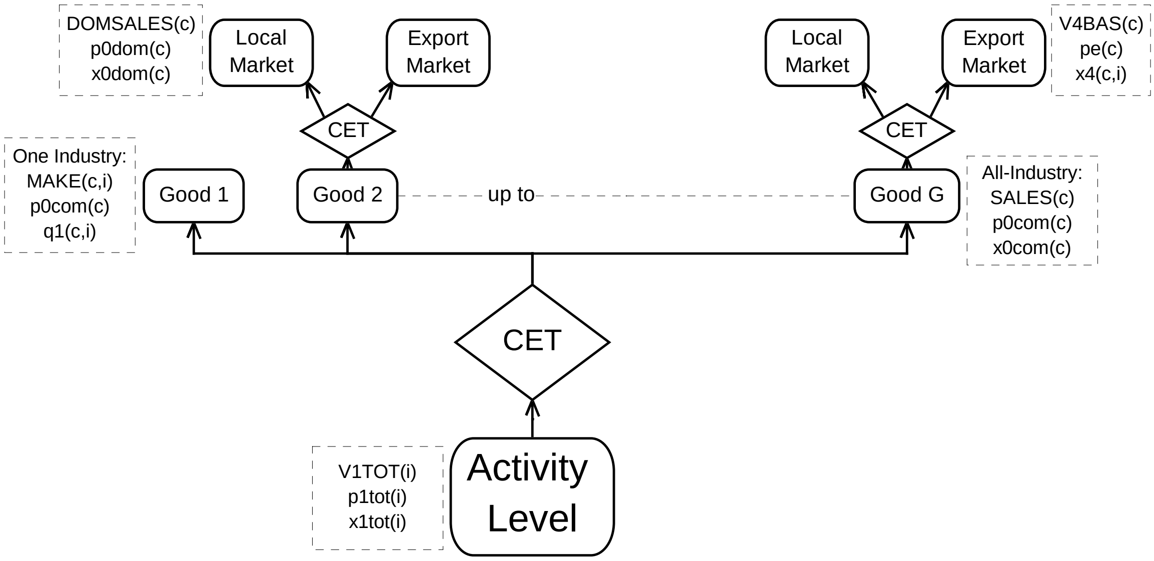

Figure 9. Composition of output

Equation E_pq1 states that all industries that produce, say, Cereals, receive the same unit price, p0com("Cereals"). Cereals produced by different industries are deemed to be perfect substitutes[12]. Equation E_x0com simply adds up all industries' output of each commodity to get the total supply, x0com.

Most non-Australian applications of the ORANI-G framework enforce a one-to-one correspondence between industries and commodities This is implied whenever all off-diagonal elements of the MAKE matrix are zero. In this case, the equations of Excerpt 12 just equate corresponding elements of p0com and p1tot. Similarly, x1tot and x0com become, in effect, the same variable. The computational overhead of including the MAKE mechanism is very slight.

[11] Multiproduction can be useful even where each industry produces just one commodity. For example we could split electricity generation into 2 parts: oil-fired and nuclear, each producing the same commodity, electricity.

[12] The perfect substitute assumption causes problems when we have two industries just producing the same commodity, and neither industry has a fixed factor; eg, in a long-run closure with mobile capital, and two electricity industries (say, nuclear and coal-fired) both making electric power. The model will find it hard to decide what proportion of generation should be nuclear. To cover such a case, the TABLO input file contains optional equations (not shown here), which allow (for example) nuclear electricity to be an imperfect substitute for coal-fired electricity.

```
! Excerpt 12 of TABLO input file: !
! Output mix of commodities !

Coefficient (all,c,COM)(all,i,IND) MAKE(c,i) # Multiproduction matrix #;
Variable
 (all,c,COM)(all,i,IND)  q1(c,i)   # Output by commodity and industry #;
 (all,c,COM)(all,i,IND)  pq1(c,i)  # Price of com c produced by ind i #;
 (all,c,COM)  p0com(c)   # General output price of locally-produced commodity #;
Read MAKE from file BASEDATA header "MAKE";
Update (all,c,COM)(all,i,IND) MAKE(c,i)= pq1(c,i)*q1(c,i);
Variable
 (all,c,COM)  x0com(c)        # Output of commodities #;
Coefficient
 (parameter)(all,i,IND) SIGMA1OUT(i) # CET transformation elasticities #;
Read SIGMA1OUT from file BASEDATA header "SCET";
Equation E_q1  # Supplies of commodities by industries #
 (all,c,COM)(all,i,IND)
  q1(c,i) = x1tot(i) + SIGMA1OUT(i)*[p0com(c) - p1tot(i)];
Coefficient
 (all,i,IND) MAKE_C(i) # All production by industry i #;
 (all,c,COM) MAKE_I(c) # Total production of commodities #;
Formula
 (all,i,IND) MAKE_C(i) = sum{c,COM, MAKE(c,i)};
 (all,c,COM) MAKE_I(c) = sum{i,IND, MAKE(c,i)};

Equation E_x1tot # Average price received by industries #
 (all,i,IND) p1tot(i) = sum{c,COM, [MAKE(c,i)/MAKE_C(i)]*pq1(c,i)};

Equation
 E_pq1  # Each industry gets the same price for a given commodity #
 (all,c,COM)(all,i,IND) pq1(c,i) = p0com(c);
 E_x0com # Total output of commodities (as simple addition) #
 (all,c,COM) x0com(c) = sum{i,IND, [MAKE(c,i)/MAKE_I(c)]*q1(c,i)};
```

4.13. Export and local market versions of each good

Excerpt 13 allows for the possibility that goods destined for export are not the the same as those for local use[13]. Conversion of an undifferentiated commodity into goods for both destinations is governed by a CET transformation frontier. Conceptually, the system is the same as Excerpt 12, but it is expressed a little differently; partly because there are only two outputs; and partly to facilitate switching the system off. This is achieved by setting TAU to zero, so that p0com, p0dom and pe are all equal.

```
! Excerpt 13 of TABLO input file: !
! CET between outputs for local and export markets !
Variable
 (all,c,COM)  x0dom(c)  # Output of commodities for local market #;
Coefficient
 (all, c,COM) EXPSHR(c) # Share going to exports #;
 (all, c,COM) TAU(c)    # 1/Elast. of transformation, exportable/locally used #;
Zerodivide default 0.5;
Formula
 (all,c,COM) EXPSHR(c) = V4BAS(c)/MAKE_I(c);
 (all,c,COM) TAU(c) = 0.0; ! if zero, p0dom = pe, and CET is nullified !
Zerodivide off;
Equation E_x0dom  # Supply of commodities to export market #
 (all,c,COM) TAU(c)*[x0dom(c) - x4(c)] = p0dom(c) - pe(c);
Equation E_pe     # Supply of commodities to domestic market #
 (all,c,COM) x0com(c) = [1.0-EXPSHR(c)]*x0dom(c) + EXPSHR(c)*x4(c);
Equation E_p0com  # Zero pure profits in transformation #
 (all,c,COM) p0com(c) = [1.0-EXPSHR(c)]*p0dom(c) + EXPSHR(c)*pe(c);
```

[13] This feature is not part of the ORANI tradition, but appears in some other applied GE models.

The names of the prices, quantities and flows in the two CET nests of Excerpt 12 are shown below:

	Joint Production CET Nest				
Type of Variable	Industry Output	Commodity Outputs	Undifferentiated Commodity	Local Destination	Export Destination
%Δ quantity	x1tot(i)	q1(c,i)	x0com(c)	x0dom(c)	x4(c)
%Δ price	p1tot(i)	p0com(c)	p0com(c)	p0dom(c) = p0(c,"dom")	pe(c)
Value of flow	V1TOT(i)	MAKE(c,i)	SALES(c)	DOMSALES(c)	V4BAS(c)
			Export/Domestic CET nest		

Note that V1TOT(i) = Σ_cMAKE(c,i) and SALES(c) = Σ_iMAKE(c,i) = DOMSALES(c) + V4BAS(c)

4.14. Demands for investment goods

Figure 10 shows the nesting structure for the production of new units of fixed capital. Capital is assumed to be produced with inputs of domestically produced and imported commodities. The production function has the same nested structure as that which governs intermediate inputs to current production. No primary factors are used directly as inputs to capital formation.

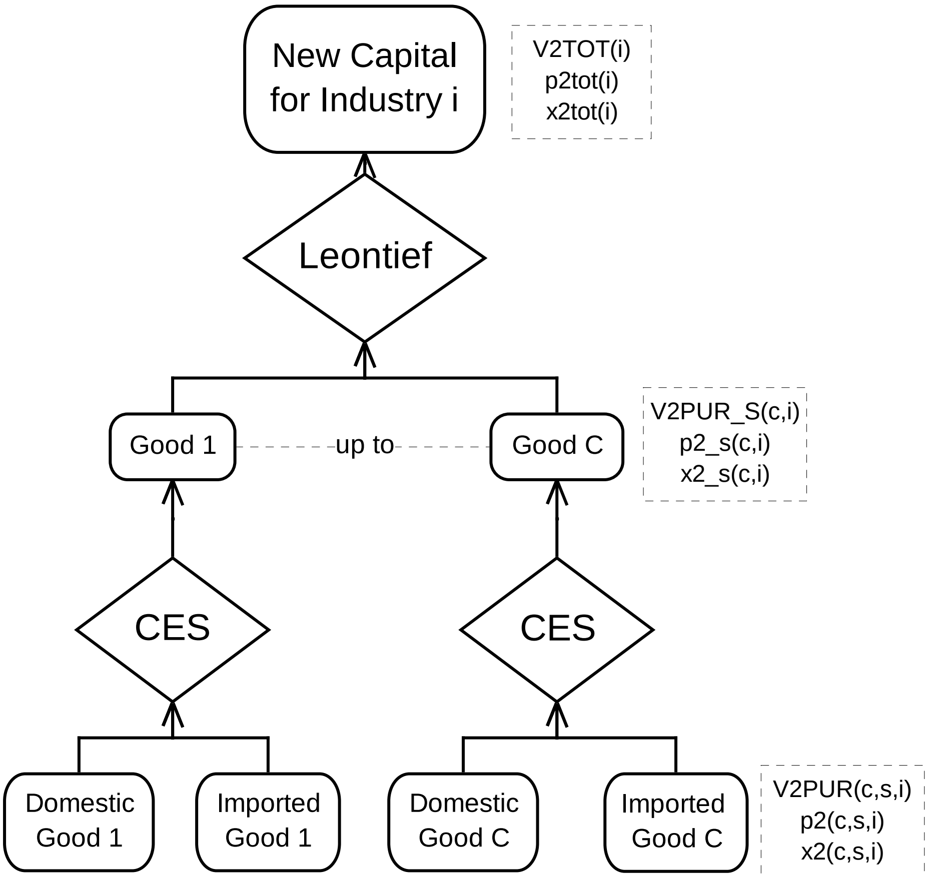

Figure 10. Structure of Investment Demand

The investment demand equations (see Excerpt 14) are derived from the solutions to the investor's two-part cost-minimisation problem. At the bottom level, the total cost of imported and domestic good i is minimised subject to the CES production function:

$$X2\_S(c, i) = CES[All,s,SRC: \frac{X2(c,s,i)}{A2(c,s,i)}], \tag{20}$$

while at the top level the total cost of commodity composites is minimised subject to the Leontief production function:

$$X2TOT(i) = \frac{1}{A2TOT(i)} MIN[All,c,COM: \frac{X2\_S(c,i)}{A2\_S(c,i)}] . \qquad (21)$$

The total amount of investment in each industry, X2TOT(i), is exogenous to the above cost-minimisation problem. It is determined by other equations, covered later on.

The equations in Excerpt 14 describing the demand for source-specific inputs (E_x2 and E_p2_s) and for composites (E_x2_s) are very similar to the corresponding intermediate demand equations in previous excerpts. The source-specific demand equation (E_x2) requires an elasticity of substitution, SIGMA2(i). Also included is an equation which determines the price of new units of capital as the average cost of producing a unit—a *Zero Pure Profits* condition.

```
! Excerpt 14 of TABLO input file: !
! Investment demands !

Variable
 (all,c,COM)(all,i,IND)  x2_s(c,i)  # Investment use of imp/dom composite #;
 (all,c,COM)(all,i,IND)  p2_s(c,i)  # Price, investment imp/dom composite #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  a2(c,s,i) # Investment basic tech change #;
Coefficient
 (parameter) (all,c,COM)  SIGMA2(c) # Armington elasticities: investment #;
Read SIGMA2 from file BASEDATA header "2ARM";
Coefficient ! Source Shares in Flows at Purchaser's prices !
 (all,c,COM)(all,i,IND)     V2PUR_S(c,i) # Dom+imp investment purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i) # Investment source shares #;
Zerodivide default 0.5;
Formula
  (all,c,COM)(all,i,IND)     V2PUR_S(c,i)  = sum{s,SRC, V2PUR(c,s,i)};
  (all,c,COM)(all,s,SRC)(all,i,IND)  S2(c,s,i) = V2PUR(c,s,i) / V2PUR_S(c,i);
Zerodivide off;

Equation E_x2  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND)
x2(c,s,i)-a2(c,s,i) - x2_s(c,i) = - SIGMA2(c)*[p2(c,s,i)+a2(c,s,i) - p2_s(c,i)];

Equation E_p2_s  # Effective price of commodity composite #
(all,c,COM)(all,i,IND)
p2_s(c,i) = sum{s,SRC, S2(c,s,i)*[p2(c,s,i)+a2(c,s,i)]};

! Investment top nest !

Variable
 (all,i,IND)  a2tot(i)        # Neutral technical change - investment #;
 (all,i,IND)  p2tot(i)        # Cost of unit of capital #;
 (all,i,IND)  x2tot(i)        # Investment by using industry #;
 (all,c,COM)(all,i,IND) a2_s(c,i) # Tech change, investment imp/dom composite #;
Coefficient (all,i,IND) V2TOT(i)  # Total capital created for industry i #;
Formula     (all,i,IND) V2TOT(i)  = sum{c,COM, V2PUR_S(c,i)};
Equation
 E_x2_s  (all,c,COM)(all,i,IND)  x2_s(c,i) - [a2_s(c,i) + a2tot(i)] = x2tot(i);
 E_p2tot (all,i,IND) p2tot(i)
  = sum{c,COM, (V2PUR_S(c,i)/ID01[V2TOT(i)])*[p2_s(c,i) +a2_s(c,i) +a2tot(i)]};
```

4.15. Household demands

As Figure 11 shows, the nesting structure for household demand is nearly identical to that for investment demand. The only difference is that commodity composites are aggregated by a Klein-Rubin, rather than a Leontief, function, leading to the linear expenditure system (LES).

The equations for the lower, import/domestic nest (see Excerpt 15) are similar to the corresponding equations for intermediate and investment demands.

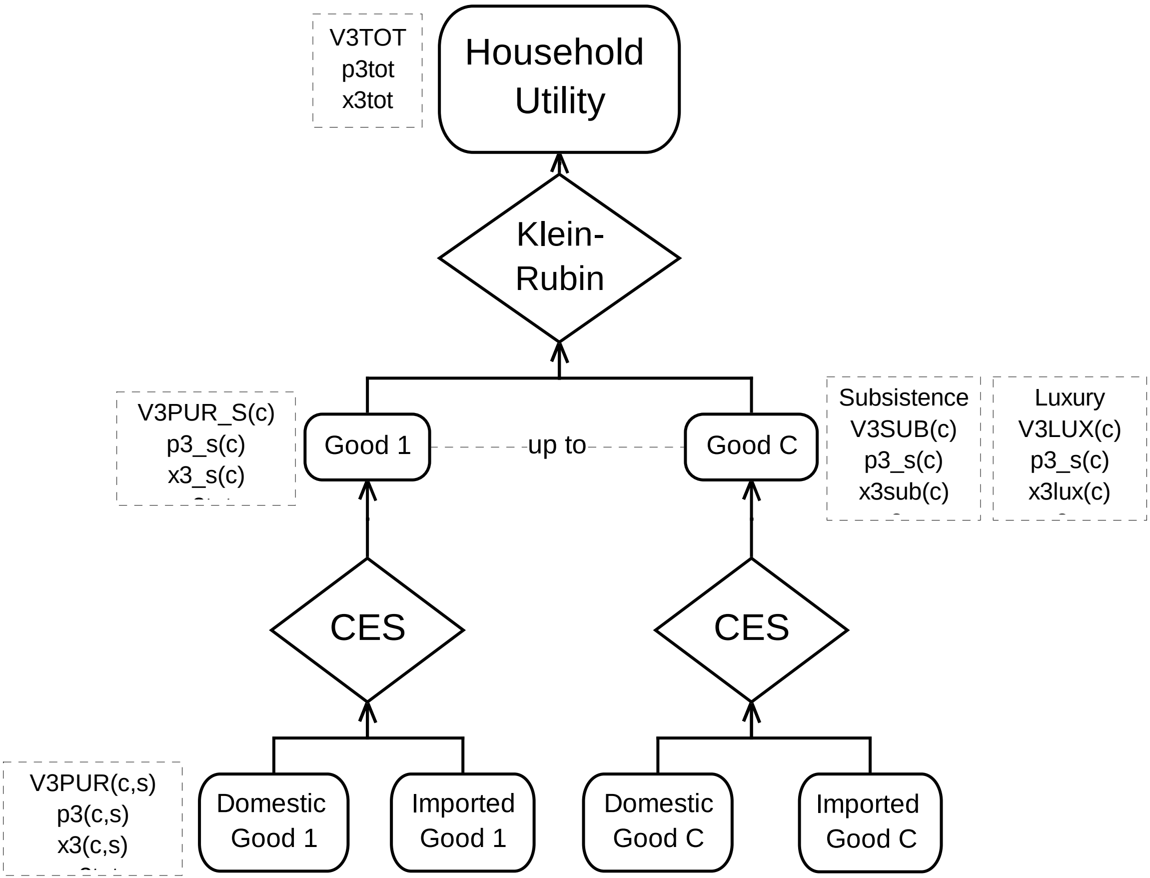

Figure 11. Structure of Consumer Demand

```
! Excerpt 15 of TABLO input file: !
! Import/domestic composition of household demands !

Variable
(all,c,COM)(all,s,SRC)  a3(c,s)   # Household basic taste change #;
(all,c,COM)             x3_s(c)   # Household use of imp/dom composite #;
(all,c,COM)             p3_s(c)   # Price, household imp/dom composite #;
Coefficient
 (parameter)(all,c,COM) SIGMA3(c) # Armington elasticities: households #;
Read SIGMA3 from file BASEDATA header "3ARM";

Coefficient ! Source Shares in Flows at Purchaser's prices !
 (all,c,COM)           V3PUR_S(c) # Dom+imp households purch. value #;
 (all,c,COM)(all,s,SRC)   S3(c,s) # Household source shares #;
Zerodivide default 0.5;
Formula
 (all,c,COM)           V3PUR_S(c) = sum{s,SRC, V3PUR(c,s)};
 (all,c,COM)(all,s,SRC)   S3(c,s) = V3PUR(c,s)   / V3PUR_S(c);
Zerodivide off;

Equation E_x3  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)
x3(c,s)-a3(c,s) = x3_s(c) - SIGMA3(c)*[ p3(c,s)+a3(c,s) - p3_s(c) ];

Equation E_p3_s  # Effective price of commodity composite #
(all,c,COM) p3_s(c) = sum{s,SRC, S3(c,s)*[p3(c,s)+a3(c,s)]};
```

Excerpt 16 of the TABLO input file determines the allocation of household expenditure between commodity composites. This is derived from the Klein-Rubin utility function:

$$\text{Utility per household} = \frac{1}{Q}\prod_{c} \{X3\_S(c) - X3SUB(c)\}^{S3LUX(c)}, \qquad (22)$$

The X3SUB and S3LUX are behavioural coefficients—the S3LUX must sum to unity. Q is the number of households. The demand equations that arise from this utility function are:

$$X3\_S(c) = X3SUB(c) + S3LUX(c)*V3LUX\_C/P3\_S(c), \qquad (23)$$

where:

$$V3LUX\_C = V3TOT - \sum X3SUB(c)*P3\_S(c) \qquad (24)$$

The name of the linear expenditure system derives from its property that expenditure on each good is a linear function of prices (P3_S) and expenditure (V3TOT). The form of the demand equations gives rise to the following interpretation. The X3SUB are said to be the 'subsistence' requirements of each good—these quantities are purchased regardless of price. V3LUX_C is what remains of the consumer budget after subsistence expenditures are deducted—we call this 'luxury' or 'supernumerary' expenditure. The S3LUX are the shares of this remnant allocated to each good—the marginal budget shares. Such an interpretation facilitates our transition to percentage change form, which begins from the levels equations:

$$X3\_S(c) = X3SUB(c) + X3LUX(c) \qquad (25)$$

$$X3LUX(c)*P3\_S(c) = S3LUX(c)*V3LUX\_C \qquad (26)$$

$$X3SUB(c) = Q*A3SUB(c) \qquad (27)$$

As equation (25) makes plain, the X3LUX are luxury usages, or the difference between the subsistence quantities and total demands. Equation (26) states that luxury expenditures follow the marginal budget shares S3LUX. Together, equations (25) and (26) are equivalent to (23). Equation (27) is necessary because our demand system applies to aggregate instead of to individual households. It states that total subsistence demand for each good c is proportional to the number of households, Q, and to the individual household subsistence demands, A3SUB(c). The percentage change forms of equations (27), (26) and (25) appear as the first three items in Excerpt 16 of the Tablo Input File. Note that a3lux(c) and w3lux are respectively the percentage changes in S3LUX(c) and V3LUX_C.

```
! Excerpt 16 of TABLO input file: !
! Household demands for composite commodities !
Variable        p3tot # Consumer price index #;
                x3tot # Real household consumption #;
                w3lux # Total nominal supernumerary household expenditure #;
                w3tot # Nominal total household consumption #;
                    q # Number of households #;
              utility # Utility per household #;
 (all,c,COM) x3lux(c) # Household - supernumerary demands #;
 (all,c,COM) x3sub(c) # Household - subsistence demands #;
 (all,c,COM) a3lux(c) # Taste change, supernumerary demands #;
 (all,c,COM) a3sub(c) # Taste change, subsistence demands #;
 (all,c,COM)  a3_s(c) # Taste change, household imp/dom composite #;
Coefficient
                V3TOT # Total purchases by households #;
               FRISCH # Frisch LES 'parameter'= - (total/luxury) #;
 (all,c,COM)   EPS(c) # Household expenditure elasticities #;
 (all,c,COM)  S3_S(c) # Household average budget shares #;
 (all,c,COM) B3LUX(c) # Ratio, (supernumerary expenditure/total expenditure) #;
 (all,c,COM) S3LUX(c) # Marginal household budget shares #;
Read   FRISCH from file BASEDATA header "P021";
          EPS from file BASEDATA header "XPEL";
Update (change)            FRISCH = FRISCH*[w3tot - w3lux]/100.0;
       (change)(all,c,COM) EPS(c) = EPS(c)*[x3lux(c)-x3_s(c)+w3tot-w3lux]/100.0;
```

```
Formula
                V3TOT = sum{c,COM, V3PUR_S(c)};
 (all,c,COM)  S3_S(c) = V3PUR_S(c)/V3TOT;
 (all,c,COM) B3LUX(c) = EPS(c)/ABS[FRISCH]; ! initial sign of Frisch ignored !
 (all,c,COM) S3LUX(c) = EPS(c)*S3_S(c);
Write  S3LUX   to file SUMMARY header "LSHR";
       S3_S    to file SUMMARY header "CSHR";
Equation
 E_x3sub # Subsistence demand for composite commodities #
  (all,c,COM) x3sub(c) = q + a3sub(c);

 E_x3lux # Luxury demand for composite commodities #
  (all,c,COM) x3lux(c) + p3_s(c) = w3lux + a3lux(c);

 E_x3_s  # Total household demand for composite commodities #
  (all,c,COM) x3_s(c) = B3LUX(c)*x3lux(c) + [1-B3LUX(c)]*x3sub(c);

 E_utility # Change in utility disregarding taste change terms #
  utility + q = sum{c,COM, S3LUX(c)*x3lux(c)};

 E_a3lux # Default setting for luxury taste shifter #
  (all,c,COM) a3lux(c) = a3sub(c) - sum{k,COM, S3LUX(k)*a3sub(k)};

 E_a3sub # Default setting for subsistence taste shifter #
  (all,c,COM) a3sub(c) = a3_s(c) - sum{k,COM, S3_S(k)*a3_s(k)};

 E_x3tot # Real consumption #
  x3tot = sum{c,COM, sum{s,SRC, [V3PUR(c,s)/V3TOT]*x3(c,s)}};

 E_p3tot # Consumer price index #
  p3tot = sum{c,COM, sum{s,SRC, [V3PUR(c,s)/V3TOT]*p3(c,s)}};

 E_w3tot # Household budget constraint: determines w3lux #
  w3tot = x3tot + p3tot;
```

Equation E_utility is the percentage-change form of the utility function (22). Equations E_a3sub and E_a3lux provide default settings for the taste-change variables, a3sub and a3lux, which allow the average budget shares to be shocked, *via* the a3_s, in a way that preserves the pattern of expenditure elasticities. See Appendix F for further details.

The equations just described determine the composition of household demands but do not determine total consumption. That could be done in a variety of ways: (i) set exogenously, (ii) determined by a consumption funcntion, or (iii) determined *via* a balance of trade constraint.

The reader may wonder why there is no equation based on (24) which would determine the variable w3lux. The reason is that (24) can be deduced from (23) and the definition of V3TOT:

$$\text{V3TOT} = \sum \text{X3\_S(c)} * \text{P3\_S(c)} \tag{28}$$

The percentage change form of (28) in fact appears as the final equation E_w3tot. Hence any additional equation defining w3lux would be redundant.

4.16. Export demands

To model export demands, commodities in ORANI-G are divided into two groups:

- For an *individual export* commodity, foreign demand is inversely related to that commodity's price.
- For the remaining, *collective export*, commodities, foreign demand is inversely related to the average price of *all* collective export commodities.

```
! Excerpt 17 of TABLO input file: !
! Export demands !

Coefficient
 (parameter)(all,c,COM) IsIndivExp(c) # >0.5 For individual export commodities#;
Read IsIndivExp from file BASEDATA header "ITEX";
! This way of defining a set facilitates aggregation of the data base !
Set TRADEXP # Individual export commodities # = (all,c,COM: IsIndivExp(c)>0.5);
Write (Set) TRADEXP  to file SUMMARY header "TEXP";

Variable
              phi     # Exchange rate, local currency/$world #;
 (all,c,COM)  f4p(c)  # Price (upward) shift in export demand schedule #;
 (all,c,COM)  f4q(c)  # Quantity (right) shift in export demands #;
Coefficient (parameter)(all,c,COM) EXP_ELAST(c)
  # Export demand elasticities: typical value -5.0 #;
Read EXP_ELAST from file BASEDATA header "P018";
Equation E_x4A  # Individual export demand functions #
(all,c,TRADEXP) x4(c) - f4q(c) = -ABS[EXP_ELAST(c)]*[p4(c) - phi - f4p(c)];
! note: ABS function above fixes common mistake: positive EXP_ELAST values !

Set NTRADEXP # Collective Export Commodities # = COM - TRADEXP;
Write (Set) NTRADEXP  to file SUMMARY header "NTXP";
Variable
 x4_ntrad     # Quantity, collective export aggregate #;
 f4p_ntrad    # Upward demand shift, collective export aggregate #;
 f4q_ntrad    # Right demand shift, collective export aggregate #;
 p4_ntrad     # Price, collective export aggregate #;

Coefficient V4NTRADEXP # Total collective export earnings #;
Formula     V4NTRADEXP = sum{c,NTRADEXP, V4PUR(c)};

Equation E_X4B  # Collective export demand functions #
 (all,c,NTRADEXP) x4(c) - f4q(c) = x4_ntrad;

Equation E_p4_ntrad  # Average price of collective exports #
     [TINY+V4NTRADEXP]*p4_ntrad = sum{c,NTRADEXP, V4PUR(c)*p4(c)};

Coefficient (parameter) EXP_ELAST_NT # Collective export demand elasticity #;
Read EXP_ELAST_NT from file BASEDATA header "EXNT";
Equation E_x4_ntrad # Demand for collective export aggregate #
        x4_ntrad - f4q_ntrad = -ABS[EXP_ELAST_NT]*[p4_ntrad - phi - f4p_ntrad];
```

The individual export group, which would normally include all the main export commodities, is defined by the set TRADEXP[14] in Excerpt 17. Equation E_x4A specifies downward-sloping foreign demand schedules for these commodities. In the levels, the equation would read:

$$\text{X4(c)} = \text{F4Q(c)}\left[\frac{\text{P4(c)}}{\text{PHI*F4P(c)}}\right]^{\text{EXP\_ELAST(c)}}, \qquad (29)$$

where EXP_ELAST(c) is a negative[15] parameter—the constant elasticity of demand. That is, export volumes, X4(c), are declining functions of their prices in foreign currency, (P4(c)/PHI). The exchange rate PHI converts local to foreign currency units. The variables F4Q(i) and F4P(i) allow for horizontal (quantity) and vertical (price) shifts in the demand schedules.

The collective export group, defined by the set NTRADEXP, could include all those commodities for which the above equation is inappropriate. For models based on ORANI-G this has typically included the bulk of the service commodities, and other commodities (examples might be Air Transport or Gold)

[14] The original version of ORANI referred to individual exports as *traditional* exports; the rest were called *non-traditional* exports. For Australia, the traditional exports were all primary products.
[15] The ABS (absolute value) function is used to neutralize mistakes about the sign of EXP_ELAST.

where export volumes do not seem to depend mainly on the corresponding price. The list would be country-specific.

The commodity composition of aggregate collective exports is exogenised by treating collective exports as a Leontief aggregate (see equation E_x4B). Demand for the aggregate is related to its average price *via* a constant-elasticity demand curve, similar to those for individual exports (see equation E_x4_ntrad).

It is permissible for the set TRADEXP to contain *all* commodities, so that the set NTRADEXP is empty. This disactivates the collective export mechanism. In addition, exports of particular commodities may be fixed or shocked by exogenising the corresponding elements of the vector x4, while at the same time endogenising matching elements of the vector f4q.

4.17. Other final demands

Equations E_x5 and E_f5tot determine government usage. With both of the shift variables f5 and f5tot exogenous, the level and composition of government consumption is exogenously determined. Then equation E_f5tot merely determines the value of the endogenous variable f5tot2, which appears nowhere else. Alternatively, many ORANI applications have assumed that, in the absence of shocks to the shift variables, aggregate government consumption moves with real aggregate household consumption, x3tot. This is achieved by *endogenising* f5tot and *exogenising* f5tot2. The trick of changing behavioural specifications by switching the exogenous/endogenous status of shift variables is used frequently in applying ORANI. It helps to avoid proliferation of model variants, allowing the same TABLO Input file to contain different versions of some equations. The choice of which shift variables are exogenous determines at run time which version is operative in the rest of the model.

```
! Excerpt 18 of TABLO input file: !
! Government and inventory demands !
Variable
 f5tot  # Overall shift term for government demands #;
 f5tot2 # Ratio between f5tot and x3tot #;
 (all,c,COM)(all,s,SRC) f5(c,s) # Government demand shift #;
 (change) (all,c,COM)(all,s,SRC)  fx6(c,s)    # Shifter on rule for stocks #;
Equation
 E_x5 # Government demands # (all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;
 E_f5tot # Overall government demands shift # f5tot = x3tot + f5tot2;

Coefficient (all,c,COM)(all,s,SRC) LEVP0(c,s) # Levels basic prices #;
Formula (initial) (all,c,COM)(all,s,SRC) LEVP0(c,s) = 1; ! arbitrary setting !
Update   (all,c,COM)(all,s,SRC) LEVP0(c,s) = p0(c,s);
Equation
 E_delx6 # Stocks follow domestic output # (all,c,COM)(all,s,SRC)
  100*LEVP0(c,s)*delx6(c,s) = V6BAS(c,s)*x0com(c) + fx6(c,s);
 E_delV6 # Update formula for stocks #     (all,c,COM)(all,s,SRC)
  delV6(c,s) = 0.01*V6BAS(c,s)*p0(c,s) + LEVP0(c,s)*delx6(c,s);
```

Equation E_delx6 shows one way that delx6, the change in the volume of goods going to inventories, might be endogenized. It states that the percentage change in the volume of each commodity, domestic or imported, going to inventories, is the same as the percentage change in domestic production of that commodity. Like the previous equation, E_delx6 can be insulated from the rest of the equation system—by leaving fx6 endogenous. A chief purpose for this equation is to facilitate the *real homogeneity test* described in Appendix I.

Equation E_delV6 defines ordinary changes in the values of inventory demands. These are used above to update the V6BAS coefficient. The form of the equation arises because delx6 is an ordinary (rather than percentage) change variable. It may be derived by:

$$\Delta V = P.X\left(\frac{\Delta P}{P} + \frac{\Delta X}{X}\right) = V\frac{p}{100} + P\Delta X. \qquad (30)$$

Notice that we are now required to define and update the levels price, P, i.e., we are obliged to specify units of measurement for quantities. In the TABLO code the coefficient LEVP0 contains current basic prices. The initial values of its elements are set (arbitrarily) to 1 *via* an earlier 'Formula (Initial)' statement. Thus, the unit of measurement of delx6 is *base-period-dollars-worth*.

4.18. Demands for margins

The equations in Excerpt 19 indicate that, in the absence of technical change, demands for margins are proportional to the commodity flows with which the margins are associated. The 'a' variables allow for technical change in margins usage.

```
! Excerpt 19 of TABLO input file: !
! Margin demands !

Variable
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                         a1mar(c,s,i,m)  # Intermediate margin tech change #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                         a2mar(c,s,i,m)  # Investment margin tech change #;
 (all,c,COM)(all,s,SRC)(all,m,MAR) a3mar(c,s,m) # Household margin tech change#;
 (all,c,COM)(all,m,MAR)            a4mar(c,m)   # Export margin tech change #;
 (all,c,COM)(all,s,SRC)(all,m,MAR) a5mar(c,s,m) # Governmnt margin tech change#;

Equation
 E_x1mar  # Margins to producers #  (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
  x1mar(c,s,i,m) = x1(c,s,i) + a1mar(c,s,i,m);
 E_x2mar  # Margins to investment # (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
  x2mar(c,s,i,m) = x2(c,s,i) + a2mar(c,s,i,m);
 E_x3mar  # Margins to households # (all,c,COM)(all,s,SRC)(all,m,MAR)
  x3mar(c,s,m)   = x3(c,s) + a3mar(c,s,m);
 E_x4mar  # Margins to exports #    (all,c,COM)(all,m,MAR)
  x4mar(c,m)     = x4(c) + a4mar(c,m);
 E_x5mar  # Margins to government # (all,c,COM)(all,s,SRC)(all,m,MAR)
  x5mar(c,s,m)   = x5(c,s) + a5mar(c,s,m);
```

4.19. Formulae for sales aggregates

The next two excerpts are concerned with computing aggregate demands for domestic and imported commodities. Excerpt 20 contains coefficients and formulae for these demands. The aggregate SALE matrix breaks down demand for domestic and imported goods, valued at basic prices, by their main destinations. This is written to the SUMMARY file for later use in analysing results. Note that margin use is identified separately.

The V0IMP, SALES and DOMSALES aggregates are simply subtotals of the SALE matrix.

```
! Excerpt 20 of TABLO input file: !
! Sales Aggregates !

Coefficient (all,c,COM) MARSALES(c) # Total usage for margins purposes #;
Formula
 (all,n,NONMAR) MARSALES(n) = 0.0;
 (all,m,MAR)    MARSALES(m) = sum{c,COM, V4MAR(c,m) +
                               sum{s,SRC, V3MAR(c,s,m) + V5MAR(c,s,m) +
                                sum{i,IND, V1MAR(c,s,i,m) + V2MAR(c,s,i,m)}}};

Set DEST # Sale Categories #
(Interm, Invest, HouseH, Export, GovGE, Stocks, Margins);

Coefficient (all,c,COM)(all,s,SRC)(all,d,DEST) SALE(c,s,d) # Sales aggregates #;
Formula
 (all,c,COM)(all,s,SRC) SALE(c,s,"Interm")      = sum{i,IND, V1BAS(c,s,i)};
 (all,c,COM)(all,s,SRC) SALE(c,s,"Invest")      = sum{i,IND, V2BAS(c,s,i)};
 (all,c,COM)(all,s,SRC) SALE(c,s,"HouseH")      = V3BAS(c,s);
 (all,c,COM)            SALE(c,"dom","Export")  = V4BAS(c);
 (all,c,COM)            SALE(c,"imp","Export")  = 0;
 (all,c,COM)(all,s,SRC) SALE(c,s,"GovGE")       = V5BAS(c,s);
```

```
 (all,c,COM)(all,s,SRC) SALE(c,s,"Stocks")      = V6BAS(c,s);
 (all,c,COM)            SALE(c,"dom","Margins") = MARSALES(c);
 (all,c,COM)            SALE(c,"imp","Margins") = 0;
Write SALE to file SUMMARY header "SALE";

Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports of good c #;
Formula     (all,c,COM) V0IMP(c) = sum{d,DEST, SALE(c,"imp",d)};
Coefficient (all,c,COM) SALES(c) # Total sales of domestic commodities #;
Formula     (all,c,COM) SALES(c) = sum{d,DEST, SALE(c,"dom",d)};
Coefficient (all,c,COM) DOMSALES(c) # Total sales to local market #;
Formula     (all,c,COM) DOMSALES(c) = SALES(c) - V4BAS(c);
```

4.20. Market-clearing equations

Excerpt 21 includes market-clearing equations for locally-consumed commodities, both domestic and imported. It begins by defining equations for the delSale matrix variable, which corresponds to the SALE coefficient just described. Each element of delSale shows the ordinary change in a quantity, measured in current prices. This is seen most clearly in the inventory (stocks) terms. The other right hand side terms have the form:

$$V.x/100 = P.X.x/100 = P\Delta x$$

Having constructed delSale, the next two equations are rather simple. E_p0A just adds up all non-export demand for domestic commodities: the sum is equal to the previously defined supply variable, x0dom. Similarly, E_x0imp computes the total demand for imports. By exogenously setting the world price of imports, pf0cif(c), we assume infinite elasticity of the supply of imports.

```
! Excerpt 21 of TABLO input file: !
! Market clearing equations !

Variable (change)
 (all,c,COM)(all,s,SRC)(all,d,DEST) delSale(c,s,d) # Sales aggregates #;
Equation
E_delSaleA (all,c,COM)(all,s,SRC) delSale(c,s,"Interm") =
                   0.01*sum{i,IND,V1BAS(c,s,i)*x1(c,s,i)};
E_delSaleB (all,c,COM)(all,s,SRC) delSale(c,s,"Invest") =
                   0.01*sum{i,IND,V2BAS(c,s,i)*x2(c,s,i)};
E_delSaleC (all,c,COM)(all,s,SRC) delSale(c,s,"HouseH")=0.01*V3BAS(c,s)*x3(c,s);
E_delSaleD (all,c,COM)            delSale(c,"dom","Export")=0.01*V4BAS(c)*x4(c);
E_delSaleE (all,c,COM)            delSale(c,"imp","Export")=   0;
E_delSaleF (all,c,COM)(all,s,SRC) delSale(c,s,"GovGE") =0.01*V5BAS(c,s)*x5(c,s);
E_delSaleG (all,c,COM)(all,s,SRC) delSale(c,s,"Stocks") = LEVP0(c,s)*delx6(c,s);
E_delSaleH (all,m,MAR)            delSale(m,"dom","Margins") = 0.01*
  sum{c,COM, V4MAR(c,m)*x4mar(c,m)   ! note nesting of sum parentheses !
 + sum{s,SRC, V3MAR(c,s,m)*x3mar(c,s,m) + V5MAR(c,s,m)*x5mar(c,s,m)
  + sum{i,IND, V1MAR(c,s,i,m)*x1mar(c,s,i,m) + V2MAR(c,s,i,m)*x2mar(c,s,i,m)}}};
E_delSaleI (all,n,NONMAR)         delSale(n,"dom","Margins") = 0;
E_delSaleJ (all,c,COM)            delSale(c,"imp","Margins") = 0;

Set LOCUSER # Non-export users #(Interm, Invest, HouseH, GovGE, Stocks,Margins);
Subset LOCUSER is subset of DEST;

Equation E_p0A # Supply = Demand for domestic commodities #
(all,c,COM) 0.01*[TINY+DOMSALES(c)]*x0dom(c) =sum{u,LOCUSER,delSale(c,"dom",u)};

Variable (all,c,COM)  x0imp(c)        # Total supplies of imported goods #;
Equation E_x0imp # Import volumes #
 (all,c,COM) 0.01*[TINY+V0IMP(c)]*x0imp(c) = sum{u,LOCUSER,delSale(c,"imp",u)};
```

4.21. Purchasers' prices

The equations in Excerpt 22 define purchasers' prices for each of the first five user groups: producers; investors; households; exports; and government. Purchasers' prices (in levels) are the sums of basic values, sales taxes and margins. Sales taxes are treated as *ad valorem* on basic values, with the sales-tax variables t in the linearised model being percentage changes in the powers of taxes (The power of a tax is one plus the *ad valorem* rate). For example, equation E_p3 is derived from the levels form:

X3(c,s)∗P3(c,s) = X3(c,s)∗P0(c,s)∗T3(c,s)

+ sum{m,MAR, X3MAR(c,s,m)∗P0(m,"dom") }.

In percentage-change form this is:

V3PUR(c,s)∗{x3(c,s) + p3(c,s)} =

{V3TAX(c,s)+V3BAS(c,s)}∗{x3(c,s)+p0(c,s)+t3(c,s)}

+ sum{m, MAR, V3MAR(c,s,m)∗[x3mar(c,s,m)+p0(m,"dom")]}.

By using Equation E_x3mar from Excerpt 19 to eliminate x3mar(c,s,m), we can cancel out the x3(c,s) terms to obtain:

V3PUR(c,s)∗p3(c,s) =

[V3BAS(c,s)+V3TAX(c,s)]∗[p0(c,s)+ t3(c,s)]
+ sum{m,MAR, V3MAR(c,s,m)∗[p0(m,"dom")+a3mar(c,s,m)]}.

For a commodity which is not used by households, V3PUR(c,s) and its constituents would all be zero, leaving p3(i,s) undefined. To finesse this problem, the TABLO file adds the coefficient TINY to V3PUR(c,s) so that if it is zero, equation E_p3 becomes:

p3(c,s) = 0.

The same procedure is used for the purchasers'-price equations referring to intermediate, investment, export and government users.

The comment at the end shows how the final equation would appear if the t5 variable (% change in power) was replaced by delt5: an ordinary change in the ad valorem rate.

```
! Excerpt 22 of TABLO input file: !
! Purchasers prices !

Variable  ! Powers of Commodity Taxes on Basic Flows !
 (all,c,COM)(all,s,SRC)(all,i,IND) t1(c,s,i) # Power of tax on intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND) t2(c,s,i) # Power of tax on investment #;
 (all,c,COM)(all,s,SRC)            t3(c,s)   # Power of tax on household #;
 (all,c,COM)                       t4(c)     # Power of tax on export #;
 (all,c,COM)(all,s,SRC)            t5(c,s)   # Power of tax on government #;

Equation E_p1 # Purchasers prices - producers #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  [V1PUR(c,s,i)+TINY]*p1(c,s,i) =
   [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)]
    + sum{m,MAR, V1MAR(c,s,i,m)*[p0dom(m)+a1mar(c,s,i,m)]};

Equation E_p2 # Purchasers prices - capital creators #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  [V2PUR(c,s,i)+TINY]*p2(c,s,i) =
   [V2BAS(c,s,i)+V2TAX(c,s,i)]*[p0(c,s)+ t2(c,s,i)]
    + sum{m,MAR, V2MAR(c,s,i,m)*[p0dom(m)+a2mar(c,s,i,m)]};

Equation E_p3 # Purchasers prices - households #
 (all,c,COM)(all,s,SRC)
  [V3PUR(c,s)+TINY]*p3(c,s) =
   [V3BAS(c,s)+V3TAX(c,s)]*[p0(c,s)+ t3(c,s)]
    + sum{m,MAR, V3MAR(c,s,m)*[p0dom(m)+a3mar(c,s,m)]};

Equation E_p4 # Zero pure profits in exporting #
 (all,c,COM)
  [V4PUR(c)+TINY]*p4(c) =
   [V4BAS(c)+V4TAX(c)]*[pe(c)+ t4(c)]
    + sum{m,MAR, V4MAR(c,m)*[p0dom(m)+a4mar(c,m)]};
```

```
! note that we refer to export taxes,not subsidies !

Equation E_p5 # Zero pure profits in distribution to government #
 (all,c,COM)(all,s,SRC)
  [V5PUR(c,s)+TINY]*p5(c,s) =
   [V5BAS(c,s)+V5TAX(c,s)]*[p0(c,s)+ t5(c,s)]
    + sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)]};

! alternate form
Equation E_p5q # Zero pure profits in distribution of government #
(all,c,COM)(all,s,SRC)
[V5PUR(c,s)+TINY]*p5(c,s) =
  [V5BAS(c,s)+V5TAX(c,s)]*p0(c,s)
+ 100*V5BAS(c,s)*delt5(c,s)
+ sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)]};  !
```

4.22. Indirect taxes

ORANI-G allows for great flexibility in the treatment of indirect taxes. However, it is cumbersome to shock 3-dimensional variables such as t1 and t2 directly, because they have so many elements. Besides, most projected changes to tax rates have a fairly simple structure. For example, an increase in the tax on petrol might raise the price to all users by 10%. To simulate a tax change like this, it helps to include equations which implement the tax regime to be simulated. The effect is to replace multi-dimensional exogenous tax variables with vectors that are easier to shock.

Excerpt 23 contains default rules for setting sales-tax rates for producers, investors, households, and government. Sales taxes are treated as *ad valorem* on basic values, with the sales-tax variables in the linearised model being percentage changes in the powers of the taxes. Each equation allows the changes in the relevant tax rates to be commodity-specific or user-specific. To simulate more complex patterns of tax changes, we would omit or modify these equations.[16]

```
! Excerpt 23 of TABLO input file: !
! Tax rate equations !

Variable
f1tax_csi    # Uniform % change in powers of taxes on intermediate usage #;
f2tax_csi    # Uniform % change in powers of taxes on investment #;
f3tax_cs     # Uniform % change in powers of taxes on household usage #;
f4tax_ntrad  # Uniform % change in powers of taxes on nontradtnl exports #;
f4tax_trad   # Uniform % change in powers of taxes on tradtnl exports #;
f5tax_cs     # Uniform % change in powers of taxes on government usage #;
(all,c,COM)  f0tax_s(c)      # General sales tax shifter #;
Equation
E_t1  # Power of tax on sales to intermediate #
  (all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;
E_t2  # Power of tax on sales to investment #
  (all,c,COM)(all,s,SRC)(all,i,IND)  t2(c,s,i)  = f0tax_s(c) + f2tax_csi;
E_t3  # Power of tax on sales to households #
  (all,c,COM)(all,s,SRC)             t3(c,s)    = f0tax_s(c) + f3tax_cs;
E_t4A # Power of tax on sales to individual exports #
  (all,c,TRADEXP)                    t4(c)      = f0tax_s(c) + f4tax_trad;
E_t4B # Power of tax on sales to collective exports #
  (all,c,NTRADEXP)                   t4(c)      = f0tax_s(c) + f4tax_ntrad;
E_t5  # Power of tax on sales to government #
  (all,c,COM)(all,s,SRC)             t5(c,s)    = f0tax_s(c) + f5tax_cs;
```

[16] The same problem, that exogenous variables have too many dimensions, sometimes arises when we wish to simulate technical change. Suppose we wished to shock the variable a1 (which varies by commodity, source and industry). It might be simplest to write a new equation, like the equations of Excerpt 28, that related a1 to one or more new vector variables. The modeller is expected to add these equations and variables as required, since their form is experiment-specific.

The equations of Excerpt 24 compute ordinary changes in the indirect tax flows. Their main use is in the Update statements for the various commodity tax matrices (see above). To understand the equations, note that the bases for the sales taxes are the basic values of the corresponding commodity flows, and the tax-rate variables appearing in the model are powers of the sales-tax rates. Hence, for any component of sales tax, we can express revenue (VTAX), in levels, as the product of the base (VBAS) and the power of the tax (T) minus one, i.e.,

$$\text{VTAX} = \text{VBAS(T-1)}. \tag{31}$$

Hence: $\Delta\text{VTAX} = \Delta\text{VBAS(T-1)} + \text{VBAS}\Delta\text{T}$,

$$= \text{VBAS(T-1)}\frac{\Delta\text{VBAS}}{\text{VBAS}} + \text{VBAS}*\text{T}\frac{\Delta\text{T}}{\text{T}},$$

$$= \text{VBAS(T-1)wbas}/100 + \text{VBAS}*\text{T}*\text{t}/100,$$

$$= \text{VTAX}*\text{wbas}/100 + \text{(VBAS+VTAX)t}/100,$$

where wbas and t are percentage changes in VBAS and T. VBAS is in turn a product of a quantity (X) and a basic price (P), so its percentage change wbas can be written as (x + p). Hence:

$$\Delta\text{VTAX} = \text{VTAX(x+p)}/100 + \text{(VBAS+VTAX)t}/100 \tag{32}$$

The RHS shows two components of revenue change; due to changes in the base and rate respectively.

```
! Excerpt 24 of TABLO input file: !
! Update formulae for commodity taxes !

Equation
 E_delV1TAX (all,c,COM)(all,s,SRC)(all,i,IND)
   delV1TAX(c,s,i) = 0.01*V1TAX(c,s,i)* [x1(c,s,i) + p0(c,s)] +
     0.01*[V1BAS(c,s,i)+V1TAX(c,s,i)]*t1(c,s,i);
 E_delV2TAX (all,c,COM)(all,s,SRC)(all,i,IND)
   delV2TAX(c,s,i)=  0.01*V2TAX(c,s,i)* [x2(c,s,i) + p0(c,s)] +
     0.01*[V2BAS(c,s,i)+V2TAX(c,s,i)]*t2(c,s,i);
 E_delV3TAX (all,c,COM)(all,s,SRC)
   delV3TAX(c,s)  = 0.01*V3TAX(c,s)* [x3(c,s) + p0(c,s)] +
     0.01*[V3BAS(c,s)+V3TAX(c,s)]*t3(c,s);
 E_delV4TAX (all,c,COM)
   delV4TAX(c) = 0.01*V4TAX(c)* [x4(c) + pe(c)] +
     0.01*[V4BAS(c)+V4TAX(c)]*t4(c);
 E_delV5TAX (all,c,COM)(all,s,SRC)
   delV5TAX(c,s) = 0.01*V5TAX(c,s)*[x5(c,s) + p0(c,s)] +
     0.01*[V5BAS(c,s)+V5TAX(c,s)]*t5(c,s);

! alternate form
E_delV5TAX (all,c,COM)(all,s,SRC)
  delV5TAX(c,s) = 0.01*V5TAX(c,s)*[x5(c,s) + p0(c,s)] +
     V5BAS(c,s)*delt5(c,s);  !
```

The comment at the end shows how the final equation would appear if the t5 variable (% change in power) was replaced by delt5: an ordinary change in the ad valorem rate.

In the next excerpt, equation E_p0B relates the domestic-currency prices of imports (c.i.f., duty-paid) to their foreign-currency prices. It is derived from the levels form:

$$P0(c,"imp") = PF0CIF(c)*PHI*T0IMP(c). \quad (33)$$

The other equation computes changes in tariff revenues, used to update V0TAR.

```
! Excerpt 25 of TABLO input file: !
! Import prices and tariff revenue !

Variable
(all,c,COM)  pf0cif(c) # C.I.F. foreign currency import prices #;
(all,c,COM)  t0imp(c)  # Power of tariff #;

Equation E_p0B # Zero pure profits in importing #
(all,c,COM) p0(c,"imp") = pf0cif(c) + phi + t0imp(c);

Equation E_delV0TAR   (all,c,COM)
 delV0TAR(c) = 0.01*V0TAR(c)*[x0imp(c)+pf0cif(c)+phi] + 0.01*V0IMP(c)*t0imp(c);
```

Excerpt 26 computes various aggregates of indirect tax revenue—both in the levels and in ordinary change form. Both equations and formulae are simple add-ups.

```
! Excerpt 26 of TABLO input file: !
! Indirect tax revenue aggregates !
Coefficient
 V1TAX_CSI  # Total intermediate tax revenue #;
 V2TAX_CSI  # Total investment tax revenue #;
 V3TAX_CS   # Total households tax revenue #;
 V4TAX_C    # Total export tax revenue #;
 V5TAX_CS   # Total government tax revenue #;
 V0TAR_C    # Total tariff revenue #;
Formula
 V1TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V1TAX(c,s,i)}}};
 V2TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V2TAX(c,s,i)}}};
 V3TAX_CS   = sum{c,COM, sum{s,SRC,            V3TAX(c,s)}};
 V4TAX_C    = sum{c,COM,                       V4TAX(c)};
 V5TAX_CS   = sum{c,COM, sum{s,SRC,            V5TAX(c,s)}};
 V0TAR_C    = sum{c,COM,                       V0TAR(c)};
Variable
(change) delV1tax_csi # Aggregate revenue from indirect taxes on intermediate #;
(change) delV2tax_csi # Aggregate revenue from indirect taxes on investment #;
(change) delV3tax_cs  # Aggregate revenue from indirect taxes on households #;
(change) delV4tax_c   # Aggregate revenue from indirect taxes on export #;
(change) delV5tax_cs  # Aggregate revenue from indirect taxes on government #;
(change) delV0tar_c   # Aggregate tariff revenue #;

Equation
E_delV1tax_csi delV1tax_csi = sum{c,COM,sum{s,SRC,sum{i,IND, delV1TAX(c,s,i)}}};
E_delV2tax_csi delV2tax_csi = sum{c,COM,sum{s,SRC,sum{i,IND, delV2TAX(c,s,i)}}};
E_delV3tax_cs  delV3tax_cs  = sum{c,COM,sum{s,SRC, delV3TAX(c,s)}};
E_delV4tax_c   delV4tax_c   = sum{c,COM, delV4TAX(c)};
E_delV5tax_cs  delV5tax_cs  = sum{c,COM,sum{s,SRC,delV5TAX(c,s)}};
E_delV0tar_c   delV0tar_c   = sum{c,COM, delV0TAR(c)};
```

4.23. GDP from the income and expenditure sides

Excerpt 27 defines the nominal aggregates which make up GDP from the income side. These include totals of factor payments, the value of other costs, and the total yield from commodity taxes. Their derivation is straightforward. For example, the formula for total land revenue:

V1LND_I = Sum{i,IND, V1LND(i)} = Sum{i,IND, X1LND(i)∗P1LND(i) },

becomes, in percentage-change form:

V1LND_I∗w1lnd_i = Sum{i,IND, V1LND(i)∗[x1lnd(i)+p1lnd(i)]}.

```
! Excerpt 27 of TABLO input file: !
! Factor incomes and GDP !

Coefficient
  V1CAP_I   # Total payments to capital #;
  V1LAB_IO  # Total payments to labour #;
  V1LND_I   # Total payments to land #;
  V1PTX_I   # Total production tax/subsidy #;
  V1OCT_I   # Total other cost ticket payments #;
  V1PRIM_I  # Total primary factor payments#;
  V0GDPINC  # Nominal GDP from income side #;
  V0TAX_CSI # Total indirect tax revenue #;
Formula
  V1CAP_I   = sum{i,IND, V1CAP(i)};
  V1LAB_IO  = sum{i,IND, V1LAB_O(i)};
  V1LND_I   = sum{i,IND, V1LND(i)};
  V1PTX_I   = sum{i,IND, V1PTX(i)};
  V1OCT_I   = sum{i,IND, V1OCT(i)};
  V1PRIM_I  = V1LAB_IO + V1CAP_I + V1LND_I;
  V0TAX_CSI  = V1TAX_CSI + V2TAX_CSI + V3TAX_CS + V4TAX_C + V5TAX_CS
               + V0TAR_C + V1OCT_I + V1PTX_I;
  V0GDPINC  = V1PRIM_I + V0TAX_CSI;

Variable
 w1lab_io  # Aggregate payments to labour #;
 w1cap_i   # Aggregate payments to capital #;
 w1lnd_i   # Aggregate payments to land #;
 w1prim_i  # Aggregate primary factor payments #;
 w1oct_i   # Aggregate "other cost" ticket payments #;
 (change) delV1PTX_i # Ordinary change in all-industry production tax revenue #;
 (change) delV0tax_csi # Aggregate revenue from all indirect taxes #;
 w0tax_csi # Aggregate revenue from all indirect taxes #;
 w0gdpinc  # Nominal GDP from income side #;
Equation
 E_w1lab_io V1LAB_IO*w1lab_io =
              sum{i,IND,sum{o,OCC, V1LAB(i,o)*[x1lab(i,o)+p1lab(i,o)]}};
 E_w1cap_i  V1CAP_I*w1cap_i = sum{i,IND, V1CAP(i)*[x1cap(i)+p1cap(i)]};
 E_w1lnd_i  ID01[V1LND_I]*w1lnd_i = sum{i,IND, V1LND(i)*[x1lnd(i)+p1lnd(i)]};
 E_w1prim_i V1PRIM_I*w1prim_i=V1LAB_IO*w1lab_io+V1CAP_I*w1cap_i+V1LND_I*w1lnd_i;
 E_w1oct_i  ID01[V1OCT_I]*w1oct_i = sum{i,IND, V1OCT(i)*[x1oct(i)+p1oct(i)]};
 E_delV1PTX_i delV1PTX_i = sum{i,IND,delV1PTX(i)};
 E_delV0tax_csi  delV0tax_csi =
    delV1tax_csi + delV2tax_csi + delV3tax_cs + delV4tax_c + delV5tax_cs
  + delV0tar_c + delV1PTX_i + 0.01*V1OCT_I*w1oct_i;
 E_w0tax_csi  [TINY+V0TAX_CSI]*w0tax_csi = 100*delV0tax_csi;
 E_w0gdpinc   V0GDPINC*w0gdpinc = V1PRIM_I*w1prim_i + 100*delV0tax_csi;
```

Because TABLO does not distinguish upper and lower case, we cannot use 'v1lnd_i' to refer to the change in V1LND_I—instead we use 'w1lnd_i'. This conflict arises only for aggregate flows, since only these flows appear simultaneously as variables and coefficients.

Excerpt 28 defines the aggregates which make up GDP from the expenditure side. We could have computed percentage changes in the nominal aggregates as in the previous section. For example, in equation E_w2tot_i, total nominal investment could have been written as:

V2TOT_I∗w2tot_i = Sum{i,IND,V2TOT(i)∗[x2tot(i)+p2tot(i)]}.

We choose to decompose this change into price and quantity components—see equations E_p2tot_i and E_x2tot_i. The nominal percentage change is the sum of percentage changes in these two Divisia indices.

For investment, and for each other expenditure component of GDP, we define a quantity index and a price index which sum to the (percentage change in the) nominal value of the aggregate. We weight these together to form expenditure-side measures of percentage changes in real GDP, the GDP deflator and nominal GDP.

```
! Excerpt 28 of TABLO input file: !
! GDP expenditure aggregates !

Coefficient ! Expenditure Aggregates at Purchaser's Prices !
 (all,c,COM) V0CIF(c) # Total ex-duty imports of good c #;
 V0CIF_C  # Total local currency import costs, excluding tariffs #;
 V0IMP_C  # Total basic-value imports (includes tariffs) #;
 V2TOT_I  # Total investment usage #;
 V4TOT    # Total export earnings #;
 V5TOT    # Total value of government demands #;
 V6TOT    # Total value of inventories #;
 V0GNE    # GNE from expenditure side #;
 V0GDPEXP # GDP from expenditure side #;
Formula
 (all,c,COM) V0CIF(c) = V0IMP(c) - V0TAR(c);
 V0CIF_C   = sum{c,COM, V0CIF(c)};
 V0IMP_C   = sum{c,COM, V0IMP(c)};
 V2TOT_I   = sum{i,IND, V2TOT(i)};
 V4TOT     = sum{c,COM, V4PUR(c)};
 V5TOT     = sum{c,COM, sum{s,SRC, V5PUR(c,s)}};
 V6TOT     = sum{c,COM, sum{s,SRC, V6BAS(c,s)}};
 V0GNE     = V3TOT + V2TOT_I + V5TOT + V6TOT;
 V0GDPEXP  = V0GNE + V4TOT - V0CIF_C;

Variable
 x2tot_i    # Aggregate real investment expenditure #;
 p2tot_i    # Aggregate investment price index #;
 w2tot_i    # Aggregate nominal investment #;
Equation
 E_x2tot_i  V2TOT_I*x2tot_i = sum{i,IND, V2TOT(i)*x2tot(i)};
 E_p2tot_i  V2TOT_I*p2tot_i = sum{i,IND, V2TOT(i)*p2tot(i)};
 E_w2tot_i  w2tot_i = x2tot_i + p2tot_i;

Variable
 x4tot      # Export volume index #;
 p4tot      # Exports price index, local currency #;
 w4tot      # Local currency border value of exports #;
Equation
 E_x4tot    V4TOT*x4tot = sum{c,COM, V4PUR(c)*x4(c)};
 E_p4tot    V4TOT*p4tot = sum{c,COM, V4PUR(c)*p4(c)};
 E_w4tot    w4tot = x4tot + p4tot;

Variable
 x5tot      # Aggregate real government demands #;
 p5tot      # Government price index #;
 w5tot      # Aggregate nominal value of government demands #;
Equation
 E_x5tot    V5TOT*x5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*x5(c,s)}};
 E_p5tot    V5TOT*p5tot = sum{c,COM, sum{s,SRC, V5PUR(c,s)*p5(c,s)}};
 E_w5tot    w5tot = x5tot + p5tot;
```

```
Variable
 x6tot      # Aggregate real inventories #;
 p6tot      # Inventories price index #;
 w6tot      # Aggregate nominal value of inventories #;
Equation
 E_x6tot    [TINY+V6TOT]*x6tot =100*sum{c,COM,sum{s,SRC,LEVP0(c,s)*delx6(c,s)}};
 E_p6tot    [TINY+V6TOT]*p6tot = sum{c,COM, sum{s,SRC, V6BAS(c,s)*p0(c,s)}};
 E_w6tot    w6tot = x6tot + p6tot;

Variable
 x0cif_c    # Import volume index, C.I.F. weights #;
 p0cif_c    # Imports price index, C.I.F., local currency #;
 w0cif_c    # C.I.F. local currency value of imports #;
Equation
 E_x0cif_c  V0CIF_C*x0cif_c = sum{c,COM, V0CIF(c)*x0imp(c)};
 E_p0cif_c  V0CIF_C*p0cif_c = sum{c,COM, V0CIF(c)*[phi+pf0cif(c)]};
 E_w0cif_c  w0cif_c = x0cif_c + p0cif_c;

Variable  !section added Oct 2002!
 x0gne   # Real GNE from expenditure side #;
 p0gne   # GNE price index, expenditure side #;
 w0gne   # Nominal GNE from expenditure side #;
Equation
 E_x0gne V0GNE*x0gne = V3TOT*x3tot + V2TOT_I*x2tot_i + V5TOT*x5tot +V6TOT*x6tot;
 E_p0gne V0GNE*p0gne = V3TOT*p3tot + V2TOT_I*p2tot_i + V5TOT*p5tot +V6TOT*p6tot;
 E_w0gne w0gne = x0gne + p0gne;

Variable
 x0gdpexp   # Real GDP from expenditure side #;
 p0gdpexp   # GDP price index, expenditure side #;
 w0gdpexp   # Nominal GDP from expenditure side #;
Equation
 E_x0gdpexp x0gdpexp = [1/V0GDPEXP]*[V3TOT*x3tot + V2TOT_I*x2tot_i + V5TOT*x5tot
             + V6TOT*x6tot + V4TOT*x4tot - V0CIF_C*x0cif_c];
 E_p0gdpexp p0gdpexp = [1/V0GDPEXP]*[V3TOT*p3tot + V2TOT_I*p2tot_i + V5TOT*p5tot
             + V6TOT*p6tot + V4TOT*p4tot - V0CIF_C*p0cif_c];
 E_w0gdpexp w0gdpexp = x0gdpexp + p0gdpexp;
```

Superficially, price and quantity components such as p2tot_i and x2tot_i resemble the price and quantity indices which arise from the nested production functions of agents. The latter Divisia indices arise from homothetic functional forms. However, the model contains no analogous function to aggregate investment quantities across industries. Similarly, our definition of real consumption is not derived from the household utility function. We use these price-quantity decompositions only as convenient summary measures[17].

It is an accounting identity that GDP from the expenditure and income sides must be equal, both in the levels and in percentage changes. That is:

$$\text{V0GDPEXP} \equiv \text{V0GDPINC}, \text{ and } \text{w0gdpexp} \equiv \text{w0gdpinc}. \quad (34)$$

Nonetheless, we find it useful to compute and print these values separately as a check on the model's accounting relations.

[17] There is indeed no levels equation corresponding to our change definition of, say, the investment price index. A levels formulation could use either initial or final weights; our formula uses weights that vary continuously between these two values. Because our formula for p2tot_i can only be written in change form, results for that variable suffer from path-dependence: they depend slightly on details of the solution algorithm that should be irrelevant. The effect however is normally very small, and rarely propagates through to other equations.

4.24. The trade balance and other aggregates

Because zero is a plausible base-period value, the balance of trade is computed in the first equation in Excerpt 29 as an ordinary change (delB), not a percentage change. We avoid choosing units by expressing this change as a fraction of GDP. Note that delB is the [change in the] ratio of two nominal variables.

The next three equations measure percentage changes in imports at tariff-inclusive prices. Finally, the excerpt contains measures of percentage changes in the terms of trade and the real exchange rate.

```
! Excerpt 29 of TABLO input file: !
! Trade balance and other indices !

Variable
 (change) delB # (Nominal balance of trade)/{nominal GDP} #;
       x0imp_c # Import volume index, duty-paid weights #;
       w0imp_c # Value of imports plus duty #;
       p0imp_c # Duty-paid imports price index, local currency #;
     p0realdev # Real devaluation #;
        p0toft # Terms of trade #;
Equation
 E_delB 100*V0GDPEXP*delB=V4TOT*w4tot -V0CIF_C*w0cif_c-[V4TOT-V0CIF_C]*w0gdpexp;
 E_x0imp_c       x0imp_c = sum{c,COM, [V0IMP(c)/V0IMP_C]*x0imp(c)};
 E_p0imp_c       p0imp_c = sum{c,COM, [V0IMP(c)/V0IMP_C]*p0(c,"imp")};
 E_w0imp_c      w0imp_c = x0imp_c + p0imp_c;
 E_p0toft        p0toft = p4tot - p0cif_c;
 E_p0realdev  p0realdev =  p0cif_c - p0gdpexp;
```

4.25. Primary factor aggregates

Excerpt 30 begins by computing some quantity measures of employment, capital usage, and GDP at factor cost. These aggregates indicate the aggregate productive capacities of the relevant factors. For example, in computing the aggregate employment measures, we use wage-bill weights, reflecting the relative marginal products of different workers. Different aggregates could be defined, using as weights hours worked, or numbers employed[18].

Next are computed three indices of primary factor prices.

```
! Excerpt 30 of TABLO input file: !
! Primary factor aggregates !

Variable
 (all,i,IND) employ(i) # Employment by industry #;
 employ_i   # Aggregate employment: wage bill weights #;
 x1cap_i    # Aggregate capital stock, rental weights #;
 x1lnd_i    # Aggregate land stock, rental weights #;
 x1prim_i   # Aggregate effective primary factor use #;
 xgdpfac    # Real GDP at factor cost (inputs) = x1prim_i #;
 p1prim_i   # Index of factor cost #;
 p1lab_io   # Average nominal wage #;
 realwage   # Average real wage #;
 p1cap_i    # Average capital rental #;
 p1lnd_i    # Average land rental #;
Equation
 E_employ  (all,i,IND) V1LAB_O(i)*employ(i) = sum{o,OCC, V1LAB(i,o)*x1lab(i,o)};
 E_employ_i V1LAB_IO*employ_i = sum{i,IND, V1LAB_O(i)*employ(i)};
 E_x1cap_i  V1CAP_I*x1cap_i   = sum{i,IND, V1CAP(i)*x1cap(i)};
 E_x1lnd_i  ID01[V1LND_I]*x1lnd_i   = sum{i,IND, V1LND(i)*x1lnd(i)};
 E_x1prim_i V1PRIM_I*x1prim_i = sum{i,IND, V1PRIM(i)*x1prim(i)};
 E_xgdpfac  xgdpfac = [1/V1PRIM_I]*
              [V1LAB_IO*employ_i + V1CAP_I*x1cap_i + V1LND_I*x1lnd_i];
```

[18] The TABLO input file contains optional code, not shown here, which could be used to compute such indices, data permitting.

```
E_p1prim_i V1PRIM_I*p1prim_i = sum{i,IND, V1PRIM(i)*p1prim(i)};
E_p1lab_io V1LAB_IO*p1lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*p1lab(i,o)}};
E_realwage realwage = p1lab_io - p3tot;
E_p1cap_i  V1CAP_I*p1cap_i   = sum{i,IND, V1CAP(i)*p1cap(i)};
E_p1lnd_i  ID01[V1LND_I]*p1lnd_i   = sum{i,IND, V1LND(i)*p1lnd(i)};
```

4.26. Rates of return and investment

Excerpt 31 contains equations determining x2tot, the amount of new capital stock created for each industry. In recent years, ORANI has evolved into a dynamic model and the specification of investment behaviour has been in a state of flux. ORANI-G contains 3 alternate investment rules, one of which will be active for each industry. The active rule either determines industry investment, or (if aggregate investment is fixed) it determines that industry's share in aggregate investment.

Rule 1 relates the creation of new capital stock in each industry to profitability in that industry. It follows the original ORANI computer model. For a fuller explanation, the reader is referred to DPSV, Section 19. The effect of the equation is that industries which become more profitable (gret(i) rising) attract more investment (higher ggro(i)).

Equation E_finv1 relates the investment/capital ratio to the rate of return (relative to the variable invslack, which is interpretable here as an economy-wide rate of return). It is to be interpreted as a risk-related relationship with relatively fast- (slow-) growing industries requiring premia (accepting discounts) on their rates of return. If exogenous, the variable finv1(i) could be shocked to allow for additional shifts in investment. If, for some industry, finv1(i) is endogenous (and x2tot(i) is determined in some other way), equation E_finv1 serves only to determine finv1(i), which appears in no other equation.

Rule 2, given by Equation E_finv2, may be used to determine investment in those industries for which Rule 1 is deemed inappropriate. These might be industries where investment is determined by government policy. For such an industry the corresponding element of finv2 should be exogenous, causing that industry's investment to follow the national trend. For the other industries, E_finv2 just determines finv2.

Rule 3, given by Equation E_finv3, is intended for long run simulations. For an industry with fixed finv3, it fixes gross capital growth rates (ggro=I/K ratios). The effect is that investment follows the industry capital stock.

If the variable invslack is exogenous, the preceding equations will determine investment by industry, and therefore in aggregate. However, many short-run simulations have aggregate investment exogenous. This is made possible by leaving the variable invslack endogenous, with x2tot_i exogenous. Or, using equation E_f2tot, link aggregate investment to aggregate real consumption by holding f2tot exogenous with invslack endogenous.

```
! Excerpt 31 of TABLO input file: !
! Investment equations !

Variable
 (all,i,IND) ggro(i) # Gross growth rate of capital = Investment/capital #;
 (all,i,IND) gret(i) # Gross rate of return = Rental/[Price of new capital] #;
Equation
 E_ggro (all,i,IND) ggro(i) = x2tot(i) - x1cap(i);
 E_gret (all,i,IND) gret(i) = p1cap(i) - p2tot(i);

! Three alternative rules for investment:
  Choose which applies to each industry by setting JUST ONE of
  the corresponding elements of x2tot, finv1, finv2, or finv3 exogenous.
  Iff aggregate investment x2tot_i is exogenous, invslack must be endogenous. !
Variable
 (all,i,IND)  finv1(i)# Shifter to enforce DPSV investment rule #;
 (all,i,IND)  finv2(i)# Shifter for "exogenous" investment rule #;
 (all,i,IND)  finv3(i)# Shifter for longrun investment rule #;
 invslack # Investment slack variable for exogenizing aggregate investment #;

! Rule 1: Follows Section 19 of DPSV. The ratios Q and G are treated as
  parameters, just as in the original ORANI implementation.  Attempts to
  improve the theory by updating these parameters have been found to
  occasionally lead to perversely signed coefficients !
Equation E_finv1 # DPSV investment rule #
 (all,i,IND) ggro(i) = finv1(i) + 0.33*[2.0*gret(i) - invslack];
! Note: above equation comes from substituting together DPSV
  equations 19.7-9. The value 0.33 and 2.0 correspond to the DPSV ratios
  [1/G.Beta] and Q (= ratio, gross to net rate of return) and are typical
  values of this ratio. In DPSV invslack was called "omega" and was interpreted
  as the "economy-wide rate of return" !

! Rule 2: For industries where investment is not mainly driven by current
  profits (eg, Education) make investment follow aggregate investment. !
Equation E_finv2 # Alternative rule for "exogenous" investment industries #
 (all,i,IND) x2tot(i) = x2tot_i + finv2(i);
! NB: you must not set ALL of finv2 exogenous else above would conflict with
  Equation E_x2tot_i !

! Rule 3: longrun investment rule: investment/capital ratios are exogenous !
Equation E_finv3 # Alternative long-run investment rule #
 (all,i,IND) ggro(i) = finv3(i) + invslack;

Variable f2tot   # Ratio, investment/consumption #;
Equation E_f2tot  x2tot_i = x3tot + f2tot;
! set f2tot exogenous and invslack endogenous
  to link aggregate investment to real consumption !

! Mechanism to allow fixed total capital to flow between sectors !
Variable
 (all,i,IND) fgret(i) # Shifter to lock together industry rates of return #;
             capslack # Slack variable to allow fixing aggregate capital #;
Equation E_fgret # Equation to force rates of return to move together #
 (all,i,IND) gret(i) = fgret(i) + capslack;
! normally, capslack is exogenous and fgret endogenous, so above just
  determines fgret. To allow capital to be mobile between sectors, yet
  fixed in aggregate, swap [newly exogenous at left]:
    x1cap_i   with   capslack
    fgret     with   x1cap        !
```

The last equation of Excerpt 31 may be used to enforce the rule that capital is fixed in aggregate, yet freely mobile between sectors. In this case, real returns to capital, gret(i), move together (with capslack).

4.27. The labour market

Like ORANI, ORANI-G contains no theory of labour supply. Users of the model have the option of setting employment exogenously, with market-clearing wage rates determined endogenously, or setting wage rates (real or nominal) exogenously, allowing employment to be demand determined.

In Excerpt 32, equation E_x1lab_i computes changes in the aggregate demand for labour of each skill. Equation E_p1lab is a wage setting equation. In the standard ORANI short-run closure, the 'f1lab' variables are exogenous, so that all wages are indexed to the CPI. Then, if shocked, the 'f1lab' variables allow for deviations in the growth of some or all wages relative to the growth of the CPI. This short-run labour market closure was originally devised to reflect the centralised wage-fixing mechanisms that used to operate in Australia. However, it has proven popular in quite different contexts. It assumes that labour is mobile between industries, and that supply of each skill type is elastic.

As a variant on the standard shortrun closure, the average nominal wage, p1lab_io, may be fixed, while endogenizing the overall wage shifter, f1lab_io. The effect will be to fix all the p1lab, giving the model a Keynesian flavour.

The typical long-run closure sets employ_i (aggregate employment: wage bill weights) exogenous, while endogenizing the overall wage shifter, f1lab_io. The other 'f1lab' variables remain exogenous, reflecting fixed wage relativities. This assumes that labour is mobile between industries *and* occupations.

These labour-market modelling decisions are usually made at an economy-wide level, but could be applied individually and perhaps differentially to different industries or types of labour. For example, we could exogenize the supply of skilled workers and the wages of unskilled workers. Or, we could exogenize employment in agriculture and wages in other sectors[19].

In the standard long-run and short-run closures, wage relativities are fixed, so firms do not substitute between labour of different types. Thus the values of SIGMA1LAB, the CES substitution elasticity between skill types, do not affect simulation results. This is handy for the modeller who is agnostic about those values (econometric evidence is scant). The more exotic labour market closures, which do allow wage relativities to change, focus attention on the values assumed for SIGMA1LAB.

```
! Excerpt 32 of TABLO input file: !
! Labour market !

Variable
 (all,i,IND)(all,o,OCC) f1lab(i,o) # Wage shift variable #;
            (all,o,OCC) f1lab_i(o) # Occupation-specific wage shifter #;
            (all,o,OCC) x1lab_i(o) # Employment by occupation #;
 (all,i,IND)            f1lab_o(i) # Industry-specific wage shifter #;
                        f1lab_io   # Overall wage shifter #;

Coefficient (all,o,OCC) V1LAB_I(o) # Total wages, occupation o #;
Formula     (all,o,OCC) V1LAB_I(o) = sum{i,IND, V1LAB(i,o)};
Equation
 E_x1lab_i # Demand equals supply for labour of each skill #
  (all,o,OCC) V1LAB_I(o)*x1lab_i(o) = sum{i,IND, V1LAB(i,o)*x1lab(i,o)};

 E_p1lab   # Flexible setting of money wages #
  (all,i,IND)(all,o,OCC)
    p1lab(i,o)= p3tot + f1lab_io + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);

Variable (all,o,OCC) p1lab_i(o) # Average wage of occupation #;
Equation E_p1lab_i # Average wage of occupation #
  (all,o,OCC) V1LAB_I(o)*p1lab_i(o) = sum{i,IND, V1LAB(i,o)*p1lab(i,o)};
```

4.28. Miscellaneous equations

Equation E_p1oct in Excerpt 33 allows for indexation of the unit price of 'other costs' to the CPI. The variable f1oct(i) can be interpreted as the percentage change in the real price of 'other costs' to industry i.

[19] The TABLO input file contains optional code, not shown here, to implement upward-sloping labour supply schedules.

Equation E_f3tot implements a simple, optional, consumption function. If f3tot is exogenous, the equation links household spending to nominal GDP. Otherwise, there is no effect on the rest of the system, since the variable f3tot appears nowhere else.

The next two equations define two vector variables, p0dom and p0imp, which are simply equal to the corresponding columns of the basic price matrix, p0. They are included to facilitate the viewing of simulation results: in that situation, vectors are often more convenient to work with than are matrices.

The equations described thus far define the main part of ORANI-G. The remaining excerpts of the TABLO input file contain supplementary material which does not directly affect simulation results.

```
! Excerpt 33 of TABLO input file: !
! Miscellaneous equations !

Variable (all,i,IND) f1oct(i)# Shift in price of "other cost" tickets #;
Equation E_p1oct # Indexing of prices of "other cost" tickets #
 (all,i,IND) p1oct(i) = p3tot + f1oct(i);   ! assumes full indexation !

Variable f3tot # Ratio, consumption/ GDP #;
Equation E_f3tot # Consumption function #
 w3tot = w0gdpexp + f3tot;

! Map between vector and matrix forms of basic price variables !
Variable
 (all,c,COM)  p0imp(c) # Basic price of imported goods = p0(c,"imp") #;
Equation E_p0dom  # Basic price of domestic goods = p0(c,"dom") #
 (all,c,COM) p0dom(c) = p0(c,"dom");
Equation E_p0imp  # Basic price of imported goods = p0(c,"imp") #
 (all,c,COM) p0imp(c) = p0(c,"imp");
```

4.29. Adding variables for explaining results

Part of the ORANI tradition is that simulation results, although voluminous, must all be capable of verbal explanation based on model equations and data. It is customary to examine and present results in great detail. The aim is to dispel any tendency to treat the model as a black box. These detailed analyses sometimes yield theoretical insights; for example, we may find that some mechanism which we thought to be of minor significance exerts a dominant force in certain sectors. More often we discover errors—either in the data or in the model equations. Inappropriate theory may also lead to implausible results.

Results analysis, then, is an indispensable (but laborious) part of quality control for an economic model. To make it less painful, we often add equations and variables merely to help explain results. The next two excerpts are examples of this type of addition.

4.30. Sales decomposition

The sales decomposition, implemented in Excerpt 34, breaks down the percentage change in the total sales of each commodity into various intermediate and final demand categories. This would be useful, for example, if we wondered whether an increase in motor vehicle output was due to increases in either investment or household demand.

To decompose a percentage change in this way (i.e., find parts which add up to the whole), we have to perform some arithmetical manipulations. Suppose we have a variable X which is the sum of 2 parts:

$$X = A + B \qquad \text{or} \qquad PX = PA + PB \text{ (where P is a common price)} \tag{35}$$

then, for small percentage changes, we can write:

$$x = \text{conta} + \text{contb} \qquad \text{where conta} = (PA/PX)a \quad \text{and} \quad \text{contb} = (PB/PX)b \tag{36}$$

We call conta and contb the *contributions* of A and B to the percentage change in X.

For larger changes, which require a multistep computation, equation (36) would result in values for conta and contb which did not quite add up to the total percentage change in X[20]. To avoid this, it is useful to specify both conta and contb as ordinary change variables and to define a new ordinary change variable,

[20] The reason is that during a multistep computation percentage changes are compounded, whilst ordinary changes are added.

q, in such a way that the final result for q (after results for several computational steps have been acccumulated) is identical to that for x. This leads to the small change equation:

$X^0q = Xx$ where X^0 is the initial value of X, (37)

and to the revised decomposition:

q = conta+ contb (38)

where conta = $(PA/PX^0)a$ and contb = $(PB/PX^0)b$ (39)

In Excerpt 34, INITSALES is the *initial quantity* of SALES *measured in current prices*, analogous to PX^0 above. The last, Total, column of the SalesDecomp variable is the sum of the preceding 7 and should be identical to x0com(c), the percentage change in commodity output. Each of the first 7 columns shows how some demand category contributed to x0com. The delSale variable, calculated earlier, contains the ordinary changes in quantities, measured in current prices.

```
! Excerpt 34 of TABLO input file: !
! Decomposition of sales change by destination !

Coefficient
 (all,c,COM) INITSALES(c) # Initial volume of SALES at current prices #;
Formula
 (initial) (all,c,COM) INITSALES(c) = SALES(c);
Update (all,c,COM) INITSALES(c) = p0com(c);
Set DESTPLUS # Sale Categories #
 (Interm, Invest, HouseH, Export, GovGE, Stocks, Margins, Total);
Subset DEST is subset of DESTPLUS;
Variable (change)
  (all,c,COM)(all,d,DESTPLUS) SalesDecomp(c,d) # Sales decomposition #;
Equation
 E_SalesDecompA
(all,c,COM)(all,d,DEST) INITSALES(c)*SalesDecomp(c,d) = 100*delSale(c,"dom",d);
 E_SalesDecompB
 (all,c,COM) SalesDecomp(c,"Total")= sum{d,DEST, SalesDecomp(c,d)};
```

4.31. The Fan decomposition

Suppose our simulation predicts an increase in domestic production of Textiles. This could be due to three causes:

- the local market effect: an increase in local usage of Textiles, whether domestically-produced or imported;
- the export effect: an increase in exports of Textiles; or
- the domestic share effect: a shift in local usage of Textiles, from imported to domestically-produced.

Very often these 3 effects will work in different directions; for example, a increase in foreign demand might pull local producers up the supply curve, so increasing the domestic price and facilitating import penetration. The decomposition of Fan[21] aims to show the relative magnitude of these 3 contributions to output change.

Excerpt 35 starts by defining x0loc, the percentage change in local sales from both sources. Equation E_fandecompA says that this percentage, weighted by the value of local domestic sales, is the local market component of the percentage change in domestic production. Similarly, equation E_fandecompB defines the export component. In these equations INITSALES corresponds to the term PX^0 in equation (39): it is the initial value of sales, updated only by the change in price. Equation E_fandecompC defines the domestic share component as a residual[22]. Finally, equation E_fandecompD corresponds to equation (37).

[21] Named after Fan Ming-Tai of the Academy of Social Sciences, Beijing; their PRCGEM is one of the most elaborate versions of ORANI-G.

[22] No interactive term is concealed in the residual. Because these decompositions are specified in small change terms, the changes due to each part add up to the change in the whole. To convince yourself, retrace the example starting at equation (35) with the multiplicative form X = AB, leading to $X^0q = Xa + Xb$, with contribution terms

```
! Excerpt 35 of TABLO input file: !
! Decomposition of Fan !

Set FANCAT # Parts of Fan decomposition #
  (LocalMarket, DomShare, Export, Total);
Variable
(all,c,COM) x0loc(c)  # Real percent change in LOCSALES (dom+imp)  #;
(change)(all,c,COM)(all,f,FANCAT) fandecomp(c,f) # Fan decomposition #;
Coefficient (all,c,COM) LOCSALES(c)  # Total local sales of dom + imp good c #;
Formula     (all,c,COM) LOCSALES(c) = DOMSALES(c) + V0IMP(c);

Equation
 E_x0loc # %Growth in local market #
  (all,c,COM) LOCSALES(c)*x0loc(c) = DOMSALES(c)*x0dom(c) + V0IMP(c)*x0imp(c);

 E_fandecompA # Growth in local market effect #
  (all,c,COM)  INITSALES(c)*fandecomp(c,"LocalMarket") = DOMSALES(c)*x0loc(c);
! The local market effect is the % change in output that would have occurred
if local sales of the domestic product had followed dom+imp sales (x0loc) !

 E_fandecompB # Export effect #
  (all,c,COM) INITSALES(c)*fandecomp(c,"Export") = V4BAS(c)*x4(c);

 E_fandecompC # Import leakage effect - via residual #
  (all,c,COM) fandecomp(c,"Total") = fandecomp(c,"LocalMarket")
     + fandecomp(c,"DomShare") + fandecomp(c,"Export");

 E_fandecompD # Fan total = x0com #
  (all,c,COM) INITSALES(c)*fandecomp(c,"Total") = SALES(c)*x0com(c);
```

4.32. The expenditure side GDP decomposition

Excerpt 36 breaks down changes in real GDP into the contributions of the main expenditure-side aggregates (contGDPexp). This enables us to quickly see how much of the change in real expenditure-side GDP is due, say, to a change in aggregate investment. The mathematics is the same as that of the Sales decomposition in Excerpt 34. For convenience, the contributions of exports and imports are combined into the variable contBOT. Note that contBOT, like each component of contGDPexp, is a *real* contribution: it takes no account of changes in export or import prices. It is the same (apart from units of measurement) as the ΔB variable in the original ORANI model.

(X/X^0)a and (X/X^0)b. However, the cumulative results of these contributions can be defined only as a path integral of the contribution terms computed at each solution step. Hence they are not (quite) invariant to the details of our solution procedure. See also footnote 17.

```
! Excerpt 36 of TABLO input file: !
! GDP decomposition !

Set EXPMAC # Expenditure Aggregates #
 (Consumption, Investment, Government, Stocks, Exports, Imports);
Variable (change) (all,e,EXPMAC)
  contGDPexp(e) # Contributions to real expenditure-side GDP #;
Coefficient INITGDP # Initial real GDP at current prices #;
Formula (initial) INITGDP = V0GDPEXP;
Update INITGDP = p0gdpexp;
Equation
  E_contGDPexpA  INITGDP*contGDPexp("Consumption") = V3TOT*x3tot;
  E_contGDPexpB  INITGDP*contGDPexp("Investment")  = V2TOT_I*x2tot_i;
  E_contGDPexpC  INITGDP*contGDPexp("Government")  = V5TOT*x5tot;
  E_contGDPexpD  INITGDP*contGDPexp("Stocks")      = V6TOT*x6tot;
  E_contGDPexpE  INITGDP*contGDPexp("Exports")     = V4TOT*x4tot;
  E_contGDPexpF  INITGDP*contGDPexp("Imports")     = - V0CIF_C*x0cif_c;

Variable (change) contBOT # Contribution of BOT to real expenditure-side GDP #;
Equation  E_contBOT contBOT =  contGDPexp("Exports") + contGDPexp("Imports");

Variable x0gdpinc # Decomposition of real GDP from income side #;
Equation E_x0gdpinc
  # Real GDP from the income side #
x0gdpinc = [1/V0GDPINC]*[
! primary factor contributions !
V1LAB_IO*employ_i + V1CAP_I*x1cap_i + V1LND_I*x1lnd_i
! indirect tax contributions !
  + sum{i,IND, V1OCT(i)*x1oct(i)}
  + sum{i,IND, V1PTX(i)*x1tot(i)}
  + sum{c,COM, V0TAR(c)*x0imp(c)}
  + sum{c,COM,sum{s,SRC, sum{i,IND, V1TAX(c,s,i)*x1(c,s,i)}}}
  + sum{c,COM,sum{s,SRC, sum{i,IND, V2TAX(c,s,i)*x2(c,s,i)}}}
  + sum{c,COM,sum{s,SRC, V3TAX(c,s)*x3(c,s)}}
  + sum{c,COM, V4TAX(c)*x4(c)}
  + sum{c,COM,sum{s,SRC, V5TAX(c,s)*x5(c,s)}}
! technical change contributions !
  - sum{c,COM,sum{s,SRC, sum{i,IND, V1PUR(c,s,i)*[a1(c,s,i)+a1_s(c,i)]}}}
  - sum{c,COM,sum{s,SRC, sum{i,IND, V2PUR(c,s,i)*[a2(c,s,i)+a2_s(c,i)]}}}
  - sum{i,IND, V1LAB_O(i)*a1lab_o(i)}
  - sum{i,IND, V1CAP(i)*a1cap(i)}
  - sum{i,IND, V1LND(i)*a1lnd(i)}
  - sum{i,IND, V1OCT(i)*a1oct(i)}
  - sum{i,IND, V1PRIM(i)*a1prim(i)}
  - sum{c,COM,sum{s,SRC,sum{i,IND,sum{m,MAR, V1MAR(c,s,i,m)*a1mar(c,s,i,m)}}}}
  - sum{c,COM,sum{s,SRC,sum{i,IND,sum{m,MAR, V2MAR(c,s,i,m)*a2mar(c,s,i,m)}}}}
  - sum{c,COM,sum{s,SRC,sum{m,MAR, V3MAR(c,s,m)*a3mar(c,s,m)}}}
  - sum{c,COM,sum{m,MAR, V4MAR(c,m)*a4mar(c,m)}}
  - sum{c,COM,sum{s,SRC,sum{m,MAR, V5MAR(c,s,m)*a5mar(c,s,m)}}}
  - sum{i,IND, V2TOT(i)*a2tot(i)}
  - sum{i,IND, V1CST(i)*a1tot(i)}];
```

The second part of Excerpt 36 breaks down changes in real GDP from the income side: into the contributions due to primary factor usage, indirect taxes, and technological change. If primary factor endowments and technology are fixed, the indirect tax terms may be identified with changes in allocative efficiency.

4.33. Checking the data

A model rendered in the TABLO language is a type of computer program, and like other computer programs tends to contain errors. We employ a number of strategies to prevent errors and to make errors apparent. One strategy is to check all conditions which the initial data must satisfy. This is done in Excerpt 37. The conditions are:

- The row sums of the MAKE matrix must equal the row sums of the BAS and MAR rows of Figure 4. That is, the output of domestically produced commodities must equal the total of the demands for them.
- The column sums of the MAKE matrix must equal the sum of the first, producers', column of Figure 4. That is, the value of output by each industry must equal the total of production costs.
- The average value of the household expenditure elasticities, EPS, should be one. The average should be computed using the expenditure weights, V3PUR_S.

To check these conditions, the items PURE_PROFITS, LOST_GOODS, and EPSTOT are stored on the SUMMARY file. Their values should be near to zero (or one, for EPSTOT).

The Assertion statements which come next enforce the above rules. If the specified condition is not met during some simulation, GEMPACK will stop with an error message indicating which condition is not satisfied. The first two Assertions are checked before every stage of a multi-step simulation. The last one, for EPSTOT, should be true before and after (but not necessarily *during*) a simulation.

It should be emphasized that the validity of percentage change equations depends on the validity of the data from which the equation coefficients are calculated. The GEMPACK solution method must start from a database which is consistent, in the levels, with all the equations.

There are other formal tests which can reveal errors in model formulation. These are set out in Appendix I.

```
! Excerpt 37 of TABLO input file: !
! Check identities !

Coefficient                     ! coefficients for checking !
 (all,i,IND) DIFFIND(i)  # COSTS-MAKE_C : should be zero #;
 (all,c,COM) DIFFCOM(c)  # SALES-MAKE_I : should be zero #;
             EPSTOT      # Average Engel elasticity: should = 1 #;
Formula
 (all,i,IND) DIFFIND(i)  = V1TOT(i) - MAKE_C(i);
 (all,c,COM) DIFFCOM(c)  = SALES(c) - MAKE_I(c);
             EPSTOT      = sum{c,COM, S3_S(c)*EPS(c)};

Write ! we file these numbers BEFORE the assertions below !
 DIFFIND to file SUMMARY header "DIND";
 DIFFCOM to file SUMMARY header "DCOM";
 EPSTOT  to file SUMMARY header "ETOT";

Assertion ! if below not true, program will stop with message !
 # DIFFIND = V1TOT-MAKE_C = tiny # (all,i,IND) ABS[DIFFIND(i)/V1TOT(i)] <0.001;
 # DIFFCOM = SALES-MAKE_I = tiny # (all,c,COM) ABS[DIFFCOM(c)/SALES(c)] <0.001;
 (initial) # Average Engel elasticity = 1 #  ABS[1-EPSTOT] <0.001;
```

4.34. Summarizing the data

The next few Excerpts collect together various summaries of the data and store these on file in a form that is convenient for later viewing. These summaries are useful for checking the plausibility of data and for explaining simulation results. Excerpt 38 groups into vectors the various components of, first, GDP from the expenditure side; second, GDP from the income side; and third, the components of total indirect taxes[23].

[23] GEMPACK stores data in its own, binary, format. A Windows program, ViewHAR, is normally used for viewing or modifying these so-called HAR files. The data matrices created here are designed to be convenient for

```
! Excerpt 38 of TABLO input file: !
! Summary: components of GDP from income and expenditure sides !

Coefficient (all,e,EXPMAC)  EXPGDP(e) # Expenditure Aggregates #;
Formula
 EXPGDP("Consumption") = V3TOT;
 EXPGDP("Investment")  = V2TOT_I;
 EXPGDP("Government")  = V5TOT;
 EXPGDP("Stocks")      = V6TOT;
 EXPGDP("Exports")     = V4TOT;
 EXPGDP("Imports")     = -V0CIF_C;
Write EXPGDP to file SUMMARY header "EMAC";

Set INCMAC # Income Aggregates #
 (Land, Labour, Capital,  IndirectTax);
Coefficient (all,i,INCMAC)  INCGDP(i) # Income Aggregates #;
Formula
 INCGDP("Land")        = V1LND_I;
 INCGDP("Labour")      = V1LAB_IO;
 INCGDP("Capital")     = V1CAP_I;
 INCGDP("IndirectTax") = V0TAX_CSI;
Write INCGDP to file SUMMARY header "IMAC";

Set TAXMAC # Tax Aggregates #
  (Intermediate,Investment,Consumption,Exports,Government,OCT,ProdTax,Tariff);
Coefficient (all,t,TAXMAC)  TAX(t) # Tax Aggregates #;
Formula
 TAX("Intermediate") = V1TAX_CSI;
 TAX("Investment")   = V2TAX_CSI;
 TAX("Consumption")  = V3TAX_CS;
 TAX("Exports")      = V4TAX_C;
 TAX("Government")   = V5TAX_CS;
 TAX("OCT")          = V1OCT_I;
 TAX("ProdTax")      = V1PTX_I;
 TAX("Tariff")       = V0TAR_C;
Write TAX to file SUMMARY header "TMAC";
```

Excerpt 39 forms a matrix showing the main parts of production cost for each industry.

```
! Excerpt 39 of TABLO input file: !
! Summary: matrix of industry costs !

Set COSTCAT # Cost Categories #
 (IntDom, IntImp, Margin, ComTax, Lab, Cap, Lnd, ProdTax, OCT);
Coefficient (all,i,IND)(all,co,COSTCAT) COSTMAT(i,co) # Cost Matrix #;
Formula
 (all,i,IND) COSTMAT(i,"IntDom")  = sum{c,COM, V1BAS(c,"dom",i)};
 (all,i,IND) COSTMAT(i,"IntImp")  = sum{c,COM, V1BAS(c,"imp",i)};
 (all,i,IND) COSTMAT(i,"Margin")  =
                     sum{c,COM, sum{s,SRC, sum{m,MAR, V1MAR(c,s,i,m)}}};
 (all,i,IND) COSTMAT(i,"ComTax")  = sum{c,COM, sum{s,SRC, V1TAX(c,s,i)}};
 (all,i,IND) COSTMAT(i,"Lab")     = V1LAB_O(i);
 (all,i,IND) COSTMAT(i,"Cap")     = V1CAP(i);
 (all,i,IND) COSTMAT(i,"Lnd")     = V1LND(i);
 (all,i,IND) COSTMAT(i,"ProdTax") = V1PTX(i);
 (all,i,IND) COSTMAT(i,"OCT")     = V1OCT(i);
Write COSTMAT to file SUMMARY header "CSTM";
```

examining with ViewHAR. ViewHAR automatically calculates and displays subtotals, so that total GDP, for example, does not need to be included in the summary vectors defined here.

Excerpt 40 calculates for each main destination, the basic, margin, and commodity tax components of purchases by commodity and source.

```
! Excerpt 40 of TABLO input file: !
! Summary: basic, margins and taxes !
Set
SALECAT2 # SALE Categories # (Interm, Invest, HouseH, Export, GovGE, Stocks);
FLOWTYPE # Type of flow # (Basic, Margin, TAX);
Coefficient
(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2) SALEMAT2(c,f,s,sa)
    # Basic, margin and tax components of purchasers' values #;
Formula
(all,c,COM)(all,f,FLOWTYPE)(all,s,SRC)(all,sa,SALECAT2) SALEMAT2(c,f,s,sa)=0;
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Interm") = sum{i,IND,V1BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"  ,s,"Interm") = sum{i,IND,V1TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"Interm") =
                                      sum{i,IND, sum{m,MAR, V1MAR(c,s,i,m)}};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Invest") = sum{i,IND,V2BAS(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"  ,s,"Invest") = sum{i,IND,V2TAX(c,s,i)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"Invest") =
                                      sum{i,IND, sum{m,MAR, V2MAR(c,s,i,m)}};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"HouseH") = V3BAS(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"  ,s,"HouseH") = V3TAX(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"HouseH")= sum{m,MAR,V3MAR(c,s,m)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"GovGE") = V5BAS(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Tax"  ,s,"GovGE") = V5TAX(c,s);
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Margin",s,"GovGE")= sum{m,MAR,V5MAR(c,s,m)};
(all,c,COM)            SALEMAT2(c,"Basic","dom","Export") = V4BAS(c);
(all,c,COM)            SALEMAT2(c,"Tax"  ,"dom","Export") = V4TAX(c);
(all,c,COM)          SALEMAT2(c,"Margin","dom","Export")= sum{m,MAR,V4MAR(c,m)};
(all,c,COM)(all,s,SRC) SALEMAT2(c,"Basic",s,"Stocks") = V6BAS(c,s);
Write SALEMAT2 to file SUMMARY header "MKUP";
```

4.35. Import shares and short-run supply elasticities

Excerpt 41 computes and stores 2 more items which help explain results. The higher is the import share IMPSHR for some commodity, the more vulnerable is the associated local industry to import competition.

Short-run simulation results are often coloured by the effects of inelastic supply schedules for capital-intensive industries. We compute and store the short-run supply elasticity SUPPLYELAST to help identify such industries. The formula used is derived in Appendix J. The closely-related primary factor shares can be seen from the FACTOR matrix (using the *row shares* feature of the GEMPACK program ViewHAR).

```
! Excerpt 41 of TABLO input file: !
! Import shares and short-run supply elasticities !

Coefficient  (all,c,COM) IMPSHR(c) # Share of imports in local market #;
Formula      (all,c,COM) IMPSHR(c) = V0IMP(c)/[TINY+DOMSALES(c)+V0IMP(c)];
Write IMPSHR to file SUMMARY header "MSHR";

Coefficient (all,i,IND) SUPPLYELAST(i) # Short-run supply elasticity #;
Zerodivide default 999;
Zerodivide (nonzero_by_zero) default 999;
Formula     (all,i,IND) SUPPLYELAST(i) =
    SIGMA1PRIM(i)*V1LAB_O(i)*V1TOT(i)/[V1PRIM(i)*{V1CAP(i)+V1LND(i)}];
Zerodivide off;
Zerodivide (nonzero_by_zero) off;
Write SUPPLYELAST to file SUMMARY header "SRSE";
```

```
Set FAC # Primary Factors #  (Lab, Cap, Lnd);
Coefficient (all,i,IND)(all,f,FAC) FACTOR(i,f) # Primary Factor Costs #;
Formula
 (all,i,IND) FACTOR(i,"Lab")     = V1LAB_O(i);
 (all,i,IND) FACTOR(i,"Cap")     = V1CAP(i);
 (all,i,IND) FACTOR(i,"Lnd")     = V1LND(i);
Write FACTOR to file SUMMARY header "FACT";
```

4.36. Storing Data for Other Computations

It is often useful to extract data from the model for other calculations. For example, we might wish to combine levels data with change results in our presentation of simulation results. Another important use of such data is in aggregating the model database. It is wise to prepare the initial model database at the highest level of disaggregation supported by available Input-Output tables. This large database can be aggregated later, if desired, to a smaller number of sectors. A specialized program, AggHAR, may ease the aggregation task.

For flows data, each item in the aggregated database is simply the sum of corresponding sectors in the original database. Parameters, however, can not normally be added together. Instead, aggregated parameters are normally weighted averages of the original parameters. The purpose of Excerpt 42 is store such weights on a file. For example, the parameter SIGMA2 (Armington elasticity between domestic and imported commodities used for investment) could be aggregated using the weight vector V2PUR_SI. Information about which weight to use for each elasticity is conveyed to AggHAR by the WAGGSET vector of strings. For example, the first element of WAGGSET, “SCET@@@@1TOT” indicates that the MAKE CET elasticities stored at header SCET on the ORANIG input data file should be aggregated using the industry output values stored at header 1TOT on the summary file[24].

```
! Excerpt 42 of TABLO input file: !
! Weight vectors for use in aggregation and other calculations !

Coefficient (all,c,COM) V1PUR_SI(c)  # Dom+imp intermediate purch. value #;
            (all,c,COM) V2PUR_SI(c)  # Dom+imp investment purch. value #;
            (all,c,COM) V5PUR_S(c)   # Dom+imp government purch. value #;
            (all,c,COM) V6BAS_S(c)   # Dom+imp inventories #;
Formula     (all,c,COM) V1PUR_SI(c)  = sum{i,IND, V1PUR_S(c,i)};
            (all,c,COM) V2PUR_SI(c)  = sum{i,IND, V2PUR_S(c,i)};
            (all,c,COM) V5PUR_S(c)   = sum{s,SRC, V5PUR(c,s)};
            (all,c,COM) V6BAS_S(c)   = sum{s,SRC, V6BAS(c,s)};

Write                                   ! weight to aggregate...... !
 V1TOT    to file SUMMARY header "1TOT";!MAKE CET elasticities at SCET !
 V4PUR    to file SUMMARY header "4PUR";!export elasticities at header P018!
 V1LAB_O  to file SUMMARY header "LAB1";!CES inter-skill elasticities at P018!
 V1PRIM   to file SUMMARY header "VLAD";!CES primary-factor elasts at P018!
 V1PUR_SI to file SUMMARY header "1PUR";!Armington elasticities at 1ARM !
 V2PUR_SI to file SUMMARY header "2PUR";!Armington elasticities at 2ARM !
 V3PUR_S  to file SUMMARY header "3PUR";!Armington elasticities at 2ARM !

Set WAGGSET # Instructions to AGGHAR for weighted aggregation of parameters # (
    SCET@@@@1TOT,
    P018@@@@4PUR,
    ITEX@@@@4PUR,
    XPEL@@@@3PUR,
    P028@@@@VLAD,
    SLAB@@@@LAB1,
    xx1ARM@@1PUR,  ! leading "xx" is ignored by AGGHAR !
    xx2ARM@@2PUR,
    xx3ARM@@3PUR);
Write (set) WAGGSET to file SUMMARY header "WAGG";
```

[24] The set WAGGSET is used to work around a GEMPACK limitation: the only way to write lists of strings (such as headers) to a file is to write them as set elements. Furthermore, set elements may not begin with a digit.

```
! Other useful values !
Coefficient  (all,c,COM) TARFRATE(c) # Ad valorem tariff rate #;
Formula      (all,c,COM) TARFRATE(c) = V0TAR(c)/[TINY+V0CIF(c)];
Write
  TARFRATE to file SUMMARY header "TRAT";
  V0TAR    to file SUMMARY header "0TAR";
  V0CIF    to file SUMMARY header "0CIF";
  V0IMP    to file SUMMARY header "0IMP";
  MAKE     to file SUMMARY header "MAKE";
  V1CAP    to file SUMMARY header "1CAP";
  V6BAS_S  to file SUMMARY header "6BSS";
  V2TOT    to file SUMMARY header "2TOT";
  V5PUR_S  to file SUMMARY header "5PUR";
```

The remainder of the excerpt simply files some other values that have proved useful.

5. A Top-down Regional Extension

The final excerpts of the TABLO Input file are not shown here: they implement an optional extension to ORANI-G which enables national quantity results to be broken down according to regions. The term “top-down” indicates that, in principle, we could compute all the national results first, and then compute the regional results. This approach requires less data (and computing resources) than the alternative “bottom-up” approach of constructing models like ORANI-G for each region, linked by a matrix of inter-regional trade.

The “top-down” approach is fully described in Chapter 6 of DPSV (1982). In brief, its database requires that we split each (user) column in Figure 4 into R columns (for R regions). To do this, we assume that each industry uses the same technology in each region, so that the main additional data needed is a matrix showing how industry output is distributed between regions. The remaining, final demand, columns of Figure 4, are also split by region, either by using available data, or by invoking default assumptions (eg, that household budget shares are the same across regions). A full matrix of regional trade in each commodity is not needed.

The regional equations assume that industry inputs follow the rule:

$$X_{ijr}/X_{ij} = Z_{jr}/Z_j$$

where X_{ijr} is the use of input i by sector j in region r, Z_{jr} is output of sector j in region r, and X_{ij} and Z_j are the corresponding national equivalents. Household consumption of each good is given by a linear expenditure sytem (as at the national level), tied to regional labour income.

The regional industries are divided into 2 groups: *national* and *local* industries. National industries produce commodities that are freely traded: output of each such industry is assumed to move with the corresponding x1tot (national output). Local industries produce commodities (mainly services) that are scarcely traded across regional borders; output of each such regional industry is assumed to move in line with the local demand for the corresponding commodity[25]. This assumption produces local multiplier effects: those regions that specialize in expanding national industries benefit also from increased demands for local commodities.

The “top-down” regional equation system translates national simulation results into estimates of regional income and employment which are of great interest to to policy-makers. It can also be used to estimate the effects of region-specific demand shocks (such as increased investment or government spending). However, it contains no theory of regional variation in prices, and so is less capable of modelling region-specific supply effects (such as local labour shortages, or efficiency increases in one region only).

[25] The assumption is that for local industries, the MAKE matrix is pretty well diagonal. ORANIG-FR is a version of ORANI-G that copes with multiproduction for local industries; it is available from the ORANI-G web page.

6. Closing the Model

The model specified in Section 4 has more variables than equations. To *close* the model, we choose which variables are to be exogenous and which endogenous[26]. The number of endogenous variables must equal the number of equations. For a complex AGE model, it may be surprisingly difficult to find a sensible closure which satisfies this accounting restriction.

Table 2 allows us to attack the task systematically. It arranges the model's 132 equations and 179 variables according to their dimensions. Equations broken into parts, such as E_x4A (covering individual export commodities) and E_x4B (covering collective exports) are treated as one equation block for this purpose. The first column lists the various combinations of set indices that occur in the model. The second column shows how many variables have these combinations. For example, 10 variables are dimensioned by COM, SRC and IND. The third column counts equations in the same way. For example, there are 56 macro, i.e., scalar, equations.

In most straightforward closures of the model, the correspondence between equations and endogenous variables applies for each row of the table, as well as in total. The fourth column shows the difference between the preceding two, i.e, it shows how many variables of that size would normally be exogenous.

Table 2 Tally of Variables and Equations

1 Dimension	2 Variable Count	3 Equation Count	4 Exogenous Count	5 List of unexplained variables (Mechanical closure)
MACRO	71	56	15	f1lab_io f4p_ntrad phi f4q_ntrad q f4tax_trad f4tax_ntrad *f5tot2* capslack *invslack* *w3lux* f1tax_csi f2tax_csi f3tax_cs f5tax_cs
COM	25	19	6	f0tax_s t0imp a3_s f4p f4q pf0cif
COM∗IND	7	5	2	a1_s a2_s
COM∗MAR	2	1	1	a4mar
COM∗SRC	14	11	3	f5 a3 *fx6*
COM∗SRC∗IND	10	8	2	a1 a2
COM∗SRC∗IND∗MAR	4	2	2	a1mar a2mar
COM∗SRC∗MAR	4	2	2	a3mar a5mar
IND	34	21	13	a1cap a1lab_o a1lnd a1oct a1prim a1tot f1lab_o f1oct *x2tot* x1lnd a2tot x1cap delPTXRate
IND∗OCC	3	2	1	f1lab
OCC	2	1	1	f1lab_l
COM∗SRC∗DEST	1	1	0	
COM∗DESTPLUS	1	1	0	
COM*FANCAT	1	1	0	
EXPMAC	1	1	0	
TOTAL	179	132	47	

In constructing the TABLO Input file, we chose to name each equation after the variable it seemed to explain or determine[27]. Some variables had no equation named after them—they appear in the fifth column. Those variables are promising candidates for exogeneity. They include:

[26] In GEMPACK parlance, a *closure* is a list of exogenous variables.

[27] If equations are named after variables, the GEMPACK program TABmate will automatically perform the analysis summarized in Table 2. The equation naming system is slightly arbitrary. For example, where a supply equation and a demand equation jointly determine price and quantity, we could say that the supply equation explained the price variable, and that the demand equation explained the quantity variable. Or we could pair supply with quantity and demand with price. It would not matter which way we chose: the two equations between them endogenize both price and quantity.

- technical change variables, mostly beginning with the letter 'a';
- tax rate variables, mostly beginning with 't';
- shift variables, mostly beginning with 'f';
- land endowments x1lnd, and the number of households q;
- industry capital stocks, x1cap;
- foreign prices, pf0cif, and the investment slack variable, invslack;
- inventory to sales ratios, fx6;
- the exchange rate phi, which could serve as numeraire; and
- w3lux (household above-subsistence expenditure).

Although Column 5 contains a perfectly valid exogenous set for the model, we choose, for typical shortrun simulations, to adopt a slightly different closure. The macro variables italicised in Column 5 are *swapped* as follows.

- We exogenize x5tot instead of f5tot2, so disconnecting government from household consumption.
- We exogenize x2tot_i (aggregate investment), rather than invslack.
- We exogenize x3tot (household consumption), rather than w3lux.
- We exogenize delx6 (inventory changes), rather than fx6.
- We exogenize realwage (average real wage), rather than f1lab_io (overall wage shift).
- For each industry, we exogenize the corresponding element of either finv1 or finv2 in place of the x2tot vector.

These changes give rise to the closure shown in Table 3 (swapped variables are italicized).

Table 3 The ORANI short-run closure

Exogenous variables constraining real GDP from the supply side	
x1cap x1lnd	industry-specific endowments of capital and land
capslack	allows industry-specific rates of return
a1cap a1lab_o a1lnd a1prim a1tot a2tot	all technological change
realwage	average real wage
Exogenous settings of real GDP from the expenditure side	
x3tot	aggregate real private consumption expenditure
x2tot_i	aggregate real investment expenditure
x5tot	aggregate real government expenditure
f5	distribution of government demands
delx6	real demands for inventories by commodity
Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes	
pf0cif	foreign prices of imports
f4p f4q	individual exports
f4p_ntrad f4q_ntrad	collective exports
All tax rates are exogenous	
delPTXRATE f0tax_s f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp f4tax_trad f4tax_ntrad f1oct	
Distribution of investment between industries	
finv1(selected industries)	investment related to profits
finv2(the rest)	investment follows aggregate investment
Number of households and their consumption preferences are exogenous	
q	number of households
a3_s	household tastes
Numeraire assumption	
phi	nominal exchange rate

A choice of closure reflects two different types of consideration. First, the closure is associated with our idea of the simulation *timescale*, that is, the period of time which would be needed for economic vari-

To name some other equations, we must have a closure in mind. For example, the factor demand equations of Excerpt 8 are named E_x1lab_o, E_p1cap, and E_p1lnd. Thus the equation names suggest that the labour demand equation determines employment while the other two equations determine the unit rentals of capital and land. That naming choice reflects the standard ORANI short-run closure, which fixes industry use of capital and land.

ables to adjust to a new equilibrium. The timescale assumption affects the way we model factor markets. For example, in a shortrun simulation we normally hold capital stocks fixed, as in Table 3. The idea is that capital stocks take some time to install—too long for them to be affected, in the short run, by the shocks. Shortrun closures often also allow for rigidities in the labour market: in this case by holding real wages fixed. The length of the 'short' run is not explicit, but is usually thought to be between 1 and 3 years.

Second, the choice of closure is affected by the needs of a particular simulation and by our view of the most appropriate assumption for those variables that the model does not explain. For example, ORANI-G provides little theory to explain the size and composition of absorption. In Table 3 the major expenditure-side aggregates are simply held fixed. Therefore, if some shock reduced GDP, the balance of trade (which is endogenous) might move towards deficit, reflecting national dis-saving. We might wish to prevent this by fixing the balance of trade, delB, instead of, say, x3tot. This would allow us to use the endogenous x3tot as a simple index of welfare.

Table 4 A possible long-run closure

Exogenous variables constraining real GDP from the supply side	
gret	*gross sectoral rates of return*
capslack	allows industry-specific rates of return
x1lnd	industry-specific endowments of land
a1cap a1lab_o a1lnd a1prim a1tot a2tot	all technological change
employ_i	*total employment - wage weights*
Exogenous settings of real GDP from the expenditure side	
delB	*balance of trade/GDP*
invslack	*aggregate investment determined by industry specific rules*
f5tot2	*link government demands to total household*
f5	distribution of government demands
delx6	real demands for inventories by commodity
Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes	
pf0cif	foreign prices of imports
f4p f4q	individual exports
f4p_ntrad f4q_ntrad	collective exports
All tax rates are exogenous	
delPTXRATE f0tax_s f1tax_csi f2tax_csi f3tax_cs f5 f5tax_cs t0imp f4tax_trad f4tax_ntrad f1oct	
Distribution of investment between industries	
finv3(selected industries)	*fixed investment/capital ratios*
finv2(the rest)	investment follows aggregate investment
Number of households and their consumption preferences are exogenous	
q	number of households
a3_s	household tastes
Numeraire assumption	
phi	nominal exchange rate

Table 4 shows a possible longrun closure. Differences from the shortrun closure of Table 3 are shown in italics. The main differences are:

- Capital stocks are free to adjust in such a way that fixed rates of return (gret) are maintained. An open capital market is implicitly assumed, since there is no link between capital formation and domestic saving.
- Aggregate employment is fixed and the real wage adjusts. This would be consistent with the idea that both the labour force and the rate of unemployment (NAIRU) are, in the long run, determined by mechanisms outside of the model.
- Household and government expenditure move together, to accomodate a balance of trade constraint: DelB (the balance of trade as a fraction of GDP) is fixed. The idea here is that, in the long run the rest of the world might be reluctant to fund an increased trade deficit. Aggregate investment follows the aggregate capital stock.

Another possible closure, often used for small theoretical models in textbooks of international trade, is the *trade-theoretic* closure. This is almost the same as the long-run closure just described except that aggregate capital x1cap_i is fixed instead of the variable capslack. Rates of return then move in unison to accomodate the x1cap_i constraint. In this closure, capital and labour are both fixed in aggregate but mobile between industries.

It should be emphasized that, particularly in a more complex model, many closures might be used for different purposes. There is not a unique natural or correct closure. On the other hand, every sensible closure must satisfy certain requirements. For example, price variables in the model's equations always appear as price ratios; it is a feature of most neo-classical models that only relative prices matter. Thus, if we have a solution of the model, we can always create another solution just by increasing all local prices by, say, 10%. Therefore, for the overall price level to be determined, there has to be at least one exogenous variable measured in local currency units. This variable—there is normally just one—is called the *numeraire*. In Tables 3 and 4 the exchange rate, phi, is the numeraire. Another popular choice is p3tot, the CPI.

For similar reasons, there is no mechanism in ORANI-G which would determine the total size of the economy. Some quantity variables must be exogenous: these often include primary factor endowments and final demand aggregates.

In summary, ORANI-G lacks theories which explain:

- *Changes in the absolute price level.* We have to exogenously set either the exchange rate or some domestic price index. This setting determines, in an arbitrary way, whether changes in the real exchange rate are manifested either as changes in domestic prices or as changes in the exchange rate. However, results for real variables are unaffected by this decision.
- *Labour supply.* We have to exogenously set either the average wage level (real or nominal) or employment. This setting determines whether a more buoyant labour market is manifested either as higher wages or as greater employment.
- *Changes in the size and composition of absorption.* Either we must set these exogenously or else the trade balance must be fixed while one or more components of absorption adjust. This setting determines whether increased national income appears either as increased absorption, or alternatively as an improved balance of trade.

As well as suggesting a closure, Table 2 allows us to estimate the size of our model. With its 23 commodities, 22 industries, 2 sources, 2 margin goods and 2 occupations, the standard Australian version of ORANI-G has about 25,000 scalar variable elements and 17,000 scalar equations. A typical larger version of ORANI used for policy analysis might have 115 commodities, 113 industries, 2 sources, 9 margin goods and 8 occupations, leading to 1.3 million variables and 0.75 million equations. In its raw form, such a model would be far too big to solve. The next section explains how GEMPACK can condense a model to manageable size.

7. Using GEMPACK to Solve the Model

Figures 12 and 13 show, in simplified form, the main stages in the GEMPACK process. The first and largest task, the specification of the model's equations using the TABLO language, has been described at length in the previous sections. This material is contained in the ORANIG.TAB file (at top left of the figure).

The model as described so far has too many equations and variables for efficient solution. Their numbers are reduced by instructing the TABLO program to:

- omit specified variables from the system. This option is useful for variables which will be exogenous and unshocked (zero percentage change). Normally it allows us to dispense with the bulk of the technical change terms. Of course, the particular selection of omitted variables will alter in accordance with the model simulations to be undertaken.
- substitute out specified variables using specified equations. This results in fewer but more complex equations. Typically we use this method to eliminate multi-dimensional matrix variables which are defined by simple equations. For example, the equation:

```
Equation E_x1_s  # Demands for Commodity Composites #
(All,c,COM)(All,i,IND)  x1_s(c,i) - {a1_s(c,i) + a1tot(i)} = x1tot(i);
```

which appears in Excerpt 10 of the TABLO Input file, can be used to substitute out variable x1_s. In fact the names of the ORANI-G equations are chosen to suggest which variable each equation could eliminate.[28]

The variables for omission and the equation-variable pairs for substitution are listed in a second, instruction, file: ORANIG.STI.

The TABLO program converts the TAB and STI files into a FORTRAN source file, ORANIG.FOR, which contains the model-specific code needed for a solution program.

The Fortran compiler combines ORANIG.FOR with other, general-purpose, code to produce the executable program ORANIG.EXE, which can be used to solve the model specified by the user in the TAB and STI files.

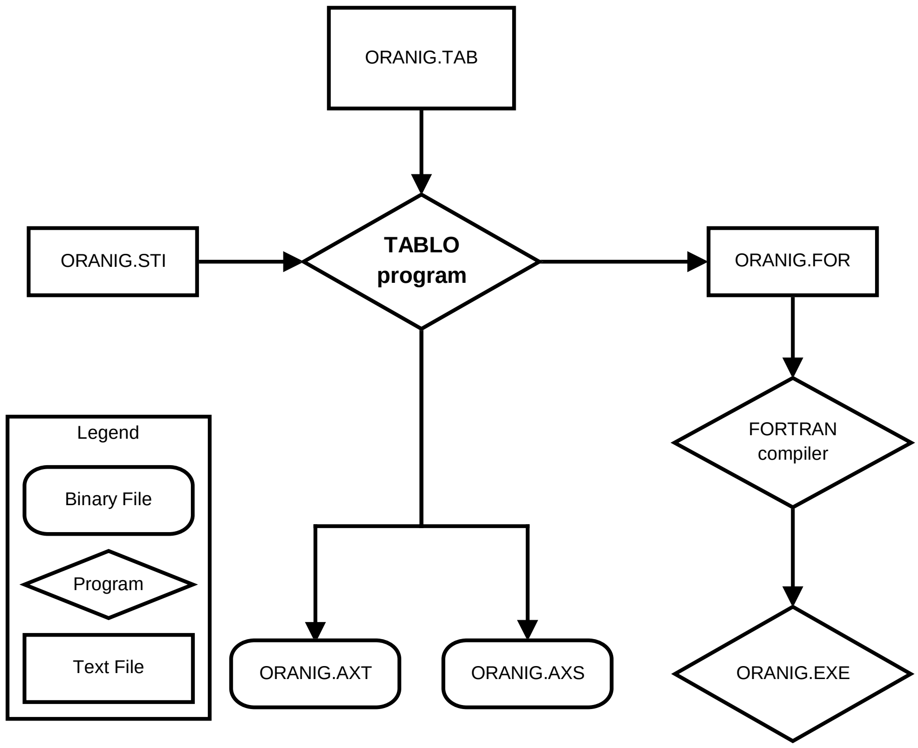

Figure 12. Building a model-specific EXE file

Simulations are conducted using ORANIG.EXE. Its inputs are:

- a data file, containing input-output data and behavioural parameters. This data file contains all necessary information about the initial equilibrium.
- user input from a text (CMF) file, which specifies:
  - (a) which variables are to be exogenous;
  - (b) shocks to some exogenous variables;
  - (c) into how many steps the computation is divided; and
  - (d) the names of input and output files, and other details of the solution process.

Each simulation produces an SL4 (Solution) file. The SL4 file has a binary format: it may be viewed with the non-model-specific Windows program ViewSOL.

---

28 Substituted variables are necessarily endogenous and are not stored in the results file. GEMPACK also allows *back-substituted* variables; these do appear in the results file but use slightly more computing resources.

GEMPACK only allows a variable to be substituted using a single equation of just the same dimensions. For a larger model, it is very important that the model equations and variables are arranged in a way that allows large matrix variables to be substituted or back-substituted.

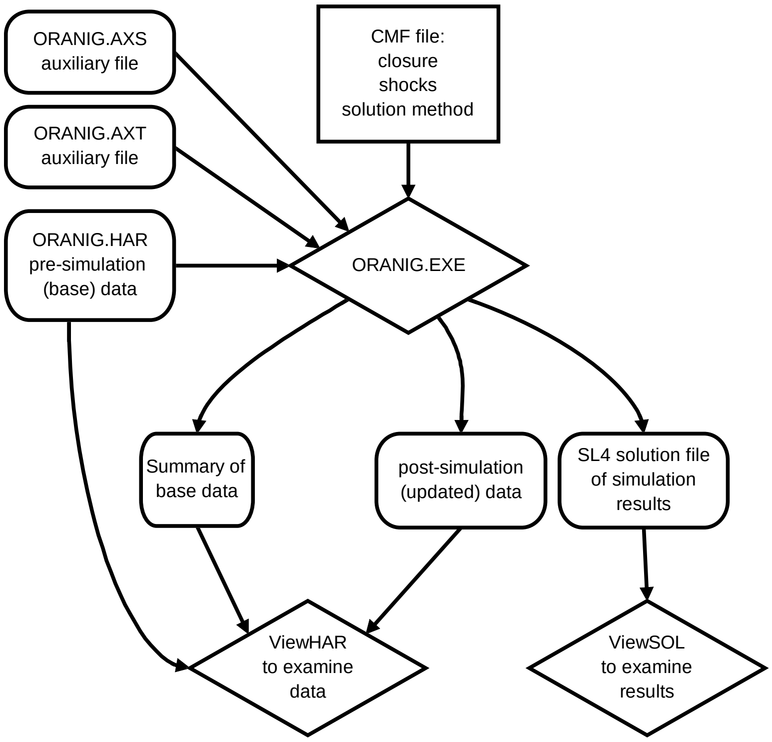

Figure 13. Using the model-specific EXE to run a simulation

For small databases, the processes depicted in Figure 13 do not require a GEMPACK licence. The computer files necessary to run ORANI-G with its standard 23-sector Australian database are freely downloadable from the Internet. Modellers who wish to use larger databases with the standard model, or who wish to use ORANI-G as a starting point to build their own general equilibrium model, would require a GEMPACK licence.

Figure 14 shows a variation on the processes depicted in Figures 12 and 13. This time, TABLO has produced a GSS file. Unlike the FOR file of Figure 8, the GSS file need not be compiled: it is interpreted directly by the standard program GEMSIM. The advantages of this approach is that no FORTRAN compiler is needed and that the required GEMPACK licence is cheaper. The disadvantage is that larger models may solve only slowly, or may altogether exceed size limits built in to GEMSIM. Both methods give the same numerical results.

The programs and steps depicted in Figures 12 to 14 can be (and still are) run in the traditional manner by typing into a command prompt. In recent years various Windows "shell" programs have become available, which give model users "point-and-click" control of these processes. The oldest, WinGEM, manages the whole process: from creating or modifying a model, to running simulations. Other programs are more specialized: TABmate is used to create and edit models; while RunGEM is concerned only with running simulations. Another program, AnalyseGE, assists with analysing simulation results.

8. Conclusion

Our experience has been that AGE models can be fruitful and flexible vehicles for practical policy analysis. In Australia, versions of the ORANI model, which have been available since the late 1970s, have been used widely by economists in the public, private and academic sectors. The key ingredients in the process of making the model accessible to such a wide range of users have been:

- comprehensive documentation of all aspects of the model—theoretical structure, data, computational procedures and illustrative applications;
- user friendly, readily transportable and low-cost computer software—GEMPACK; and

- establishment of a pool of potential users who have acquired the necessary training as employees or graduate students within the development team, on the job in organisations (especially the Australian Productivity Commission) committed to routine use of the model, or in special training courses.

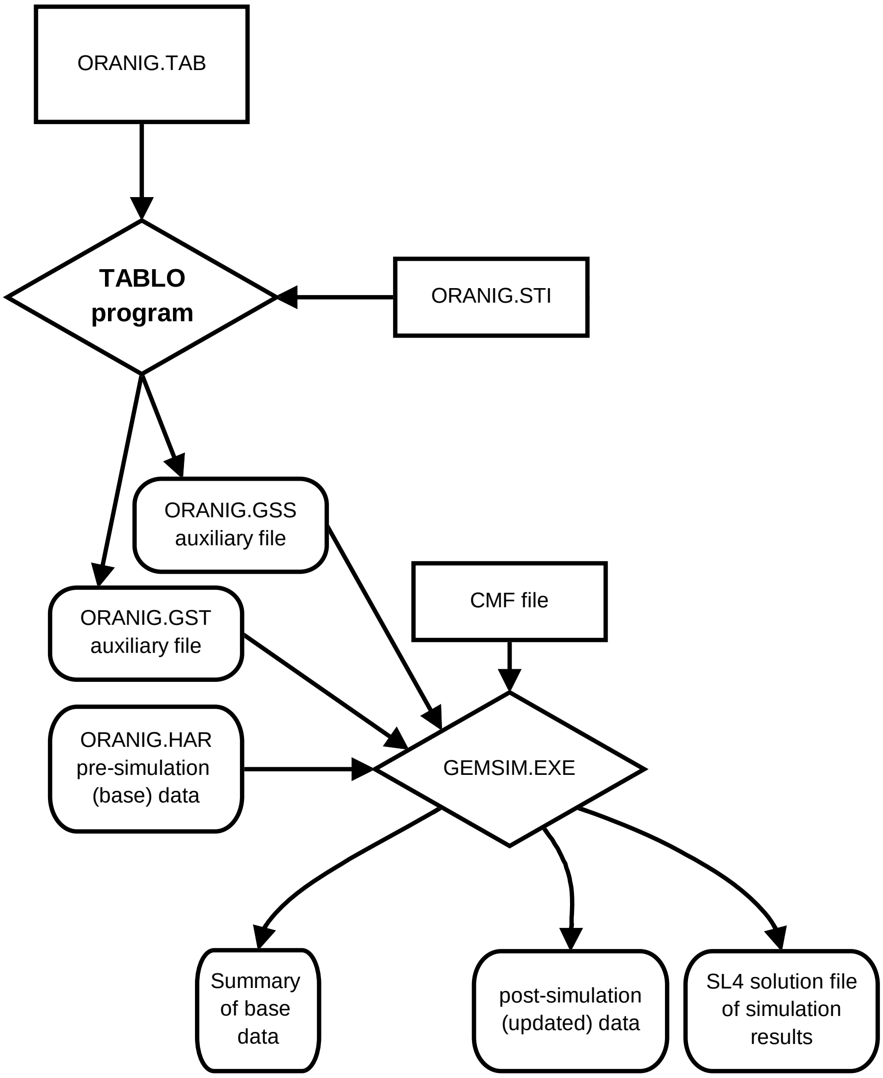

Figure 14. The GEMSIM alternative

This document is designed to extend the accessibility of ORANI-style models within the international community. It provides comprehensive documentation of a generic version of the model (ORANI-G). ORANI-G can be used for comparative-static policy analysis of the Australian economy as well as for developing similar models for other countries.

A distinctive feature of the document is that its account of the theoretical structure and data of the model is framed around the precise representation which is required as input to the GEMPACK computer system. This tight integration of economic and computational aspects of the modelling is intended to allow readers to acquire a hands-on familiarity with the model. The companion files (see Appendix B) contain enough of the GEMPACK system to allow readers to conduct their own simulations with ORANI-G.

We hope that some readers will be stimulated to go beyond conducting simulations with the model described here. Our documentation could also be used as a template for the construction of models which are similar but which use different data (perhaps referring to different countries), have different dimensions or incorporate modifications to the theoretical structure. To make these steps, more of the GEMPACK system than is included with the companion files is required. Appendix C explains how the necessary software can be obtained.

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A large number of working papers may be downloaded from: www.copsmodels.com/elecpapr.htm
Several books may be downloaded from: www.copsmodels.com/pubs.htm

Appendix A: Percentage-Change Equations of a CES Nest

Problem: Choose inputs $X_i>0$ (i = 1 to N), to minimise the cost $\sum_i P_i X_i$ of producing given output Z, subject to the CES production function:

$$Z = \left(\sum_i \delta_i X_i^{-\rho}\right)^{-1/\rho}. \qquad -1>\rho>\infty \tag{A1}$$ [29]

The associated first order conditions are:

$$P_k = \Lambda \frac{\partial Z}{\partial X_k} = \Lambda \delta_k X_k^{-(1+\rho)} \left(\sum_i \delta_i X_i^{-\rho}\right)^{-(1+\rho)/\rho}. \tag{A2}$$

Hence $$\frac{P_k}{P_i} = \frac{\delta_k}{\delta_i}\left(\frac{X_i}{X_k}\right)^{1+\rho}, \tag{A3}$$

or $$X_i^{-\rho} = \left(\frac{\delta_i P_k}{\delta_k P_i}\right)^{-\rho/(\rho+1)} X_k^{-\rho}. \tag{A4}$$

Substituting the above expression back into the production function we obtain:

$$Z = X_k \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k}\right]^{\rho/(\rho+1)}\right)^{-1/\rho}. \tag{A5}$$

This gives the input demand functions:

$$X_k = Z \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k}\right]^{\rho/(\rho+1)}\right)^{1/\rho}, \tag{A6}$$

or $$X_k = Z\, \delta_k^{1/(\rho+1)} \left[\frac{P_k}{P_{ave}}\right]^{-1/(\rho+1)}, \tag{A7}$$

where $$P_{ave} = \left(\sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)}\right)^{(\rho+1)/\rho}. \tag{A8}$$

Transforming to percentage changes (see Appendix E) we get:

$$x_k = z - \sigma\left(p_k - p_{ave}\right), \tag{A9}$$

and $$p_{ave} = \sum_i S_i p_i, \tag{A10}$$

where $$\sigma = \frac{1}{\rho+1} \quad \left[\text{ie, } \rho = \frac{1-\sigma}{\sigma} \text{ so } 0>\sigma>\infty\right] \quad \text{and} \quad S_i = \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} \Big/ \sum_k \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)}. \tag{A11}$$

Multiplying both sides of (A7) by P_k we get:

$$P_k X_k = Z\, \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} P_{ave}^{1/(\rho+1)}. \tag{A12}$$

---

[29] Some people write $Z = K\left(\sum_i \delta_i X_i^{-\rho}\right)^{-1/\rho}$ and require that $\sum_i \delta i = 1$. Others reverse the sign of ρ. This makes no difference to the percent change equations. In fact there are lots of equivalent ways of writing the CES production function. Rutherford formulates it usefully as: $Z/Z^* = \left(\sum_i S_i (X_i/X^*_i)^{\rho}\right)^{1/\rho}$ where the S_i are initial cost shares and Z^* and X^*_i are initial values of output and input quantities. This greatly simplifies the 'calibration' problem which troubles levels modellers and is avoided altogether by those who work in percent changes.

Hence $\dfrac{P_k X_k}{\sum_i P_i X_i} = \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} \Big/ \sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} = S_k$, (A13)

i.e., the S_i of (A11) turn out to be cost shares.

Technical Change Terms

With technical change terms, we must choose inputs X_i so as to:

minimise $\sum_i P_i X_i$ subject to: $Z = \left(\sum_i \delta_i \left[\dfrac{X_i}{A_i}\right]^{-\rho}\right)^{-1/\rho}$. (A14)

Setting $\tilde{X}_i = \dfrac{X_i}{A_i}$ and $\tilde{P}_i = P_i A_i$ we get: (A15)

minimise $\sum_i \tilde{P}_i \tilde{X}_i$ subject to: $Z = \left(\sum_i \delta_i \tilde{X}_i^{-\rho}\right)^{-1/\rho}$, (A16)

which has the same form as problem (A1). Hence the percentage-change form of the demand equations is:

$$\tilde{x}_k = z - \sigma\left(\tilde{p}_k - \tilde{p}_{ave}\right), \qquad (A17)$$

and $\tilde{p}_{ave} = \sum_i S_i \tilde{p}_i$. (A18)

But from (A15), $\tilde{x}_k = x_i - a_i$, and $\tilde{p}_i = p_i + a_i$, giving:

$$x_k - a_k = z - \sigma\left(p_k + a_k - \tilde{p}_{ave}\right). \qquad (A19)$$

and $\tilde{p}_{ave} = \sum_i S_i\,(p_i + a_i)$. (A20)

When technical change terms are included, we call $\tilde{x}_k$, $\tilde{p}_k$ and $\tilde{p}_{ave}$ *effective* indices of input quantities and prices. Sometimes (A20) is rewritten to group the a_k terms together:

$$x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) \quad + a_k - \sigma\left(a_k - \sum_i S_i a_i\right)$$

The following three sub-topics are more advanced, and could be omitted at the first reading.

Change in the Distribution Parameters

From above we know that the cost-minimizing problem:

Choose inputs X_i to:minimise $\sum_i P_i X_i$ subject to: $Z = \left(\sum_i \delta_i \left[\dfrac{X_i}{A_i}\right]^{-\rho}\right)^{-1/\rho}$. (A14)

gives rise to percent change equations:

$$x_k - a_k = z - \sigma\left(p_k + a_k - \tilde{p}_{ave}\right) \text{ and } \tilde{p}_{ave} = \sum_i S_i\,(p_i + a_i). \qquad (A19/20)$$

But by inspection of the production function we see that a 1% increase in A_i would have the same effect (on the summed term) as a ρ% rise in δ_i. So, defining d_i as the percent change in δ_i, we could write $d_i=\rho a_i$ or $a_i=(1/\rho)d_i$. Recalling from above that $1/\rho=\sigma/(1-\sigma)$, we could write this as $a_i=[\sigma/(1-\sigma)]d_i$. So our demand equations become:

$$x_k - a_k = z - \sigma\left(p_k + a_k - \tilde{p}_{ave}\right) \text{ and } \tilde{p}_{ave} = \sum_i S_i\,(p_i + a_i) \text{ and } a_i=[\sigma/(1-\sigma)]d_i. \qquad (A19/20)$$

or $x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) \quad + [\sigma/(1-\sigma)]\left[d_k - \sigma\left(d_k - \sum_i S_i d_i\right)\right]$ (A21)

We develop this idea further in the multi-input twist section below.

Two Input CES: Reverse Shares

Where a CES nest has only two inputs we can write (A19) and (A20) in a way which speeds up computation. Suppose we have domestic and imported inputs, with suffixes d and m. (A19) becomes:

$$x_d - a_d = z - \sigma\Big(p_d + a_d - S_d(p_d + a_d) - S_m(p_m + a_m)\Big),$$

and $$x_m - a_m = z - \sigma\Big(p_m + a_m - S_d(p_d + a_d) - S_m(p_m + a_m)\Big). \qquad (A22)$$

Simplifying, we get:

$$x_d - a_d = z - \sigma S_m\Big((p_d + a_d) - (p_m + a_m)\Big) \quad \text{and} \quad x_m - a_m = z + \sigma S_d\Big((p_d + a_d) - (p_m + a_m)\Big). \qquad (A23)$$

In order for TABLO to substitute out x, we must express (A23) as a single vector equation:

$$x_k - a_k = z - \sigma R_k\Big((p_d + a_d) - (p_m + a_m)\Big). \qquad k = d, m \qquad (A24)$$

The R_k are *reverse shares*, defined by:

$$R_d = S_m \quad \text{and} \quad R_m = R_d – 1 = S_m - 1 = - S_d \qquad \text{note that } R_d - R_m = 1 \qquad (A25)$$

(A20) becomes:

$$\tilde{p}_{ave} = \sum_i S_i\,(p_i + a_i) = R_d(p_m + a_m) - R_m(p_d + a_d). \qquad (A26)$$

Twist for Two Input CES

A twist is a combination of small technical changes which, taken together, are locally cost neutral. For example, we might ask, what values for a_d and a_m would, in the absence of price changes, cause the ratio (x_d - x_m) to increase by t% without affecting $\tilde{p}_{ave}$? That is, find a_d and a_m such that:

$$S_d a_d + S_m a_m = 0, \qquad \text{using (A20), and} \qquad (A27)$$

$$x_d - x_m = (1-\sigma)(a_d - a_m) = t, \qquad \text{using (A22);} \qquad (A28)$$

giving $$a_d = S_m t/(1-\sigma) \quad \text{and} \quad a_m = -S_d t/(1-\sigma). \qquad (A29)$$

Adopting *reverse share* notation: $$a_k = R_k t/(1-\sigma) \qquad k = d, m \qquad (A30)$$

and substituting (A30) back into (A24) we get:

$$x_k = z + R_k t/(1-\sigma) - \sigma R_k\Big(p_d - p_m + R_d t/(1-\sigma) - R_m t/(1-\sigma)\Big) \qquad k = d, m$$

so $$x_k = z + R_k t - \sigma R_k\Big(p_d - p_m\Big) \qquad k = d, m$$

allowing us to rewrite (A19) and (A20) as:

$$x_k = z + R_k\Big(t - \sigma(p_d - p_m)\Big) \qquad k = d, m \qquad (A31)$$

and $$\tilde{p}_{ave} = R_d p_m - R_m p_d. \qquad (A32)$$

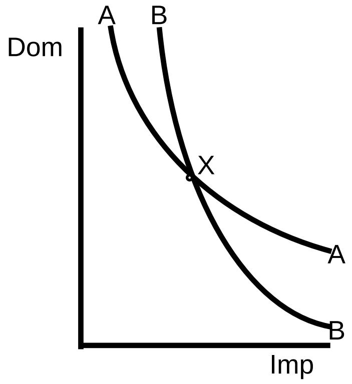

Figure A1

Twist variables, such as t, are often used in dynamic models where they are used to simulate secular (i.e., not price-induced) trends in import shares. Figure A1 shows how 'twist' variables get their name. AA is an isoquant showing what quantities of domestic and imported goods can be combined to give the same utility. The chosen combination is at X. Technical changes a_d and a_m translate AA both down and to the right, in such a way that BB still passes through X. It is as if AA had been twisted or pivoted around X.

A small change concept of cost neutrality is used to develop the notion of twist variables. Where budget shares change by a large amount, the same technical change cannot be cost-neutral at both initial and final input proportions, although it will usually be cost-neutral at some intermediate proportion. Thus, there are no levels formulae corresponding to (A27), and so results may be path-dependent.

Twist for Multi-Input CES

Building on our two-input example we can see that if we added to our normal demand equations:

$$x_k - a_k = z - \sigma\left(p_k + a_k - \tilde{p}_{ave}\right) \quad \text{and} \quad \tilde{p}_{ave} = \sum_i S_i\,(p_i + a_i). \qquad \text{(A19/20)}$$

the additional equation: $a_k = b_k - \sum_i S_i b_i$ (with the b_i exogenous), we could be sure that $\sum_i S_i a_i = 0$, and therefore the technological changes a_i would be locally cost-neutral and so qualify as a twist. In this case we could write:

$$x_k - a_k = z - \sigma\left(a_k + p_k - \sum_i S_i p_i\right)$$

or $$x_k = z + (1-\sigma)a_k - \sigma\left(p_k - \sum_i S_i p_i\right) \quad \text{where } a_k = b_k - \sum_i S_i b_i \qquad \text{(A33)}$$

Alternatively our additional equation could be: $(1-\sigma)a_k = c_k - \sum_i S_i c_i$ (with the c_i exogenous), still ensuring that $\sum_i S_i a_i = 0$, and now giving:

$$x_k = z + [c_k - \sum_i S_i c_i] - \sigma\left(p_k - \sum_i S_i p_i\right) \qquad \text{(A34)}$$

In the above formulation, the effect of a c_k twist is independent of the σ value.

Similar results arise from the equation above showing the effect of changes in distribution parameters:

$$x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) + [\sigma/(1-\sigma)]\left[d_k - \sigma\left(d_k - \sum_i S_i d_i\right)\right] \qquad \text{(A21)}$$

If $\sum_i S_i d_i = 0$, we have

$$x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) + [\sigma/(1-\sigma)]\left[d_k - \sigma d_k\right]$$

or $$x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) + \sigma d_k$$

Now suppose we set $d_k = (1/\sigma)[t_k - \sum_i S_i t_i]$ (so ensuring $\sum_i S_i d_i = 0$), we would have:

$$x_k = z - \sigma\left(p_k - \sum_i S_i p_i\right) + [t_k - \sum_i S_i t_i] \quad \text{which is essentially the same as (A34).}$$

Appendix B: ORANI-G on the World Wide Web

Computer files mentioned in this document can be downloaded from: www.copsmodels.com/oranig.htm That page also contains supplementary material used for preparing or aggregating data, plus information about some of the adaptations of ORANI-G that have been made for different countries.

Appendix C: Hardware and Software Requirements for Using GEMPACK

The essential parts of GEMPACK can be used on most desktop and mainframe computers: wherever an ANSI-standard FORTRAN is available. Customized installation kits are available for Windows PCs. Additional visual programs (eg, ViewHAR) are available that require Microsoft Windows. Details of GEMPACK products and pricing can be seen at: www.copsmodels.com/gempack.htm

Appendix D: Main differences between full-size ORANI and the version described here

ORANI-G follows the original version of ORANI fairly closely. The main departures from the full-size version of ORANI described by DPSV (1982) are as follows.

- The model is more aggregated: there are only 23 commodities, 22 industries and 2 occupations (down from 114, 112 and 8).
- CRESH primary factor aggregators have been replaced by CES forms.
- The Leontief-CRETH double nest which, in ORANI, defines the commodity composition of output by joint-product industries is simplified to a single CET nest.
- Many percentage-change equations have been re-arranged—normally to avoid unnecessary computation of shares.

In addition, ORANI-G contains many new variables and equations. Most of these are used to merely to explain or report results; others allow for the use of new closures not allowed by the original model.

Table E1 Examples of Percentage-Change Forms

Example	(1) Original or Levels Form	(2) Intermediate Form	(3) Percentage-Change Form
1	$Y = 4$	$Yy = 4*0$	$y = 0$
2	$Y = X$	$Yy = Xx$	$y = x$
3	$Y = 3X$	$Yy = 3Xx$	$y = x$
4	$Y = XZ$	$Yy = XZx + XZz$	$y = x + z$
5	$Y = X/Z$	$Yy = (X/Z)x - (X/Z)z$	$y = x - z$ *or* $100(Z)\Delta Y = Xx - Xz$
6	$X_1 = M/4P_1$	$X_1x_1 = (M/4P_1)m - (M/4P_1)p_1$	$x_1 = m - p_1$
7	$Y = X^3$	$Yy = X^3 3x$	$y = 3x$
8	$Y = X^\alpha$	$Yy = X^\alpha \alpha x$	$y = \alpha x$ (α assumed constant)
9	$Y = X + Z$	$Yy = Xx + Zz$	$y = S_x x + S_z z$ where $S_x = X/Y$, etc
10	$Y = X - Z$	$Yy = Xx - Zz$	$y = S_x x - S_z z$ *or* $100(\Delta Y) = Xx - Zz$
11	$PY = PX + PZ$	$PY(y+p) = PX(x+p) + PZ(z+p)$ *or* $PYy = PXx + PZz$	$y = S_x x + S_z z$ where $S_x = PX/PY$, etc
12	$Z = \Sigma X_i$	$Zz = \Sigma X_i x_i$ *or* $0 = \Sigma X_i(x_i - z)$	$z = \Sigma S_i x_i$ where $S_i = X_i/Z$
13	$XP = \Sigma X_i P_i$	$XP(x+p) = \Sigma X_i P_i (x_i + p_i)$	$x+p = \Sigma S_i(x_i+p_i)$ where $S_i = X_i P_i/XP$
14	Ordinary change in a ratio $R = X/Y$	$Rr = 100\Delta R = (X/Y)(x-y)$ $100\Delta R = R(x-y)$	$100(\Delta R)/R = r = x - y$
15	Ordinary change in a ratio $N = (X-M)/(X+M)$	$200(X+M)(X+M)\Delta N = 4MX(x-m)$	$200\Delta N = (1-N^2)(x-m)$

Appendix E: Deriving Percentage-Change Forms

Using first principles, a levels equation, for example,

$$Y = X^2 + Z,$$

is turned into percentage-change form by first taking total differentials:

$$dY = 2XdX + dZ.$$

Percentage changes x, y, and z are defined *via*:

$$y = 100\frac{dY}{Y} \quad \text{or} \quad dY = \frac{Yy}{100}, \quad \text{similarly} \quad dX = \frac{Xx}{100} \quad \text{and} \quad dZ = \frac{Zz}{100}.$$

Thus our sample equation becomes:

$$\frac{Yy}{100} = 2X\frac{Xx}{100} + \frac{Zz}{100}, \quad \text{or} \quad Yy = 2X^2x + Zz.$$

In practice such formal derivations are often unnecessary. Most percentage-change equations follow standard patterns which the modeller soon recognizes. Some of these are shown in Table E1.

Column (2) in Table E1 corresponds closely to the total differential form of column (1), and may be thought of as a step on the way to column (3). Alternatively, we may use column (2) directly, either because it is simpler, or to avoid computing shares.

The 2nd alternate form in column (3) for example 10 shows how ordinary and percentage changes may be mixed. It is based on the identity $Yy \equiv 100\Delta Y$. See also example 5.

Variables can only be added or subtracted (as in examples 9 and 12) where they share the same units. In adding quantities, we can normally identify a common price (often the basic price). By multiplying through additive expressions by a common price, we can express the coefficients of percentage-change equations as functions of flows, rather than quantities, so obviating the need to define physical units (compare examples 9 and 11).

Appendix F: Algebra for the Linear Expenditure System

The purpose of this appendix is to expand on some of the algebra underlying Excerpt 16 of the TABLO input file.

First note that, the utility function (22) in the text can be written:

$$\text{Utility per household} = \prod_c \left\{\frac{X3\_S(c)}{Q} - A3SUB(c)\right\}^{S3LUX(c)}, \qquad \text{(F1)}$$

using equation (27). Here, X3_S(c)/Q is the average consumption of each composite good c, and A3SUB(c) is a parameter. The household's problem is to choose X3_S(c)/Q to maximise utility subject to the constraint:

$$\sum_c X3\_S(c)/Q*P3\_S(c) = V3TOT/Q, \qquad \text{(F2)}$$

The associated additional first order conditions are:

$$\Lambda P3\_S(c) = \frac{\partial U}{\partial(X3\_S(c)/Q}) $$
$$= S3LUX(c).U.\left\{\frac{X3\_S(c)}{Q} - A3SUB(c)\right\}^{-1} \qquad \text{(F3)}$$

Manipulation (and use of equation (27)) yields:

$$P3\_S(c)\{X3\_S(c) - X3SUB(c)\} = S3LUX(c).Q.U/\Lambda. \qquad \text{(F4)}$$

or

$$P3\_S(c).X3\_S(c) = P3\_S(c).X3SUB(c) + S3LUX(c).Q.U/\Lambda. \qquad \text{(F5)}$$

(F5) is really the same as equations (25) to (27) in the text. The key to the simplicity of the equations there is that no attempt is made to eliminate the Lagrange multiplier term, Q.U/Λ. Instead, the constraint (F2) is written down as part of the equation system: see (28). This implicit approach often yields dividends. Here in the appendix we press forward more conventionally to express demands directly as a function of prices and income. Summing over c and using (F2), we see that

or $$Q.U/\Lambda = V3TOT - \sum_{c} P3\_S(c).X3SUB(c) \qquad (F6)$$

so that Q.U/Λ is identified as the V3LUX_C of equation (24) in the text. Equation (23) then follows from (F4) above. Combining (F4) with (F6) we get the linear expenditure system (LES):

$$P3\_S(c).X3\_S(c) = P3\_S(c).X3SUB(c) + S3LUX(c).\{V3TOT - \sum_{k} X3SUB(k)*P3\_S(k)\}. \qquad (F7)$$

To find the expenditure elasticities, we convert to percentage change form, ignoring all changes in prices and tastes:

$$x3\_s(c) = - FRISCH.B3LUX(c).\ w3tot \qquad (F8)$$

where FRISCH is defined, by tradition, as $-\frac{V3TOT}{V3LUX\_C}$,

and the B3LUX(c) are the shares of 'luxury' in total expenditure on good c,

i.e. $$B3LUX(c) = \frac{X3\_S(c) - X3SUB(c)}{X3\_S(c)}.$$

Thus the expenditure elasticities are given by:

$$EPS(c) = - FRISCH.B3LUX(c) \qquad (F9)$$

In the TABLO program, (F9) is reversed to derive B3LUX(c) from EPS(c) and FRISCH.

Taste Change Terms

Often we wish to simulate the effect of a switch in consumer spending, induced by a taste change. This could be be brought about by a shock *either* to the a3lux(c) (marginal budget shares) *or* to the a3sub(c) (subsistence quantities). Two problems arise. First, what combination of a3sub and a3lux shocks is best? Second, the a3lux shocks must obey the rule that marginal budget shares add to 1. To tie down the relation between the a3lux and the a3sub, we will assume that they move in proportion:

$$a3lux(c) = a3sub(c) - \lambda, \qquad (F12)$$

and that the constant of proportionality λ is given by the adding-up requirement:

$$\sum_{k} S3LUX(k).a3lux(k) = 0 \qquad (F13)$$

implying that:

$$a3lux(c) = a3sub(c) - \sum_{k} S3LUX(k).a3sub(k), \qquad E\_a3lux$$

We also suppose that

$$\sum_{k} S3\_S(k).a3sub(k) = 0 \qquad (F14)$$

This is guaranteed by equation E_a3sub:

$$a3sub(c) = a3\_s(c) - \sum_{k} S3\_S(k).a3\_s(k) \qquad E\_a3sub$$

The effect of these assumptions is to allow budget shares to be shocked whilst altering expenditure elasticities and the Frisch parameter as little as possible.

Appendix G: Making your own AGE model from ORANI-G

In conjunction with the full GEMPACK system, the ORANI-G.TAB file (which appears in Excerpts listed previously) forms an excellent starting-point for constructing your own AGE model. This file is available from the World-Wide Web (see Appendix B). The best plan is to start from something that works (ORANI-G) and modify it in small steps until it suits your needs.

The most minimal change is to attach a different data file, appropriate to another country. Use either of the GEMPACK programs ViewHAR or MODHAR to turn data in text files into GEMPACK's binary format. Table G1 lists the data matrices that will be needed.

Table G1 Contents of ORANI-G Data File

Header	Dimension	Symbol	Name
COM	23 strings	COM	Set COM commodities
IND	22 strings	IND	Set IND industries
OCC	2 strings	OCC	Set OCC occupations
MAR	2 strings	MAR	Set MAR margin commodities
1BAS	COM*SRC*IND	V1BAS	Intermediate Basic
2BAS	COM*SRC*IND	V2BAS	Investment Basic
3BAS	COM*SRC	V3BAS	Households Basic
4BAS	COM	V4BAS	Exports Basic
5BAS	COM*SRC	V5BAS	Government Basic
6BAS	COM*SRC	V6BAS	Inventory Changes
1MAR	COM*SRC*IND*MAR	V1MAR	Intermediate Margins
2MAR	COM*SRC*IND*MAR	V2MAR	Investment Margins
3MAR	COM*SRC*MAR	V3MAR	Households Margins
4MAR	COM*MAR	V4MAR	Exports Margins
5MAR	COM*SRC*MAR	V5MAR	Government Margins
1TAX	COM*SRC*IND	V1TAX	Intermediate Tax
2TAX	COM*SRC*IND	V2TAX	Investment Tax
3TAX	COM*SRC	V3TAX	Households Tax
4TAX	COM	V4TAX	Exports Tax
5TAX	COM*SRC	V5TAX	Government Tax
1CAP	IND	V1CAP	Capital
1LAB	IND*OCC	V1LAB	Labour
1LND	IND	V1LND	Land
1PTX	IND	V1PTX	Production Tax
1OCT	IND	V1OCT	Other Costs
MAKE	COM*IND	MAKE	Multiproduct Matrix
0TAR	COM	V0TAR	Tariff Revenue
SLAB	IND	SIGMA1LAB	Labour Sigma
P028	IND	SIGMA1PRIM	Primary Factor Sigma
1ARM	COM	SIGMA1	Intermediate Armington
SCET	IND	SIGMA1OUT	Output Sigma
2ARM	COM	SIGMA2	Investment Armington
3ARM	COM	SIGMA3	Households Armington
P021	1	FRISCH	Frisch Parameter
XPEL	COM	EPS	Household Expenditure Elasticities
P018	COM	EXP_ELAST	Individual Export Elasticities
EXNT	1	EXP_ELAST_NT	Collective Export Elasticity
ITEX	COM	IsIndivExp	Flag, >0.5 for individual export coms, else collective export
Additional data for regional extension			
REG	8 strings		Set REG Regions
LCOM	COM	IsLocCom	Flag for regional extension, >0.5 for local coms, else national
R001	IND*REG	REGSHR1	Regional output shares
R002	IND*REG	REGSHR2	Regional investment shares
R003	COM*REG	REGSHR3	Regional consumption shares
R004	COM*REG	REGSHR4	Regional export shares
R005	COM*REG	REGSHR5	Regional government shares
R006	COM*REG	REGSHR6	Regional inventory shares

The dimensions of the model (e.g., the number of sectors) are controlled by the 'Set' data at the beginning of the list above.

Your own national input-output tables may not support the ORANI-G level of detail. For example, you may be unable to distinguish land as a third primary factor. Rather than deleting all mention of land from the equations, achieve the same effect by supplying a data vector of land rentals (header '1LND' in Table G1) which is filled with tiny non-zero numbers. Again, if you cannot gather margins data, you may restrict the set of margins commodities (in Excerpt 1) to a single commodity, and fill all margins matrices with tiny numbers or zeroes. Define one occupational labour category only, if need be. A diagonal MAKE matrix is equivalent to removing multi-production. All these techniques are less error-prone than altering the equations, and leave scope for later collection of more data.

As your confidence grows, you may wish to change or extend the equation system. For example, you could easily alter the consumption function. More ambitiously, you could alter the production nesting system of Figure 5 to allow intermediate usage of energy to be substitutable with primary factors.

Appendix H: Additions and Changes for the 1998 edition

ORANI-G has been adapted to a number of countries beside Australia. Each national version has, in addition to a unique database, various special additions and modifications to the basic TAB file. Some of these changes are so frequently needed that they have now been included in the basic model. They are:

- allowance for imported as well as domestic inventory changes;
- the addition of more TINY coefficients to combat zero-divide errors;
- an optional CET transformation between goods for local and export markets;
- a new output file that contains convenient summaries of the base data;
- the addition of variables which help to explain results

Appendix I: Formal Checks on Model Validity; Debugging Strategies

A number of tests should be performed each time a model's equations or data are changed. We set out here the proper procedure to follow.

1. Price homogeneity test

It is a property of neoclassical models that agents respond to changes in relative prices, but not to changes in the absolute level of prices. That is, a uniform increase in *all* prices does not affect any quantity variables. Nearly always there is only one exogenous variable measured in domestic currency units—it is called the numeraire. Typical choices of numeraire include the exchange rate (phi) or the consumer price index (p3tot). If we shock the numeraire by 1% we would expect to see that all domestic prices and flows increase by 1% while real variables remain unchanged.

The supplied file HOMOTEST.CMF can be used to perform this test. Check that it refers to the right model and data and that the only shock is a 1% shock to phi. Run the simulation and examine the solution file. You should see that all prices move by 1% whilst quantities are unchanged.

2. Check initial data

The price homogeneity simulation should have produced a HAR file that summarizes the initial data. Examine this file (using ViewHAR) and check that the database is balanced, using the headers written by Excerpt 37 of the TAB file (see main text).

3. Real homogeneity test

Neoclassical models normally display constant returns to scale. This means that if all real exogenous variables (not ratios or prices) are shocked by 1%, all endogenous real variables should also move by 1%, leaving prices unchanged.

To test this properly, you have to ensure that any real ordinary change variables are shocked by the right amount and that export demand curves move outwards by an amount corresponding to a 1% increase in the size of the rest of the world. The supplied file HOMOTEST.CMF simplifies this task.

Comment out the numeraire shock used for the price homogeneity test and reinstate the series of real shocks which were originally commented out. Run the simulation and examine the results.

4. Change in GDP should be the same from both sides

Now run a simulation where relative prices change, ie, not a homogeneity test. For example, you could use the closure in HOMOTEST.CMF and shock real household consumption by 10%. It's best to administer a shock that is large enough to make at least a 1% difference to the majority of variables. Stick with a one-step or Johansen simulation for now. Check that the results for the two nominal GDP variables, w0gdpexp and w0gdpinc are the same up to 5 significant figures. An unbalanced data-base or errors in equations could disturb this equality.

5. Updated data-base should also be balanced.

An updated data file will have been produced by the previous (10% real consumption increase) simulation. Use this updated data as the starting point for a second simulation with the same shock. Again, a HAR file of summary data will be produced, incorporating the effects of the first but not the second simulation. As in Step 2, use this to check whether the updated data is balanced. If not, and if all the previous tests were passed, there is probably something wrong with some Update statement.

6. Repeat above tests using a multistep solution method.

Go through the above steps this time using a 2-4-8 Euler extrapolation solution method. If there is a problem, but there was no problem with the Johansen tests, you have a subtle problem. Possibly a percentage change variable is passing through zero; or maybe you are using formulae to alter the data after it has been read (always a bad idea).

7. Be sure you can explain the results.

It is important to realize that there are many errors that Tests 1 to 6 above will not detect. For example, if the export demand elasticities in the database had the wrong sign, the model would still pass these tests. Only a careful 'eye-balling' of results will uncover this type of error. After modifying the model, it is a good idea to run a standard experiment for which the results have already been analysed. You should be able to understand how and why the new results differ.

Other tips

Change little, check often

Although the above tests can reveal the existence of a problem, they give little direct indication of its cause. The wise modeller performs the various tests both before and after making each small alteration to the model. Then, if there is a problem, the cause must lie with the minor changes just made.

Duplication of previous results.

Extensions and modifications to model equations should be designed so that you can still duplicate simulation results computed with the previous version of the model. For example, when adding new equations it is often a good idea to include shift variables which can be left endogenous. This prevents the new equations from affecting the rest of the system, and allows a standard closure to be used. To 'switch on' your new equations, exogenize these shift variables while at the same time endogenizing an equal number of other model variables. Sometimes modifications can be switched on and off by suitable parameter settings (an example might be the CET between goods for export and domestic markets in Excerpt 19B of the ORANI-G TAB file).

If you designed your extension in this flexible way, you could test that you are able to duplicate results that you computed before adding new equations. If the new results are different, you may have inadvertently made some other change that was overlooked.

Always check that GDP results are the same from both sides

It should become a reflex action, every time you look at results, to check that w0gdpexp and w0gdpinc are the same. It takes little time, and gives early warning of many possible errors.

Beware of rarely used exogenous variables

Shocks to rarely used exogenous variables often bring errors to light. Since in nearly all simulations these variables have zero change, the values of their coefficients are usually irrelevant. For example, when you shock normally-omitted technical change variables you are using parts of the model which have undergone relatively infrequent testing. So be alert.

To identify the problem, try different closures
Suppose you noticed that some problem occurred in long-run closures where capital stocks are mobile, but did not occur in short-run closures where capital stocks are fixed. That might suggest that some coefficient of x1cap (percentage change in capital stocks) was wrongly computed, or that x1cap had been inadvertently omitted from an equation or update statement.
Use Assertions frequently
Suppose you discovered (after some painful hours) that curious simulation results were caused by a negative Armington elasticity (a typo). You could place an Assertion statement in the TAB file which will stop the simulation if that problem is detected. Then you could at least be sure that you would not again waste time tracking down that particular problem. In emergencies, you can disable the Assertion checking, but *do not make this a habit!*

Appendix J: Short-Run Supply Elasticity

Where capital stocks are fixed, we can derive an approximate expression for a short-run supply schedule as follows. Imagine that output, z, is a CES function of capital and labour, and that other, material, inputs are demanded in proportion to output. Using percentage change form, we may write:

$$p = H_K p_K + H_L p_L + H_M p_M \qquad \text{zero pure profits} \qquad (J1)$$

$$x_L - x_K = \sigma(p_K - p_L) \qquad \text{factor proportions} \qquad (J2)$$

$$z = S_L x_L + S_K x_K \qquad \text{production function} \qquad (J3)$$

where H_K, H_L and H_M are the shares in total costs of capital, labour and materials, and where S_K and S_L are the shares in primary factor costs of capital and labour. p is output price, and p_K, p_L and p_M are the prices of capital, labour and materials respectively. z is output, and x_K and x_L are the input quantities of capital and labour. "Capital" should be interpreted as covering all fixed factors, including land.

In the short run closure we set x_K to zero, so that the last 2 equations become:

$$x_L = \sigma(p_K - p_L) \quad \text{and} \quad z = S_L x_L \qquad \text{giving:} \qquad (J4)$$

$$z = S_L\sigma(p_K - p_L) \quad \text{or} \quad p_K = p_L + z/(S_L\sigma) \qquad (J5)$$

Substituting (J5) into (J1) we get:

$$p = H_K\big(p_L + z/(S_L\sigma)\big) + H_L p_L + H_M p_M \qquad (J6)$$

$$p = zH_K/(S_L\sigma) + (H_K + H_L)p_L + H_M p_M \qquad (J7)$$

$$zH_K/(S_L\sigma) = p - (H_K + H_L)p_L - H_M p_M \qquad (J8)$$

$$z = \big(S_L\sigma/H_K\big)\big[p - (H_K + H_L)p_L - H_M p_M\big] \qquad (J9)$$

Call H_F the share of primary factor in total costs (= $H_K + H_L$). Then $H_K = S_K H_F$

so $$z = \big(\sigma S_L/S_K\big)\big[p/H_F - p_L - (H_M/H_F)p_M\big] \text{....compare DPSV eq. 45.19} \qquad (J10)$$

The shortrun supply elasticity is the coefficient on p, namely:

$$\sigma S_L/(S_K H_F) \qquad (J11)$$

In other words, supply is more elastic as either the labour/capital ratio is higher, or the share of materials in total cost is higher. (J11) is only a partial equilibrium estimate; it assumes that all inputs except capital are in elastic supply.

For industries which have permanently fixed factors (eg, land or natural resources) we could compute longrun supply elasticities in a similar way. In (J11) S_L should be interpeted as the share of *mobile* factors in primary factor cost, with $S_K = 1 - S_L$.

Appendix K: List of Variables

Symbol	Dimensions	Description
a1(c,s,i)	c∈COM s∈SRC i∈IND	Intermediate basic tech change
a1_s(c,i)	c∈COM i∈IND	Tech change, int'mdiate imp/dom composite
a1cap(i)	i∈IND	Capital-augmenting technical change
a1lab_o(i)	i∈IND	Labor-augmenting technical change
a1lnd(i)	i∈IND	Land-augmenting technical change
a1mar(c,s,i,m)	c∈COM s∈SRC i∈IND m∈MAR	Intermediate margin tech change
a1oct(i)	i∈IND	"Other cost" ticket augmenting techncal change
a1prim(i)	i∈IND	All factor augmenting technical change
a1tot(i)	i∈IND	All input augmenting technical change
a2(c,s,i)	c∈COM s∈SRC i∈IND	Investment basic tech change
a2_s(c,i)	c∈COM i∈IND	Tech change, investment imp/dom composite
a2mar(c,s,i,m)	c∈COM s∈SRC i∈IND m∈MAR	Investment margin tech change
a2tot(i)	i∈IND	Neutral technical change - investment
a3(c,s)	c∈COM s∈SRC	Household basic taste change
a3_s(c)	c∈COM	Taste change, household imp/dom composite
a3lux(c)	c∈COM	Taste change, supernumerary demands
a3mar(c,s,m)	c∈COM s∈SRC m∈MAR	Household margin tech change
a3sub(c)	c∈COM	Taste change, subsistence demands
a4mar(c,m)	c∈COM m∈MAR	Export margin tech change
a5mar(c,s,m)	c∈COM s∈SRC m∈MAR	Governmnt margin tech change
contBOT		Contribution of BOT to real expenditure-side GDP
contGDPexp(e)	e∈EXPMAC	Contributions to real expenditure-side GDP
delB		(Balance of trade)/GDP
delPTXRATE(i)	i∈IND	Change in rate of production tax
delSale(c,s,d)	c∈COM s∈SRC d∈DEST	Sales aggregates
delV0TAR(c)	c∈COM	Ordinary change in tariff revenue
delV0tar_c		Aggregate tariff revenue
delV0tax_csi		Aggregate revenue from all indirect taxes
delV1CST(i)	i∈IND	Change in ex-tax cost of production
delV1PRIM(i)	i∈IND	Ordinary change in cost of primary factors
delV1PTX(i)	i∈IND	Ordinary change in production tax revenue
delV1PTX_i		Ordinary change in all-industry production tax revenue
delV1TAX(c,s,i)	c∈COM s∈SRC i∈IND	Interm tax rev
delV1tax_csi		Aggregate revenue from indirect taxes on intermediate
delV1TOT(i)	i∈IND	Change in tax-inc cost of production
delV2TAX(c,s,i)	c∈COM s∈SRC i∈IND	Invest tax rev
delV2tax_csi		Aggregate revenue from indirect taxes on investment
delV3TAX(c,s)	c∈COM s∈SRC	H'hold tax rev
delV3tax_cs		Aggregate revenue from indirect taxes on households
delV4TAX(c)	c∈COM	Export tax rev
delV4tax_c		Aggregate revenue from indirect taxes on export
delV5TAX(c,s)	c∈COM s∈SRC	Govmnt tax rev
delV5tax_cs		Aggregate revenue from indirect taxes on government
delV6(c,s)	c∈COM s∈SRC	Value of inventories
delx6(c,s)	c∈COM s∈SRC	Inventories demands
employ(i)	i∈IND	Employment by industry
employ_i		Aggregate employment: wage bill weights
f0tax_s(c)	c∈COM	General sales tax shifter
f1lab(i,o)	i∈IND o∈OCC	Wage shift variable
f1lab_i(o)	o∈OCC	Occupation-specific wage shifter
f1lab_io		Overall wage shifter
f1lab_o(i)	i∈IND	Industry-specific wage shifter

.../continued

Appendix K: List of Variables (continued)

Symbol	Dimensions	Description
f1oct(i)	i∈IND	Shift in price of "other cost" tickets
f1tax_csi		Uniform % change in powers of taxes on intermediate usage
f2tax_csi		Uniform % change in powers of taxes on investment
f2tot		Ratio, investment/consumption
f3tax_cs		Uniform % change in powers of taxes on household usage
f3tot		Ratio, consumption/ GDP
f4p(c)	c∈COM	Price (upward) shift in export demand schedule
f4p_ntrad		Upward demand shift, Collective export aggregate
f4q(c)	c∈COM	Quantity (right) shift in export demands
f4q_ntrad		Right demand shift, Collective export aggregate
f4tax_ntrad		Uniform % change in powers of taxes on nontradtnl exports
f4tax_trad		Uniform % change in powers of taxes on tradtnl exports
f5(c,s)	c∈COM s∈SRC	Government demand shift
f5tax_cs		Uniform % change in powers of taxes on government usage
f5tot		Overall shift term for government demands
f5tot2		Ratio between f5tot and x3tot
fandecomp(c,f)	c∈COM f∈FANCAT	Fan decomposition
finv1(i)	i∈IND	Shifter to enforce DPSV investment rule
finv2(i)	i∈IND	Shifter for "exogenous" investment rule
finv3(i)	i∈IND	Shifter for longrun investment rule
fx6(c,s)	c∈COM s∈SRC	Shifter on rule for stocks
ggro(i)	i∈IND	Gross growth rate of capital = Investment/capital
gret(i)	i∈IND	Gross rate of return = Rental/[Price of new capital]
invslack		Investment slack variable for exogenizing aggregate investment
p0(c,s)	c∈COM s∈SRC	Basic prices for local users
p0cif_c		Imports price index, C.I.F., local currency
p0com(c)	c∈COM	Output price of locally-produced commodity
p0dom(c)	c∈COM	Basic price of domestic goods = p0(c,"dom")
p0gdpexp		GDP price index, expenditure side
p0gne		GNE price index
p0imp(c)	c∈COM	Basic price of imported goods = p0(c,"imp")
p0imp_c		Duty-paid imports price index, local currency
p0realdev		Real devaluation
p0toft		Terms of trade
p1(c,s,i)	c∈COM s∈SRC i∈IND	Purchaser's price, intermediate
p1_s(c,i)	c∈COM i∈IND	Price, intermediate imp/dom composite
p1cap(i)	i∈IND	Rental price of capital
p1cap_i		Average capital rental
p1cst(i)	i∈IND	Index of production costs (for AnalyseGE)
p1lab(i,o)	i∈IND o∈OCC	Wages by industry and occupation
p1lab_io		Average nominal wage
p1lab_o(i)	i∈IND	Price to each industry of labour composite
p1lnd(i)	i∈IND	Rental price of land
p1lnd_i		Average land rental
p1mat(i)	i∈IND	Intermediate cost price index
p1oct(i)	i∈IND	Price of "other cost" tickets
p1prim(i)	i∈IND	Effective price of primary factor composite
p1tot(i)	i∈IND	Average input/output price
p1var(i)	i∈IND	Short-run variable cost price index
p2(c,s,i)	c∈COM s∈SRC i∈IND	Purchaser's price, investment
p2_s(c,i)	c∈COM i∈IND	Price, investment imp/dom composite
p2tot(i)	i∈IND	Cost of unit of capital
p2tot_i		Aggregate investment price index
p3(c,s)	c∈COM s∈SRC	Purchaser's price, household
p3_s(c)	c∈COM	Price, household imp/dom composite

.../continued

Appendix K: List of Variables (continued)

Symbol	Dimensions	Description
p3tot		Consumer price index
p4(c)	c∈COM	Purchaser's price, exports,loc$
p4_ntrad		Price, Collective export aggregate
p4tot		Exports price index, local currency
p5(c,s)	c∈COM s∈SRC	Purchaser's price, government
p5tot		Government price index
p6tot		Inventories price index
pe(c)	c∈COM	Basic price of exportables
pf0cif(c)	c∈COM	C.I.F. foreign currency import prices
pq1(c,i)	c∈COM i∈IND	Price of output by commodity and industry
phi		Exchange rate, local currency/$world
q		Number of households
q1(c,i)	c∈COM i∈IND	Output by commodity and industry
realwage		Average real wage
SalesDecomp(c,d)	c∈COM d∈DESTPLUS	Sales decomposition
t0imp(c)	c∈COM	Power of tariff
t1(c,s,i)	c∈COM s∈SRC i∈IND	Power of tax on intermediate
t2(c,s,i)	c∈COM s∈SRC i∈IND	Power of tax on investment
t3(c,s)	c∈COM s∈SRC	Power of tax on household
t4(c)	c∈COM	Power of tax on export
t5(c,s)	c∈COM s∈SRC	Power of tax on government
utility		Utility per household
w0cif_c		C.I.F. local currency value of imports
w0gdpexp		Nominal GDP from expenditure side
w0gdpinc		Nominal GDP from income side
w0gne		Nominal GNE
w0imp_c		Value of imports plus duty
w0tax_csi		Aggregate revenue from all indirect taxes
w1cap_i		Aggregate payments to capital
w1lab_io		Aggregate payments to labour
w1lnd_i		Aggregate payments to land
w1oct_i		Aggregate "other cost" ticket payments
w2tot_i		Aggregate nominal investment
w3lux		Total nominal supernumerary household expenditure
w3tot		Nominal total household consumption
w4tot		Local currency border value of exports
w5tot		Aggregate nominal value of government demands
w6tot		Aggregate nominal value of inventories
x0cif_c		Import volume index, C.I.F. weights
x0com(c)	c∈COM	Output of commodities
x0dom(c)	c∈COM	Output of commodities for local market
x0gdpexp		Real GDP from expenditure side
x0gdpinc		Real GDP from income side
x0gne		Real GNE
x0imp(c)	c∈COM	Total supplies of imported goods
x0imp_c		Import volume index, duty-paid weights
x0loc(c)	c∈COM	Real percent change in LOCSALES (dom+imp)
x1(c,s,i)	c∈COM s∈SRC i∈IND	Intermediate basic demands
x1_s(c,i)	c∈COM i∈IND	Intermediate use of imp/dom composite
x1cap(i)	i∈IND	Current capital stock
x1cap_i		Aggregate capital stock, rental weights
x1lab(i,o)	i∈IND o∈OCC	Employment by industry and occupation
x1lab_i(o)	o∈OCC	Employment by occupation
x1lab_o(i)	i∈IND	Effective labour input

.../continued

Appendix K: List of Variables (continued)

Symbol	Dimensions	Description
x1lnd(i)	i∈IND	Use of land
x1lnd_i		Aggregate land stock, rental weights
x1mar(c,s,i,m)	c∈COM s∈SRC i∈IND m∈MAR	Intermediate margin demand
x1oct(i)	i∈IND	Demand for "other cost" tickets
x1prim(i)	i∈IND	Primary factor composite
x1prim_i		Aggregate output: value-added weights
x1tot(i)	i∈IND	Activity level or value-added
x2(c,s,i)	c∈COM s∈SRC i∈IND	Investment basic demands
x2_s(c,i)	c∈COM i∈IND	Investment use of imp/dom composite
x2mar(c,s,i,m)	c∈COM s∈SRC i∈IND m∈MAR	Investment margin demands
x2tot(i)	i∈IND	Investment by using industry
x2tot_i		Aggregate real investment expenditure
x3(c,s)	c∈COM s∈SRC	Household basic demands
x3_s(c)	c∈COM	Household use of imp/dom composite
x3lux(c)	c∈COM	Household - supernumerary demands
x3mar(c,s,m)	c∈COM s∈SRC m∈MAR	Household margin demands
x3sub(c)	c∈COM	Household - subsistence demands
x3tot		Real household consumption
x4(c)	c∈COM	Export basic demands
x4_ntrad		Quantity, Collective export aggregate
x4mar(c,m)	c∈COM m∈MAR	Export margin demands
x4tot		Export volume index
x5(c,s)	c∈COM s∈SRC	Government basic demands
x5mar(c,s,m)	c∈COM s∈SRC m∈MAR	Government margin demands
x5tot		Aggregate real government demands
x6tot		Aggregate real inventories

List of Regional Variables

Symbol	Dimensions	Description
delregx6(c,s,r)	c∈COM s∈SRC r∈REG	Inventories demand
ffreg1(i)	i∈IND	Complement of rsum1
ffreg2(i)	i∈IND	Complement of rsum2
ffreg3(c)	c∈COM	Complement of rsum3
ffreg4(c)	c∈COM	Complement of rsum4
ffreg5(c)	c∈COM	Complement of rsum5
ffreg6(c)	c∈COM	Complement of rsum6
freg1(i,r)	i∈IND r∈REG	Regional share shifter
freg2(i,r)	i∈IND r∈REG	Regional share shifter
freg3(c,r)	c∈COM r∈REG	Regional share shifter
freg4(c,r)	c∈COM r∈REG	Regional share shifter
freg5(c,r)	c∈COM r∈REG	Regional share shifter
freg6(c,r)	c∈COM r∈REG	Regional share shifter
regadvantage(i,r)	i∈IND r∈REG	Reg advantage decomposition
regemploy(i,r)	i∈IND r∈REG	Employment by reg and ind
regemploy_i(r)	r∈REG	Aggregate regional employment
regemploycon(i,r)	i∈IND r∈REG	Contributions to regional empl
regw1lab_io(r)	r∈REG	Wage bills by region
regx0(c,r)	c∈LOCCOM r∈REG	Regional usage of local commodities
regx1(c,s,i,r)	c∈COM s∈SRC i∈IND r∈REG	Regional demands for intermediate inputs
regx1mar(c,s,i,m,r)	c∈COM s∈SRC i∈IND m∈MAR r∈REG	Margins - production
regx1prim_i(r)	r∈REG	Gross region products

.../continued

Appendix K: List of Regional Variables (continued)

Symbol	Dimensions	Description
regx1primcon(i,r)	i∈IND r∈REG	Contributions to regional gdp
regx1tot(i,r)	i∈IND r∈REG	Output of regional industries
regx2(c,s,i,r)	c∈COM s∈SRC i∈IND r∈REG	Regional demands for inputs for investment
regx2mar(c,s,i,m,r)	c∈COM s∈SRC i∈IND m∈MAR r∈REG	Margins - capital creation
regx3(c,s,r)	c∈COM s∈SRC r∈REG	Household demand for goods
regx3mar(c,s,m,r)	c∈COM s∈SRC m∈MAR r∈REG	Margins - households
regx4(c,r)	c∈COM r∈REG	Exports by region
regx4mar(c,m,r)	c∈COM m∈MAR r∈REG	Margins - exports
regx5(c,s,r)	c∈COM s∈SRC r∈REG	Demands for inputs for "Other" demands
regx5mar(c,s,m,r)	c∈COM s∈SRC m∈MAR r∈REG	Margins - "Other"
rgshr1(i,r)	i∈IND r∈REG	Region share in national output
rgshr2(i,r)	i∈IND r∈REG	Region share in national investmment
rgshr3(c,r)	c∈COM r∈REG	Region share in national consumption
rgshr4(c,r)	c∈COM r∈REG	Region share in national exports
rgshr5(c,r)	c∈COM r∈REG	Region share in national gov.usage
rgshr6(c,r)	c∈COM r∈REG	Region share in national stocks
rsum1(i)	i∈IND	Addup term - should be zero
rsum2(i)	i∈IND	Addup term - should be zero
rsum3(c)	c∈COM	Addup term - should be zero
rsum4(c)	c∈COM	Addup term - should be zero
rsum5(c)	c∈COM	Addup term - should be zero
rsum6(c)	c∈COM	Addup term - should be zero

	Size	1 Producers	2 Investors	3 Household	4 Export*	5 Government	6 Stocks
		Absorption Matrix					
	Size	← I →	← I →	← H →	← 1 →	← 1 →	← 1 →
Basic Flows domestic	↑ C ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Basic Flows imported	↑ C ↓	V1BAS	V2BAS	V3BAS		V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					
Production Tax	↑ 1 ↓	V1PTX					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported,

O = Number of Occupation Types

M = Number of Commodities used as Margins

H = 1: Number of Household Types

* **Note: Export column is for domestic goods only.**

Size	Make Matrix ← I →	Total
↑ C ↓	MAKE	= sales row totals
Total	=col total absorptn	

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

ORANI-G flows database

Section 4

ORANI-G slides

ORANI-G

A Generic CGE Model

Document: ORANI-G***: a Generic Single-Country Computable General Equilibrium Model***

Please tell me if you find any mistakes in the document !

Contents

Introduction
Database structure
Solution method
TABLO language
Production: input decisions
Production: output decisions
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Household demands
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Margin demands
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Investment allocation
Labour market
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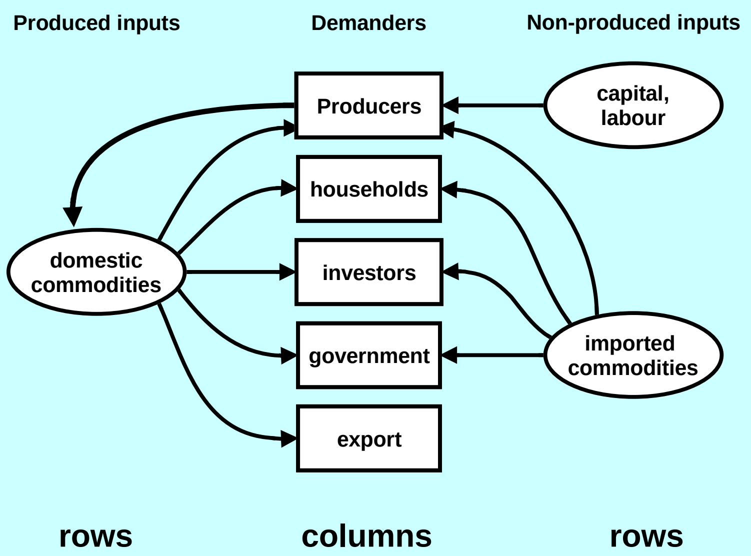
Closure
Regional extension

Stylized GE model: material flows



Stylized GE model: database (IO) table of transaction values

	Producer i	Absorption C I G	Export	Total Demand
Domestic good c	....	....	....	sum(left)
Imported good c	....	....		
Primary factor f	....			
Production cost	total cost of above			

Value of dom good c used by sector i

Costs = Sales

We need equations to determine
- a quantity for each cell, and
- a price for each row

Stylized GE model: demand equations

5

	Producer i	Absorption C I G	Export	Total Demand
Domestic good c	$Q_i F(P/PD_c)$	$E_u F(P, PD_c)$	$F(1/PD_c)$	Q_c= sum(left)
Imported good c	$Q_i F(P/PM_c)$	$E_u F(P, PM_c)$		
Primary factor f	$Q_i F(P/PF_f)$			QF_f= sum(left)
Production cost	total cost of above = $PD_i Q_i$			

Supply = demand

Quantity of good c used by sector i

Costs = Sales

Notation:

PD_c = price dom good c	PM_c = price imp good c	PF_f = price factor f	P = full price vector [PD,PM,PF]
Q_i = output good i	F = various functions	QF_f = supply factor f	E_u = expenditure final user u

Stylized CGE model: Number of equations = number endogenous variables

6

Variable	Determined by:
PD_c = price dom good c	ZERO PURE PROFITS values of sales = $PD_c Q_c$= sum(input costs) = F(all variables)
Q_c = output good c	MARKET CLEARING Q_c = sum(individual demands) = F(all variables)
PF_f = price factor f	For each f, one of PF or QF fixed, the other determined by:
QF_f = quantity factor f	QF_f = sum(individual demands) = F(all variables)
E_u = spending final user u	either fixed, or linked to factor incomes (with more equations)
PM_c = price imp good c	fixed

Red: exogenous (set by modeler)
Green: endogenous (explained by system)

What is an applied CGE model ?

- Computable, based on data
- It has many sectors
- And perhaps many regions, primary factors and households
- A big database of matrices
- Many, simultaneous, equations (hard to solve)

Unlike Input-Output models:

- Nonlinear equations (harder to solve)
- Prices guide demands by agents
- Prices determined by supply and demand
- Trade focus: elastic foreign demand and supply

CGE simplifications

- Not much dynamics (leads and lags)
- An imposed structure of behaviour, based on theory
  - Neoclassical assumptions (optimizing, competition)
  - Nesting (separability assumptions)

Why: time series data for huge matrices cannot be found.
Theory and assumptions (partially) replace econometrics

What is a CGE model good for ?

Analysing policies that affect different sectors in different ways

The effect of a policy on different:

- **Sectors**
- **Regions**
- **Factors (Labour, Land, Capital)**
- **Household types**

Policies (tariff or subsidies) that help one sector a lot, and harm all the rest a little.

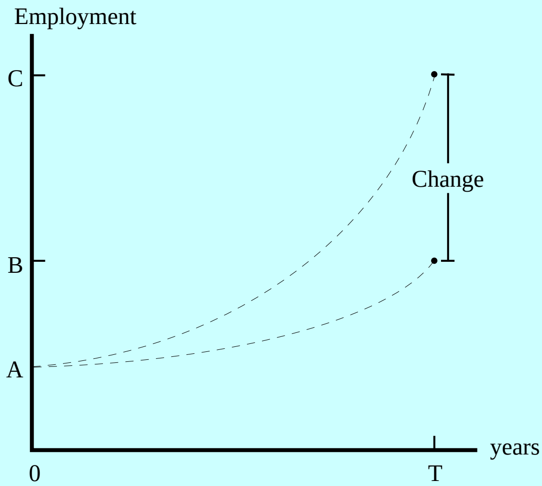
What-if questions

What if productivity in agriculture increased 1%?
What if foreign demand for exports increased 5%?
What if consumer tastes shifted towards imported food?
What if CO2 emissions were taxed?
What if water became scarce?

A great number of exogenous variables (tax rates, endowments, technical coefficients).
Comparative static models: Results show effect of policy shocks only, in terms of changes from initial equilibrium

p2

Comparative-static interpretation of results



Results refer to changes at some future point in time.

p1

ORANI-G

- **A model of the Australian economy, still used, but superseded at CoPS (by MMRF and other models).**
- **A teaching model.**
- **A template model, adapted for use in many other countries (INDORANI, TAIGEM, PRCGEM).**
- **Most versions do not use all features and add their own features.**
- **Still evolving: latest is ORANIG06.**
- **Various Australian databases:**

  23 sector 1987 data is public and free (document),

  34 sector 1994 data used in this course (simulations).

  144 sector 1997 data used by CoPS.

p2

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ORANI-G like other GE models

Equations typical of an AGE model, including:

- market-clearing conditions for commodities and primary factors;
- producers' demands for produced inputs and primary factors;
- final demands (investment, household, export and government);
- the relationship of prices to supply costs and taxes;
- a few macroeconomic variables and price indices.

Neo-classical flavour

- Demand equations consistent with optimizing behaviour (cost minimisation, utility maximisation).
- competitive markets: producers price at marginal cost.

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What makes ORANI special ?

Australian Style	USA style
Percentage change equations	Levels equations
Big, detailed data base	Less detailed data
Industry-specific fixed factors	Mobile capital, labour
Shortrun focus (2 years)	Long, medium run (7-20 yr)
Many prices	Few prices
Used for policy analysis	Prove theoretical point
Winners and Losers	National welfare
Missing macro relations (more exogenous variables)	Closed model:labour supply income-expenditure links
Variety of different closures	One main closure
Input-output database	SAM database
"Dumb" solution procedure	Special algorithm

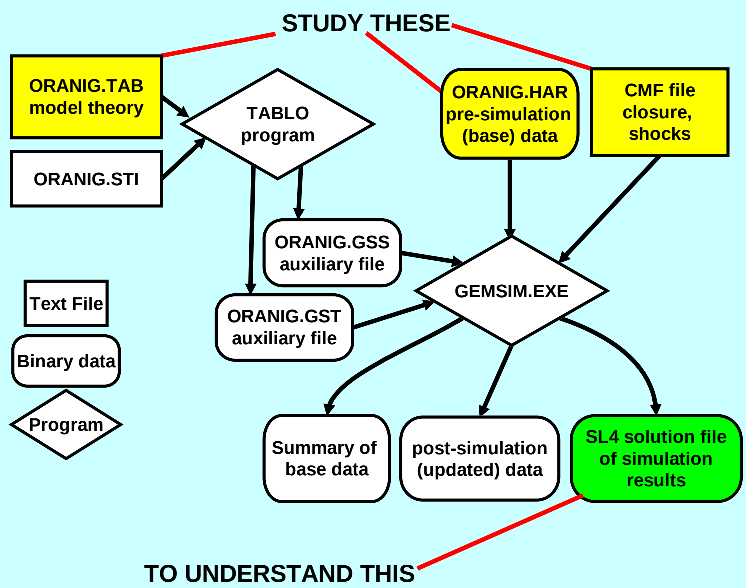
p1

page no. in document

You will learn

- how microeconomic theory -- cost-minimizing, utility-maximizing -- underlies the equations;
- the use of nested production and utility functions:
- how input-output data is used in equations;
- how model equations are represented in percent change form;
- how choice of exogenous variables makes model more flexible;
- how GEMPACK is used to solve a CGE model.

CGE models mostly similar, so skills will transfer.



Progress so far . . .

- **Introduction**
- ➔ **Database structure**
- Solution method
- TABLO language
- Production: input decisions
- Production: output decisions
- Investment: input decisions
- Household demands
- Export demands
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- Inventory demands
- Margin demands
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- Price equations
- Aggregates and indices
- Investment allocation
- Labour market
- Decompositions
- Closure
- Regional extension

p9

Model Database

memorize numbers

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S ↕	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M ↕	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S ↕	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O ↕	V1LAB					
Capital	1 ↕	V1CAP					
Land	1 ↕	V1LND					
Production Tax	1 ↕	V1PTX					
Other Costs	1 ↕	V1OCT					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported

O = Number of Occupation Types

M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
↑ C ↓	MAKE

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

p8

Features of Database

- Commodity flows are valued at "basic prices": do not include user-specific taxes or margins.
- For each user of each imported good and each domestic good, there are numbers showing:
  - tax levied on that usage.
  - usage of several margins (trade, transport).
- MAKE multiproduction:
  - Each commodity may be produced by several industries.
  - Each industry may produce several commodities.
- For each industry the total cost of production is equal to the total value of output (column sums of MAKE).
- For each commodity the total value of sales is equal to the total value of output (row sums of MAKE).
- No data regarding direct taxes or transfers. Not a full SAM.

Progress so far . . .

Introduction
Database structure
→ **Solution method**
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p1

Johansen method: overview

1. We start with the model's equations represented in their levels form

2. The equations are linearised: take total differential of each equation

3. Total differential expressions converted to (mostly) % change form

4. Linear equations evaluated at initial solution to the levels model

5. Exog. variables chosen. Model then solved for movements in endog. variables, given user-specified values for exog. variables.

But, a problem: Linearisation error

Multi-step, extrapolation

p68

Percent-change equations - examples

Levels form: $A = B + C$

Ordinary change form: $\Delta A = \Delta B + \Delta C$

Convert to % change form: $A(\underline{100.\Delta A/A}) = B(\underline{100.\Delta B/B}) + C(\underline{100.\Delta C/C})$

$A\ \underline{a} \quad = B\ \underline{b} \quad + C\ \underline{c}$

Typically two ways of expressing % change form

Intermediate form: $A\ a = B\ b + C\ c$

Percentage change (share) form: $a = S_b\ b + S_c\ c$

where $S_b = B/A$; $S_c = C/A$

p68

Percent-change equations - examples

Levels form: $A = B\,C$

Ordinary change form: $\Delta A = \Delta B\,C + \Delta C\,B$

Convert to % change form:

$A(100.\Delta A/A)=BC(100.\Delta B/B)+BC(100.\Delta C/C)$

$A \quad a \quad = BC \quad b \quad + BC \quad c$

$a \quad = \quad b \quad + \quad c$

PRACTICE: $X = F\,P^{\varepsilon}$

Ordinary Change and Percent Change are both linearized

Linearized equations easier for computers to solve

% change equations easier for economists to understand:elasticities

p4

Percent-change Numerical Example

Levels form $Z = X*Y$

2nd-order

Ordinary Change form $\Delta Z = Y*\Delta X + X*\Delta Y$ $[+ \Delta X\, \Delta Y]$

multiply by 100: $100*\Delta Z = 100*Y*\Delta X + 100*X*\Delta Y$

define x = % change in X, so $X*x=100\Delta X$

so: $Z*z = X*Y*x + X*Y*y$

divide by Z=X*Y to get:

Percent Change form $z = x + y$

Initially $X=4$, $Y=5$, so $Z = X*Y = 20$

Suppose x=25%, y=20% [ie, X:4⇒5, Y:5⇒6]

linear approximation z = x + y gives z = 45%

true answer: 30 = 5*6…… = 50% more than original 20

Error 5% is 2nd order term: $z = x+y + x*y/100$

Note: reduce shocks by a factor of 10, error by factor of 100

25%*20%
=5%
=50%- 45%

p4

Johansen method: example

F(Y,X) = 0   the model (thousands of equations)

Y = vector of endogenous variables (explained by model)

X = vector of exogenous variables (set outside model).

For example, a simple 2 equation model (but with no economic content)   (see DPPW p. 73 - 79)

(1) $Y_1 = X^{-1/2}$

(2) $Y_2 = 2 - Y_1$

Model in original levels form

or

(1) $Y_1 X^{1/2} - 1 = 0$

(2) $Y_2 - 2 + Y_1 = 0$

Vector function notation

p4

Johansen method (cont.)

We have initial values Y^0, X^0 which are a solution of F :

$F(Y^0, X^0) = 0$

We require an initial solution to the levels model

EG: In our simple 2 equation example:

$V^0 = (Y_1^0, Y_2^0, X^0) = (1, 1, 1)$ might be the initial solution

(1) $Y_1 X^{1/2} - 1 = 0$ → $1\,1^{1/2} - 1 = 0$

(2) $Y_2 - 2 + Y_1 = 0$ → $1 - 2 + 1 = 0$

p4

Johansen method (cont.)

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$F_Y(Y,X).dY + F_X(Y,X).dX = 0$

dY, dX are ordinary changes

Linearised model

We prefer percentage changes y = 100dY/Y, x = 100dX/X

$G_Y(Y,X).y + G_X(Y,X).x = 0$

$A.y + B.x = 0$

A = matrix of derivatives of endogenous variables

B = matrix of derivatives of exogenous variables

A and B depend on current values of levels variables: we exploit this in multi-step simulation to increase accuracy (see below)

p4

Johansen method (cont.)

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Back to 2 equation example:

(1) $Y_1 X^{1/2} - 1 = 0$

(2) $Y_2 - 2 + Y_1 = 0$

Convert to % change form:

(1a) $2 y_1 + x = 0$

(2a) $Y_2 y_2 + Y_1 y_1 = 0$

Which in matrix form is:

$$\begin{bmatrix} 2 & 0 & 1 \\ Y_1 & Y_2 & 0 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ x \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

We can re-write this, distinguishing endogenous and exogenous variables

p4

Johansen method (cont.)

Each column corresponds to a variable

Each row corresponds to an equation

$$\begin{bmatrix} 2 & 0 \\ Y_1 & Y_2 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} x = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$G_Y(Y,X) \quad y \ + \ G_X(Y,X) \ x \quad = \quad 0$$

$$A.y + B.x = 0$$

$$y = [- A^{-1} B] \, x$$

NB: Elasticities depend on initial solution

p4

Johansen method (cont.)

Continuing with our two equation example:

$$y = [- A^{-1} B] \, x$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = - \begin{bmatrix} 2 & 0 \\ Y_1 & Y_2 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 0 \end{bmatrix} x$$

NB: Elasticities depend on initial solution

Johansen: $[- A^{-1} B]$ evaluated once, using initial solution

Euler: change in x broken into small steps. $[- A^{-1} B]$ is repeatedly re-evaluated at the end of each step. By breaking the movement in x into a sufficiently small number of steps, we can get arbitrarily close to the true solution. Extrapolation: further improves accuracy.

p4

System of linear equations in matrix notation:

A.y + B.x = 0

y = vector of endogenous variables (explained by model)

x = vector of exogenous variables (set outside model).

A and B are matrices of coefficients:

each row corresponds to a model equation;

each column corresponds to a single variable.

Express y in terms of x by:

$y = - A^{-1}B.x$ where A^{-1} = inverse of A

A is: square: number of endogenous variable = number of equations

big: thousands or even millions of variables

mostly zero: each single equation involves only a few variables.

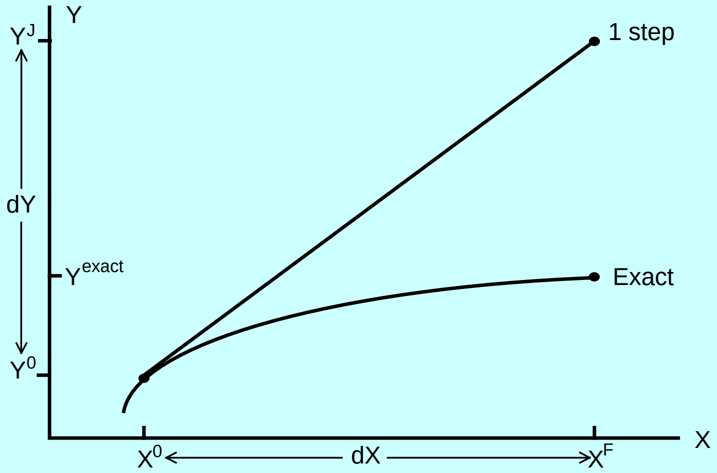
Linearized equation is

- **just an approximation to levels equation**
- **accurate only for small changes.**

GEMPACK repeatedly solves linear system to get exact solution

p4

Linearization Error



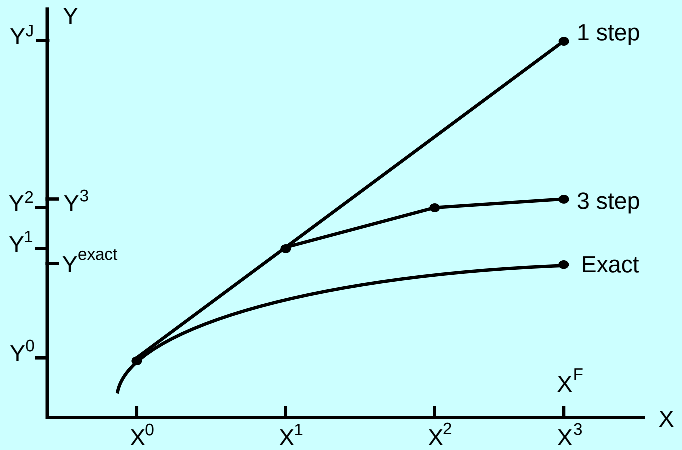
Y^J is *Johansen* estimate.

Error is proportionately less for smaller changes

p5

33

Breaking large changes in X into a number of steps



Multistep process to reduce linearisation error

p4

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Extrapolating from Johansen and Euler approximations

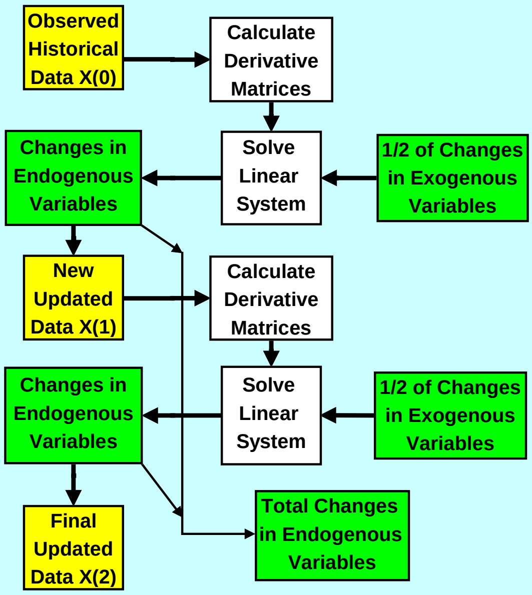
Method	y	Error
Johansen (1-step)	150%	50%
Euler 2-step	125%	25%
Euler 4-step	112.3%	12.3%
Euler ∞-step (exact)	100%	0

The error follows a rule.

Use results from 3 approximate solutions to estimate exact solution + error bound.

p6

2-step Euler computation in GEMPACK



At each step:

- compute coefficients from data;
- solve linear equation system;
- use changes in variables to update data.

p9

Entire Database is updated at each step

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S ↕	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M ↕	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S ↕	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O ↕	V1LAB					
Capital	1 ↕	V1CAP					
Land	1 ↕	V1LND					
Production Tax	1 ↕	V1PTX					
Other Costs	1 ↕	V1OCT					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported

O = Number of Occupation Types

M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
↑ C ↓	MAKE

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

Progress so far . . .

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Database structure	Margin demands
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Production: output decisions	Investment allocation
Investment: input decisions	Labour market
Household demands	Decompositions
Export demands	Closure
Government demands	Regional extension

p7

The TABLO language

```
Set
 IND # Industries #  (AgricMining, Manufacture, Utilities, Construction,
                TradeTranspt, FinanProprty, Services);   ! subscript i !
 FAC # Primary factors # (Labour, Capital);              ! subscript f !
Coefficient
 (all,f,FAC)(all,i,IND) FACTOR(f,i) # Wages and profits #;
 (all,i,IND)                  V1PRIM(i)   # Wages plus profits #;
Variable
 (all,i,IND) p1prim(i)  # Price of primary factor composite #;
             p1lab      # Wage rate #;
 (all,i,IND) p1cap(i)   # Rental price of capital #;
Read FACTOR     from file BASEDATA header "1FAC";
Formula (all,i,IND)  V1PRIM(i)  = sum{f,FAC,FACTOR(f,i)};
Equation E_p1prim
 (all,i,IND) V1PRIM(i)*p1prim(i)
         = FACTOR("Labour",i)*p1lab + FACTOR("Capital",i)*p1cap(i);
```

header = location in file

$\sum_{f \in FAC} \text{Factor}_{fi}$

Above equation defines average price to each industry of primary factors.

p11

The ORANI-G Naming System

or *GLOSS*

COEFFICIENT

variable

1 intermediate
2 investment
3 households
4 exports
5 government
6 inventories
0 all users

V levels value
p % price
x % quantity
del ord.change

V2TAX(c,s,i)

p1lab_o(i)

x3mar(c,s,m)

c COMmodities
s SouRCe (dom/imp)
i INDustries
m MARgin
o OCCupation
_o add over OCC

bas	basic (often omitted)	cap	capital
mar	margins	lab	labour
tax	indirect taxes	lnd	land
pur	at purchasers' prices	prim	all primary factors
imp	imports (duty paid)	tot	total inputs for a user

p10

Excerpt 1: Files and Sets

```
File     BASEDATA  # Input data file #;
 (new) SUMMARY  # Output for summary and checking data #;
Set
 COM # Commodities #
    read elements from file BASEDATA header "COM";          ! c !
 SRC # Source of commodities # (dom,imp);                   ! s !
 IND # Industries #
    read elements from file BASEDATA header "IND";          ! i !
 OCC # Occupations #
    read elements from file BASEDATA header "OCC";          ! o !
 MAR # Margin commodities #
    read elements from file BASEDATA header "MAR";          ! m !
Subset MAR is subset of COM;
Set NONMAR # Non-margins # = COM - MAR;                     ! n !
```

p10

Core Data and Variables

We begin by declaring variables and data coefficients which appear in many different equations.

Other variables and coefficients will be declared as needed.

p9

Basic Flows

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported

O = Number of Occupation Types

M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
C	MAKE

Size	Import Duty ← 1 →
C	V0TAR

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Excerpt 2a: Basic Commodity Flows

```
Coefficient  ! Basic flows of commodities (excluding margin demands)!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  # Intrmediate basic flows #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2BAS(c,s,i)  # Investment basic flows #;
 (all,c,COM)(all,s,SRC)             V3BAS(c,s)    # Household basic flows #;
 (all,c,COM)                        V4BAS(c)      # Export basic flows #;
 (all,c,COM)(all,s,SRC)             V5BAS(c,s)    # Govment basic flows #;
 (all,c,COM)(all,s,SRC)             V6BAS(c,s)    # Inventories basic flows #;

Read
 V1BAS from file BASEDATA header "1BAS";
 V2BAS from file BASEDATA header "2BAS";
 V3BAS from file BASEDATA header "3BAS";
 V4BAS from file BASEDATA header "4BAS";
 V5BAS from file BASEDATA header "5BAS";
 V6BAS from file BASEDATA header "6BAS";
```

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Coefficients and Variables

<u>Coefficients</u>

example: V1BAS(c,s,i) UPPER CASE

Mostly values

Either read from file

or computed with formulae

Constant during each step

<u>Variables</u>

example: x1bas (c,s,i) lower case

Often prices or quantities

Percent or ordinary change

Related via equations

Exogenous or endogenous

Vary during each step

p13

Excerpt 2b: Basic Commodity Flows

```
Variable  ! used to update flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)     x1(c,s,i)  # Intermediate demands #;
. . . . . . . . . . . . . . . . . . . . . . . . .
 (all,c,COM)                       x4(c)      # Export basic demands #;
 (all,c,COM)(all,s,SRC)     x5(c,s) # Government basic demands #;
 (change) (all,c,COM)(all,s,SRC) delx6(c,s) # Inventories #;
 (all,c,COM)(all,s,SRC)      p0(c,s) # Basic prices for local users #;
 (all,c,COM)                 pe(c)      # Basic price of exportables #;
 (change)(all,c,COM)(all,s,SRC)  delV6(c,s)    # inventories #;
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1BAS(c,s,i)  = p0(c,s)*x1(c,s,i);
. . . . . . . . . . . . . . . . . . . . . . . . .
 (all,c,COM)                            V4BAS(c)      = pe(c)*x4(c);
 (all,c,COM)(all,s,SRC)                 V5BAS(c,s)    = p0(c,s)*x5(c,s);
 (change)(all,c,COM)(all,s,SRC)     V6BAS(c,s)    = delV6(c,s);
```

p13

Ordinary Change Variables

```
Variable  ! used to update flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)  x1(c,s,i)    # Intermediate #;
. . . . . . . . . . . . . . . . . . . . . . . . .
 (change) (all,c,COM)(all,s,SRC) delx6(c,s) # Inventories #;
```

By default variables are percent change.

Exact, multi-step solutions made from
a sequence of small percent changes.

Small percent changes do not allow sign change
(eg, from 2 to -1).

Variables which change sign must be ordinary change.

p13

Update Statements

Default (product) update
V ➜ V(1+p/100+x/100)

Update
(all,c,COM)(all,s,SRC)(all,i,IND) V1BAS(c,s,i) = p0(c,s)*x1(c,s,i);
. . . .
(all,c,COM) V4BAS(c) = pe(c)*x4(c);
(all,c,COM)(all,s,SRC) V5BAS(c,s) = p0(c,s)*x5(c,s);
(change)(all,c,COM)(all,s,SRC) V6BAS(c,s) = delV6(c,s);

Ordinary change update
V ➜ V + ΔV

Updates: the vital link between variables and data
show how data relates to variables

p9

Margins

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

C = Number of Commodities
I = Number of Industries
S = 2: Domestic,Imported
O = Number of Occupation Types
M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
C	MAKE

Size	Import Duty ← 1 →
C	V0TAR

p14

Excerpt 3a: Margin Flows

```
Coefficient
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                         V1MAR(c,s,i,m)  # Intermediate margins #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
                         V2MAR(c,s,i,m)  # Investment margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)
                         V3MAR(c,s,m)   # Households margins #;
 (all,c,COM)(all,m,MAR)              V4MAR(c,m)     # Export margins #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)  V5MAR(c,s,m)   # Government #;
Read
 V1MAR from file BASEDATA header "1MAR";
 V2MAR from file BASEDATA header "2MAR";
 V3MAR from file BASEDATA header "3MAR";
 V4MAR from file BASEDATA header "4MAR";
 V5MAR from file BASEDATA header "5MAR";
```

m: transport bringing
s: imported
c: leather to
i: shoe industry

- *Note: no margins on inventories*

p14

Excerpt 3b: Margin Flows

```
Variable ! Variables used to update above flows !
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x1mar(c,s,i,m)# Intermediate margin demand #;
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   x2mar(c,s,i,m)# Investment margin demands #;
 (all,c,COM)(all,s,SRC)(all,m,MAR)
   x3mar(c,s,m)  # Household margin demands #;
 (all,c,COM)
   p0dom(c) # Basic price of domestic goods = p0(c,"dom") #;
Update
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   V1MAR(c,s,i,m)  = p0dom(m)*x1mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   V2MAR(c,s,i,m)  = p0dom(m)*x2mar(c,s,i,m);
 (all,c,COM)(all,s,SRC)(all,m,MAR)
   V3MAR(c,s,m)    = p0dom(m)*x3mar(c,s,m);
```

not shown:
4: export
5: government

m: transport bringing
s: imported
c: leather to
i: shoe industry

p9

Commodity Taxes

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S ↕	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M ↕	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S ↕	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O ↕	V1LAB					
Capital	1 ↕	V1CAP					
Land	1 ↕	V1LND					
Production Tax	1 ↕	V1PTX					
Other Costs	1 ↕	V1OCT					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported

O = Number of Occupation Types

M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
↑ C ↓	MAKE

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

p15

Excerpt 4a: Commodity Taxes

```
Coefficient  ! Taxes on Basic Flows!
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1TAX(c,s,i) # Taxes on intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2TAX(c,s,i) # Taxes on investment #;
 (all,c,COM)(all,s,SRC)             V3TAX(c,s)   # Taxes on h'holds #;
 (all,c,COM)                        V4TAX(c)     # Taxes on export #;
 (all,c,COM)(all,s,SRC)             V5TAX(c,s)   # Taxes on gov'ment #;
Read
 V1TAX from file BASEDATA header "1TAX";
 V2TAX from file BASEDATA header "2TAX";
 V3TAX from file BASEDATA header "3TAX";
 V4TAX from file BASEDATA header "4TAX";
 V5TAX from file BASEDATA header "5TAX";
```

Simulate: no tax on diesel for farmers
subsidy on cement and bricks used to build schools

p15

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Excerpt 4b: Commodity Taxes

Variable
(change)(all,c,COM)(all,s,SRC)(all,i,IND) delV1TAX(c,s,i) # Interm tax rev #;
(change)(all,c,COM)(all,s,SRC)(all,i,IND) delV2TAX(c,s,i) # Invest tax rev #;
(change)(all,c,COM)(all,s,SRC) delV3TAX(c,s) # H'hold tax rev #;
(change)(all,c,COM) delV4TAX(c) # Export tax rev #;
(change)(all,c,COM)(all,s,SRC) delV5TAX(c,s) # Govmnt tax rev #;
Update
(change)(all,c,COM)(all,s,SRC)(all,i,IND) V1TAX(c,s,i) = delV1TAX(c,s,i);
(change)(all,c,COM)(all,s,SRC)(all,i,IND) V2TAX(c,s,i) = delV2TAX(c,s,i);
(change)(all,c,COM)(all,s,SRC) V3TAX(c,s) = delV3TAX(c,s);
(change)(all,c,COM) V4TAX(c) = delV4TAX(c);
(change)(all,c,COM)(all,s,SRC) V5TAX(c,s) = delV5TAX(c,s);

Note: equations defining delV#TAX tax variables appear later; they depend on type of tax;

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Primary Factors, etc

	Size	1 Producers ← I →	2 Investors ← I →	3 Household ← 1 →	4 Export ← 1 →	5 Government ← 1 →	6 Inventories ← 1 →
Basic Flows	C×S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	C×S×M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	C×S	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

- C = Number of Commodities
- I = Number of Industries
- S = 2: Domestic,Imported
- O = Number of Occupation Types
- M = Number of Commodities used as Margins

Size	Joint Production Matrix ← I →
C	MAKE

Size	Import Duty ← 1 →
C	V0TAR

Excerpt 5: Primary Factors etc

Capital example

```
Coefficient   (all,i,IND)     V1CAP(i)      # Capital rentals #;

Read V1CAP from file BASEDATA header "1CAP";

Variable     (all,i,IND)   x1cap(i)    # Current capital stock #;
             (all,i,IND)   p1cap(i)    # Rental price of capital #;

Update       (all,i,IND)   V1CAP(i)  = p1cap(i)*x1cap(i);
```


Excerpt 5a: Primary Factors etc

```
Coefficient
 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  # Wage bill matrix #;
 (all,i,IND)              V1CAP(i)    # Capital rentals #;
 (all,i,IND)              V1LND(i)    # Land rentals #;
 (all,i,IND)              V1PTX(i)    # Production tax #;
 (all,i,IND)              V1OCT(i)    # Other cost tickets #;
Read
 V1LAB from file BASEDATA header "1LAB";
 V1CAP from file BASEDATA header "1CAP";
 V1LND from file BASEDATA header "1LND";
 V1PTX from file BASEDATA header "1PTX";
 V1OCT from file BASEDATA header "1OCT";
```

Different skills (↑ OCC)

Note: V1PTX is ad valorem, V1OCT is specific

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Excerpt 5b: Primary Factors etc

```
Variable
 (all,i,IND)(all,o,OCC)   x1lab(i,o)  # Employment by industry and occupation #;
 (all,i,IND)(all,o,OCC)   p1lab(i,o)  # Wages by industry and occupation #;
 (all,i,IND)  x1cap(i)       # Current capital stock #;
 (all,i,IND)  p1cap(i)       # Rental price of capital #;
 (all,i,IND)  x1lnd(i)       # Use of land #;
 (all,i,IND)  p1lnd(i)       # Rental price of land #;
 (change)(all,i,IND) delV1PTX(i) # Ordinary change in production tax revenue #;
 (all,i,IND)  x1oct(i)       # Demand for "other cost" tickets #;
 (all,i,IND)  p1oct(i)       # Price of "other cost" tickets #;
Update
 (all,i,IND)(all,o,OCC)  V1LAB(i,o)  = p1lab(i,o)*x1lab(i,o);
 (all,i,IND)              V1CAP(i)    = p1cap(i)*x1cap(i);
 (all,i,IND)              V1LND(i)    = p1lnd(i)*x1lnd(i);
(change)(all,i,IND)       V1PTX(i)    = delV1PTX(i);   <-- equation later
 (all,i,IND)              V1OCT(i)    = p1oct(i)*x1oct(i);
```

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Excerpt 5c: Tariffs

Coefficient (all,c,COM) V0TAR(c) # Tariff revenue #;
Read V0TAR from file BASEDATA header "0TAR";
Variable (all,c,COM) (change)
delV0TAR(c) # Ordinary change in tariff revenue #;
Update (change) (all,c,COM) V0TAR(c) = delV0TAR(c);

Note: tariff is independent of user, unlike V#TAX matrices.

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Excerpt 6a: purchaser's values (basic + margins + taxes)

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```
Coefficient
 (all,c,COM)(all,s,SRC)(all,i,IND)  V1PUR(c,s,i) # Intermediate purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND)  V2PUR(c,s,i)  # Investment purch. value #;
 (all,c,COM)(all,s,SRC)             V3PUR(c,s)  # Households purch. value #;
 (all,c,COM)                        V4PUR(c)    # Export purch. value #;
 (all,c,COM)(all,s,SRC)             V5PUR(c,s)  # Government purch. value #;
Formula
 (all,c,COM)(all,s,SRC)(all,i,IND)
   V1PUR(c,s,i)  = V1BAS(c,s,i) + V1TAX(c,s,i)
                   + sum{m,MAR, V1MAR(c,s,i,m)};
. . . . . . . . . . . . .
 (all,c,COM)(all,s,SRC)
   V5PUR(c,s)    = V5BAS(c,s)   + V5TAX(c,s)
                   + sum{m,MAR, V5MAR(c,s,m)};
```

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Excerpt 6b: purchaser's prices

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```
Variable
 (all,c,COM)(all,s,SRC)(all,i,IND) p1(c,s,i) # Purchaser's price, intermediate #;
 (all,c,COM)(all,s,SRC)(all,i,IND) p2(c,s,i) # Purchaser's price, investment #;
 (all,c,COM)(all,s,SRC)            p3(c,s)   # Purchaser's price, household #;
 (all,c,COM)                       p4(c)     # Purchaser's price, exports, loc$ #;
 (all,c,COM)(all,s,SRC)            p5(c,s)   # Purchaser's price, government #;
```

Progress so far . . .

Introduction	Inventory demands
Database structure	Margin demands
Solution method	Market clearing
TABLO language	Price equations
→ **Production: input decisions**	Aggregates and indices
Production: output decisions	Investment allocation
Investment: input decisions	Labour market
Household demands	Decompositions
Export demands	Closure
Government demands	Regional extension

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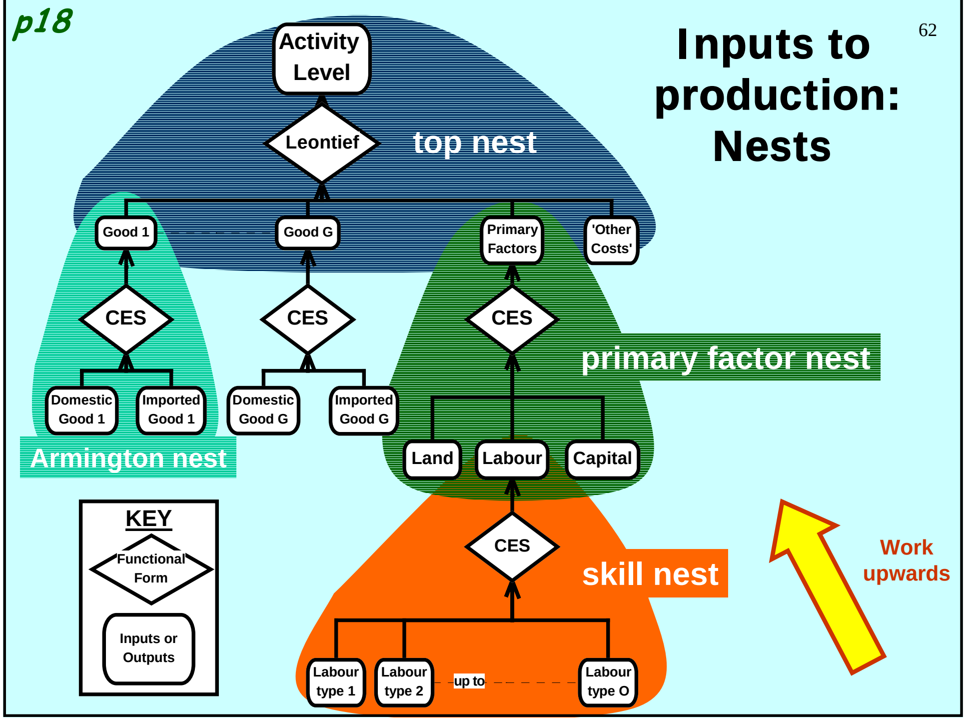
Inputs to production: Nests



Nested Structure of production

In each industry: Output = function of inputs:

output = F(inputs) = F(Labour, Capital, Land, dom goods, imp goods)

Separability assumptions simplify the production structure:

output = F(primary factor composite, composite goods)

where:

primary factor composite = CES(Labour, Capital, Land)

labour = CES(Various skill grades)

composite good (i) = CES(domestic good (i), imported good (i))

All industries share common production structure.

BUT: Input proportions and behavioural parameters vary.

Nesting is like staged decisions:

First decide how much leather to use—based on output.

Then decide import/domestic proportions, depending on the relative prices of local and foreign leather.

Each nest requires 2 or 3 equations.

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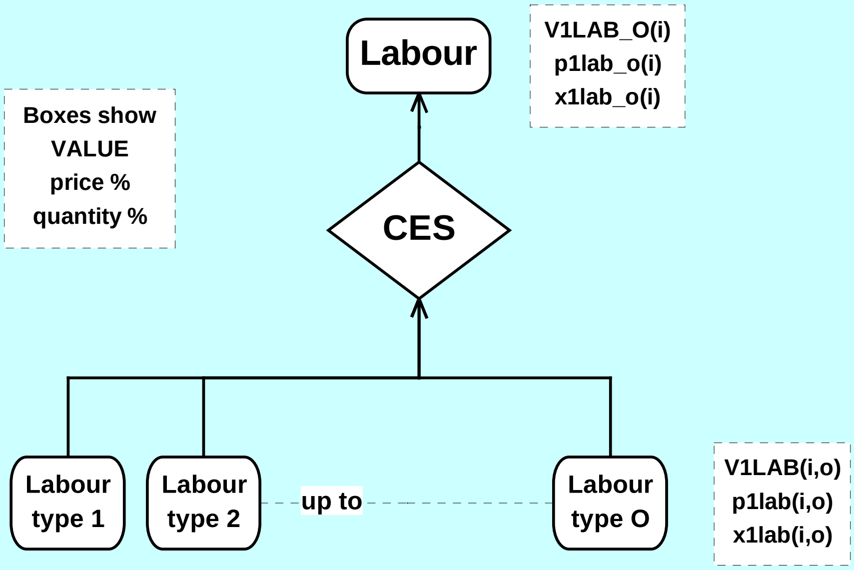
Excerpt 7: Skill Mix



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Excerpt 7: Skill Mix

Problem: for each industry i, choose labour inputs X1LAB(i,o) to minimize labour cost:

*sum{o,OCC, P1LAB(i,o)*X1LAB(i,o)}*

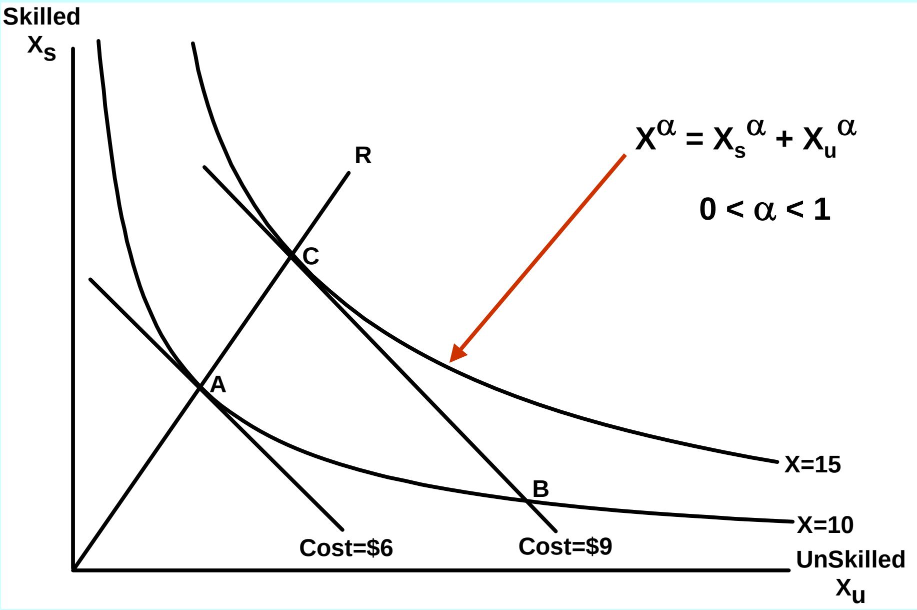
such that X1LAB_O(i) = CES(All,o,OCC: X1LAB(i,o))

given

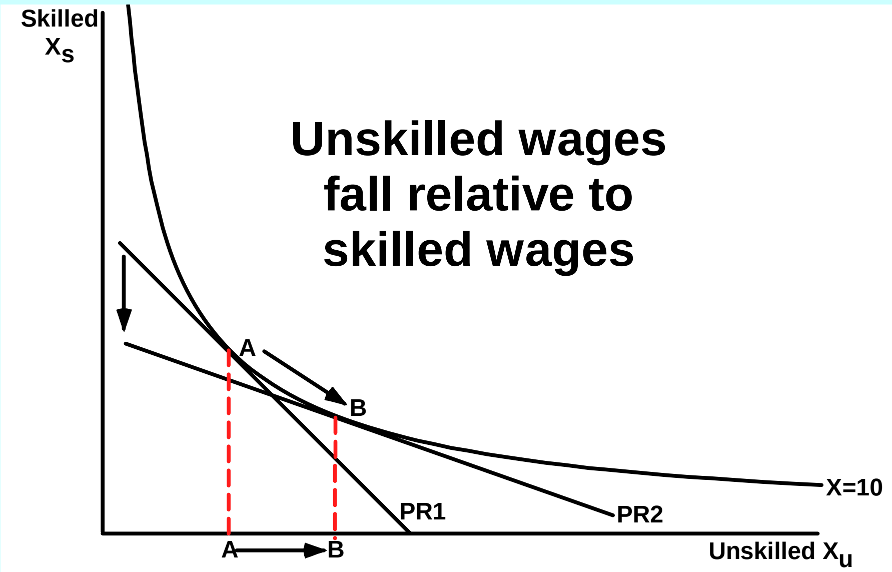
Coefficient
(all,i,IND) SIGMA1LAB(i) # CES substitution between skills #;
(all,i,IND) V1LAB_O(i) # Total labour bill in industry i #;
TINY# Small number to prevent zerodivides or singular matrix #;
Read SIGMA1LAB from file BASEDATA header "SLAB";
Formula (all,i,IND) V1LAB_O(i) = sum{o,OCC, V1LAB(i,o)};
TINY = 0.000000000001;

add over OCC

CES Skill Substitution



Effect of Price Change



Deriving the CES demand equations

See ORANI-G document Appendix A

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Excerpt 7: Skill Mix

Variable
(all,i,IND) p1lab_o(i) # Price to each industry of labour composite #;
(all,i,IND) x1lab_o(i) # Effective labour input #;
Equation
E_x1lab # Demand for labour by industry and skill group #
(all,i,IND)(all,o,OCC)
x1lab(i,o) = x1lab_o(i) - SIGMA1LAB(i)*[p1lab(i,o) - p1lab_o(i)];
E_p1lab_o # Price to each industry of labour composite #
(all,i,IND) [TINY+V1LAB_O(i)]*p1lab_o(i)
= sum{o,OCC, V1LAB(i,o)*p1lab(i,o)};

MEMORIZE $x_o = x_{average} - \sigma[p_o - p_{average}]$

CES PATTERN $p_{average} = \Sigma S_o.p_o$

relative price term

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The many faces of CES

normal nest form

$x_1 = x_{ave} - \sigma[p_1 - p_{ave}]$

$x_2 = x_{ave} - \sigma[p_2 - p_{ave}]$

$x_3 = x_{ave} - \sigma[p_3 - p_{ave}]$

$p_{ave} = S_1p_1 + S_2p_2 + S_3p_3$

multiply by share

$S_1x_1 = S_1x_{ave} - \sigma S_1 [p_1 - p_{ave}]$

$S_2x_2 = S_2x_{ave} - \sigma S_2 [p_2 - p_{ave}]$

$S_3x_3 = S_3x_{ave} - \sigma S_3 [p_3 - p_{ave}]$

add all three (price terms vanish)

$S_1x_1 + S_2x_2 + S_3x_3 = x_{ave}$

concentrated or pre-optimized production function

subtract

$x_2 - x_3 = - \sigma[p_2 - p_3]$

each new equation can be used to replace one original equation

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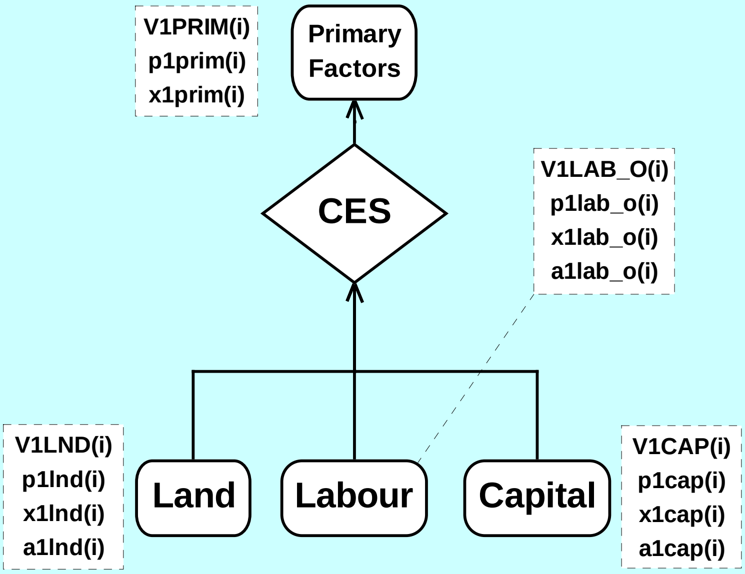
Excerpt 8: Primary factor Mix



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Excerpt 8a: Primary factor Mix

X1PRIM(i) = CES(X1LAB_O(i)/A1LAB_O(i),
X1CAP(i)/A1CAP(i),
X1LND(i)/A1LND(i))

quantity-augmenting technical change

Coefficient (all,i,IND) SIGMA1PRIM(i) # CES substitution, primary factors #;
Read SIGMA1PRIM from file BASEDATA header "P028";
Coefficient (all,i,IND) V1PRIM(i) # Total factor input to industry i#;
Formula (all,i,IND) V1PRIM(i) = V1LAB_O(i)+ V1CAP(i) + V1LND(i);
Variable
(all,i,IND) p1prim(i) # Effective price of primary factor composite #;
(all,i,IND) x1prim(i) # Primary factor composite #;
(all,i,IND) a1lab_o(i) # Labor-augmenting technical change #;
(all,i,IND) a1cap(i) # Capital-augmenting technical change #;
(all,i,IND) a1lnd(i) # Land-augmenting technical change #;
(change)(all,i,IND) delV1PRIM(i)#Ordinary change, cost of primary factors#;

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Excerpt 8b: Primary factor Mix

Equation

(x-a): effective input

E_x1lab_o # Industry demands for effective labour #
(all,i,IND) x1lab_o(i) - a1lab_o(i) =
x1prim(i) - SIGMA1PRIM(i)*[p1lab_o(i) + a1lab_o(i) - p1prim(i)];

E_p1cap # Industry demands for capital #
(all,i,IND) x1cap(i) - a1cap(i) =
x1prim(i) - SIGMA1PRIM(i)*[p1cap(i) + a1cap(i) - p1prim(i)];

(p+a): price of effective input

E_p1lnd # Industry demands for land #
(all,i,IND) x1lnd(i) - a1lnd(i) =
x1prim(i) - SIGMA1PRIM(i)*[p1lnd(i) + a1lnd(i) - p1prim(i)];

E_p1prim # Effective price term for factor demand equations #
(all,i,IND) V1PRIM(i)*p1prim(i) = V1LAB_O(i)*[p1lab_o(i) + a1lab_o(i)]
+ V1CAP(i)*[p1cap(i) + a1cap(i)] + V1LND(i)*[p1lnd(i) + a1lnd(i)];

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Excerpt 8: Primary Factor Mix

Original $x_o = x_{average} - \sigma[p_o - p_{average}]$

CES Pattern $p_{average} = \Sigma S_o . p_o$

$x \rightarrow x - a \quad p \rightarrow p + a$

With $x_f - a_f = x_{average} - \sigma[p_f + a_f - p_{average}]$

Tech Change $p_{average} = \Sigma S_f . [p_f + a_f]$

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Excerpt 8c: Cost of Primary factors

Equation

E_delV1PRIM # Ordinary change in cost, primary factors #
(all,i,IND) 100*delV1PRIM(i) =
V1CAP(i) * [p1cap(i) + x1cap(i)]
+ V1LND(i) * [p1lnd(i) + x1lnd(i)]
+ sum{o,OCC, V1LAB(i,o)* [p1lab(i,o) + x1lab(i,o)]};

100 times change in value

V = value = P.X so v = p + x
V.v = 100 times change in V = V[p+x]*

. . . will prove a convenient representation for the zero pure profit equation . . .

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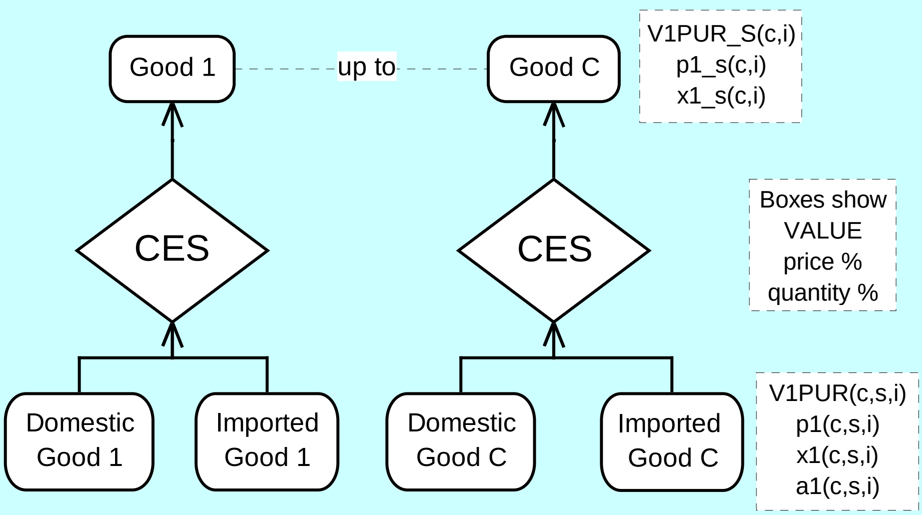
Excerpt 9a: Intermediate Sourcing



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Excerpt 9a: Intermediate Sourcing

```
X1_S(c,i) = CES( All,s,SRC: X1(c,s,i)/A1(c,s,i) )
Variable
 (all,c,COM)(all,s,SRC)(all,i,IND) a1(c,s,i) # Intermediate basic tech change #;
 (all,c,COM)(all,i,IND) x1_s(c,i)    # Intermediate use of imp/dom composite #;
 (all,c,COM)(all,i,IND) p1_s(c,i)    # Price, intermediate imp/dom composite #;
Coefficient
 (all,c,COM)              SIGMA1(c)    # Armington elasticities: intermediate #;
 (all,c,COM)(all,i,IND) V1PUR_S(c,i) # Dom+imp intermediate purch. value #;
 (all,c,COM)(all,s,SRC)(all,i,IND)   S1(c,s,i) # Intermediate source shares #;
Read SIGMA1 from file BASEDATA header "1ARM";
Zerodivide default 0.5;
Formula
 (all,c,COM)(all,i,IND)          V1PUR_S(c,i) = sum{s,SRC, V1PUR(c,s,i)};
 (all,c,COM)(all,s,SRC)(all,i,IND) S1(c,s,i)    = V1PUR(c,s,i) / V1PUR_S(c,i);
Zerodivide off;
```

alternative to TINY

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Excerpt 9b: Intermediate Sourcing

```
X1_S(c,i) = CES( All,s,SRC: X1(c,s,i)/A1(c,s,i) )

Equation E_x1  # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  x1(c,s,i)-a1(c,s,i) =
          x1_s(c,i) -SIGMA1(c)*[p1(c,s,i) +a1(c,s,i) -p1_s(c,i)];
```

x-a

```
Equation E_p1_s  # Effective price, commodity composite #
 (all,c,COM)(all,i,IND)
  p1_s(c,i) = sum{s,SRC, S1(c,s,i)*[p1(c,s,i) + a1(c,s,i)]};
```

p+a

$$x_s - a_s = x_{average} - \sigma[p_s + a_s - p_{average}]$$

$$p_{average} = \Sigma S_s.[p_s + a_s]$$

p22

Excerpt 9: Intermediate Cost Index

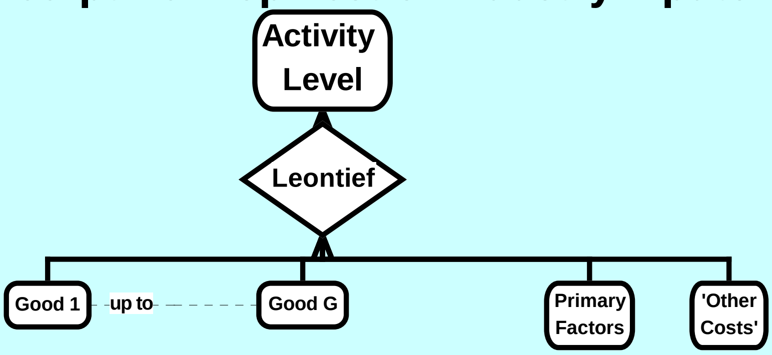
Variable (all,i,IND) p1mat(i) # Intermediate cost price index #;
Coefficient (all,i,IND) V1MAT(i)
Total intermediate cost for industry i #;
Formula
(all,i,IND) V1MAT(i) = sum{c,COM, V1PUR_S(c,i)};

Equation E_p1mat # Intermediate cost price index #
(all,i,IND)
[TINY+V1MAT(i)]*p1mat(i) =
sum{c,COM, sum{s,SRC, V1PUR(c,s,i)*p1(c,s,i)}};

Optional, could be useful for understanding results
Also p1var = average all input prices EXCEPT capital and land

p23

Excerpt 10: Top nest of industry inputs



X1TOT(i) = MIN(All,c,COM: X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)],
X1PRIM(i)/[A1PRIM(i)*A1TOT(i)],
X1OCT(i)/[A1OCT(i)*A1TOT(i)])

p23

Excerpt 10: Top nest of industry inputs

```
Variable
 (all,i,IND)  x1tot(i)     # Activity level or value-added #;
 (all,i,IND)  a1prim(i)  # All factor augmenting technical change #;
 (all,i,IND)  a1tot(i)     # All input augmenting technical change #;
 (all,i,IND)  p1tot(i)     # Average input/output price #;
 (all,i,IND)  a1oct(i)    # "Other cost" ticket augmenting techncal change#;
 (all,c,COM)(all,i,IND)
               a1_s(c,i)  #Tech change, int'mdiate imp/dom composite#;

Equation E_x1_s  # Demands for commodity composites #
 (all,c,COM)(all,i,IND)  x1_s(c,i) - [a1_s(c,i) + a1tot(i)] = x1tot(i);

Equation E_x1prim  # Demands for primary factor composite #
 (all,i,IND)  x1prim(i) - [a1prim(i) + a1tot(i)] = x1tot(i);

Equation E_x1oct  # Demands for other cost tickets #
 (all,i,IND)  x1oct(i) - [a1oct(i) + a1tot(i)] = x1tot(i);
```

p24

Excerpt 11a: Total Cost and Production Tax

```
Coefficient
 (all,i,IND)  V1CST(i)    # Total cost of industry i #;
 (all,i,IND)  V1TOT(i)    # Total industry cost plus tax #;
 (all,i,IND) PTXRATE(i)   # Rate of production tax #;
Formula
 (all,i,IND)  V1CST(i)    = V1PRIM(i) + V1OCT(i) + V1MAT(i);
 (all,i,IND)  V1TOT(i)    = V1CST(i) + V1PTX(i);
 (all,i,IND)  PTXRATE(i)  = V1PTX(i)/V1CST(i); !  VAT: V1PTX/V1PRIM   !
Write PTXRATE to file SUMMARY header "PTXR";

Variable
 (change)(all,i,IND) delV1CST(i) # Change in ex-tax cost of production #;
 (change)(all,i,IND) delV1TOT(i) # Change in tax-inc cost of production #;
 (change)(all,i,IND) delPTXRATE(i) # Change in rate of production tax #;
```

p24

Excerpt 11b: Total Cost and Production Tax

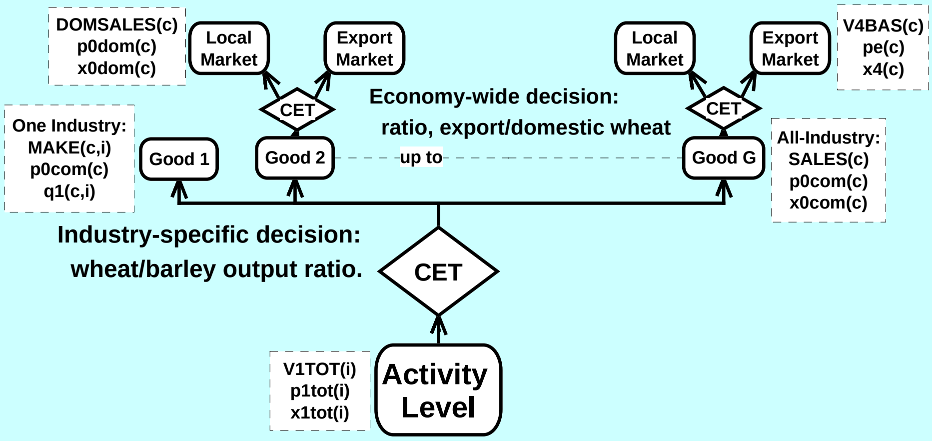
```
Equation
 E_delV1CST  (all,i,IND) delV1CST(i) = delV1PRIM(i) +
  0.01*sum{c,COM,sum{s,SRC, V1PUR(c,s,i)*[p1(c,s,i) + x1(c,s,i)]}}
                 +  0.01*V1OCT(i)*[p1oct(i)  + x1oct(i)];

 E_delV1PTX  (all,i,IND) delV1PTX(i) =
                   PTXRATE(i)*delV1CST(i)  + V1CST(i) * delPTXRATE(i);
 ! VAT alternative:
      PTXRATE(i)*delV1PRIM(i) + V1PRIM(i)* delPTXRATE(i); !

 E_delV1TOT  (all,i,IND) delV1TOT(i) = delV1CST(i) + delV1PTX(i);

 E_p1tot     (all,i,IND) V1TOT(i)*[p1tot(i) + x1tot(i)] = 100*delV1TOT(i);
```


Progress so far . . .

Introduction	Inventory demands
Database structure	Margin demands
Solution method	Market clearing
TABLO language	Price equations
Production: input decisions	Aggregates and indices
→ **Production: output decisions**	Investment allocation
Investment: input decisions	Labour market
Household demands	Decompositions
Export demands	Closure
Government demands	Regional extension

p25

Excerpt 12: Industry Output mix

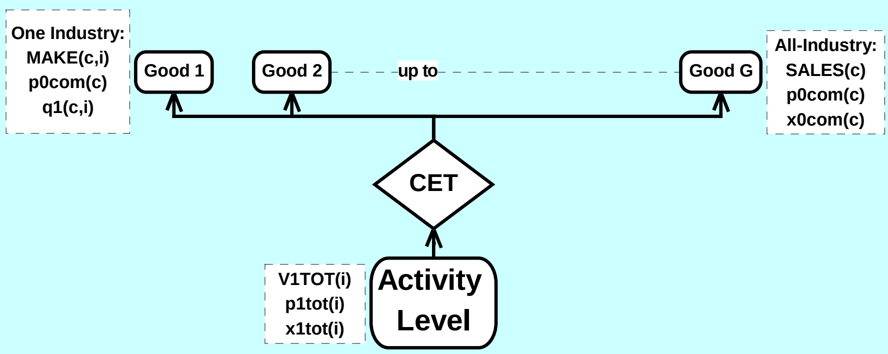


Export/domestic ratio for wheat
is same, whichever industry made it.

In practice, often not so complex:
- most industries make just one good
- export/local CET usually not active

p25

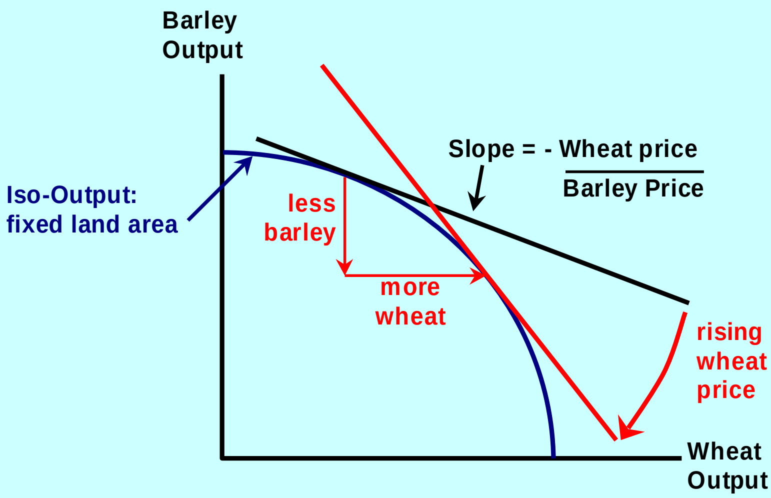
Excerpt 12: Multiproduction Commodity Mix



Industry 7 might produce Commodities 6, 7, and 8.
Commodity 3 might be produced by industries 3 and 9.
MAKE(COM,IND) shows which industry produces what.
Every industry that produces wheat gets the same wheat price.
As wheat price rises, industries make more wheat and less barley

p25

Excerpt 12: CET transformation frontier



As wheat price rises, industry makes more wheat and less barley.

Algebra same as CES, but substitution elasticity has opposite sign

Australian invention: Powell/Gruen

p25

Do we need Multiproduction?

Competing technologies for producing one commodity:
- oil-burning and nuclear plants both make electricity (Taiwan)
- zonal agriculture: intensive or extensive beef-production (Australia)

Alternative outputs for a single industry:
- Milk/Cattle/Pigs making milk, butter, pork and beef

Supplied MAKE may have many small off-diagonal elements:
- IO tables: commodity-industry
- Establishment definition:
  - a shoe factory is one that makes MAINLY shoes, but maybe belts too.
- Commodity supplies vector not quite equal to industry output vector,
- but MAKE row sums = commodity supplies vector,
- and MAKE col sums = industry output vector.
- Don't want to adjust data so that MAKE is diagonal,
- ie, form commodity-commodity or industry-industry IO table.

Excerpt 12a: Industry Output mix

```
Coefficient (all,c,COM)(all,i,IND) MAKE(c,i) # Multiproduction matrix #;
Variable (all,c,COM)(all,i,IND)  q1(c,i)   # Output by com and ind #;
 (all,c,COM)  p0com(c)       # Output price of locally-produced com #;

Read MAKE from file BASEDATA header "MAKE";
Update (all,c,COM)(all,i,IND) MAKE(c,i)= p0com(c)*q1(c,i);

Variable
 (all,c,COM)  x0com(c)       # Output of commodities #;

Coefficient (all,i,IND) SIGMA1OUT(i) # CET transformation elasticities #;
Read SIGMA1OUT from file BASEDATA header "SCET";
```


Excerpt 12b: Industry Output mix

```
Equation E_q1  # Supplies of commodities by industries #
 (all,c,COM)(all,i,IND)
  q1(c,i) = x1tot(i) + SIGMA1OUT(i)*[p0com(c) - p1tot(i)];
Coefficient
 (all,i,IND) MAKE_C(i) # All production by industry i #;
 (all,c,COM) MAKE_I(c) # Total production of commodities #;
Formula
 (all,i,IND)    MAKE_C(i)  = sum{c,COM, MAKE(c,i)};
 (all,c,COM) MAKE_I(c)  = sum{i,IND,    MAKE(c,i)};

Equation E_x1tot # Average price received by industries #
 (all,i,IND) MAKE_C(i)*p1tot(i) = sum{c,COM,
    MAKE(c,i)*p0com(c)};
Equation E_x0com # Total output of commodities #
 (all,c,COM) MAKE_I(c)*x0com(c) = sum{i,IND, MAKE(c,i)*q1(c,i)};
```

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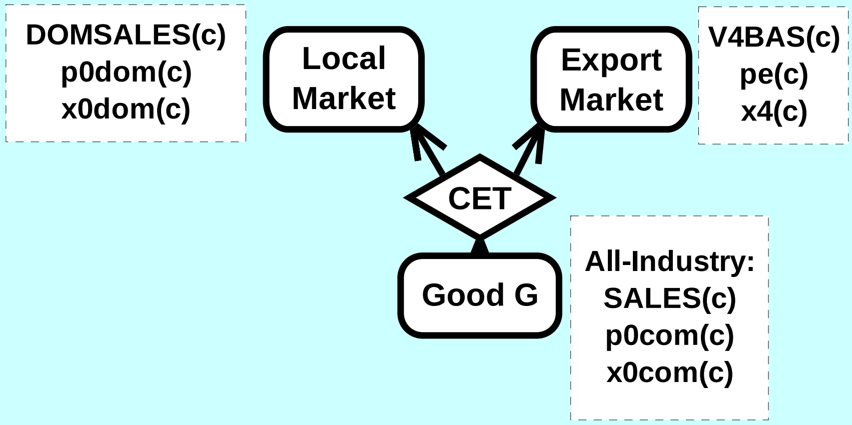
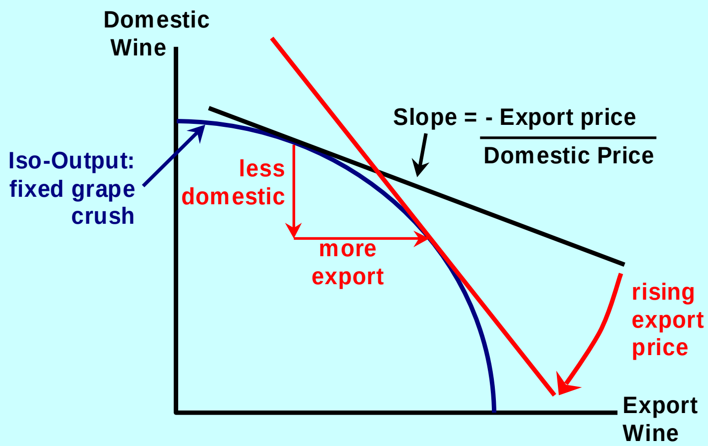
Excerpt 13: Local/Export Mix



p25

Excerpt 13: CET Export/Domestic mix



As export price rises, industry diverts production towards exports.

Not in ORANI; favoured by Americans; probably wrong

p25

Why do we need Local / Export CET?

Over-specialization: the longrun flip-flop problem
- all factors mobile between industries
  - -- very flat supply curves
- Elastic or flat export demand schedules
- Australia producing only chocolate
  - fixed by CET

Americans think long-run
Australians think short-run

Alternatives:
- Industry-specific permanently fixed factors (ORANI)
  - Agricultural Land
  - Fish or Ore Stocks
    - -- lead to upwardly sloping supply curves
    - good for primary products

Less elastic export demand schedules (manufacturing, services)

History or ABARE forecasts: local and export prices may diverge
- fixed by CET

p26

Excerpt 13: Local / Export Mix

p0dom	x0dom	price and quantity for local market
pe	x4	price and quantity for export market
p0com	x0com	average price and total quantity

X0COM = CET(X0DOM,X4)

usual 3 nest equations:

x0dom = x0com + σ(p0dom - p0com)

x4 = x0com + σ(pe - p0com)

p0com = S_{local}p0dom + S_{export}pe

subtract

implying

x0com = S_{local}x0dom + S_{export}x4

and

x0dom - x4 = σ(p0dom - pe)

$\tau = 1/\sigma$

τ(x0dom - x4) = p0dom - pe

alternate 3 nest equations

p26

Switching off the Local / Export CET

p0dom	x0dom	price and quantity for local market
pe	x4	price and quantity for export market
p0com	x0com	average price and total quantity

Set τ to zero

$\tau = 1/\sigma = 0$ ie $\sigma = \infty$ (perfect substitutes)

τ(x0dom - x4) = 0 = p0dom - pe

so p0dom = pe

p0com = S_{local}p0dom + S_{export} pe = p0dom = pe

x0com = S_{local}x0dom + S_{export}x4

p26

Excerpt 13: Local / Export Mix

```
Variable (all,c,COM) x0dom(c) # Output of commodities for local market #;
Coefficient
 (all, c,COM) EXPSHR(c) # Share going to exports #;
 (all, c,COM) TAU(c)   # 1/Elast. of transformation, exportable/locally used #;
Zerodivide default 0.5;
Formula
 (all,c,COM) EXPSHR(c) = V4BAS(c)/MAKE_I(c);
 (all,c,COM) TAU(c) = 0.0; ! if zero, p0dom = pe, and CET is nullified !
Zerodivide off;
Equation E_x0dom # Supply of commodities to export market #
 (all,c,COM) TAU(c)*[x0dom(c) - x4(c)] = p0dom(c) - pe(c);
Equation E_pe    # Supply of commodities to domestic market #
 (all,c,COM) x0com(c) = [1.0-EXPSHR(c)]*x0dom(c) + EXPSHR(c)*x4(c);
Equation E_p0com # Zero pure profits in transformation #
 (all,c,COM) p0com(c) = [1.0-EXPSHR(c)]*p0dom(c) + EXPSHR(c)*pe(c);
```

p26

Excerpt 13: Local / Export Mix

CET is joint by-products: imagine τ is large (fixed proportions):

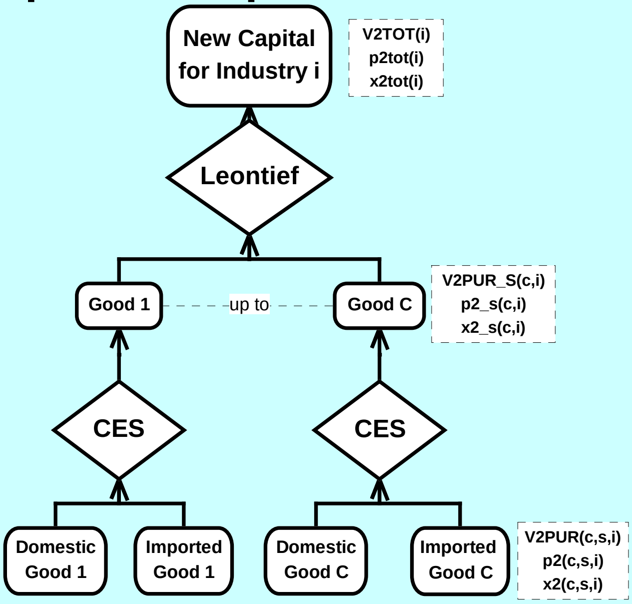
Australian pork products: meat (export) sausages(domestic)
rise in foreign demand for meat floods domestic market with sausages
so export price rises , while domestic price falls.

Australian fisheries: prawns, lobster(export) southern fish(domestic)
rise in foreign demand for lobster floods domestic market with fish ?!?
so export price rises , while domestic price falls.
A case for disaggregation: model lobster and fish separately

Progress so far . . .

Introduction
Database structure
Solution method
TABLO language
Production: input decisions
Production: output decisions
→ **Investment: input decisions**
Household demands
Export demands
Government demands
Inventory demands
Margin demands
Market clearing
Price equations
Aggregates and indices
Investment allocation
Labour market
Decompositions
Closure
Regional extension

Excerpt 14: Composition of Investment



Excerpt 14a: Composition of Investment

Variable

(all,c,COM)(all,i,IND) x2_s(c,i) # Investment use of imp/dom composite #;

(all,c,COM)(all,i,IND) p2_s(c,i) # Price, investment imp/dom composite #;

(all,c,COM)(all,s,SRC)(all,i,IND) a2(c,s,i) # Investment basic tech change #;

Coefficient (all,c,COM) SIGMA2(c) # Armington elasticities: investment #;

Read SIGMA2 from file BASEDATA header "2ARM";

Coefficient ! Source Shares in Flows at Purchaser's prices !

(all,c,COM)(all,i,IND) V2PUR_S(c,i) # Dom+imp investment purch. value #;

(all,c,COM)(all,s,SRC)(all,i,IND) S2(c,s,i) # Investment source shares #;

Zerodivide default 0.5;

Formula

(all,c,COM)(all,i,IND) V2PUR_S(c,i) = sum{s,SRC, V2PUR(c,s,i)};

(all,c,COM)(all,s,SRC)(all,i,IND) S2(c,s,i) = V2PUR(c,s,i) / V2PUR_S(c,i);

Zerodivide off;

p28

Excerpt 14b: Composition of Investment

Equation E_x2 # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)(all,i,IND)
x2(c,s,i)-a2(c,s,i) - x2_s(c,i)
= - SIGMA2(c)*[p2(c,s,i)+a2(c,s,i) - p2_s(c,i)];

Equation E_p2_s #Effective price of commodity composite #
(all,c,COM)(all,i,IND)
p2_s(c,i) = sum{s,SRC, S2(c,s,i)*[p2(c,s,i)+a2(c,s,i)]};

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Excerpt 14c: Composition of Investment

```
! Investment top nest !
!$  X2TOT(i) = MIN( All,c,COM: X2_S(c,i)/[A2_S(c,i)*A2TOT(i)] ) !

Variable
 (all,i,IND)  a2tot(i)       # Neutral technical change - investment #;
 (all,i,IND)  p2tot(i)       # Cost of unit of capital #;
 (all,i,IND)  x2tot(i)       # Investment by using industry #;
 (all,c,COM)(all,i,IND) a2_s(c,i) # Tech change, investment imp/dom
    composite #;
Coefficient (all,i,IND) V2TOT(i)  # Total capital created for industry i #;
Formula     (all,i,IND) V2TOT(i)  = sum{c,COM, V2PUR_S(c,i)};
Equation
 E_x2_s  (all,c,COM)(all,i,IND)  x2_s(c,i) - [a2_s(c,i) + a2tot(i)] = x2tot(i);
 E_p2tot (all,i,IND)    V2TOT(i)*p2tot(i)
      = sum{c,COM, V2PUR_S(c,i)*[p2_s(c,i) +a2_s(c,i) +a2tot(i)]};
```

Progress so far . . .

- Introduction
- Database structure
- Solution method
- TABLO language
- Production: input decisions
- Production: output decisions
- Investment: input decisions
- → **Household demands**
- Export demands
- Government demands
- Inventory demands
- Margin demands
- Market clearing
- Price equations
- Aggregates and indices
- Investment allocation
- Labour market
- Decompositions
- Closure
- Regional extension

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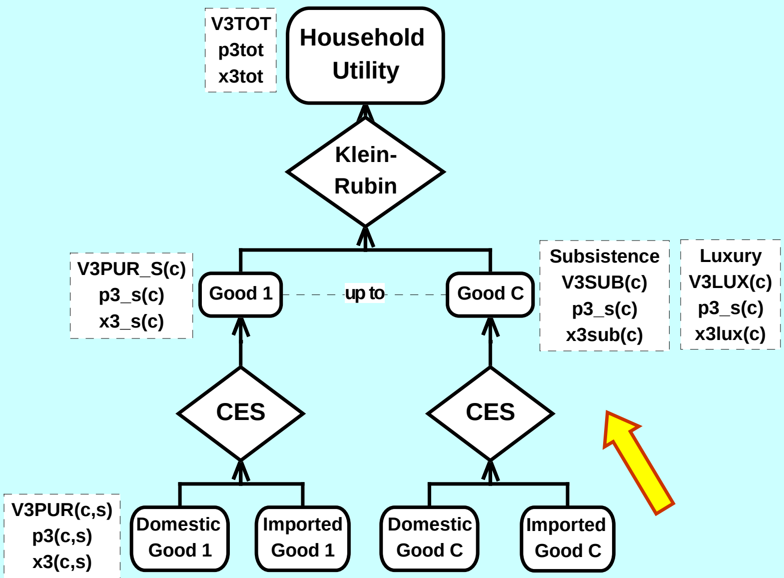
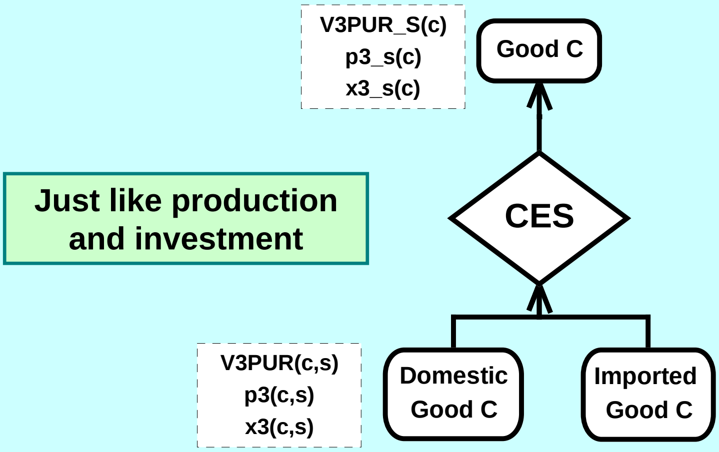
Household Demands



p29

Household imp / dom sourcing



p29

Excerpt 15a: household imp / dom sourcing

```
Variable
(all,c,COM)(all,s,SRC)  a3(c,s)   # Household basic taste change #;
(all,c,COM)             x3_s(c)   # Household use of imp/dom composite #;
(all,c,COM)             p3_s(c)   # Price, household imp/dom composite #;
Coefficient (all,c,COM) SIGMA3(c) # Armington elasticity: households #;
Read SIGMA3 from file BASEDATA header "3ARM";

Coefficient ! Source Shares in Flows at Purchaser's prices !
 (all,c,COM)           V3PUR_S(c) # Dom+imp households purch. value #;
 (all,c,COM)(all,s,SRC)   S3(c,s) # Household source shares #;
Zerodivide default 0.5;
Formula
 (all,c,COM)           V3PUR_S(c) = sum{s,SRC, V3PUR(c,s)};
 (all,c,COM)(all,s,SRC)   S3(c,s) = V3PUR(c,s)   / V3PUR_S(c);
Zerodivide off;
```

p29

Excerpt 15b: household imp/dom sourcing

```
Equation E_x3  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)
x3(c,s)-a3(c,s) = x3_s(c)
                    - SIGMA3(c)*[ p3(c,s)+a3(c,s) - p3_s(c) ];

Equation E_p3_s  # Effective price of commodity composite #
(all,c,COM) p3_s(c) = sum{s,SRC, S3(c,s)*[p3(c,s)+a3(c,s)]};
```


Numerical Example of CES demands

feel for numbers

$p = S_d p_d + S_m p_m$ average price of dom and imp Food

$x_d = x - \sigma(p_d - p)$ demand for domestic Food

$x_m = x - \sigma(p_m - p)$ demand for imported Food

Let p_m=-10%, $x=p_d=0$

Let S_m=0.3 and σ =2. This gives:

$p = -0.3*10 = -3$

$x_d = - 2(- -3) = -6$

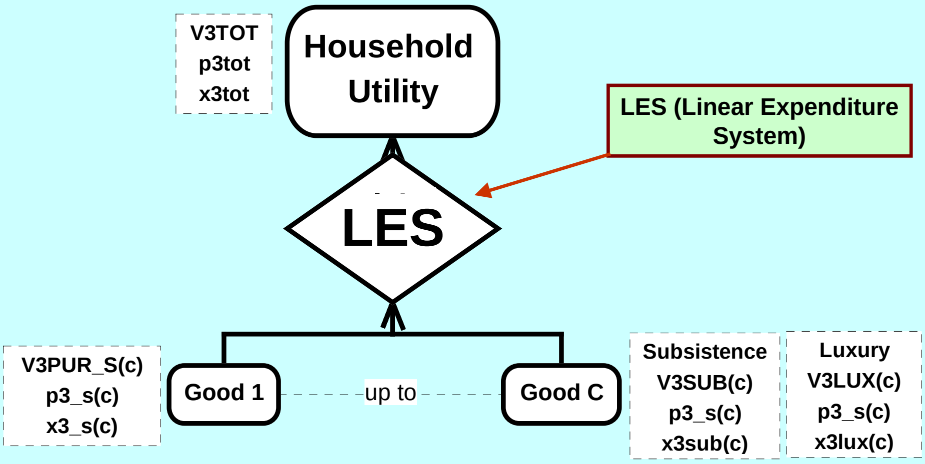
$x_m = -2(-10 - - 3) = 14$

Cheaper imports cause 14% increase in import volumes and 6% fall in domestic demand.

Effect on domestic sales is proportional to both S_m and σ.

p29

Top Nest of Household Demands



p30

Linear Expenditure System

Consumption of good c is composed of two parts:

- a **subsistence part, X3SUB(c)**, which is fixed.
- a **luxury part, X3LUX(c).** Also called *supernumerary*

After paying for all the X3SUB, the remaining budget is:

V3LUX_C = V3TOT - Σ {P3_S(c) *X3SUB(c)}

Total budget

Luxury spending on each good is a fixed share of V3LUX_C:

P3_S(c) *X3LUX(c) = S3LUX(c) *V3LUX_C

Marginal budget share

So total spending on good c is:

P3_S(c) *X3_S(c) = P3_S(c) *X3SUB(c) + S3LUX(c) *V3LUX_C

Total expenditure subsistence part luxury part

or: P3_S(c) *X3_S(c) = P3_S(c) *X3SUB(c) + S3LUX(c) *[V3TOT - Σ {P3_S(c) *X3SUB(c)}]

Expenditure on each good is a linear function of prices and income

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Utility functions for LES

Later, people noticed that the LES demand equations could be derived from the following utility function:

$$\log(U) = \Sigma_c \; S3LUX(c)*\log [X3\_S(c) - X3SUB(c)]$$

usually called the *Stone-Geary* or *Klein-Rubin* utility function

Special case:
If the X3SUB(c) were all zero, we would have

$$\log(U) = \Sigma_c \; S3LUX(c)*\log [X3\_S(c)]$$

which is the *Cobb-Douglas* utility function.

See Appendix F, ORANI-G document or Green Book for algebraic derivation of demand equations from utility function (complex).

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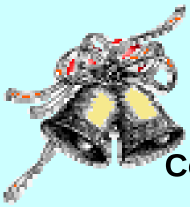
Two Happy Consumers

Mr Klein



Miss Rubin

Cobb-Douglas:
constant budget shares:
30% clothes
70% food

weekly:
300 cigarettes
30 bottles beer

p29

The Klein-Rubin Household

First buy:
300 cigarettes
30 bottles beer
subsistence
(constant)
X3SUB(c)

Allocate
remaining
money:
clothes 30%
food 70%
luxury
(goes with
income)
X3LUX(c)

Utility = $\prod \{X3LUX(c)\}^{S3LUX(c)}$

Total consumption good c
X3_S(c) = X3SUB(c) + X3LUX(c)

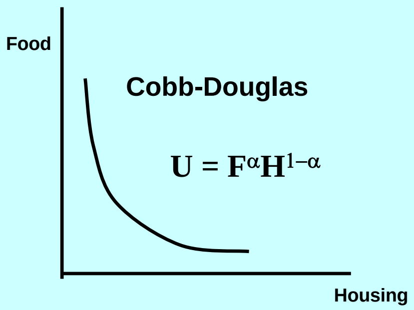
What's in a name?

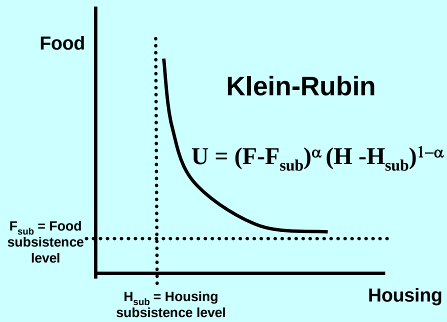
- Usually called one of:
  - Linear Expenditure System (LES)
  - Klein-Rubin utility function
  - Stone-Geary utility function
- Originating from 3 papers in *Review of Economic Studies*
  - 1947-48 Lawrence Klein and Herman Rubin (Cowles Commission, Chicago) were the first to write down the Linear Expenditure System demand equations, while developing a cost-of-living price index.
  - 1947-48 Paul Samuelson refereed the Klein-Rubin paper and proposed a utility function from which the LES could be derived.
  - 1949-50 In a simpler, more accessible way, Roy Geary also proposed a utility function for LES
- 1954 Stone is first to estimate and popularize LES.
- We could call it "the Samuelson-Geary utility function corresponding to the Klein-Rubin linear expenditure system whose estimation was pioneered by Stone".

Source: Neary, J. Peter (1997). "R.C. Geary's Contributions to Economic Theory"; In Conniffe (ed), "R.C. Geary, 1893–1983: Irish Statistician" .

Comparing Cobb-Douglas and Klein-Rubin Utility Isoquants

Klein-Rubin is like Cobb-Douglas, but with axes moved to new origin





Cobb-Douglas
α = average budget share food
= constant

Klein-Rubin
α = marginal budget share food
= constant

p29

Klein-Rubin: a non-homothetic utility function

Homothetic means:
  budget shares depend only on prices, not incomes
  eg: CES, Cobb-Douglas
Non-homothetic means:
  rising income causes budget shares to change even with price ratios fixed.
Non-unitary expenditure elasticities:
I% rise in total expenditure might cause food expenditure to rise by 0.5%; air travel expenditure to rise by 2%.

See Appendix F, ORANI-G document or Green Book for algebraic derivation of demand equations from utility function (complex).

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What are the "parameters" of the LES ?

- The true parameters (which do not change) are:
  (a) the subsistence quantities, A3SUB(c)
  (b) the marginal (or luxury) budget shares, S3LUX(c)
- But (a) and (b) are not easy to observe, or to transfer from econometric studies into a model data base.
- We can calibrate our percent-change equations from
  (i) Average budget shares S3_S (c), from IO table
  (ii) The share, for each good, of luxury in total consumption, B3LUX(c)
- We can derive B3LUX values if we know the S3_S (c), the expenditure elasticities EPS(c) and the overall share of luxury in total consumption, B3LUX_C.
- Econometric studies often yield estimates of expenditure elasticities, EPS(c), for broad commodity groups like Food, Beverages, Durables, OtherGoods, Housing, Services.
- We believe that
  (1) the Food expenditure elasticity estimated from 1995 Philippines data may be used for both Confectionery and TinnedFood sectors for Bolivia 2003.
  (2) B3LUX_C is similar across countries at similar level of development

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How many parameters -degree of flexibility

No of parameters =
  extra numbers needed to specify percent change form
  IF EXPENDITURE VALUES ARE ALREADY KNOWN

Example, CES=1:
  with input values known, 1 number, σ, is enough.

Example, CobbDouglas=0:
  with input values known, we know all.

In levels, more parameters are needed.

Example, Leontief=0:
  with input values known, we know all.

How many parameters is Klein-Rubin/LES ?

We need to divide expenditure on each good
  into subsistence and luxury parts.

(all,c,COM) B3LUX(c) # Ratio,supernumerary/total expenditure#;

One B3LUX parameter for each commodity.

These "parameters" change !

not in doc

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Deriving B3LUX from literature estimates

Normally expressed as:

EPS = Expenditure elasticities for each good

= marginal/average budget shares

$$= \frac{\text{(share this good in luxury spending)}}{\text{(share this good in all spending)}}$$

and 1969, Tinbergen

Frisch "parameter" = - 1.82

$$= - \frac{\text{(total spending)}}{\text{(total luxury spending)}}$$

= 1 + C numbers ! but average of EPS = 1

S3_S(c) = V3PUR_S(c)/V3TOT	average shares
B3LUX(c) = -EPS(c)/FRISCH	share of luxury
S3LUX(c) = EPS(c)*S3_S(c)	marginal budget shares

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Excerpt 16a: household demands

```
Variable
     p3tot # Consumer price index #;
     x3tot # Real household consumption #;
   w3lux # Total nominal supernumerary household expenditure #;
    w3tot # Nominal total household consumption #;
          q # Number of households #;
   utility # Utility per household #;
 (all,c,COM) x3lux(c) # Household - supernumerary demands #;
 (all,c,COM) x3sub(c) # Household - subsistence demands #;

(all,c,COM) a3lux(c) # Taste change, supernumerary demands #;
(all,c,COM) a3sub(c) # Taste change, subsistence demands #;
(all,c,COM)  a3_s(c) # Taste change, h'hold imp/dom composite #;
```

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Excerpt 16b: household demands

```
Coefficient
                      V3TOT   # Total purchases by households #;
                    FRISCH   # Frisch LES 'parameter'= - (total/luxury)#;
 (all,c,COM)   EPS(c)    # Household expenditure elasticities #;
 (all,c,COM)  S3_S(c)   # Household average budget shares #;
 (all,c,COM) B3LUX(c) # Ratio,supernumerary/total expenditure#;
 (all,c,COM) S3LUX(c) # Marginal household budget shares #;
Read   FRISCH from file BASEDATA header "P021";
                 EPS from file BASEDATA header "XPEL";
Update
(change)            FRISCH = FRISCH*[w3tot - w3lux]/100.0;
(change)(all,c,COM)
             EPS(c) = EPS(c)*[x3lux(c)-x3_s(c)+w3tot-w3lux]/100.0;
```

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Excerpt 16c: household demands

```
Formula
                V3TOT = sum{c,COM, V3PUR_S(c)};
 (all,c,COM)  S3_S(c) = V3PUR_S(c)/V3TOT;
 (all,c,COM) B3LUX(c) = -EPS(c)/FRISCH;
 (all,c,COM) S3LUX(c) = EPS(c)*S3_S(c);
Write  S3LUX   to file SUMMARY header "LSHR";
       S3_S    to file SUMMARY header "CSHR";
```

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Excerpt 16d: household demands

Equation

E_x3sub # Subsistence demand for composite commodities #
(all,c,COM) x3sub(c) = q + a3sub(c);

E_x3lux # Luxury demand for composite commodities #
(all,c,COM) x3lux(c) + p3_s(c) = w3lux + a3lux(c);

E_x3_s # Total household demand for composite commodities #
(all,c,COM) x3_s(c) = B3LUX(c)*x3lux(c)
+ [1-B3LUX(c)]*x3sub(c);

E_utility # Change in utility disregarding taste change terms #
utility + q = sum{c,COM, S3LUX(c)*x3lux(c)};

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Excerpt 16e: household demands

E_a3lux # Default setting for luxury taste shifter #
(all,c,COM) a3lux(c) = a3sub(c) - sum{k,COM,
S3LUX(k)*a3sub(k)};

E_a3sub # Default setting for subsistence taste shifter #
(all,c,COM) a3sub(c) = a3_s(c) - sum{k,COM, S3_S(k)*a3_s(k)};

E_x3tot # Real consumption #
V3TOT*x3tot = sum{c,COM, sum{s,SRC, V3PUR(c,s)*x3(c,s)}};

E_p3tot # Consumer price index #
V3TOT*p3tot = sum{c,COM, sum{s,SRC, V3PUR(c,s)*p3(c,s)}};

E_w3tot # Household budget constraint: determines w3lux #
w3tot = x3tot + p3tot;

Some properties of LES

- **Parameters required are *marginal budget* shares and *Frisch* parameter**
- **For *n* commodities, that is *n* parameters, given that marginal budget shares must sum to one**
- **No specific cross-price effects: only income effect in cross-price elasticities**
- **No *inferior* goods: all income elasticities are positive – if B3LUX(c) =0, EPS(c) =0**
- **B3LUX(c) = - EPS(c) / FRISCH**

Matrix of uncompensated price elasticities in ORANIG (all negative)

ETA	29 Communic	30 FinanceI	31 OwnerDw	32 PropBus	33 GovAdmir	34 Educat	35 HealthCor	36 CultuRec	37 C
17 NonMetlMi	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
18 BasicMetal	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
19 FabMetalP	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
20 TransportE	-0.0111	-0.0241	-0.0297	-0.0067	-0.0011	-0.0125	-0.0439	-0.0212	
21 OthMachnl	-0.0111	-0.0241	-0.0297	-0.0067	-0.0011	-0.0125	-0.0439	-0.0212	
22 MiscManuf	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
23 ElecGasW	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
24 Constructio	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
25 Trade	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
26 Repairs	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
27 Hotel_Cafe	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
28 Transport	-0.0124	-0.0270	-0.0333	-0.0076	-0.0012	-0.0140	-0.0493	-0.0238	
29 Communic	-0.5560	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
30 FinanceIns	-0.0085	-0.5660	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	
31 OwnerDwe	-0.0136	-0.0296	-0.9124	-0.0083	-0.0013	-0.0154	-0.0540	-0.0261	
32 PropBusSr	-0.0085	-0.0185	-0.0228	-0.5526	-0.0008	-0.0096	-0.0338	-0.0163	
33 GovAdminI	-0.0085	-0.0185	-0.0228	-0.0052	-0.5483	-0.0096	-0.0338	-0.0163	
34 Education	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.5570	-0.0338	-0.0163	
35 HealthCom	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.5812	-0.0163	
36 CultuRecre	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.5637	
37 OtherServ	-0.0085	-0.0185	-0.0228	-0.0052	-0.0008	-0.0096	-0.0338	-0.0163	

ETA Size: COM * COM ETA(COM:COM)

Matrix of uncompensated price elasticities if Cobb-Douglas

ETA	1 WoolMu	2 GrainsH	3 BeefCa	4 OtherAg	5 ForestF	6 Minir	7 MeatDa	8 OthFoodP	9 DrinksSmo	10 Textil	11 Clot
1 WoolMuttor	-1.0000	0	0	0	0	0	0	0	0	0	
2 GrainsHay	0	-1.0000	0	0	0	0	0	0	0	0	
3 BeefCattle	0	0	-1.0000	0	0	0	0	0	0	0	
4 OtherAgric	0	0	0	-1.0000	0	0	0	0	0	0	
5 ForestFish	0	0	0	0	-1.0000	0	0	0	0	0	
6 Mining	0	0	0	0	0	-1.0000	0	0	0	0	
7 MeatDairy	0	0	0	0	0	0	-1.0000	0	0	0	
8 OthFoodPro	0	0	0	0	0	0	0	-1.0000	0	0	
9 DrinksSmok	0	0	0	0	0	0	0	0	-1.0000	0	
10 Textiles	0	0	0	0	0	0	0	0	0	-1.0000	
11 ClothingFt	0	0	0	0	0	0	0	0	0	0	-1.0
12 WoodProd	0	0	0	0	0	0	0	0	0	0	
13 PaperPrint	0	0	0	0	0	0	0	0	0	0	
14 Petrol_Coa	0	0	0	0	0	0	0	0	0	0	
15 Chemicals	0	0	0	0	0	0	0	0	0	0	
16 RubberPla	0	0	0	0	0	0	0	0	0	0	
17 NonMetIMi	0	0	0	0	0	0	0	0	0	0	
18 BasicMetal	0	0	0	0	0	0	0	0	0	0	
19 FabMetalP	0	0	0	0	0	0	0	0	0	0	
20 TransportE	0	0	0	0	0	0	0	0	0	0	
21 OthMachnl	0	0	0	0	0	0	0	0	0	0	

ETA Size COM * COM ETA(COM COM)

What if we want specific substitutability?

- **Recap: in production, we nest the following: labour *(CES),* primary factors *(CES),* commodities *(CES),* all-inputs *(Leontief* or *constant proportions)***
- **Supposing our model includes both bananas and apples**
- **If the price of bananas doubles, we would expect our apple purchases to increase**
- **But the *income effect* would reduce demand for both**
- **SOLUTION: let bananas and apples form a FRUIT nest in the LES, and allow substitution (as for labour types and composite labour) – maybe a CES for bananas and apples. Specific disaggregation problem.**

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Quiz Question

Fact: with σ = 1, CES is same as Cobb-Douglas.

Question: With all expenditure elasticities = 1, is Klein-Rubin same as Cobb-Douglas ?

Answer: No. Would be Cobb-Douglas if Frisch parameter = -1 [totally luxury]. Own-price demand elasticity for Cobb-Douglas = -1; average own-price demand elasticity for Klein-Rubin is share of luxury in total spending (maybe 0.5). Tendency towards inelastic demand.

Stone-Geary = another name for Klein-Rubin

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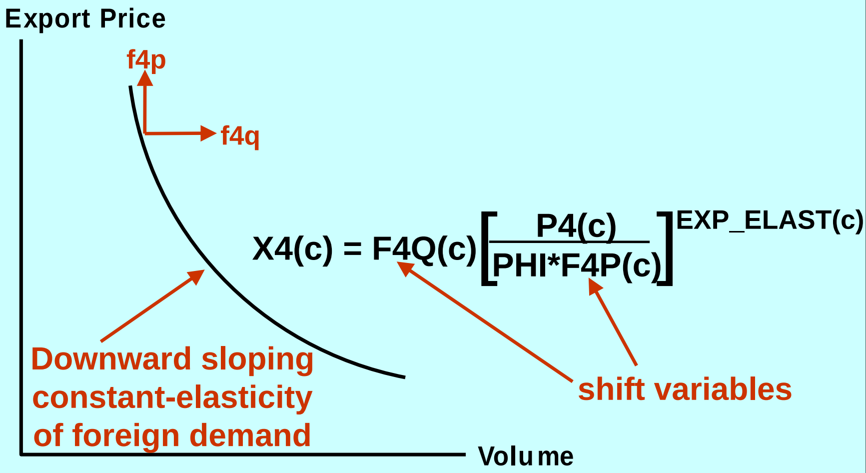
Excerpt 17: Individual Export demands



In original ORANI, only applied to main (primary) export commodities.

The rest (collective exports) are bundled together as an aggregate, with a shared demand curve.

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Excerpt 17a: Export demands

Variable phi # Exchange rate, local currency/$world #;
(all,c,COM) f4p(c) # Price (upward) shift in export demands #;
(all,c,COM) f4q(c) # Quantity (right) shift in export demands #;
Coefficient (all,c,COM) EXP_ELAST(c)
Export demand elasticities: typical value -5.0 #;
Read EXP_ELAST from file BASEDATA header "P018";
Equation E_x4A # Individual export demand functions #
(all,c,TRADEXP)
x4(c) - f4q(c) = EXP_ELAST(c)*[p4(c) - phi - f4p(c)];

levels:

$$X4(c) = F4Q(c)\left[\frac{P4(c)}{PHI*F4P(c)}\right]^{EXP\_ELAST(c)}$$

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Excerpt 17b: Export demands

```
Set NTRADEXP # Collective Export Commodities #
         = COM - TRADEXP;
Write (Set) NTRADEXP  to file SUMMARY header "NTXP";
Variable
 x4_ntrad    # Quantity, collective export aggregate #;
 f4p_ntrad  # Upward demand shift, collective export aggregate #;
 f4q_ntrad  # Right demand shift, collective export aggregate #;
 p4_ntrad   # Price, collective export aggregate #;

Coefficient V4NTRADEXP # Total collective export earnings #;
Formula     V4NTRADEXP = sum{c,NTRADEXP, V4PUR(c)};
```

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Excerpt 17c: Export demands

```
Equation E_X4B  # Collective export demand functions #
 (all,c,NTRADEXP) x4(c) - f4q(c) = x4_ntrad;   all move together

Equation E_p4_ntrad  # Average price of collective exports #
[TINY+V4NTRADEXP]*p4_ntrad
                  = sum{c,NTRADEXP, V4PUR(c)*p4(c)};

Coefficient EXP_ELAST_NT # Collective export demand elast #;
Read  EXP_ELAST_NT from file BASEDATA header "EXNT";
Equation E_x4_ntrad # Demand for collective export aggregate #
 x4_ntrad - f4q_ntrad = EXP_ELAST_NT*[p4_ntrad - phi -
    f4p_ntrad];
```

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Excerpt 18a: Government demands

```
Variable
 f5tot  # Overall shift term for government demands #;
 f5tot2 # Ratio between f5tot and x3tot #;
 (all,c,COM)(all,s,SRC) f5(c,s) # Government demand shift #;
 (change)
 (all,c,COM)(all,s,SRC)  fx6(c,s) # Shifter on stocks rule #;
Equation
 E_x5 # Government demands #
  (all,c,COM)(all,s,SRC)  x5(c,s) = f5(c,s) + f5tot;
 E_f5tot # Overall government demands shift #
   f5tot = x3tot + f5tot2;
```

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Cunning use of shift variables

(all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;
f5tot = x3tot + f5tot2;

Shift variables f5tot and f5tot2
used to switch between two rules:

With f5tot2 exogenous, f5tot endogenous, we get
(all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + x3tot + f5tot2;
ie: gov. demands follow real household consumption

with f5tot exogenous, f5tot2 endogenous, we get
(all,c,COM)(all,s,SRC) x5(c,s) = f5(c,s) + f5tot;
ie: gov. demands are exogenous

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Excerpt 18b: Inventory demands

Useful to endogenously calculate the change in the volume of goods going to inventory. (Eg. Real homogeneity test)

. . . However we have no theory to explain changes in inventory demands . . .

so we adopt a simple rule: % change inventory demand = % change in domestic production

BUT: Inventory demand can change sign - rate of change variable

x6(c,s) = x(c)

100 . [dX6(c,s) / X6(c,s)] = x(c)

100 . dX6(c,s) = X6(c,s) . x(c)

[100 . P6(c,s)] . dX6(c,s) = [P6(c,s) . X6(c,s)] . x(c) *E_delx6*

V6BAS

Change in quantity

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Excerpt 18b: Inventory demands

Coefficient (all,c,COM)(all,s,SRC)
LEVP0(c,s) # Levels basic prices #;

must specify units for ordinary change in quantities

Formula (initial) (all,c,COM)(all,s,SRC)
LEVP0(c,s) = 1; ! arbitrary setting !

Update (all,c,COM)(all,s,SRC) LEVP0(c,s) = p0(c,s);

change in quantity at "current" prices

Equation
E_delx6 # Stocks follow domestic output #
(all,c,COM)(all,s,SRC)
100*LEVP0(c,s)*delx6(c,s) = V6BAS(c,s)*x0com(c) + fx6(c,s);

or exogenous

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Excerpt 18b: Inventory demands

Recall that the update of inventory demands is via a change variable.

. . . this is defined by E_delV6 . . .

E_delV6 # Update formula for stocks #
(all,c,COM)(all,s,SRC)
delV6(c,s) = 0.01*V6BAS(c,s)*p0(c,s)+ LEVP0(c,s)*delx6(c,s);

Derivation of E_delV6

V6(c,s) = P0(c,s) . X6(c,s)

dV6 = dP0 . X6 + P0 . dX6

dV6 = [0.01] . [P0 X6] . [100 dP0 / P0] + P0 . dX6

dV6 = [0.01 . V6] . p0 + [P0] . dX6 ***E_delV6***

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Excerpt 19: Margin demands

Intermediate only - see text for rest

Variable

```
(all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
   a1mar(c,s,i,m)  # Intermediate margin tech change #;
```

Equation

```
E_x1mar  # Margins to producers #
   (all,c,COM)(all,s,SRC)(all,i,IND)(all,m,MAR)
 x1mar(c,s,i,m) = x1(c,s,i) + a1mar(c,s,i,m);
```

normally exogenous = 0

```
Coefficient (all,c,COM) MARSALES(c) # Total usage,margins purposes #;
Formula     (all,n,NONMAR) MARSALES(n) = 0.0;
 (all,m,MAR)    MARSALES(m) = sum{c,COM, V4MAR(c,m) +
                      sum{s,SRC, V3MAR(c,s,m) + V5MAR(c,s,m) +
                       sum{i,IND, V1MAR(c,s,i,m) + V2MAR(c,s,i,m) }}};
```


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Excerpt 20a: Sales Aggregates

```
Set DEST # Sale Categories #
(Interm, Invest, HouseH, Export, GovGE, Stocks, Margins);

Coefficient (all,c,COM)(all,s,SRC)(all,d,DEST)
        SALE(c,s,d) # Sales aggregates #;
Formula
 (all,c,COM)(all,s,SRC) SALE(c,s,"Interm")  = sum{i,IND, V1BAS(c,s,i)};
 (all,c,COM)(all,s,SRC) SALE(c,s,"Invest")  = sum{i,IND, V2BAS(c,s,i)};
 (all,c,COM)(all,s,SRC) SALE(c,s,"HouseH")        = V3BAS(c,s);
 (all,c,COM)            SALE(c,"dom","Export")  = V4BAS(c);
 (all,c,COM)            SALE(c,"imp","Export")   = 0;
 (all,c,COM)(all,s,SRC) SALE(c,s,"GovGE")         = V5BAS(c,s);
 (all,c,COM)(all,s,SRC) SALE(c,s,"Stocks")         = V6BAS(c,s);
 (all,c,COM)            SALE(c,"dom","Margins") = MARSALES(c);
 (all,c,COM)            SALE(c,"imp","Margins") = 0;
Write SALE to file SUMMARY header "SALE";
```

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Excerpt 20b: Sales Aggregates

```
Coefficient (all,c,COM) V0IMP(c) # Total basic-value imports, good c #;
Formula     (all,c,COM) V0IMP(c) = sum{d,DEST, SALE(c,"imp",d)};

Coefficient (all,c,COM) SALES(c) # Total sales,domestic commodities#;
Formula     (all,c,COM) SALES(c) = sum{d,DEST, SALE(c,"dom",d)};

Coefficient (all,c,COM) DOMSALES(c) # Total sales to local market #;
Formula     (all,c,COM) DOMSALES(c) = SALES(c) - V4BAS(c);
```

Excerpt 21a: Market clearing

Commodity Supply = Commodity Demand

Commodity Demands: intermediate, investment, household, export, government, stocks, margins.

It will prove handy later (*see p. 47 - 49*) to measure now each of these changes in demand as changes in physical quantities valued at current prices.

dS = P . dX

dS = [X . P / 100] . (dX / X) . 100

dS = [0.01 . VBAS] . x standard form

Excerpt 21a: Market clearing

Variable (change)
 (all,c,COM)(all,s,SRC)(all,d,DEST)
 delSale(c,s,d) # Sales aggregates #;

Standard form

Equation

```
E_delSaleA (all,c,COM)(all,s,SRC) delSale(c,s,"Interm") =
        0.01*sum{i,IND,V1BAS(c,s,i)*x1(c,s,i)};

E_delSaleB (all,c,COM)(all,s,SRC) delSale(c,s,"Invest") =
        0.01*sum{i,IND,V2BAS(c,s,i)*x2(c,s,i)};

E_delSaleC (all,c,COM)(all,s,SRC)
   delSale(c,s,"HouseH")=0.01*V3BAS(c,s)*x3(c,s);
```

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Excerpt 21a: Market clearing

E_delSaleD (all,c,COM)
delSale(c,"dom","Export")=0.01*V4BAS(c)*x4(c);

Standard form

E_delSaleE (all,c,COM)
delSale(c,"imp","Export")= 0;

No imported exports

E_delSaleF (all,c,COM)(all,s,SRC)
delSale(c,s,"GovGE") =0.01*V5BAS(c,s)*x5(c,s);

Standard form

E_delSaleG (all,c,COM)(all,s,SRC) delSale(c,s,"Stocks") =
LEVP0(c,s)*delx6(c,s);

Initial form

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Excerpt 21b: Market clearing

E_delSaleH (all,m,MAR) delSale(m,"dom","Margins")=0.01*
! note nesting of sum parentheses !

Standard form

sum{c,COM, V4MAR(c,m)*x4mar(c,m) + sum{s,SRC,
V3MAR(c,s,m)*x3mar(c,s,m) + V5MAR(c,s,m)*x5mar(c,s,m)
+ sum{i,IND, V1MAR(c,s,i,m)*x1mar(c,s,i,m) +
V2MAR(c,s,i,m)*x2mar(c,s,i,m) }}};

NONMAR not used as Margin

E_delSaleI (all,n,NONMAR) delSale(n,"dom","Margins") = 0;

No imported margins

E_delSaleJ (all,c,COM) delSale(c,"imp","Margins") = 0;

p35

Excerpt 21c: Market clearing

Equation E_p0A: Sets supply of each domestic commodity to the local market equal to the sum of local demands . . .

$X0(i) = \Sigma_{user} X(i,user)$

$dX0(i) = \Sigma_{user} dX(i,user)$

$[X0(i).P0(i)/100].[100.dX0(i)/X0(i)] = \Sigma_{user} dX(i,user).P0(i)$

$[X0(i).P0(i)/100].x0(i) = \Sigma_{user} delSales(i,user)$ E_p0A

E_x0imp has same basic form, but equates demand for imports with supply of imports.

p35

Excerpt 21c: Market clearing

```
Set LOCUSER # Non-export users #
(Interm, Invest, HouseH, GovGE, Stocks,Margins);
Subset LOCUSER is subset of DEST;

Equation E_p0A # Supply = Demand for domestic goods #
(all,c,COM)   0.01*[TINY+DOMSALES(c)]*x0dom(c)
=sum{u,LOCUSER,delSale(c,"dom",u)};

Variable (all,c,COM)  x0imp(c)  # Total supplies of imports #;
Equation E_x0imp # Import volumes #
 (all,c,COM)    0.01*[TINY+V0IMP(c)]*x0imp(c) =
sum{u,LOCUSER,delSale(c,"imp",u)};
```

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Excerpt 22: Purchasers prices

All purchaser's price equations have the same basic form:

$$P_{N,c} \,.\, X_{N,c} = P0_{c} \,.\, X_{N,c} \,.\, T_{c} + \Sigma_{mar}\, X_{N,mar,\,c} \,.\, P_{mar}$$

value preservation

Purchaser's value of commodity c used by user N

Value of margins associated with the purchase

Basic value of commodity c used by user N

Power of tax (= 1 + rate of tax) Eg. 1.03

. . . linearising (and dropping subscripts) . . .

$$[P.X]\,(p + x) = [P0.X.T]\,(p0 + x + t) + \Sigma_{mar}[X_{mar}.P_{mar}]\,(x_{mar} + p_{mar})$$

. . . noting that demand for margins is: $x_{mar} = x + a_{mar}$

$$[P.X]\,p = [P0.X.T]\,(p0 + t) + \Sigma_{mar}[X_{mar}.P_{mar}]\,(a_{mar} + p_{mar})$$

Standard form

p36

Excerpt 22: Purchasers prices

```
Variable  ! example Government  !
 (all,c,COM)(all,s,SRC)  t5(c,s)   # Power of tax on government #;

Equation E_p5 # Zero pure profits in distribution to government #
 (all,c,COM)(all,s,SRC)
  [V5PUR(c,s)+TINY]*p5(c,s) =
   [V5BAS(c,s)+V5TAX(c,s)]*[p0(c,s)+ t5(c,s)]
    + sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)]};

! alternate form    Equation E_p5q
(all,c,COM)(all,s,SRC) [V5PUR(c,s)+TINY]*p5(c,s) =
  [V5BAS(c,s)+V5TAX(c,s)]*p0(c,s)
+ 100*V5BAS(c,s)*delt5(c,s)
+ sum{m,MAR, V5MAR(c,s,m)*[p0dom(m)+a5mar(c,s,m)]};  !
```

p37

Excerpt 23: Tax rate equations

```
Variable  ! example Intermediate  !
f1tax_csi    # Uniform %change in power of tax on intermediate usage #;
(all,c,COM)  f0tax_s(c)      # General sales tax shifter #;
Equation
E_t1  # Power of tax on sales to intermediate #
  (all,c,COM)(all,s,SRC)(all,i,IND)  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;
```

power of tax =
1 + ad valorem rate:
1.2 means 20% tax

default rule:
modeller could
change for special
experiment

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Excerpt 24: Tax Updates

Before: ! example Intermediate !

Coefficient (all,c,COM)(all,s,SRC)(all,i,IND)

V1TAX(c,s,i) # Taxes on intermediate #;

Read V1TAX from file BASEDATA header "1TAX";

Variable (change)(all,c,COM)(all,s,SRC)(all,i,IND)

delV1TAX(c,s,i) # Interm tax rev #;

Update (change)(all,c,COM)(all,s,SRC)(all,i,IND)

V1TAX(c,s,i) = delV1TAX(c,s,i);

Equation

E_delV1TAX (all,c,COM)(all,s,SRC)(all,i,IND)

original tax revenue
× proportional change (=%/100) in tax base

delV1TAX(c,s,i) = 0.01*V1TAX(c,s,i)* [x1(c,s,i) + p0(c,s)]

+ 0.01*[V1BAS(c,s,i)+V1TAX(c,s,i)]*t1(c,s,i);

change in tax rate
× the original [base + tax]

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Excerpt 25: Import prices

Variable

(all,c,COM) pf0cif(c) # CIF foreign currency import prices #;

(all,c,COM) t0imp(c) # Power of tariff #;

Equation E_p0B # Zero pure profits in importing #

(all,c,COM) p0(c,"imp") = pf0cif(c) + phi + t0imp(c);

Equation E_delV0TAR (all,c,COM)

delV0TAR(c) = 0.01*V0TAR(c)*[x0imp(c)+pf0cif(c)+phi] + 0.01*V0IMP(c)*t0imp(c);

$P_{imp} = P_f \Phi(1+V)$

$= P_f \Phi(T0IMP)$ T0IMP = power = 1 + ad valorem rate

exchange rate (Φ, phi) = local dollars per foreign dollar

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Excerpt 26: Tax Revenue Totals

```
Coefficient
 V1TAX_CSI  # Total intermediate tax revenue #;
..........................
 V0TAR_C    # Total tariff revenue #;
Formula
 V1TAX_CSI  = sum{c,COM, sum{s,SRC, sum{i,IND, V1TAX(c,s,i)}}};
..........................
V0TAR_C    = sum{c,COM,   V0TAR(c)};
Variable
(change) delV1tax_csi # Agg. revenue from indirect taxes on
    intermediate #;
..........................
(change) delV0tar_c   # Aggregate tariff revenue #;

Equation
E_delV1tax_csi
delV1tax_csi = sum{c,COM, sum{s,SRC, sum{i,IND, delV1TAX(c,s,i) }}};
..........................
E_delV0tar_c   delV0tar_c   = sum{c,COM, delV0TAR(c)};
```

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Excerpt 27: Factor incomes and GDP

Example Capital

Coefficient V1CAP_I # Total payments to capital #;
Formula V1CAP_I = sum{i,IND, V1CAP(i)};

Variable w1cap_i # Aggregate payments to capital #;
Equation E_w1cap_i
V1CAP_I*w1cap_i = sum{i,IND,
V1CAP(i)*[x1cap(i)+p1cap(i)]};

E_w0gdpinc V0GDPINC*w0gdpinc =
V1LND_I*w1lnd_i + V1CAP_I*w1cap_i +
V1LAB_IO*w1lab_io + 100*delV0tax_csi;

p40

Excerpt 27: GDP - Production tax example

Coefficient V1PTX_I # Total production tax/subsidy #;
Formula V1PTX_I = sum{i,IND, V1PTX(i)};
Variable (change) delV1PTX_i
Ordinary change in all-industry production tax revenue #;
Equation E_delV1PTX_i
delV1PTX_i=sum{i,IND,delV1PTX(i)};

E_delV0tax_csi # Total indirect tax revenue #
delV0tax_csi = delV1tax_csi + delV2tax_csi +
delV3tax_cs + delV4tax_c + delV5tax_cs + delV0tar_c +
delV1PTX_i + 0.01*V1OCT_I*w1oct_i;

E_w0gdpinc V0GDPINC*w0gdpinc = V1LND_I*w1lnd_i +
V1CAP_I*w1cap_i + V1LAB_IO*w1lab_io +
100*delV0tax_csi;

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Excerpt 28a: GDP expenditure aggregates

```
Coefficient ! Expenditure Aggregates at Purchaser's Prices !
 (all,c,COM) V0CIF(c) # Total ex-duty imports of good c #;
 V0CIF_C  # Total local currency import costs, excluding tariffs #;
 V0IMP_C  # Total basic-value imports (includes tariffs) #;
 V2TOT_I  # Total investment usage #;
  . . . . . . . . . . . . . . . .
 V0GDPEXP # Nominal GDP from expenditure side #;
Formula
 (all,c,COM) V0CIF(c) = V0IMP(c) - V0TAR(c);
 V0CIF_C   = sum{c,COM, V0CIF(c)};
 V0IMP_C   = sum{c,COM, V0IMP(c)};
 V2TOT_I   = sum{i,IND, V2TOT(i)};
 V4TOT     = sum{c,COM, V4PUR(c)};
 V5TOT     = sum{c,COM, sum{s,SRC, V5PUR(c,s)}};
 V6TOT     = sum{c,COM, sum{s,SRC, V6BAS(c,s)}};
 V0GDPEXP  = V3TOT + V2TOT_I + V5TOT + V6TOT + V4TOT - V0CIF_C;
```

p41

Excerpt 28b: GDP expenditure aggregates

Investment example

```
Coefficient   V2TOT_I  # Total investment usage #;
Formula       V2TOT_I  = sum{i,IND, V2TOT(i)};
Variable
 x2tot_i     # Aggregate real investment expenditure #;
 p2tot_i     # Aggregate investment price index #;
 w2tot_i     # Aggregate nominal investment #;
Equation
 E_x2tot_i  V2TOT_I*x2tot_i = sum{i,IND, V2TOT(i)*x2tot(i)};
 E_p2tot_i  V2TOT_I*p2tot_i = sum{i,IND, V2TOT(i)*p2tot(i)};
 E_w2tot_i  w2tot_i = x2tot_i + p2tot_i;
```

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Excerpt 28c: GDP expenditure aggregates

Inventory example

Coefficient V6TOT # Total value of inventories #;
Formula V6TOT = sum{c,COM, sum{s,SRC, V6BAS(c,s)}};

Variable
x6tot # Aggregate real inventories #;
p6tot # Inventories price index #;
w6tot # Aggregate nominal value of inventories #;

Equation
E_x6tot [TINY+V6TOT]*x6tot =100*sum{c,COM,sum{s,SRC,LEVP0(c,s)*delx6(c,s)}};
E_p6tot [TINY+V6TOT]*p6tot = sum{c,COM, sum{s,SRC, V6BAS(c,s)*p0(c,s)}};
E_w6tot w6tot = x6tot + p6tot;

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Excerpt 28d: GDP expenditure aggregates

Coefficient V0GDPEXP # Nominal GDP from expenditure side #;
Formula V0GDPEXP = V3TOT + V2TOT_I + V5TOT + V6TOT + V4TOT - V0CIF_C;

Variable
x0gdpexp # Real GDP from expenditure side #;
p0gdpexp # GDP price index, expenditure side #;
w0gdpexp # Nominal GDP from expenditure side #;

Equation
E_x0gdpexp V0GDPEXP*x0gdpexp = V3TOT*x3tot + V2TOT_I*x2tot_i + V5TOT*x5tot + V6TOT*x6tot + V4TOT*x4tot - V0CIF_C*x0cif_c;
E_p0gdpexp V0GDPEXP*p0gdpexp = V3TOT*p3tot + V2TOT_I*p2tot_i + V5TOT*p5tot + V6TOT*p6tot + V4TOT*p4tot - V0CIF_C*p0cif_c;
E_w0gdpexp w0gdpexp = x0gdpexp + p0gdpexp;

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Excerpt 29: Trade measures

Variable
(change) delB # (Balance of trade)/GDP #;
x0imp_c # Import volume index, duty-paid weights #;
w0imp_c # Value of imports plus duty #;
p0imp_c # Duty-paid imports price index, local currency #;
p0realdev # Real devaluation #;
p0toft # Terms of trade #;
Equation
E_delB 100*V0GDPEXP*delB=V4TOT*w4tot -V0CIF_C*w0cif_c
- (V4TOT-V0CIF_C)*w0gdpexp;
E_x0imp_c V0IMP_C*x0imp_c=sum{c,COM, V0IMP(c)*x0imp(c)};
E_p0imp_c
V0IMP_C*p0imp_c=sum{c,COM,V0IMP(c)*p0(c,"imp")};
E_w0imp_c w0imp_c = x0imp_c + p0imp_c;
E_p0toft p0toft = p4tot - p0cif_c;
E_p0realdev p0realdev = p0cif_c - p0gdpexp;

p43

Excerpt 30: Factor Aggregates

Variable *(Selected)*
(all,i,IND) employ(i) # Employment by industry #;
employ_i # Aggregate employment: wage bill weights #;
x1cap_i # Aggregate capital stock, rental weights #;
x1prim_i # Aggregate output: value-added weights #;
p1lab_io # Average nominal wage #;
realwage # Average real wage #;
Equation
E_employ (all,i,IND) V1LAB_O(i)*employ(i)
= sum{o,OCC, V1LAB(i,o)*x1lab(i,o)};
E_employ_i V1LAB_IO*employ_i = sum{i,IND,
V1LAB_O(i)*employ(i)};
E_x1cap_i V1CAP_I*x1cap_i = sum{i,IND, V1CAP(i)*x1cap(i)};
E_x1prim_i V1PRIM_I*x1prim_i = sum{i,IND, V1PRIM(i)*x1tot(i)};
E_p1lab_io V1LAB_IO*p1lab_io = sum{i,IND, sum{o,OCC,
V1LAB(i,o)*p1lab(i,o)}};
E_realwage realwage = p1lab_io - p3tot;

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Excerpt 31: Investment

For each industry i, investment x2tot(i) follows one of three rules:

1: Investment positively related to profit rate (short-run),
x2tot(i) = f(profit) + finv1(i) + invslack

2: Investment follows national investment, x2tot_i
x2tot(i) = x2tot_i + finv2(i)

3: Investment follows industry capital stock (long-run):
x2tot(i) = x1cap(i) + finv3(i) + invslack

For each industry i, one of the finv shift variables exogenous.

Optional extra: rules can accommodate fixed national investment.

One of invslack or x2tot_i exogenous.

p44

Excerpt 31: Investment

RULE 1: Investment positively related to profit rate (short-run).

First, we define the net rate of return as: Equation E_gret

NRET(i) = P1CAP(i)/P2TOT(i) - DEP(i) = GRET(i) - DEP(i) {levels}

nret(i) = [GRET(i) / NRET(i)] * gret(i) {% change}

Substituted into RHS of E_finv1 as 2.0 * gret(i)

Variable
gret(i) # Gross rate of return = Rental/[Price of new capital] #;

Equation E_gret gret(i) = p1cap(i) - p2tot(i);

p44

Excerpt 31: Investment

Second, we define the gross growth rate of capital as:
GGRO(i) = X2TOT(i) / X1CAP(i) {levels}
Equation E_ggro ggro(i) = x2tot(i) - x1cap(i) {% change}

Third, we relate the gross growth rate to the net rate of return via

Equation E_finv1 # DPSV investment rule #
(all,i,IND) ggro(i) = finv1(i) + 0.33*[2.0*gret(i) - invslack];

ie. GRET = 2 x DEP

Sensitivity of capital growth to rates of return

Excerpt 31: "Exogenous" investment industries

RULE 2: Industry investment follows national investment.

This rule is applied in those cases where investment is not thought to be mainly driven by current profits (eg, Education)

Equation E_finv2

 # Alternative rule for "exogenous" investment industries #

(all,i,IND) x2tot(i) = x2tot_i + finv2(i);

BUT: Do not set ALL the finv2's exogenous: would conflict with:

Equation E_x2tot_i

V2TOT_I*x2tot_i = sum{i,IND, V2TOT(i)*x2tot(i)};

At solve time: "singular matrix" error.

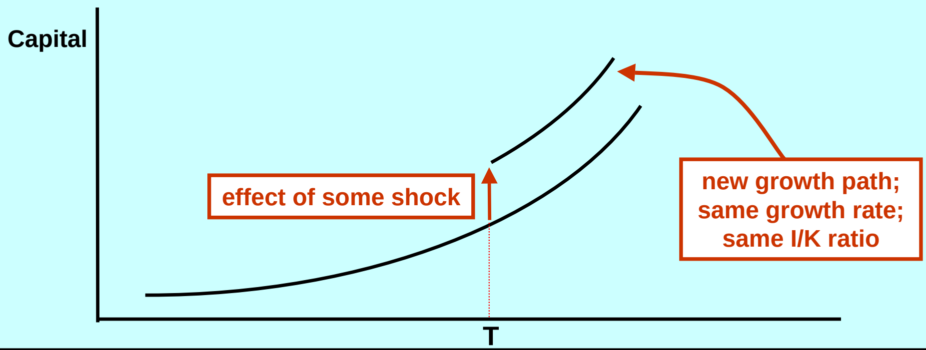
Excerpt 31: Longrun Investment Rule

RULE 3: investment/capital ratios are exogenous

Equation E_finv3 (all,i,IND) ggro(i) = finv3(i) + invslack

Recall:

ggro(i) # Gross growth rate of capital = Investment/capital #
= x2tot(i) - x1cap(i);



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Excerpt 31: Aggregate Investment

Three ways to set aggregate investment in ORANI-G

1. x2tot_i endogenous (invslack exogenous)
   industry specific rules determine aggregate

2. x2tot _i exogenous (invslack endogenous)

3. x2tot _i linked to Cr (invslack endogenous)
   Variable f2tot # Ratio, investment/consumption #;
   Equation E_f2tot x2tot_i = x3tot + f2tot;

   Implemented by seting f2tot exog and invslack endog

p45

Capital and Investment

ORANI-G: choice of 2 comp. stat. treatments

Shortrun: x1cap(i) fixed   x2tot(i) profit driven or exogenous

Longrun: gret(i) fixed   x2tot(i) follows x1cap(i)

NOT IN ORANI-G

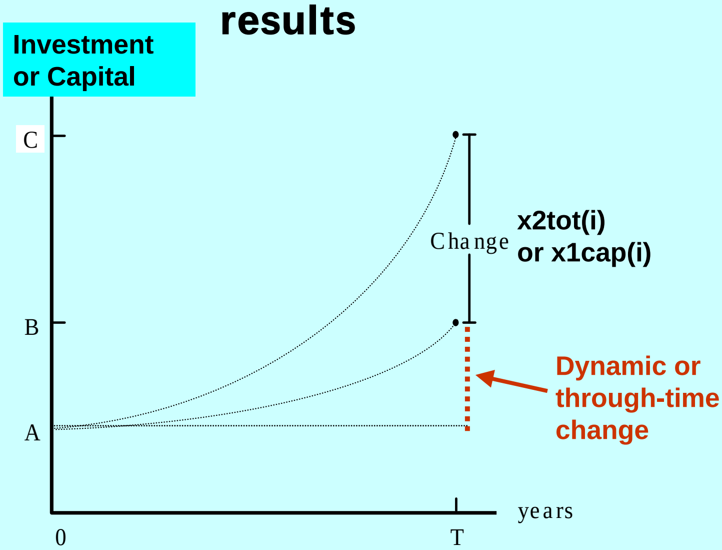
Accumulation rule: Capital = function(investment)

ΔX1CAP = X2TOT - Depreciation*(X1CAP)

ORANIG-RD: Series of shortruns:
x1cap(i) determined by previous period investment
x2tot(i) profit driven or exogenous

p44

Comparative-static interpretation of results



Results refer to changes at some future point in time.

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Fixed total capital, mobile between sectors

Equation E_fgret # *force rates of return to move together* #

(all,i,IND) gret(i) = fgret(i) + capslack;

Normally, capslack exogenous and zero, fgret endogenous:

fgret(i) = gret(i);

just determines fgret(i).

With capslack and gret endogenous,
x1cap_i and fgret(i) exogenous:

gret(i) = capslack;

all sectoral rates of return move together

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Summary of closure options

	Short-run	Long-run	Fixed capital
x1cap(i)	X	N (a)	N
finv1(i ∈ J)	X	N (b)	N
finv2(i ∉ J)	X	N (c)	N
finv3(i)	N	X (b) (c)	X
gret(i)	N	X (a)	N (a)
fgret(i)	N	N	X (a)
capslack	X	X	N (b)
x1cap_i	N	N	X (b)
x2tot(i)	N	N	N
finv1(i ∉ J)	N	N	N
finv2(i ∈ J)	N	N	N
invslack	N	X	N
x2tot_i	X	N	X

X:eXogenous
N:eNdogenous

(J : endogenous investment industries)

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Excerpt 32: Labour market

```
Variable
 (all,i,IND)(all,o,OCC) f1lab(i,o) # Wage shift variable #;
         (all,o,OCC) f1lab_i(o) # Occupation-specific wage shifter #;
         (all,i,IND)  f1lab_o(i) # Industry-specific wage shifter #;
                         f1lab_io   # Overall wage shifter #;

E_p1lab   # Wage setting #   (all,i,IND)(all,o,OCC)
   p1lab(i,o)= p3tot + f1lab_io + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);
```

Short run: f1lab_io fixed, aggregate employment varies

Long run: f1lab_io varies, aggregate employment exogenous

```
E_x1lab_i  # Employment by occupation #  (all,o,OCC)
   V1LAB_I(o)*x1lab_i(o) = sum{i,IND, V1LAB(i,o)*x1lab(i,o)};
```

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Excerpt 33: Miscellaneous

```
Variable (all,i,IND) f1oct(i)  Shift in price of "other cost" tickets
Equation E_p1oct # Indexing of prices of "other cost" tickets #
 (all,i,IND) p1oct(i) = p3tot + f1oct(i);   ! assumes full indexation !

Variable f3tot # Ratio, consumption/ GDP #;
Equation E_f3tot # Consumption function #
 w3tot = w0gdpexp + f3tot;
```

Vector variables are easier to look at in results:

Basic price of domestic goods: p0dom(c) = p0(c,"dom");

Basic price of imported goods: p0imp(c) = p0(c,"imp");

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Variables to explain results

Decomposition breaks down a percent change into contributions due to various parts or causes.

3 Decompositions:

Sales Decomposition
breaks down sales change by different markets

Fan Decomposition (causal)
breaks sales change into

- **growth of local market effect**
- **import/domestic competition effect**
- **export effect**

Expenditure-side GDP Decomposition
breaks down GDP by main expenditure aggregates

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Contributions in Decompositions

In explaining results, it is sometimes useful to be able to decompose the percentage change in *x* into the individual contributions of the RHS variables.

EG: X = A + B (Levels)

or PX = PA + PB (x through by common price, P)

Small % change: x = (PA/PX)a + (PB/PX)b

conta =(PA/PX)a

contb =(PB/PX)b

contribution of A to % change in X

contribution of B to % change in X

x = conta + contb

Would not add up right in multistep computation,

if x, conta and contb were percent changes (compounded).

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Contributions in Decompositions

Solution: define *conta* and *contb* as ordinary change variables, and make a new ordinary change variable, *q*.

EG: X = A + B

dX = dA + dB

[0.01 X0][100 .dX / X0] = dA + dB

changes: so will add

but: we want % changes

initial *ordinary change*

[0.01 X0] q = dA + dB

new change variable: q

NB: change in quantity valued @ current price

multiply through by common price:

[P X0] q = 100 [P dA] + 100 [P dB]

q = [100 / P X0] [P dA] + [100 / P X0] [P dB]

Decomp Equations

[P X0] conta = 100 [P dA]

[P X0] conta = [P A] a

Standard forms

Excerpt 34: Sales Decomposition

Breaks down %change in domestic sales
into contributions from each main customer:

Say domestic shoe sales went up 4.1%

Intermediate	1%
Investment	0
Household	5%
Government	0.1%
Export	-2%
Inventories	0
Total	4.1%

Equation
E_SalesDecompA

Excerpt 35: Fan Decomposition

Output of Shoes up 4.1% ..... why:

3 possible reasons:

Local Market Effect: demand for shoes (dom + imp) is up.

Domestic Share Effect: ratio (dom/imp) shoes is up.

Export Effect: shoe exports are up.

$X = L*S_{dom} + E$ L=all shoe sales $L*S_{dom}$=local sales dom shoes

$x = [L*S_{dom}/X][l + s_{dom}] + [E/X]e$ E=export sales

$x = [L*S_{dom}/X]\ l + [L*S_{dom}/X]s_{dom} + [E/X]e$

Local Market Domestic Share Export

Fan decomposition breaks down output change between
these three components.

Very useful for understanding results.

p50

Excerpt 36: Expenditure side GDP Decomposition

Shows contributions of main expenditure aggregates to % change in real GDP

NB: Standard form

```
INITGDP*contGDPexp("Consumption") = V3TOT*x3tot;
INITGDP*contGDPexp("Investment")  = V2TOT_I*x2tot_i;
INITGDP*contGDPexp("Government")  = V5TOT*x5tot;
INITGDP*contGDPexp("Stocks")      = V6TOT*x6tot;
INITGDP*contGDPexp("Exports")     = V4TOT*x4tot;
INITGDP*contGDPexp("Imports")     = - V0CIF_C*x0cif_c;
```

Initial GDP valued at current price (→ INITGDP)

Change variable (→ contGDPexp)

p50

Excerpt 36: Income side GDP Decomposition

Shows contributions of

- primary factor usage,
- indirect taxes, and
- technological change.

to % change in real GDP

p51-53

Excerpt 37 -42: The Summary file

Many useful aggregates

p55

Regional Extension

covered in a later lecture

Progress so far . . .

Introduction
Database structure
Solution method
TABLO language
Production: input decisions
Production: output decisions
Investment: input decisions
Household demands
Export demands
Government demands
Inventory demands
Margin demands
Market clearing
Price equations
Aggregates and indices
Investment allocation
Labour market
Decompositions
→ **Closure**
Regional extension

p56

Closing the model

Each equation explains a variable.

More variables than equations.

Endogenous variables: explained by model

Exogenous variables: set by user

Closure: choice of exogenous variables

Many possible closures

Number of endogenous variables = Number of equations

One way to construct a closure:

(a) Find the variable that each equation explains; it is endogenous.

(b) Other variables, not explained by equations, are exogenous.

ORANI-G equations are named after the variable they SEEM to explain. TABmate uses equation names for automatic closure.

p56 Variables not explained by any equation = possible exogenous list

Dimension	Variable Count	Equation Count	Exogenous Count	List of unexplained variables (Mechanical closure)
1	2	3	4	5
MACRO	70	56	14	f1lab_io f4p_ntrad f4q_ntrad f4tax_trad f4tax_ntrad *f5tot2* phi q *invslack* *w3lux* f1tax_csi f2tax_csi f3tax_cs f5tax_cs
COM	25	19	6	f0tax_s t0imp a3_s f4p f4q pf0cif
COM*IND	7	5	2	a1_s a2_s
COM*MAR	2	1	1	a4mar
COM*SRC	14	11	3	f5 a3 *fx6*
COM*SRC*IND	10	8	2	a1 a2
COM*SRC*IND*MAR	4	2	2	a1mar a2mar
COM*SRC*MAR	4	2	2	a3mar a5mar
IND	34	21	13	a1cap a1lab_o a1lnd a1oct a1prim a1tot f1lab_o f1oct *x2tot* x1lnd a2tot x1cap delPTXRate
IND*OCC	3	2	1	f1lab
OCC	2	1	1	f1lab_i
COM*SRC*DEST	1	1	0	
COM*DESTPLUS	1	1	0	
COM*FANCAT	1	1	0	
EXPMAC	1	1	0	
TOTAL	179	132	47	

p57 The ORANI short-run closure

Exogenous variables constraining real GDP from the supply side	
x1cap x1lnd	industry-specific endowments of capital and land
a1cap a1lab_o a1lnd a1prim a1tot a2tot	all technological change
f1lab_io	real wage shift variable
Exogenous settings of real GDP from the expenditure side	
x3tot	aggregate real private consumption expenditure
x2tot_i	aggregate real investment expenditure
x5tot	aggregate real government expenditure
f5	distribution of government demands
delx6	real demands for inventories by commodity
Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes	
pf0cif	foreign prices of imports
f4p f4q	individual exports
f4p_ntrad f4q_ntrad	collective exports
All tax rates are exogenous	
delPTXRATE f0tax_s f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp f4tax_trad f4tax_ntrad f1oct	
Distribution of investment between industries	
finv1(selected industries)	investment related to profits
finv2(the rest)	investment follows aggregate investment
Number of households and their consumption preferences are exogenous	
q	number of households
a3_s	household tastes
Numeraire assumption	
phi	nominal exchange rate

Length of run ,T

T is related to our choice of closure.

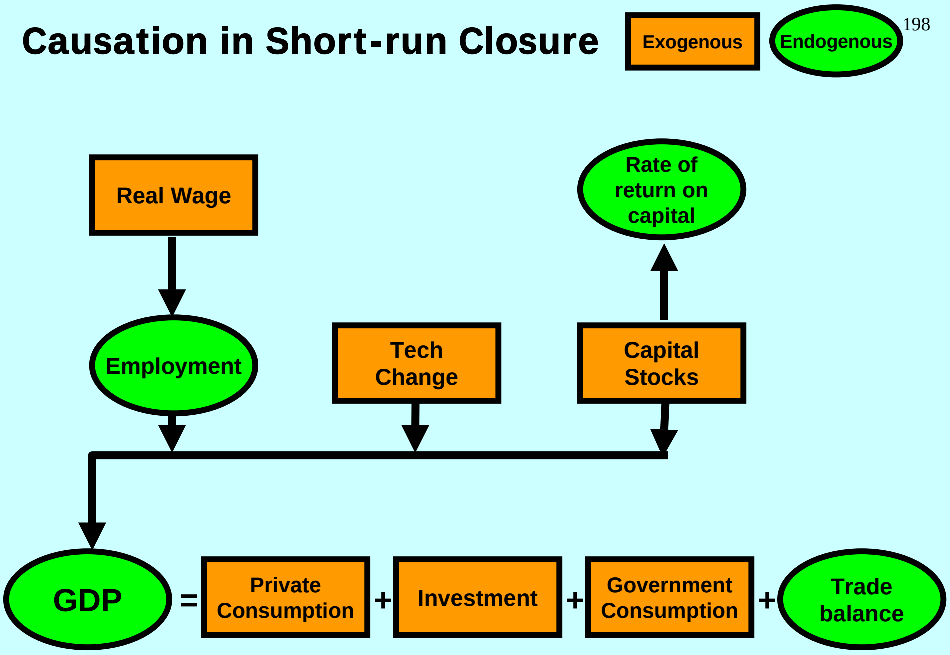
With shortrun closure we assume that:

- T is long enough for price changes to be transmitted throughout the economy, and for price-induced substitution to take place.
- T is not long enough for investment decisions to greatly affect the useful size of sectoral capital stocks. [New buildings and equipment take time to produce and install.]

T might be 2 years. So results mean:

a 10% consumption increase might lead to employment in 2 years time being 1.24% higher than it would be (in 2 years time) if the consumption increase did not occur.

Causation in Short-run Closure



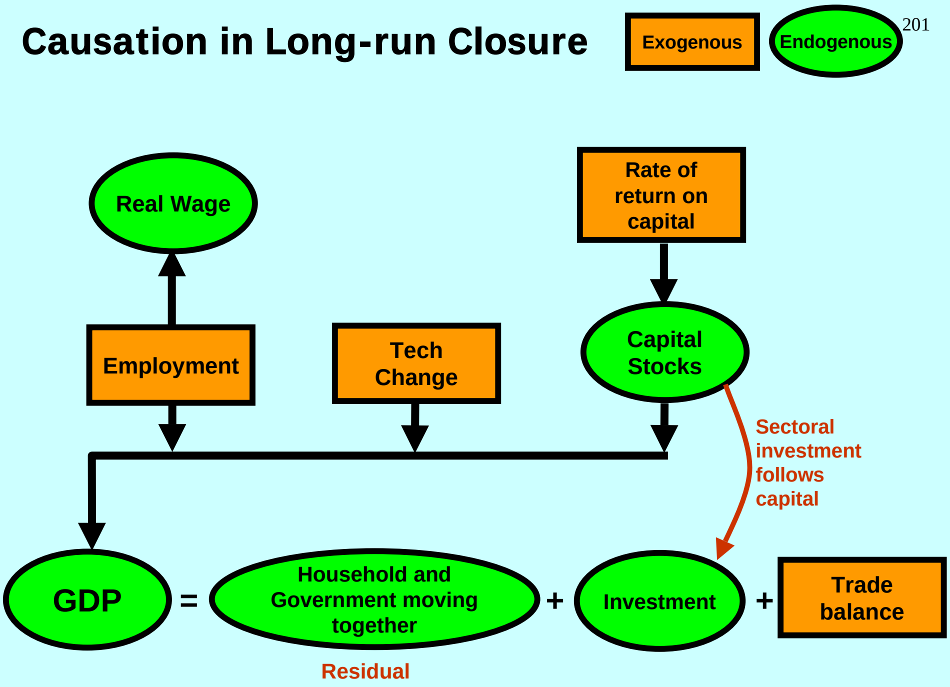
A possible long-run closure

- Capital stocks adjust in such a way to maintain fixed rates of return (gret).
- Aggregate employment is fixed and the real wage adjusts.
- DelB fixed instead of x3tot (real household consumption)
- x3tot (household) and x5tot (government) linked to move together

Table 4: A possible long-run closure

Exogenous variables constraining real GDP from the supply side	
gret	*gross sectoral rates of return*
x1lnd	industry-specific endowments of land
a1cap a1lab_o a1lnd a1prim a1tot a2tot	all technological change
employ_i	*total employment - wage weights*
Exogenous settings of real GDP from the expenditure side	
delB	*balance of trade/GDP*
invslack	*aggregate investment determined by industry specific rules*
f5tot2	*link government demands to total household*
f5	distribution of government demands
delx6	real demands for inventories by commodity
Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes	
pf0cif	foreign prices of imports
f4p f4q	individual exports
f4p_ntrad f4q_ntrad	collective exports
All tax rates are exogenous	
delPTXRATE f0tax_s f1tax_csi f2tax_csi f3tax_cs	
f5 f5tax_cs t0imp f4tax_trad f4tax_ntrad f1oct	
Distribution of investment between industries	
finv3(selected industries)	*fixed investment/capital ratios*
finv2(the rest)	investment follows aggregate investment
Number of households and their consumption preferences are exogenous	
q	number of households
a3_s	household tastes
Numeraire assumption	
phi	nominal exchange rate

Causation in Long-run Closure



Different closures

Many closures might be used for different purposes.
No unique natural or correct closure.

Must be at least one exogenous variable measured in local currency units.
Normally just one — called the *numeraire*.
Often the exchange rate, phi, or p3tot, the CPI.

Some quantity variables must be exogenous, such as:

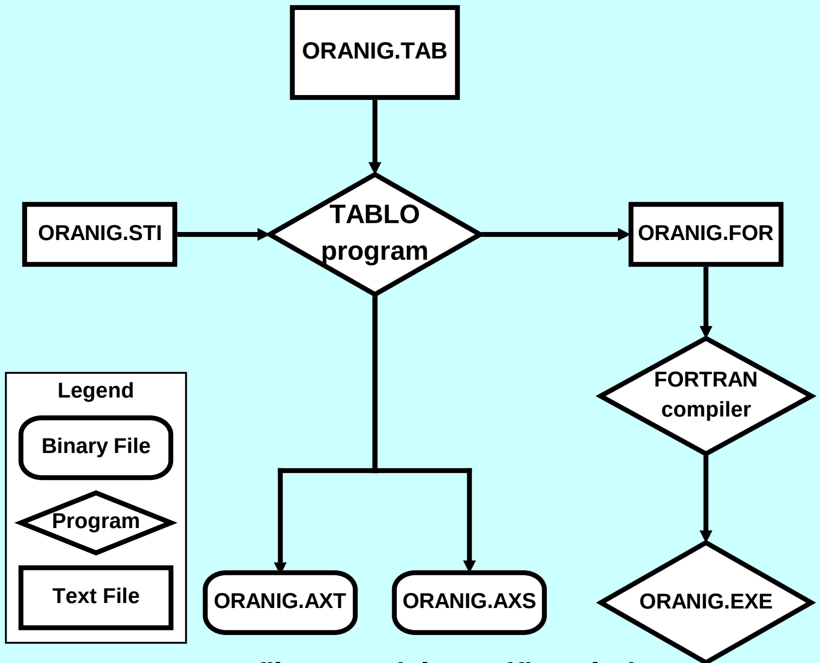
- primary factor endowments
- final demand aggregates

p59

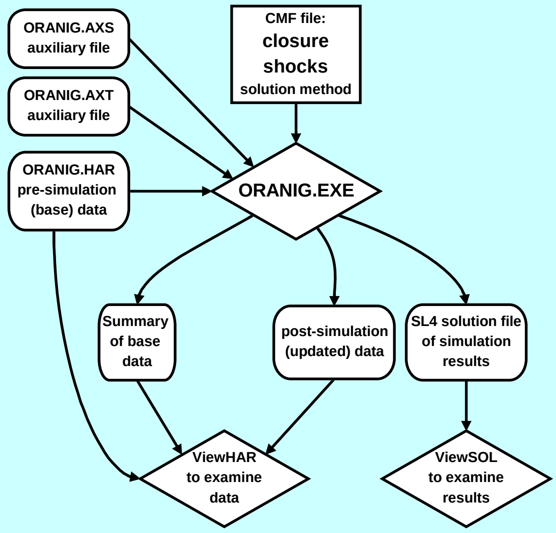
Three Macro Don't Knows

- ***Absolute price level.*** **Numeraire choice determines whether changes in the real exchange rate appear as changes in domestic prices or in changes in the exchange rate. Real variables unaffected.**
- ***Labour supply.*** **Closure determines whether labour market changes appear as changes in either wage or employment.**
- ***Size and composition of absorption.*** **Either exogenous or else adjusting to accommodate fixed trade balance. Closure determines how changes in national income appear.**

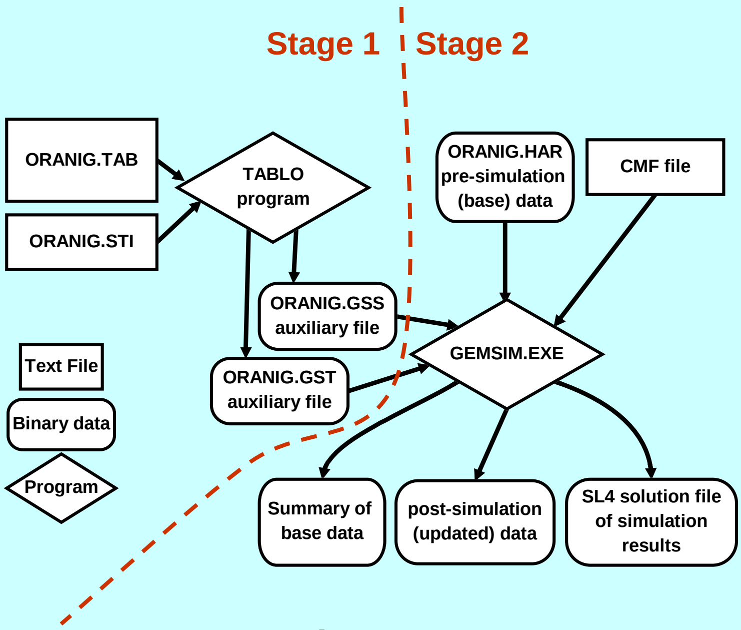
p60



Stage 1: From TAB file to model-specific solution program



Stage 2: Using the model-specific EXE to run a simulation



Using GEMSIM

The End

Section 5

ORANI-G database

Version of ORANI-G used for this course

The Model

The ORANI-G model is updated from time to time, and special features are added for particular countries.

For this Australian course we use the ORANIG06 version. This is extremely similar to the previous ORANIG03 version and uses the same database. The main new features display some capabilities of GEMPACK 9: the “postsim” section, and ranked sets. There is an 8 state top-down regional extension.

In the course documents this ORANIG06 model is referred to as “ORANI-G” or “ORANIG.TAB”.

The Data

The 35-sector database used for ORANI-G is based on the ABS 1993-94 Input-Output Tables (Cat. 5209).

The ORANI-G Database

The 35-sector database used for ORANI-G is based on the ABS 1993-94 Input-Output Tables (Cat. 5209). Disks corresponding to those tables are available from the ABS which break down the IO tables into 108 sectors.

Using supplementary data from the ABS and from ABARE the 108 sector tables were further disaggregated into a 119 industry, 122 commodity database. This wass designed to allow for the ORANI system of zonal agricultural industries, and to minimize some problems of inappropriate aggregation that have caused problems in the past.

For the training course, the large 119/122 sector database was aggregated to a more manageable size.

The following pages contain:

- Selected aggregates from the 35-sector 1993-94 database.
- Mapping between the 35 sectors and the categories of the large 119/122 sector database.

See also: http://www.copsmodels.com/techdoc.htm [btech3]

Macro Aggregates

Income-side	Levels	Share
1 Consumption	260587	0.609
2 Investment	92958	0.217
3 Government	78704	0.184
4 Stocks	-99	0.000
5 Exports	73157	0.171
6 Imports	-77503	-0.181
GDP	427804	1.000

Expenditure-side	Levels	Share
1 Land	2736	0.006
2 Labour	194981	0.456
3 Capital	180575	0.422
4 IndirectTax	49512	0.116
GDP	427804	1.000

Indirect Taxes	Levels	Share
1 Intermediate	10219	0.206
2 Investment	2838	0.057
3 Consumption	14716	0.297
4 Exports	650	0.013
5 Government	0	0.000
6 OCT	18344	0.370
7 ProdTax	0	0.000
8 Tariff	2747	0.055
Total	49512	1.000

Matrix of Domestic Sales

	1 Interm	2 Invest	3 HouseH	4 Export	5 GovGE	6 Stocks	7 Margins	Total
1 WoolMutton	1055	0	16	1640	0	100	0	2810
2 GrainsHay	2595	0	162	2155	0	-18	0	4895
3 BeefCattle	3853	0	53	111	0	23	0	4041
4 OtherAgric	8260	0	2194	1165	101	71	0	11791
5 ForestFish	1708	32	995	463	361	15	0	3573
6 Mining	15225	70	530	18168	86	-1380	0	32699
7 MeatDairy	3954	0	6674	5563	0	-9	0	16183
8 OthFoodProds	3851	0	9473	3511	0	183	0	17017
9 DrinksSmokes	476	0	5454	525	0	10	0	6465
10 Textiles	3015	75	1362	1225	0	14	0	5691
11 ClothingFtw	647	0	3420	599	0	-44	0	4621
12 WoodProds	4805	39	168	508	0	-50	0	5472
13 PaperPrint	13556	60	2371	452	69	-64	0	16445
14 Petrol_CoalP	6905	0	2445	797	0	32	0	10180
15 Chemicals	9000	0	2472	1898	0	59	0	13430
16 RubberPlastc	5314	13	747	273	0	52	0	6399
17 NonMetlMinrl	7504	0	118	221	0	27	0	7870
18 BasicMetals	12110	0	53	7765	0	-70	0	19858
19 FabMetalPrd	10686	594	323	520	0	-99	0	12023
20 TransportEqp	6271	7906	1403	1831	0	-510	0	16901
21 OthMachnEqp	7101	4526	1794	3223	0	306	0	16950
22 MiscManuf	1010	1929	2372	535	0	-46	0	5800
23 ElecGasWater	14798	0	5125	29	181	0	0	20134
24 Construction	3031	47643	0	16	1696	0	0	52386
25 Trade	2227	0	0	0	14	442	73448	76132
26 Repairs	8139	0	7364	37	0	-0	0	15540
27 Hotel_Cafe	3075	0	9882	0	0	3	4369	17329
28 Transport	9342	13	7745	7046	3668	29	15095	42938
29 CommunicSrvc	10894	0	4633	768	26	0	0	16321
30 FinanceInsur	26169	0	9970	656	187	-288	198	36893
31 OwnerDwellng	0	0	48120	0	0	-24	0	48096
32 PropBusSrvc	53681	3056	2969	1643	1663	-48	0	62963
33 GovAdminDfnc	7132	181	478	174	32107	0	0	40071
34 Education	268	0	5320	1032	16937	0	0	23557
35 HealthCommun	1195	0	19478	39	14673	-0	0	35385
36 CultuRecreat	4239	42	7976	59	2074	-0	0	14389
37 OtherService	2738	0	5830	10	4862	0	0	13440
Total	275830	66180	179490	64656	78704	-1283	93111	756687

Sales Share Matrix

	1 Interm	2 Invest	3 HouseH	4 Export	5 GovGE	6 Stocks	7 Margins	Total
1 WoolMutton	0.375	0	0.006	0.583	0.000	0.036	0	1.000
2 GrainsHay	0.530	0	0.033	0.440	0.000	-0.004	0	1.000
3 BeefCattle	0.954	0	0.013	0.028	0.000	0.006	0	1.000
4 OtherAgric	0.701	0	0.186	0.099	0.009	0.006	0	1.000
5 ForestFish	0.478	0.009	0.279	0.129	0.101	0.004	0	1.000
6 Mining	0.466	0.002	0.016	0.556	0.003	-0.042	0	1.000
7 MeatDairy	0.244	0	0.412	0.344	0.000	-0.001	0	1.000
8 OthFoodProds	0.226	0	0.557	0.206	0.000	0.011	0	1.000
9 DrinksSmokes	0.074	0	0.844	0.081	0.000	0.001	0	1.000
10 Textiles	0.530	0.013	0.239	0.215	0.000	0.002	0	1.000
11 ClothingFtw	0.140	0	0.740	0.130	0.000	-0.010	0	1.000
12 WoodProds	0.878	0.007	0.031	0.093	0.000	-0.009	0	1.000
13 PaperPrint	0.824	0.004	0.144	0.027	0.004	-0.004	0	1.000
14 Petrol_CoalP	0.678	0	0.240	0.078	0.000	0.003	0	1.000
15 Chemicals	0.670	0	0.184	0.141	0.000	0.004	0	1.000
16 RubberPlastc	0.831	0.002	0.117	0.043	0.000	0.008	0	1.000
17 NonMetlMinrl	0.954	0	0.015	0.028	0.000	0.003	0	1.000
18 BasicMetals	0.610	0	0.003	0.391	0.000	-0.004	0	1.000
19 FabMetalPrd	0.889	0.049	0.027	0.043	0.000	-0.008	0	1.000
20 TransportEqp	0.371	0.468	0.083	0.108	0.000	-0.030	0	1.000
21 OthMachnEqp	0.419	0.267	0.106	0.190	0.000	0.018	0	1.000
22 MiscManuf	0.174	0.333	0.409	0.092	0.000	-0.008	0	1.000
23 ElecGasWater	0.735	0	0.255	0.001	0.009	0.000	0	1.000
24 Construction	0.058	0.909	0	0.000	0.032	0.000	0	1.000
25 Trade	0.029	0.000	0	0	0.000	0.006	0.965	1.000
26 Repairs	0.524	0	0.474	0.002	0.000	-0.000	0	1.000
27 Hotel_Cafe	0.177	0	0.570	0	0.000	0.000	0.252	1.000
28 Transport	0.218	0.000	0.180	0.164	0.085	0.001	0.352	1.000
29 CommunicSrvc	0.668	0	0.284	0.047	0.002	0.000	0	1.000
30 FinanceInsur	0.709	0	0.270	0.018	0.005	-0.008	0.005	1.000
31 OwnerDwellng	0	0	1.000	0	0.000	-0.000	0	1.000
32 PropBusSrvc	0.853	0.049	0.047	0.026	0.026	-0.001	0	1.000
33 GovAdminDfnc	0.178	0.005	0.012	0.004	0.801	0.000	0	1.000
34 Education	0.011	0	0.226	0.044	0.719	0.000	0	1.000
35 HealthCommun	0.034	0	0.550	0.001	0.415	-0.000	0	1.000
36 CultuRecreat	0.295	0.003	0.554	0.004	0.144	-0.000	0	1.000
37 OtherService	0.204	0	0.434	0.001	0.362	0	0	1.000
Total	0.365	0.087	0.237	0.085	0.104	-0.002	0.123	1.000

Cost Matrix

	1 IntDom	2 IntImp	3 Margin	4 ComTax	5 Lab	6 Cap	7 Lnd	8 ProdTax	9 OCT	Total
1 BroadAcre	4365	547	570	349	965	3135	1544	0	270	11745
2 OtherAgric	4535	483	507	196	1480	3136	1192	0	263	11791
3 ForestFish	1292	350	300	199	816	503	0	0	110	3570
4 Mining	10797	1720	769	269	4834	14221	0	0	254	32864
5 MeatDairy	11347	163	1224	127	1908	1280	0	0	245	16293
6 OthFoodProds	9506	950	1336	189	2627	2286	0	0	201	17095
7 DrinksSmokes	3497	401	490	131	729	1190	0	0	68	6507
8 Textiles	2405	977	423	85	938	727	0	0	64	5616
9 ClothingFtw	2020	964	267	23	992	416	0	0	57	4739
10 WoodProds	2505	510	628	34	1119	574	0	0	66	5435
11 PaperPrint	5908	2279	804	392	3716	3115	0	0	332	16547
12 Petrol_CoalP	4359	3050	539	58	275	2004	0	0	50	10335
13 Chemicals	5972	2498	900	152	1815	2127	0	0	68	13533
14 RubberPlastc	2633	1138	322	43	1317	946	0	0	105	6503
15 NonMetlMinrl	3467	483	992	88	1373	1387	0	0	157	7947
16 BasicMetals	11895	1240	1224	158	2553	2682	0	0	807	20559
17 FabMetalPrd	5528	1066	664	71	2595	1398	0	0	682	12004
18 TransportEqp	6876	3404	1411	147	2899	2428	0	0	216	17382
19 OthMachnEqp	5453	3174	1341	279	3688	2862	0	0	237	17035
20 MiscManuf	2185	657	473	40	1266	603	0	0	76	5299
21 ElecGasWater	4287	541	651	254	3468	10770	0	0	189	20160
22 Construction	21166	2874	2964	407	12056	12072	0	0	561	52100
23 Trade	31281	2300	927	1423	22254	15742	0	0	2251	76178
24 Repairs	2863	1407	1115	515	3553	5152	0	0	328	14932
25 Hotel_Cafe	7774	656	509	92	5894	2234	0	0	159	17317
26 Transport	13334	2637	1166	1866	10144	12839	0	0	1136	43123
27 CommunicSrvc	4099	1031	466	269	4665	6049	0	0	433	17011
28 FinanceInsur	9446	481	109	128	11954	13447	0	0	3069	38635
29 OwnerDwellng	11653	641	406	492	0	31930	0	0	2974	48096
30 PropBusSrvc	22356	2137	792	806	19480	12613	0	0	1310	59493
31 GovAdminDfnc	20438	2352	892	-11	14883	1522	0	0	-4	40071
32 Education	1824	361	230	27	19269	1518	0	0	327	23557
33 HealthCommun	8996	1451	740	456	19415	3939	0	0	388	35385
34 CultuRecreat	5458	1143	627	187	3664	2590	0	0	719	14389
35 OtherService	4313	685	471	278	6379	1139	0	0	175	13440
Total	275830	46752	27251	10219	194981	180575	2736	0	18344	756687

Cost Share Matrix

cost share	1 IntDom	2 IntImp	3 Margin	4 ComTax	5 Lab	6 Cap	7 Lnd	8 ProdTax	9 OCT	Total
1 BroadAcre	0.372	0.047	0.049	0.030	0.082	0.267	0.131	0	0.023	1.000
2 OtherAgric	0.385	0.041	0.043	0.017	0.125	0.266	0.101	0	0.022	1.000
3 ForestFish	0.362	0.098	0.084	0.056	0.228	0.141	0	0	0.031	1.000
4 Mining	0.329	0.052	0.023	0.008	0.147	0.433	0	0	0.008	1.000
5 MeatDairy	0.696	0.010	0.075	0.008	0.117	0.079	0	0	0.015	1.000
6 OthFoodProds	0.556	0.056	0.078	0.011	0.154	0.134	0	0	0.012	1.000
7 DrinksSmokes	0.537	0.062	0.075	0.020	0.112	0.183	0	0	0.010	1.000
8 Textiles	0.428	0.174	0.075	0.015	0.167	0.129	0	0	0.011	1.000
9 ClothingFtw	0.426	0.203	0.056	0.005	0.209	0.088	0	0	0.012	1.000
10 WoodProds	0.461	0.094	0.115	0.006	0.206	0.106	0	0	0.012	1.000
11 PaperPrint	0.357	0.138	0.049	0.024	0.225	0.188	0	0	0.020	1.000
12 Petrol_CoalP	0.422	0.295	0.052	0.006	0.027	0.194	0	0	0.005	1.000
13 Chemicals	0.441	0.185	0.067	0.011	0.134	0.157	0	0	0.005	1.000
14 RubberPlastc	0.405	0.175	0.049	0.007	0.203	0.145	0	0	0.016	1.000
15 NonMetlMinrl	0.436	0.061	0.125	0.011	0.173	0.175	0	0	0.020	1.000
16 BasicMetals	0.579	0.060	0.060	0.008	0.124	0.130	0	0	0.039	1.000
17 FabMetalPrd	0.460	0.089	0.055	0.006	0.216	0.116	0	0	0.057	1.000
18 TransportEqp	0.396	0.196	0.081	0.008	0.167	0.140	0	0	0.012	1.000
19 OthMachnEqp	0.320	0.186	0.079	0.016	0.216	0.168	0	0	0.014	1.000
20 MiscManuf	0.412	0.124	0.089	0.008	0.239	0.114	0	0	0.014	1.000
21 ElecGasWater	0.213	0.027	0.032	0.013	0.172	0.534	0	0	0.009	1.000
22 Construction	0.406	0.055	0.057	0.008	0.231	0.232	0	0	0.011	1.000
23 Trade	0.411	0.030	0.012	0.019	0.292	0.207	0	0	0.030	1.000
24 Repairs	0.192	0.094	0.075	0.034	0.238	0.345	0	0	0.022	1.000
25 Hotel_Cafe	0.449	0.038	0.029	0.005	0.340	0.129	0	0	0.009	1.000
26 Transport	0.309	0.061	0.027	0.043	0.235	0.298	0	0	0.026	1.000
27 CommunicSrvc	0.241	0.061	0.027	0.016	0.274	0.356	0	0	0.025	1.000
28 FinanceInsur	0.244	0.012	0.003	0.003	0.309	0.348	0	0	0.079	1.000
29 OwnerDwellng	0.242	0.013	0.008	0.010	0.000	0.664	0	0	0.062	1.000
30 PropBusSrvc	0.376	0.036	0.013	0.014	0.327	0.212	0	0	0.022	1.000
31 GovAdminDfnc	0.510	0.059	0.022	-0.00	0.371	0.038	0	0	-0.00	1.000
32 Education	0.077	0.015	0.010	0.001	0.818	0.064	0	0	0.014	1.000
33 HealthCommun	0.254	0.041	0.021	0.013	0.549	0.111	0	0	0.011	1.000
34 CultuRecreat	0.379	0.079	0.044	0.013	0.255	0.180	0	0	0.050	1.000
35 OtherService	0.321	0.051	0.035	0.021	0.475	0.085	0	0	0.013	1.000
Total	0.365	0.062	0.036	0.014	0.258	0.239	0.004	0	0.024	1.000

Regional Value-Added Matrix

	1 NSW	2 VIC	3 QLD	4 SA	5 WA	6 TAS	7 ACT	8 NT	Total
1 BroadAcre	2071	913	996	835	591	61	5	172	5644
2 OtherAgric	1545	1784	1142	776	360	145	12	43	5807
3 ForestFish	281	329	249	129	134	166	23	9	1319
4 Mining	3409	1602	3909	1065	8178	213	0	680	19055
5 MeatDairy	838	921	808	227	280	110	2	2	3187
6 OthFoodProds	1538	1360	1165	277	387	148	17	20	4913
7 DrinksSmokes	639	498	251	286	177	29	27	13	1919
8 Textiles	427	898	89	56	111	83	0	0	1664
9 ClothingFtw	511	558	192	82	58	3	4	0	1408
10 WoodProds	523	404	395	120	154	71	18	7	1693
11 PaperPrint	2374	2295	844	398	553	265	79	23	6831
12 Petrol_CoalP	953	772	425	11	118	0	0	0	2279
13 Chemicals	1537	1463	374	176	332	60	0	0	3942
14 RubberPlastc	668	1026	235	184	135	15	0	1	2263
15 NonMetlMinrl	787	767	531	131	410	96	16	22	2760
16 BasicMetals	2234	480	809	487	813	241	0	172	5235
17 FabMetalPrd	1218	1141	791	268	462	77	12	24	3993
18 TransportEqp	868	2416	639	1047	224	119	6	7	5327
19 OthMachnEqp	2494	2083	694	580	561	78	51	9	6550
20 MiscManuf	549	562	336	160	218	27	13	4	1869
21 ElecGasWater	4553	3665	2459	1115	1623	343	302	179	14238
22 Construction	7918	5734	4465	1816	2738	545	613	299	24128
23 Trade	12804	9620	6649	2906	4040	857	728	394	37997
24 Repairs	2924	2107	1585	669	940	199	182	98	8704
25 Hotel_Cafe	2788	2000	1442	609	843	182	176	87	8128
26 Transport	8368	5488	4291	1548	2140	575	245	327	22983
27 CommunicSrvc	3553	2690	1853	807	1183	244	257	126	10714
28 FinanceInsur	8423	6447	4464	1910	2734	587	549	286	25401
29 OwnerDwellng	11013	7802	5732	2409	3216	717	708	331	31930
30 PropBusSrvc	10644	8171	5513	2359	3667	722	649	368	32092
31 GovAdminDfnc	4724	4799	2100	1246	964	368	1918	286	16405
32 Education	7155	5089	3719	1566	2097	464	478	218	20787
33 HealthCommun	7935	5678	4167	1748	2524	523	512	267	23354
34 CultuRecreat	2133	1554	1102	468	650	141	138	67	6254
35 OtherService	2584	1863	1334	564	752	167	175	79	7518
Total	122986	94977	65748	29033	44364	8643	7919	4622	378292

Regional Specialization Matrix (shares in regional value-added)

Regional Specialization	1 NSW	2 VIC	3 QLD	4 SA	5 WA	6 TAS	7 ACT	8 NT	Total
1 BroadAcre	0.017	0.010	0.015	0.029	0.013	0.007	0.001	0.037	0.015
2 OtherAgric	0.013	0.019	0.017	0.027	0.008	0.017	0.002	0.009	0.015
3 ForestFish	0.002	0.003	0.004	0.004	0.003	0.019	0.003	0.002	0.003
4 Mining	0.028	0.017	0.059	0.037	0.184	0.025	0.000	0.147	0.050
5 MeatDairy	0.007	0.010	0.012	0.008	0.006	0.013	0.000	0.000	0.008
6 OthFoodProds	0.013	0.014	0.018	0.010	0.009	0.017	0.002	0.004	0.013
7 DrinksSmokes	0.005	0.005	0.004	0.010	0.004	0.003	0.003	0.003	0.005
8 Textiles	0.003	0.009	0.001	0.002	0.002	0.010	0.000	0.000	0.004
9 ClothingFtw	0.004	0.006	0.003	0.003	0.001	0.000	0.001	0.000	0.004
10 WoodProds	0.004	0.004	0.006	0.004	0.003	0.008	0.002	0.002	0.004
11 PaperPrint	0.019	0.024	0.013	0.014	0.012	0.031	0.010	0.005	0.018
12 Petrol_CoalP	0.008	0.008	0.006	0.000	0.003	0.000	0.000	0.000	0.006
13 Chemicals	0.013	0.015	0.006	0.006	0.007	0.007	0.000	0.000	0.010
14 RubberPlastc	0.005	0.011	0.004	0.006	0.003	0.002	0.000	0.000	0.006
15 NonMetlMinrl	0.006	0.008	0.008	0.005	0.009	0.011	0.002	0.005	0.007
16 BasicMetals	0.018	0.005	0.012	0.017	0.018	0.028	0.000	0.037	0.014
17 FabMetalPrd	0.010	0.012	0.012	0.009	0.010	0.009	0.002	0.005	0.011
18 TransportEqp	0.007	0.025	0.010	0.036	0.005	0.014	0.001	0.002	0.014
19 OthMachnEqp	0.020	0.022	0.011	0.020	0.013	0.009	0.006	0.002	0.017
20 MiscManuf	0.004	0.006	0.005	0.006	0.005	0.003	0.002	0.001	0.005
21 ElecGasWater	0.037	0.039	0.037	0.038	0.037	0.040	0.038	0.039	0.038
22 Construction	0.064	0.060	0.068	0.063	0.062	0.063	0.077	0.065	0.064
23 Trade	0.104	0.101	0.101	0.100	0.091	0.099	0.092	0.085	0.100
24 Repairs	0.024	0.022	0.024	0.023	0.021	0.023	0.023	0.021	0.023
25 Hotel_Cafe	0.023	0.021	0.022	0.021	0.019	0.021	0.022	0.019	0.021
26 Transport	0.068	0.058	0.065	0.053	0.048	0.067	0.031	0.071	0.061
27 CommunicSrvc	0.029	0.028	0.028	0.028	0.027	0.028	0.032	0.027	0.028
28 FinanceInsur	0.068	0.068	0.068	0.066	0.062	0.068	0.069	0.062	0.067
29 OwnerDwellng	0.090	0.082	0.087	0.083	0.072	0.083	0.089	0.072	0.084
30 PropBusSrvc	0.087	0.086	0.084	0.081	0.083	0.084	0.082	0.080	0.085
31 GovAdminDfnc	0.038	0.051	0.032	0.043	0.022	0.043	0.242	0.062	0.043
32 Education	0.058	0.054	0.057	0.054	0.047	0.054	0.060	0.047	0.055
33 HealthCommun	0.065	0.060	0.063	0.060	0.057	0.060	0.065	0.058	0.062
34 CultuRecreat	0.017	0.016	0.017	0.016	0.015	0.016	0.017	0.014	0.017
35 OtherService	0.021	0.020	0.020	0.019	0.017	0.019	0.022	0.017	0.020
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Mapping between New and ORANI-G98 Commodities

Industries

Original		Aggregated	
1	Pastoral	1	BroadAcre
2	WheatSheep	1	BroadAcre
3	HighRainfall	1	BroadAcre
4	NorthBeef	1	BroadAcre
5	Dairy	2	OtherAgric
6	Pigs	2	OtherAgric
7	Poultry	2	OtherAgric
8	SugarCane	2	OtherAgric
9	RawCotton	2	OtherAgric
10	Grapes	2	OtherAgric
11	OtherAgric	2	OtherAgric
12	AgricSrvces	2	OtherAgric

Commodities

Original		Aggregated	
1	Wool	1	WoolMutton
2	SheepMeat	1	WoolMutton
3	Wheat	2	GrainsHay
4	Barley	2	GrainsHay
5	OtherGrains	2	GrainsHay
6	BeefCattle	3	BeefCattle
7	Dairy	4	OtherAgric
8	Pigs	4	OtherAgric
9	Poultry	4	OtherAgric
10	SugarCane	4	OtherAgric
11	RawCotton	4	OtherAgric
12	Grapes	4	OtherAgric
13	HayFodder	2	GrainsHay
14	OtherAgric	2	OtherAgric
15	AgricSrvces	4	OtherAgric

Original Sectors Ind	Com		Aggregated Sectors Ind	Com	
13	16	ForestrySrvc	3	5	ForestFish
14	17	Logging	3	5	ForestFish
15	18	Fishing	3	5	ForestFish
16	19	BlackCoal	4	6	Mining
17	20	BrownCoal	4	6	Mining
18	21	CrudeOil	4	6	Mining
19	22	LiquidGas	4	6	Mining
20	23	NaturalGas	4	6	Mining
21	24	IronOres	4	6	Mining
22	25	OthMetalOres	4	6	Mining
23	26	OtherMining	4	6	Mining
24	27	MiningSrvces	4	6	Mining
25	28	MeatProds	5	7	MeatDairy
26	29	DairyProds	5	7	MeatDairy
27	30	Fruit_Veg	6	8	OthFoodProds
28	31	Oils_Fats	6	8	OthFoodProds
29	32	Flour_Creals	6	8	OthFoodProds
30	33	Bakery	6	8	OthFoodProds
31	34	Confectionry	6	8	OthFoodProds
32	35	Sugar	6	8	OthFoodProds
33	36	SeaFood	6	8	OthFoodProds
34	37	OthFoodProd	6	8	OthFoodProds
35	38	SoftDrinks	7	9	DrinksSmokes
36	39	Beer_Malt	7	9	DrinksSmokes
37	40	Wine_Spirits	7	9	DrinksSmokes
38	41	TobaccoProds	7	9	DrinksSmokes
39	42	Fibre_Woven	8	10	Textiles
40	43	TextileProds	8	10	Textiles
41	44	KnittingMill	8	10	Textiles
42	45	Clothing	9	11	ClothingFtw
43	46	Footwear	9	11	ClothingFtw
44	47	LeatherProds	9	11	ClothingFtw
45	48	SawmillProds	10	12	WoodProds
46	49	OthWoodProds	10	12	WoodProds
47	50	Pulp_Paper	11	13	PaperPrint
48	51	PaperProds	11	13	PaperPrint
49	52	Printing	11	13	PaperPrint
50	53	Publishing	11	13	PaperPrint
51	54	Petrol_CoalP	12	14	Petrol_CoalP
52	55	BasicChemicl	13	15	Chemicals
53	56	Paints	13	15	Chemicals
54	57	Pharmaceutic	13	15	Chemicals
55	58	Soaps	13	15	Chemicals
56	59	Cosmetics	13	15	Chemicals
57	60	OthChemPrd	13	15	Chemicals

Mapping between New and ORANI-G98 Commodities (cont.)

Original			Aggregated		
Ind	Com		Ind	Com	
58	61	RubberProds	14	16	RubberPlastc
59	62	PlasticProds	14	16	RubberPlastc
60	63	GlassProds	15	17	NonMetlMinrl
61	64	CeramicProds	15	17	NonMetlMinrl
62	65	Cement_lime	15	17	NonMetlMinrl
63	66	PlasterEtc	15	17	NonMetlMinrl
64	67	ONmtlMinProd	15	17	NonMetlMinrl
65	68	Iron_Steel	16	18	BasicMetals
66	69	BasicNferMtl	16	18	BasicMetals
67	70	StrucMetlPrd	17	19	FabMetalPrd
68	71	SheetMetlPrd	17	19	FabMetalPrd
69	72	FabrcMetlPrd	17	19	FabMetalPrd
70	73	MVP_OthTrnEq	18	20	TransportEqp
71	74	Ships_Boats	18	20	TransportEqp
72	75	RailwayEquip	18	20	TransportEqp
73	76	Aircraft	18	20	TransportEqp
74	77	Photo_SciEqp	19	21	OthMachnEqp
75	78	ElectrnicEqp	19	21	OthMachnEqp
76	79	HouseholdApp	19	21	OthMachnEqp
77	80	OthElecEquip	19	21	OthMachnEqp
78	81	AgrMinMachnr	19	21	OthMachnEqp
79	82	OtherMachnry	19	21	OthMachnEqp
80	83	PrefabBuildn	20	22	MiscManuf
81	84	Furniture	20	22	MiscManuf
82	85	OtherManufac	20	22	MiscManuf
83	86	ElecSupply	21	23	ElecGasWater
84	87	GasSupply	21	23	ElecGasWater
85	88	WaterDrains	21	23	ElecGasWater
86	89	ResidBuildng	22	24	Construction
87	90	OthConstruct	22	24	Construction
88	91	WholesaleTrd	23	25	Trade
89	92	RetailTrade	23	25	Trade
90	93	MechRepairs	24	26	Repairs
91	94	OtherRepairs	24	26	Repairs
92	95	Hotel_Cafe	25	27	Hotel_Cafe
93	96	RoadTransprt	26	28	Transport
94	97	RailTransprt	26	28	Transport
95	98	WaterTranspt	26	28	Transport
96	99	AirTransport	26	28	Transport
97	100	TransprtSrvc	26	28	Transport
98	101	CommunicSrvc	27	29	CommunicSrvc
99	102	Banking	28	30	FinanceInsur
100	103	NonBankFnanc	28	30	FinanceInsur
101	104	FinancAsset	28	30	FinanceInsur
102	105	Insurance	28	30	FinanceInsur
103	106	FinanceSrvce	28	30	FinanceInsur
104	107	OwnerDwellng	29	31	OwnerDwellng
105	108	OthPrprtySvc	30	32	PropBusSrvc
106	109	TechServices	30	32	PropBusSrvc
107	110	LawAccMkting	30	32	PropBusSrvc
108	111	OtherBusSrvc	30	32	PropBusSrvc
109	112	GovAdmin	31	33	GovAdminDfnc
110	113	Defence	31	33	GovAdminDfnc
111	114	Education	32	34	Education
112	115	HealthSrvces	33	35	HealthCommun
113	116	CommunSrvces	33	35	HealthCommun
114	117	FilmRadioTV	34	36	CultuRecreat
115	118	LbryMseumArt	34	36	CultuRecreat
116	119	SportGambRec	34	36	CultuRecreat
117	120	PersonalSrvc	35	37	OtherService
118	121	OtherServces	35	37	OtherService
119	122	NonCompImps	35	37	OtherService

Section 6

Hands-on computing:
Part A

HANDS-ON COMPUTING WITH ORANI-G: PART A
INTERROGATING THE DATA

Starting WinGEM

If the WinGEM icon (resembling:) appears on your desktop, double-click on it to start WinGEM. Otherwise, click on the ***Start*** button at the bottom left hand side of the screen. Choose ***All Programs*** then in the ***GEMPACK*** section select ***WinGEM***.
WinGEM is a Windows interface to GEMPACK. When it starts it shows a narrow menu across the top of the screen:

WinGEM - GEMPACK for Windows
File Simulation HA files Other tasks Programs Options Window Help

Setting the Directory for Model ORANIG

To keep all examples files for this model together in one area, we have created a separate directory called ORANIG on your C: drive. First choose

File | Change both default directories

In the file selection box, choose drive **C**: and subdirectory **C:\GPWork\ORANIG**

TABLO Input file for ORANIG

Choose ***File | Edit*** and open the TABLO Input file **ORANIG.TAB**. You will need to refer to both the TABLO Input file and the data file for ORANIG to answer the following questions because the sets in the TABLO Input file are read from the data file. For example, the set of commodities is read from the Header array called "COM".

Looking directly at the Data file for ORANIG

There is one data file associated with ORANIG, a Header Array file called **BASEDATA.HAR**.
(This stands for Australian data for the year 1993/1994.)
Use ViewHAR to look at this file. You can access ViewHAR by choosing the menu item on the WinGEM main menu: ***HA*** Files.

Questions Write your answers beside the questions

1. Which Header contains the set of industries?
   How many commodities are there, and how many industries? 37

2. How many margins commodities are there? Which commodities are they?

3. What does the Header "ITEX" contain? What is the name of the set containing individual exports? What are the individual export commodities?

4. What are the names of the COEFFICIENTs used in ORANIG.TAB to represent the Armington elasticities? From what Headers are their values read?

5. What are the values used for the Armington elasticities? What do these parameters represent? Which products have the highest elasticities? Which have the lowest?

6. What is the value at basic prices of household consumption of imports of commodity "DrinksSmokes"? What is the value of household consumption of domestically-produced

commodity "DrinksSmokes"?

7. What is the value of capital rental for industry "ElecGasWater"?

8. What is the value at basic prices of the intermediate input of domestically produced commodity "ElecGasWater" to production in industry "Mining" ?

Note: ViewHAR can only view two dimensions at a time. Use one of the little boxes at top right for aggregating matrices in different dimensions and choose " ElecGasWater". See the ViewHAR help under "Options for real matrices" for more details.

Consequences of the data

You will also need to look at consequences of the data (for example, totals and shares calculated from the data which is read in).

The main TABLO Input file **ORANIG.TAB** can be used for this purpose. As well as solving the model, it writes out various useful data calculated from the original data to a SUMMARY file. You can use GEMSIM to produce this file without actually performing a simulation.

Look at ORANIG.TAB in the editor (***File | Edit...***). Search for "summary".
To produce the SUMMARY file proceed as follows. Choose

Simulation | TABLO Implement

The TABLO window appears: click the ***Options*** item in *this* window, and choose

Run from STI.

Then use the ***Select*** button to choose the file **ORANIG.STI**. [This file contains instructions for ‘condensation’, which we explain later.]

Click the ***Run*** button to run TABLO.

Then ***Go to GEMSIM***... and ***Select*** the Command file **FORMULAS.CMF**.

Then ***Run*** GEMSIM. This GEMSIM run will read all the data, calculate all coefficients, and write the summary data.

Once the run has finished, press the button ***View Input/Output files*** to see the name of the data file read in and also the name of the SUMMARY file which is created by GEMSIM.
Use ViewHAR to examine the summary file. You can answer the questions below by examining ORANIG.TAB, BASEDATA.HAR, and SUMMARY.HAR.

Later you will add statements to ORANIG.TAB to compute and write more data to SUMMARY.HAR. These will be used to answer more questions.

Questions

Most of the following questions can be answered by examining SUMMARY.HAR. Each data item there has a descriptive "long name". As a guide, you might in each case look first in the TAB file to find

- the correct name of the COEFFICIENT
- how each item was calculated (and whether it is really what you want to find out)
- the Header used in writing this COEFFICIENT to file SUMMARY.
- Then look in SUMMARY.HAR in ViewHAR to find the Header and double-click on it to see the values.
- ViewHAR options: You can get ViewHAR to show the name of the Coefficient by selecting *File | Options* and then clicking on the box *Show coefficient names.* Another good idea is to select *File | Use advanced editing menu* rather than *Use simplified, read-only menu.*

Headers CSTM and FACT are useful for the next two questions:

9. The COEFFICIENT used for the total labour bill in industry "i" is V1LAB_O(i).
   (a) What COEFFICIENT is used for the total cost in industry "i" (plus tax)? 52099.8
   (b) What COEFFICIENT is used for the total factor input to industry "i"?
   (c) What are the calculated values of these three coefficients for industry "Construction"?
   (d) What is the share of labour in the total costs of industry "Construction" ?

10. (a) What is the total payments to labour summed over all industries? (V1LAB_IO)
    (b) What is the total primary factor payments for all industries? (V1PRIM_I)
    (c) What is the share of labour in total factor cost for all industries?

11. What is the value at purchasers prices of exports of domestically-produced commodity "BasicMetals"?
    For example, what COEFFICIENT is this? V4PUR
    what set element do you need to look up? V4PUR("BasicMetals")
    then what header on file SUMMARY "4PUR"

12. What is the different between the Coefficients SALE, SALES and DOMSALES? What is the value at basic prices of total sales of domestically-produced commodity "ElecGasWater"?

13. Which header in SUMMARY.HAR tells us about Sales structure? Look at the Sales shares. Which industry sells the highest fraction of its output to investment? After that, which is second highest? Explain.

14. Look at the header CSTM in SUMMARY.HAR which tells us about Cost structure.
    What is unusual about the cost structure of "OwnerDwellng"?
    What does the production of this industry represent?

15. The header MSHR in SUMMARY.HAR shows the import penetration for each commodity:
    ratio of (sales of imported good)/(total domestic sales of domestic+imported good)
    Look at the Formula for IMPSHR in the ORANIG.TAB file.
    Which commodity has the highest import penetration[1]?

16. Which header shows the share of exports of commodity c in total export earnings. (Use the value at purchasers' prices.) What commodity has the greatest share? Hint: use the "column" share" feature in ViewHAR.

17. Use the header SALE to see the ratio of export sales to total sales of domestically-produced commodity c (using basic prices).
    Which commodities export more than 50 percent of the value produced?
    Which commodities are not exported?

[1] Once you are skilled, two buttons at top left help you answer “which is greater” questions: the green Sparse Sorted and yellow Transpose buttons.

GDP questions

18. Are the values of Nominal GDP from the income and expenditure sides equal?

19. Nominal GDP from the expenditure side is often given by the formula

GDP = C + I + G + X - M

where C is Consumption, I is Investment, G is Government, X is Exports, M is Imports.
What COEFFICIENT names are used for C, I, G, X and M in the ORANIG TABLO Input file? Find the values of all these quantities and verify whether the above formula is correct.
(Hint: Textbook definitions of GDP often ignore inventories.)

Fill in the following list of values:

```
        Coefficient Name          Value               Share of GDP
        (in TAB file)             (in Summary file)   ("col" shareof EMAC)

C      =                          =                   =
I      =                          =                   =
G      =                          =                   =
X      =                          =.                  =
-M     = -                        = -                 =-
Stocks=                           =   -               =-

GDP    =                          =                   = 100%
```

20. Nominal GDP from the income side is given by the formula

V0GDPINC = V1PRIM_I + V0TAX_CSI

What do V1PRIM_I and V0TAX_CSI represent? Fill in the following list of values :

```
Share of GDP (V1PRIM_I / V0GDPINC)= ?
                           Share of GDP
V1LND      =               =
V1LAB_IO   =               =
V1CAP_I    =               =
V0TAX_CSI =                =
V0GDPINC =
```

Adding more statements to ORANIG.TAB

21. What is the value at purchasers' prices of the intermediate input of domestically-produced commodity BeefCattle to production in the MeatDairy industry ?
(First what COEFFICIENT is this? What set elements are you looking for - for example the set element for the commodity is "BeefCattle".)

To answer this, you will need to add a **WRITE** statement to the TABLO Input file ORANIG.TAB to report a COEFFICIENT calculated by FORMULA. It will appear in file SUMMARY.HAR.

Right at the end of the TAB file, add the WRITE statement:

```
Write
????? to file SUMMARY header "PUR1” longname "Intermediate purch. value";
```

Replace ????? with the right coefficient name.

Question: why not call the header “1PUR” ?.

Edit the TABLO Input file ORANIG.TAB to add the WRITE statement. Then run TABLO to process the new version of ORANIG.TAB (Don’t forget to choose the STI file first, via **TABLO:Options**…**Run from STI…Select… ORANIG.STI**.) Finally run GEMSIM with the Command file FORMULAS.CMF to calculate the values and write them to the Summary file.

Calculating New Coefficients

As you analyse simulation results, you will need to calculate other values derived from the data file. Often the best way of doing this will be to add extra COEFFICIENTs, FORMULAs and WRITEs to the bottom of ORANIG.TAB.

22. The share of labour (V1LAB_O) in primary factor cost (V1PRIM) has a close connection to the concept of shortrun supply elasticity. Explain[2].

Add statements to the end of ORANIG.TAB which:

(a) define a new coefficient LABSHR dimensioned over IND.
(b) give the formula for LABSHR
(c) write LABSHR to the summary file with header "SHLB".

Which industry has steepest shortrun supply curve? And which the flattest?

[2] Appendix J of the ORANI-G document covers this.

Basic, Margin and Tax Components for Main Users

An elaborate example of an addition calculating and writing out values calculated from the data file is in Excerpt 40 of ORANIG.TAB.

The excerpt constructs a four-dimensional matrix showing:

for each good
for each source (dom, imp)
for each main user (Intermediate, Investment, Household, ... etc)
basic, margin, and tax components

of purchasers' values.
By manipulating this matrix within ViewHAR, a variety of information may be learned.

Use ViewHAR to examine the matrix MKUP in file SUMMARY.HAR. Use the matrix to answer the following questions -- you will need to make extensive use of ViewHAR's facilities for viewing shares and for slicing or summing.

23. Which commodity has the highest rate of tax ? (Use ViewHAR row shares).
What share of total commodity tax revenue does that good account for? (Use col shares).

24. For which commodity does margins form the highest share of purchase cost?

25. What is the value at purchasers prices of household consumption of domestically-produced commodity RubberPlastc?

26. Adding all commodities together, what fraction of purchasers' prices do commodity taxes form?
For domestic commodities only? for imported commodities only?

27. What % of government demands are imported? What % of government spending is on Education?

28. What is the value at purchasers' prices of household consumption of imports of commodity DrinksSmokes?

Section 7

Hands-on computing
Part B

HANDS-ON COMPUTING WITH ORANI-G
PART B: SIMULATIONS

Implementing ORANIG

The GEMPACK program TABLO is used to process the TABLO Input file ORANIG.TAB. We call this *implementing* the model. TABLO prepares files which contain information about the variables and the equations of the model, in a form ready to be used when running a simulation using the program GEMSIM. These files are called GEMSIM Auxiliary files (they are suffixed GST and GSS).

Set the Default Directory

First select in the main WinGEM menu,

File | Change both default directories

and set the working directory as subdirectory **C:\GPWork\ORANIG**
The following box contains a set of instructions which are the wrong way to implement the ORANI-G model. This method does not work because the model is too big to be run without condensation[1]:

The WRONG Way to run TABLO for ORANI-G

To implement ORANI-G, open a TABLO Window by choosing

Simulation | TABLO Implement

Choose the TABLO Input file ORANIG.TAB, ***Run*** **TABLO.** **!*WRONG***

If you do this, when you try to run the model using the program GEMSIM,
you will get an error message saying that the model has exceeded the dimensions of your type of Executable-Image licence. [Or you may get a message that the closure is not valid.[2]]

Condensation

ORANI-G is quite a large model that will not run on the laboratory PC unless it is condensed. So the moral of this exercise is <u>don't choose the TAB file, use a STI file instead</u> to carry out condensation.

The Correct Way to Run TABLO for ORANI-G

To implement ORANI-G correctly, carrying out the condensation, open a TABLO Window by choosing

Simulation | TABLO Implement

In doing a condensation, you need to say which variables are to be condensed out and which equations are to be used. This information is prepared in a Stored Input file called ORANIG.STI. To tell TABLO to use this file, choose **in the menu for the TABLO Window**

Options | Run from STI file ***!CORRECT***

and then ***Select*** the name of the Stored Input file as ORANIG.STI

Now select ***Run*** and wait while TABLO processes ORANIG.TAB and performs the condensation.

---

[1] "Condensation" reduces the number of model variables by using equations to "substitute out" some variables. See Section 7 of the ORANI-G document.
[2] The reason why you get a non-valid closure is because during condensation some of the variables are omitted and this alters the closure.

When large models such as ORANI-G or GTAP are implemented, it is usually necessary to **condense** the model. This means carrying out algebraic substitutions to reduce the size of the system of linear equations to be solved at each step of a multi-step calculation. This condensation is carried out by TABLO after the stage where the syntax of the TABLO Input file is checked and before the GEMSIM Auxiliary files are written.

Here TABLO is taking all of its instructions from the Stored-input file ORANIG.STI. In particular, this contains a large number of instructions to substitute out and/or backsolve for different variables.

TABLO will produce GEMSIM Auxiliary files ORANIG.GSS and ORANIG.GST. These contain all the theory in ORANIG.TAB and the condensation actions in ORANIG.STI.

When TABLO has finished, look at the Log file. Go to the end (Ctrl-End) to see that TABLO has completed successfully. In the Information file, search for "Final status" to see variables and equations that are in the model after condensation.

Now return to WinGem and choose ***Go to GEMSIM***

Preparing the Command File

Before you run a simulation, you need to prepare a small text file called a Command file. Because it is a text file, you can use the text editor to prepare it. Select, in the main WinGEM menu,

File | Edit file....

and select the *incomplete* Command file called ORANIG.CMF to edit.

You are going to run a Homogeneity simulation on ORANI-G as a check. In this simulation all Nominal variables are to be increased by one percent while keeping all Real variables fixed.

Each simulation needs its own Command file. Follow the steps below to modify the file in the editor.

(1) Choose ***File | Save As...*** and change the name of this file[3] to ORANIGHO.CMF.
This simulation will produce a Solution file with the name ORANIGHO.SL4 (an abbreviation for "ORANIG homogeneity test").

(2) Type in the name of the GEMSIM Auxiliary files for the model we are using for this simulation.

```
auxiliary files = ??? ;
```

(3) We would like to include a description of the simulation to remind us of the purpose of this CMF file. Edit the line

```
verbal description = ???? ;
```

to include the description – ORANI-G homogeneity test. You can add more than one line if you like. The verbal description ends with a semi-colon ;

(4) Add the closure and shocks as described in the next two sections.

(5) Save your Command file

Closure

[3] It is now possible to use longer filenames in GEMPACK. It is probably better not to use file or folder names containing spaces since then you have to remember to add quotes " " whenever you refer to the name. However, the Fortran compilers cannot handle non-English (eg Asian or Scandinavian) characters in your file or directory names. Strange characters (such as '&') might also cause problems.

When you are creating your own model, it can be difficult to find a valid closure. The first test your closure needs to satisfy is that the number of endogenous variables (actually the number of separate components of variables) must be equal to the number of equations (the number of separate equations). The second test is whether you can solve the equations, that is, that the set of equations is not structurally or numerically singular.

In the ORANI-G model the equations are all called "E_xxx" where xxx is the name of some variable in the model. We can usefully imagine that each equation explains a particular variable. Variables not explained by any equation are deemed to be exogenous in the standard closure. Although this is not really true since the solution of a set of equations depends on all the equations in the set, it gives us a starting point in finding a closure.

TABmate has a tool that helps us find a closure when this system[4] of naming equations is used. In TABmate, leave the Command file ORANIGHO.CMF open. Open the file ORANIG.TAB and click on the button marked **TABLO STI**. Select the STI file ORANIG.STI and run TABLO within TABmate. When the run has finished, we are ready to find a closure.

In the TABmate menu, select ***Tools | Closure*** This will produce a report on the Closure. Briefly read this report, then search for the section which starts

```
Section 4. Unmatched variables
******************************

Following variables are unmatched - probably exogenous
(text below is formatted so you can paste straight into the CMF file):

! Automatic closure generated by TABmate
!                Variable     Size
Exogenous            a1cap ; ! IND   Capital-augmenting technical change
Exogenous          a1lab_o ; ! IND   Labor-augmenting technical change
Exogenous            a1lnd ; ! IND   Land-augmenting technical change
Exogenous           a1prim ; ! IND   All factor augmenting technical change
Exogenous            a1tot ; ! IND   All input augmenting technical change
Exogenous            a2tot ; ! IND   Neutral technical change - investment
Exogenous             a3_s ; ! COM   Taste change, household imp/dom composite
Exogenous         capslack ; ! 1   Slack variable to allow fixing aggregate capital
Exogenous        delPTXRATE ; ! IND   Change in rate of production tax
```

Select all the lines in this section starting with the word "Exogenous", copy them and then paste them into the file ORANIGHO.CMF. This is a list of exogenous variables. Add the following line to tell the program that the remainder of the variables are endogenous:

```
rest endogenous ;
```

This closure is sometimes called the "structural" closure. See Section 5 of the ORANI-G document for further discussion on closures.

Shocks

The final edit we need to make is to add appropriate shock commands. We need to complete the line beginning with the word "shock" in the CMF file. The way to write shock statements is

shock <*variable name*> = <*list of shock values*> ;

Look through the list of exogenous variables in the Command file to find the names of the variables you wish to shock in order to increase all Nominal variables by one percent while keeping all Real variables

[4] In order for TABmate to know which variable is explained by a given equation, the modeller must follow a naming convention for equations. The convention is that the equation which explains variable "p1", say, is named "E_p1" (prefix E_). If you do not follow this convention, the Closure command will be no use to you, although the rest of TABmate will work normally. Each equation must be of the same dimensions (range over the same sets) as the variable which it explains. TABmate checks that the dimensions match.

fixed. (You can only shock variables which are exogenous.) For each shocked variable, complete a shock statement in ORANIGHO.CMF, replacing the question marks below with this variable name.

```
shock  ????  =  1 ;
```

Now save this file and exit from the editor.

Running a Homogeneity Simulation

In WinGEM select ***Simulation | GEMSIM Solve*** In the GEMSIM window, click on the ***Select*** button and select the Command file that you have just made, called ORANIGHO.CMF.

Now run this simulation by clicking on the ***Run*** button.

When the simulation has completed, choose ***Go to ViewSOL***.
View the results. Check the results for some real variables and some nominal ones. Is this model simulation homogeneous?

The homogeneity simulation illustrates the economic proposition that *only relative prices matter*. The general idea is that:

if all nominal variables on the exogenous list are shocked by X%,
and if the model is homogeneous,
then all nominal %change variables should change by X%
but real variables will not change.

Check the exogenous list to see if ALL nominal exogenous variables have been shocked.
Nominal variables are expressed in local currency.]
[Hints: Look at section 4.4 of the main ORANIG document to see the naming system used.
Variables whose names begin with "**a**" are tech change variables. Are these real or nominal?
Variables whose names begin with "**f**" are shifters.

Continue working along these lines until your results show homogeneity.

Using Swap Statements

Once we have one valid closure it is possible to "**swap**" variables to obtain a different valid closure.

In the previous simulation, the variable *f5tot2* was exogenous. In the next simulation we want *f5tot2* to be endogenous and instead we want *x5tot* to be exogenous. (Both of these variables have one component so the number of exogenous variables will stay the same.) One way to swap these variables is to delete the line

```
Exogenous  f5tot2 ;
```

and replace it with the line

```
Exogenous  x5tot ;
```

A better way is to leave the closure in the file as it is and add "swap" statements after the closure:

```
exogenous ......   ;
exogenous.......   ;
.....
rest endogenous ;
swap f5tot2 = x5tot ;
```

The advantage of this is that you can easily see how this closure is different from the original closure.
Add the swap statement to the file ORANIGHO.CMF and save it.In the GEMSIM window, run a simulation with this file. Look at the results in ViewSOL. In general if you change the closure, you would expect to get different results, even if you have the same shocks. Why do you get the same results here?

Notes on Closure - Using Swaps to get the Short Run Closure

You do not need to carry out the swaps in this section as part of the exercises in the computer labs.

This section is for your information at some time when you are thinking about closures, perhaps when you are developing your own closure for some simulation, or for your own model. The short-run closure is described in section 5 of the ORANI-G document and is listed in Table 3. In the command file ORANIGSR.CMF above, it is given in the simplest possible form, just a list of exogenous variables followed by "rest endogenous". It doesn't give you many ideas as to how this closure was made or how ir relates to the structural closure used in the Homogeneity Simulation.

To derive the short run closure from the structural closure, we could use the following swap statements: (In each case we follow the convention that the variable on the left-hand side is exogenous in the old closure, and the variable on the right-hand side is exogenous in the new closure.)

```
!       Old exogenous      New Exogenous
       swap w3lux    =     x3tot ;
       swap invslack =     x2tot_i ;
       swap f5tot2   =     x5tot ;
       swap fx6      =     delx6 ;
       swap f1lab_io =     realwage ;

xSet EXOGINV  # 'exogenous' investment industries #
 (ElecGasWater, Construction, FinanceInsur, OwnerDwellng,
  PropBusSrvc, GovAdminDfnc, Education, HealthCommun);
xSubset EXOGINV is subset of IND;
xSet ENDOGINV # 'endogenous' investment industries # = IND - EXOGINV;

! investment linked to profits
       swap x2tot(ENDOGINV) = finv1(ENDOGINV);
! investment follows aggregate investment
       swap x2tot(EXOGINV) = finv2(EXOGINV);
```

Here the ***xSet*** and ***xSubset*** statements are used to divide the industry set IND into two subsets ENDOGINV and EXOGINV. In set ENDOGINV, finv1 is exogenous and the ENDOGINV set of industries follow Rule 1 in the TAB file. In set EXOGINV, finv2 is exogenous and the EXOGINV set of industries follows Rule 2 in the TAB file. See Excerpt 31 in the TAB file and section 4.26 in the ORANI-G document.

Having trouble finding a closure

You do not need to carry out the swaps in this section as part of the exercises in the computer labs.

If you are developing your own model at home or changing an existing model or changing the closure in a model, you may have difficulties finding a good closure. One way of proceeding is to return back to an existing closure that works. To proceed to your new closure, put in one swap statement at a time and run a test simulation until you reach the new closure that you want to use.

[However sometimes this does not work. For example if you add the swap

```
       swap invslack = x2tot_i ;
```

which makes the aggregate investment x2tot_i exogenous, you would need to free up at least one component of x2tot by a swap to make it endogenous at the same time. See Excerpt 31 for more details.]

Another tip, for when you add a new equation which will affect the rest of the system: include a new shift variable which can be left endogenous. This prevents the new equation from interacting with others, and allows the previous closure to be used. To 'switch on' your new equation, ‘swap’ the shift variable with another model variable of equal size (that your new equation will determine).

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export*	Government	Stocks
	Size	← I →	← I →	← H →	← 1 →	← 1 →	← 1 →
Basic Flows domestic	↑ C ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Basic Flows imported	↑ C ↓	V1BAS	V2BAS	V3BAS		V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					
Production Tax	↑ 1 ↓	V1PTX					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported,

O = Number of Occupation Types

M = Number of Commodities used as Margins

H = 1: Number of Household Types

* Note: Export column is for domestic goods only.

	Make Matrix	
Size	← I →	Total
↑ C ↓	MAKE	= sales row totals
Total	=col total absorptn	

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

ORANI-G flows database

Section 8

Real wage simulation

HANDS-ON COMPUTING WITH ORANI-G
PART W: A Short-run Simulation:

A Five Percent Reduction in Real Wages

You are now going to perform a short run comparative static experiment simulating the effects of a five percent reduction in real wages for all occupations in all industries.

In WinGEM, select from the *Simulation* option in the main menu.

Simulation | GEMSIM Solve...

The Command file ORANIGSR.CMF contains instructions for GEMSIM. ***Select*** the CMF file, ORANIGSR.CMF (an abbreviation for ORANIG Short Run). Look at ORANIGSR.CMF before you run the simulation. Choose the button ***Edit***.

The short-run closure is described in section 6 of the ORANI-G document and is listed in Table 3.

The solution method is **Johansen**. This gives a simple **one-step** approximation of the model's non-linear equations. The simple one-step is easier for an initial interpretation of the results.

method = Johansen ;

A better solution method is **Gragg** with a 2 4 6 multi-step solution followed by extrapolation. This produces results that are a good solution of the model's non-linear equations. However we have commented out this solution method and steps by placing an exclamation mark **!** at the start of these lines.

! method = **Gragg** ; *! alternative to above*
! steps = **2 4 6 ;**

We suggest you try both solution methods and compare the results. The Command file ORANIGSR.CMF gives the Johansen solution. To use the Gragg solution method, comment out the Johansen line with an exclamation mark and remove the exclamation marks from the Gragg lines and save with a different name ORANIGSR_G.CMF. Run the two simulations, then open both Solution files at once in ViewSOL.

Remember that the Johansen solution gives a set of results which satisfy the linearised equations in the TAB file exactly and the Gragg solution results do not satisfy the linear equations exactly. However the Gragg solution is a better solution to the non-linear equations of the model. The non-linear equations are the equations we really want to solve.

In analysing the results below, use the Johansen simulation ORANIGSR.SL4.

In the Command file ORANIGSR.CMF, the updated data file is called <cmf>.UPD. This means that the updated data file will be called ORANIGSR.UPD. This data file depends on the data and the simulation we are running.

The verbal description indicates that a short run simulation is being performed with a wage-cut shock.

In the Command file ORANIGSR.CMF that contains the Short-run closure, the list of exogenous variables is written out explicitly instead of using “swap” statements. For a short-run closure, the capital stock ***x1cap*** is exogenous and not shocked. This means that the capital stock is fixed for a short-run simulation. Check that the variable ***realwage*** is exogenous. You can only shock exogenous variables.

The shocked variable is ***realwage***. From the equations contained in ORANIG.TAB, what is the meaning of a 5 percent reduction in ***realwage***? Look at the equation E_realwage.

```
Equation E_realwage realwage = p1lab_io - p3tot;
```

How does ***realwage*** relate to the variable ***f1lab_io***? Look at Equations E_p1lab and E_p1lab_io.

```
Equation E_p1lab   # Flexible setting of money wages #
  (all,i,IND)(all,o,OCC)
    p1lab(i,o)= p3tot + f1lab_io + f1lab_o(i) + f1lab_i(o) + f1lab(i,o);

Equation E_p1lab_io
V1LAB_IO*p1lab_io = sum{i,IND, sum{o,OCC, V1LAB(i,o)*p1lab(i,o)}};
```

In Equation E_p1lab, the variables *f1lab_i*, *f1lab_o* and *f1lab* are exogenous and not shocked so they have a value of zero. So this equation means that all values of the variable p1lab(i,o) for all industries i and occupation o are the same. For all industries and all ocupations,

```
p1lab(i,o) =  p3tot + f1lab_io
```

Hence, from Equation E_p1lab_io, the share-weighted sum p1lab_io also equals this value:

p1lab_io = p3tot + f1lab_io

From equation E_realwage, *f1lab_io* must be the same as *realwage*.

Now exit from the editor and ***Run*** GEMSIM with the CMF file ORANIGSR.CMF.

Check the results in ViewSOL – this is a simple way to start looking at the changes and percentage changes in the solution.

In a later session you will learn to use the AnalyseGE tool – useful when you want to track down individual variables or coefficients or when you want to look at the relative size of terms in an equation.

A GUIDE TO THE INTERPRETATION OF THE REAL-WAGE-CUT SIMULATION

INTRODUCTION

Now that you have run a simulation and produced a solution, you will probably feel overwhelmed by the volume of numbers the model produces. The question you now face is how to make sense of the output.

We have prepared a series of questions that guide you to the answers of some interesting results. The questions are not exhaustive and you may think of many others that are of interest.

The questions we are asking below are designed to rationalise particular results in terms of the model's theoretical framework and underlying database. Often, it is difficult to unravel all of the mechanisms leading to a particular result. However, you need to attempt to rationalise results within the context of the main identifiable mechanisms of the model. This process, apart from giving you insights into a particular economic phenomenon, serves as an informal verification of the simulation's results.

The experiment you are analysing is based on a shock to a macroeconomic variable; the real wage. You may have noticed in the closure of the model that many macro variables are on the exogenous list. For example, on the supply-side of the economy, we fixed the level of capital usage by fixing capital in each industry (x1cap). On the demand side, we fixed domestic absorption (i.e., Gross National Expenditure: real household consumption, x3tot; aggregate real investment, x2tot_i, aggregate real other demands, x5tot; and aggregate real inventories). Therefore, in the closure for the real wage experiment, we have largely imposed the macroeconomic environment.

The constraints that our choice of macro environment places on the economy will be important in determining relative price changes, and therefore the responses of agents to the effects of the cut in real wages. It is handy if we keep the nature of the macro environment in the back of our minds when attempting to interpret the results. Figure 1 presents a schematic representation of the short-run macro environment.

In Figure 1, exogenous variables are depicted in rectangles and endogenous variables are depicted in ovals. The arrows indicate a plausible direction of causation between variables. Thus, on the supply-side of the macroeconomy, we have exogenised the capital stock, technology and the real wage. With the real wage given, the model can determine aggregate employment (why?). With employment, technology and capital determined, the model can determine aggregate output (GDP).

On the demand side, aggregate household consumption, investment, other demands (and inventories) are fixed. With GDP determined from the supply side and domestic absorption (household consumption, investment, government consumption and inventories) given, the trade balance must act as an endogenous 'swing' variable to satisfy the GDP identify. That is, if as a result of our shock GDP increases/decreases relative to domestic absorption, the trade balance must move toward surplus/deficit.

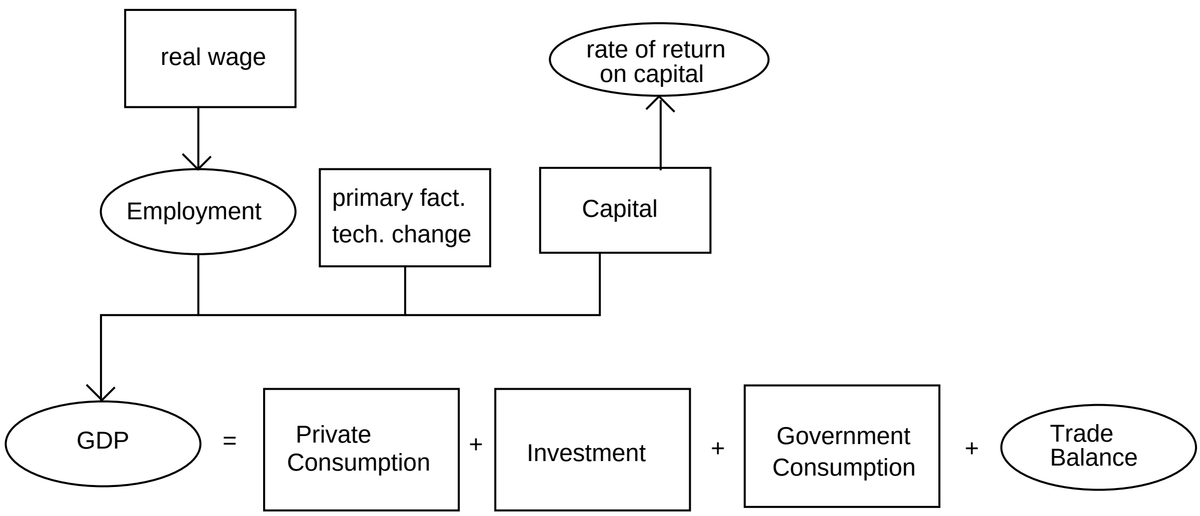


Figure 1. Schematic Representation of the Short-run closure of ORANI

We will interpret the results of the real wage cut beginning with the impact on some main macroeconomic variables. This will enable us to determine the consequences of the shock for the main endogenous macroeconomic variables, and in particular, the trade balance. This will give us insights into broad (economy-wide) relative price movements that result from the shock. A knowledge of the main relative price movements will help us interpret the industry results.

Fill in the following table with the results from this simulation:

Description	Variable	Value
Real household consumption	x3tot	
Real investment	x2tot_i	
Real government demands	x5tot	
Export volume	x4tot	
Import volume CIF	x0cif_c	
Real GDP	x0gdpexp	
Aggregate capital stock	x1cap_i	
Aggregate employment	employ_i	
Absorption price index*	p0gne	
GDP price index	p0gdpexp	
CPI	p3tot	
Exports price index	p4tot	
Real devaluation*	p0realdev	
Average nominal wage	p1lab_io	
Average real wage	realwage	
Contribution of BOT to real GDP	contBOT	
Terms of trade*	p0toft	
Aggregate primary factor use	x1prim_i	

MACROECONOMIC RESULTS

Determining the impact on aggregate employment and output

1. First, check the results to see if the shock has been implemented correctly. You should check the value of the shocked variable ***realwage***
   the value of the variable ***f1lab_io***
   the economy-wide nominal wage ***p1lab_io***
   What is the difference between the values of ***p1lab_io*** and the CPI ***p3tot***.
   What are the values of ***p1lab***?

2. What effect do you expect the reduction of the real wage to have on aggregate employment? Verify your intuition by checking the value of aggregate employment ***employ_i***.

3. There are two variables in the model for real value added, commonly known as GDP at factor cost: ***x1prim_i*** and ***x0gdpfac***. Are these two values equal? Look at the equations for these variables.

   From the change in aggregate employment, can you verify the change in real aggregate value added *x0gdpfac*? Hint: find the equation for *x0gdpfac* that calculates the change in aggregate value added using the share weighted average of the percentage changes in real factor inputs (i.e., labour, capital and land).

   x0gdpfac= SL * employ_i + SC * x1cap_i + SN * x1lnd_i

   where SL, SC and SN are the shares of labour, capital and land in aggregate value added. How do you calculate the share of the wage bill in aggregate value added?
   [Hint: in looking at the data yesterday, you found
   V1LND_I(2736), V1LAB_IO(194981), V1CAP_I(180575).]

4. You will have noticed that both real GDP at factor cost ***x0gdpfac*** and real GDP at market prices ***x0gdpinc*** have increased, but with real GDP at factor cost rising by more than real GDP at market prices. The difference between the two aggregates is indirect taxes. The dominant effect on aggregate output is the change in employment and this causes GDP to increase (see equations determining contGDPinc and x0gdpinc).

Determining the composition of final demand

Now you have explained the change in GDP from the income side. Next we will attempt to explain the changes in the expenditure-side components of GDP.

5. Given the changes in real GDP and the components of national domestic absorption, what must happen to the change in the foreign trade balance? (Hint: be careful, don't use the variable delb which is the ordinary change in the nominal trade balance to GDP ratio. We wish to know the change in the real trade balance. The formula for the ordinary change in the real trade balance is
   (V4TOT*x4tot - V0CIF_C*x0cif_c)/V0GDPEXP.

   This will give you the ordinary change in the real trade balance in basecase values).
   Hint: Use Summary.har to look at the values of V4TOT, V0CIF_C and V0GDPEXP. Then calculate the expression (V4TOT*x4tot - V0CIF_C*x0cif_c)/V0GDPEXP.

   Look at the variables ***contGDPexp*** and ***contBOT***.

   How is the trade balance being moved? By a change in imports (***x0cif_c***) or a change in exports (***x4tot***) or by some combination?

6. Movements in the international trade balance occur due to activity effects and relative price effects. Changes in domestic demand (with given prices) will tend to change the demand for imports - an

activity effect. Changes in international competitiveness (changes in domestic costs relative to foreign prices/costs) will change foreign export demands and domestic demand for imports. How do you think exports and imports are responding in this simulation? What is the activity effect? Hint: imports are demanded for intermediate use as well as for final use. What is the relative price effect? Hint, check the variable ***p0realdev***.

Now we turn our attention to the results at the industry level.

INDUSTRY RESULTS

7. Look at the industry output (***x1tot***) and employment responses(employ). Note some of the outstanding results (spend about 10 minutes).

You have probably noticed that some industries have performed better than others; the impact of the real wage shock changes the industrial structure of the economy. We will now attempt to explain the impact of the real wage shock on the industrial structure, exploiting insights gained from our interpretation of the macro results.

8. In our analysis of the macro economy, we noticed a move towards trade surplus. We argued that the movement to trade surplus required an improvement in international competitiveness, i.e., a reduction in domestic costs relative to foreign prices. We might speculate that the improvement in competitiveness would favour the traded goods industries, i.e., those industries that sell a large share of their output to foreigners and/or which compete in domestic markets with imports. Can you verify that the traded goods industries do well (x1tot and employ)? Hint: note elements of the set *tradexp* in ORANIG TABLO Input file. Using ViewHAR to look at the header array file SUMMARY.HAR, check sales shares of industries contained in the header "SALE" to further identify export oriented industries, import competing industries and non-traded-sector industries.

   Look also at the results of the Fan decomposition, which you will see by clicking open the variable ***fandecomp*** using ViewSOL. The first column of numbers in the Fan decomposition (LocalMarket) shows us by how much we would expect local-commodity output to change, if output of the local commodity increased in line with the change in domestic demand for the commodity regardless of source (i.e., domestic or imported). The second column of numbers (DomShare) can be interpreted as the amount by which local-commodity output changes due to a relative price change favouring import replacement. The third column of numbers (Export) shows the contribution to the change in the output of the local commodity, brought about by the change in exports. The last column (Total) is the sum of the values in columns 1 to 3. For example, the increase in textile output is 4.9 per cent (last column of the Fan decomposition). Column 1 of the Fan decomposition can be interpreted as saying that given the increase in domestic demand for textiles (local and imported), we may have anticipated the rise in output to be 2.1 per cent. However, column 2 can be interpreted as saying that due to a relative price change favouring locally produced texiles, output of the domestic textile industry increased by an additional 0.7 percentage points (over the growth in local demand). The third column shows that increased export demand accounted for 2.1 percentage points of the total expansion in textile production.

9. Can you explain any anomalies? That is, do you find any seemingly traded-goods industries that perform poorly or non-traded goods industries that perform well? Hint: remember the underlying input-output linkages in the model.

10. Can you explain the performance of the dwelling ownership industry? Hint: what is its composition of primary factor inputs to the production process? Who are its main customers?

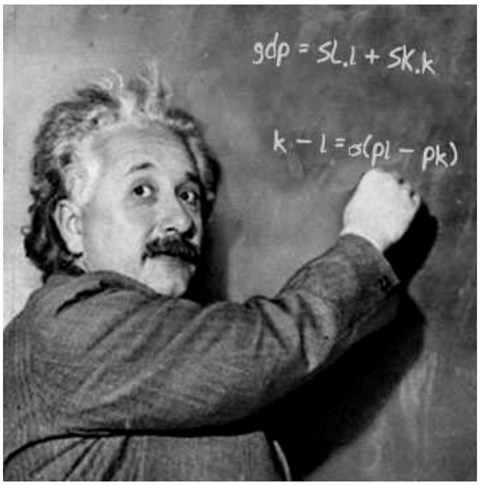
11. Can you explain the performance of the construction industry? Hint: what is its sales pattern, i.e., who are its main customers and for what purpose do they buy the construction commodity? (Try to explain why demand is moving the way it is.)

12. Can you explain the performance of the government industry?

13. Can you explain why total indirect tax revenue falls despite a general increase in economic activity? Hint: for which uses are indirect taxes the highest? (Also, don’t forget that tariffs are indirect taxes.) Has indirect tax revenue increased *in real terms*?

```
! Command file for ORANIG model, short-run closure

check-on-read elements = warn; ! very often needed
cpu=yes ; ! (Optional) Reports CPU times for various stages
log file = yes;  ! Optional
auxiliary files = ORANIG; ! needed by GEMSIM

! Solution method
!method = GRAGG ;
!steps = 2 4 6 ;
method = johansen; ! alternative to above

! Data and summary file
file basedata = BaseData.har ;
updated file basedata =<cmf>.upd;
file summary  = summary.har;

! Closure

! Exogenous variables constraining real GDP from the supply side
exogenous  x1cap              ! all sectoral capital
           x1lnd              ! all sectoral agricultural land
           a1cap a1lab_o a1lnd
           a1prim a1tot a2tot  ! all technological change
           realwage ;         ! Average real wage

! Exogenous settings of real GDP from the expenditure side
exogenous  x3tot              ! real private consumption expenditure
           x2tot_i            ! real investment expenditure
           x5tot              ! real government expenditure on goods
           delx6 ;            ! real demands for inventories by commodity

! The demand curves of exports are fixed in both quantity and price axes
exogenous  f4p f4q              ! individual exports
           f4p_ntrad f4q_ntrad ; ! collective exports
! Exogenous foreign prices of imports ;
exogenous  pf0cif ;

! All tax rates are exogenous
exogenous  delPTXRATE f0tax_s  f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp
           f4tax_trad f4tax_ntrad f1oct ;

! distribution of government demands !
exogenous  f5 ;

! The nominal exchange rate is the numeraire
exogenous phi ;

! Number of households and their consumption preferences are exogenous
exogenous q a3_s ;

exogenous capslack; ! switch off aggregate capital constraint !

! Distribution of investment between industries
xSet EXOGINV  # 'exogenous' investment industries #
 (ElecGasWater, Construction, FinanceInsur, OwnerDwellng,
  PropBusSrvc, GovAdminDfnc, Education, HealthCommun);
xSubset EXOGINV is subset of IND;
xSet ENDOGINV # 'endogenous' investment industries # = IND - EXOGINV;
exogenous finv1(ENDOGINV); ! investment linked to profits
exogenous finv2(EXOGINV);  ! investment follows aggregate investment


! Exogenous variables for regional extension
exogenous    freg1 freg2 freg3 freg4 freg5 freg6;
exogenous    rsum1 rsum2 rsum3 rsum4 rsum5 rsum6;

rest endogenous ;

verbal description =
 ORANIG: Wage cut, DPSV shortrun closure;

shock   realwage = -5 ;     ! real wage shift variable
```

Wagecut.ppt



INTERPRETATION:

REAL WAGE CUT

1

BASIC TASKS IN CGE ANALYSIS

- Theoretical derivation of model
  - Formal theory
  - Linearisation
- Calibration
  - database construction
  - evaluation of coefficients
- Solving
  - closure
- Interpretation

2

INTERPRETATION

- Explaining in a logical sequence the projections from a model:
  - at each point in the sequence a result is explained drawing only on:
    - results explained earlier and/or
    - values given in the database and/or
    - underlying theory.
  - explanations should be simple enough to be understood by economists not familiar with the details of the model.

3

INTERPRETATION

- Why?
  - a check on the model's implementation
  - enhance credibility
  - economic insights
- Poor strategies
  - variable/equation trace
  - appealing to different models (whackery)

4

INTERPRETATION

- Keys to a good strategy
  - understand the closure
  - identify first-round impacts of the shock
  - use simplified models of the model

5

GENERAL STRATEGY FOR INTERPRETING MACRO RESULTS

- First, find a way to enter the loop
  - generally this will the point of first impact of the shock.
- Then use aspects of the macro closure to explain the outcomes for the major components of real GDP from the income side and from the expenditure side
  - explanations follow for the real exchange rate, GDP deflator, the terms of trade, the trade balance.

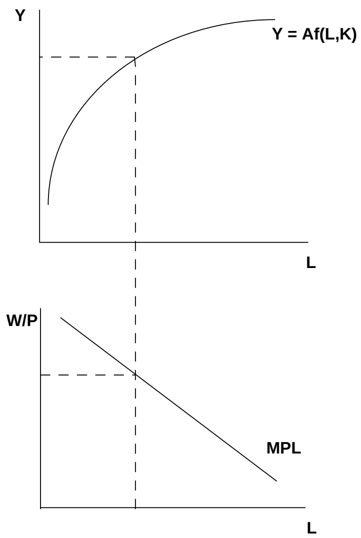
6

BOTE: a model of a model

- BOTE stands for Back-Of-The-Envelope
- Often uses actual model equations applied to a one-sector aggregation of the model database.
- BOTE equations often closely approximate actual model results
  - especially for macro shocks that affect all sectors.
  - May work less well if shock affects one or a few sectors with cost/sales shares quite different to economy-wide average

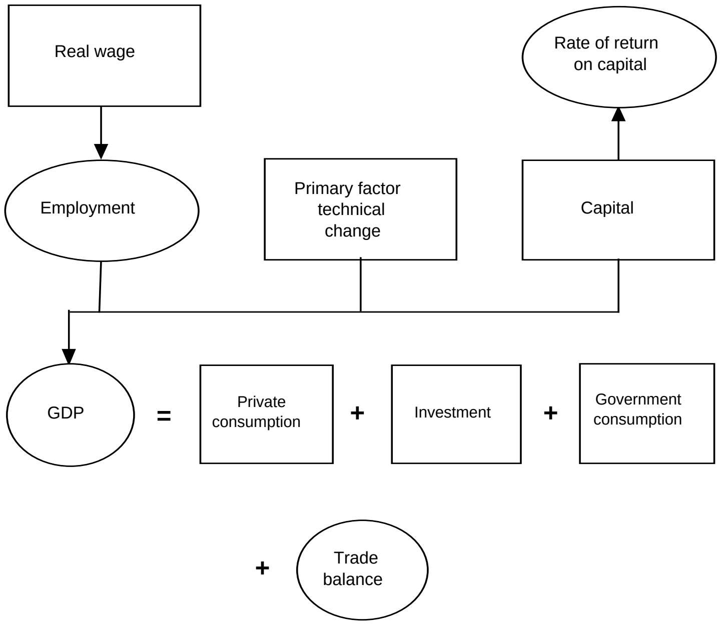
7

IMMEDIATE IMPACT OF WAGE CUT



8

MACRO CLOSURE: SHORT-RUN



9

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- From factor demand equations (ignoring land and allowing only for labour-saving technological change)

$$x1lab_i - a1lab_i = x1tot_i - \sigma_{LK} SK_i \times [(p1lab_i + a1lab_i) - p1cap_i]$$

$$x1cap_i = x1tot_i - \sigma_{LK} SL_i \times [p1cap_i - (p1lab_i + a1lab_i)]$$

10

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- Multiplying the first equation through by the share of labour in industry i's value added, multiplying the second equation through by the share of capital, and adding gives

$$x1tot_i = SL_i \times (x1lab_i - a1lab_i) + SK_i \times x1cap_i$$

11

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- Subtracting the second equation from the first gives:

$$x1lab_i - x1cap_i = -\sigma_{LK} \times [p1lab_i - p1cap_i]$$

- From the zero-pure profit conditions in industry production:

$$p1prim_i = SL_i \times [p1lab_i + a1lab_i] + SK_i \times p1cap_i$$

12

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- Which implies:

$$[(\mathrm{p1lab_i} + \mathrm{a1lab_i}) - \mathrm{p1prim_i}] = -\frac{\mathrm{SK_i}}{\mathrm{SL_i}} \times [\mathrm{p1cap_i} - \mathrm{p1prim_i}]$$

13

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- Three industry-level equations derived above suggest three macro-level relationships.

(A) Change in real GDP at factor cost = change in employment plus change in capital plus cost savings from technological progress

$$\mathrm{V1PRIM\_I} \times \mathrm{x1prim\_i} = \mathrm{V1LAB\_I} \times \mathrm{employ\_i} + \mathrm{V1CAP\_I} \times \mathrm{x1cap\_i} - \mathrm{V1LAB\_I} \times \mathrm{a1lab}$$

14

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

(B) Percentage change in the ratio of primary factors = percentage change in the ratio primary factor prices multiplied by minus the capital/labour substitution elasticity

$$\text{employ\_i} - \text{x1cap\_i} = -\sigma_{LK} \times [\text{p1lab\_i} - \text{p1cap\_i}]$$

15

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

(C) Percentage change in the real price of labour (marginal product of labour) = the percentage change in the real price of capital (marginal product of capital) multiplied by minus the capital/labour ratio

$$[(\text{p1lab\_i} + \text{a1lab}) - \text{p1prim\_i}] = -\frac{SK}{SL} \times [\text{p1cap\_i} - \text{p1prim\_i}]$$

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USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- Two more useful Back-of-envelope macro equations:

(D)
$$\frac{(\mathrm{P1LAB\_I} \times \mathrm{A1LAB})}{\mathrm{P1PRIM\_I}} = \frac{(\mathrm{P1LAB\_I} \times \mathrm{A1LAB})}{\mathrm{P3TOT}} \times \frac{\mathrm{P3TOT}}{\mathrm{P0GNE}} \times \frac{\mathrm{P0GNE}}{\mathrm{P0GDPEXP}} \times \frac{\mathrm{P0GDPEXP}}{\mathrm{P1PRIM\_I}}$$

- Very useful for short-run analysis.

17

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

(E)
$$\frac{\mathrm{P1CAP\_I}}{\mathrm{P1PRIM\_I}} = \frac{\mathrm{P1CAP\_I}}{\mathrm{P2TOT}} \times \frac{\mathrm{P2TOT}}{\mathrm{P0GNE}} \times \frac{\mathrm{P0GNE}}{\mathrm{P0GDPEXP}} \times \frac{\mathrm{P0GDPEXP}}{\mathrm{P1PRIM\_I}}$$

- Very useful for long-run analysis.

18

USEFUL BACK-OF-ENVELOPE MACRO EQUATIONS

- In short-run, real wage (P1LAB_I/P3TOT) fixed.
- In long-run, rate of return (P1CAP_I/P2TOT) fixed
- In general, P2TOT and P3TOT move with PGNE
- P0GNE/P0GDPEXP is a function of the terms of trade only
- P0GDPEXP/P1PRIM_I is a function of rates of indirect tax.

19

GENERAL STRATEGY FOR INTERPRETING MACRO RESULTS: SUMMARY

- First, find a way to enter the loop
- Then use aspects of the macro closure and a model of a model to explain the outcomes for the major components of real GDP from the income side and from the expenditure side
- Equations (A) to (E) are a very useful model of a model.
  - For short-run, explain changes in the producer real wage rate using (D)
  - For long-run, explain change in the producer real cost of capital using (E)
  - then follow through to employment, capital and real GDP

20

GENERAL STRATEGY FOR INTERPRETING INDUSTRY RESULTS

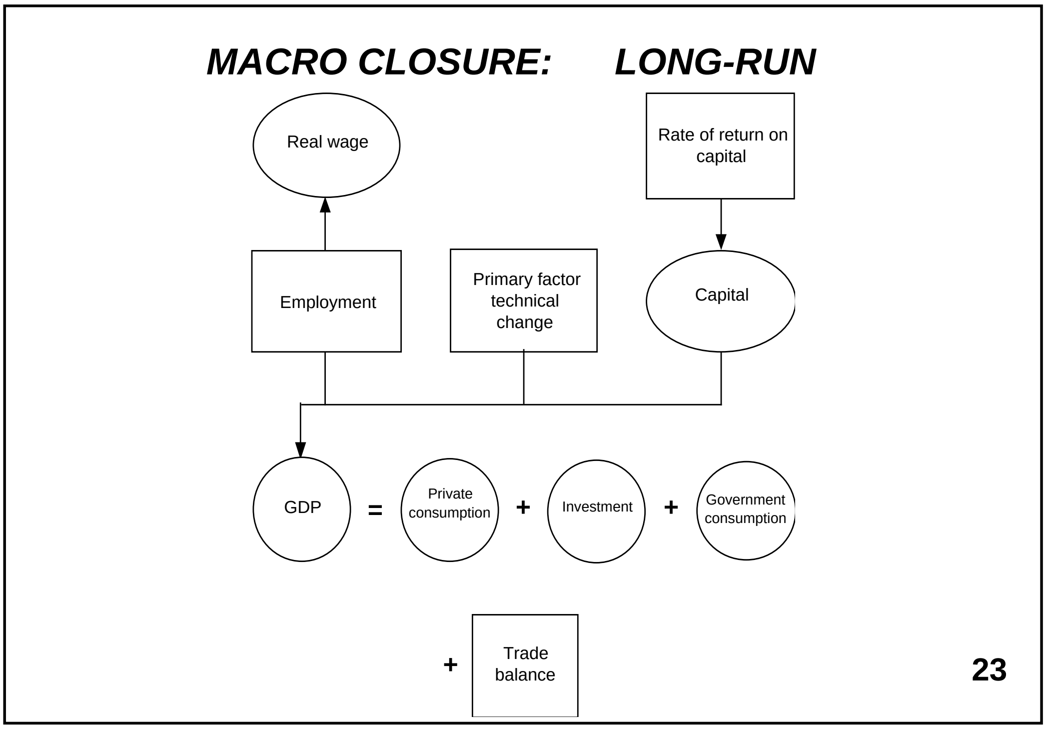
- First, try to explain the results for industry outputs drawing on the macro results and input-output linkages
  - movements in competitiveness, as indicated by changes in the real exchange rate, strongly influence outcomes for traded goods industries
  - changes in the aggregate components of final demand strongly influence outcomes for non-traded goods industries, particularly services.
  - input-output linkages are important for industries like beef cattle and non-metallic products.

21

GENERAL STRATEGY FOR INTERPRETING INDUSTRY RESULTS

- Having explained results for industry output, then move to employment, investment, etc.
  - changes in output and relative factor prices are critical drivers of the changes in most other industry variables.

22


MACRO CLOSURE: LONG-RUN
Real wage
Rate of return on capital
Employment
Primary factor technical change
Capital
GDP
=
Private consumption
+
Investment
+
Government consumption
+
Trade balance
23

! Wage cut: DPSV shortrun closure

Macro	Variables	
capslack		Slack variable to allow fixing aggregate capital
contBOT	1.4844	Contribution of BOT to real expenditure-side GDP (change)
delB	0.0130	(Nominal balance of trade)/{nominal GDP} (change)
delV0tar_c	-16.54	Aggregate tariff revenue (change)
delV0tax_csi	-16.50	Aggregate revenue from all indirect taxes (change)
delV1PTX_i		Ordinary change in all-industry production tax revenue (change)
delV1tax_csi	311.30	Aggregate revenue from indirect taxes on intermediate (change)
delV2tax_csi	-23.50	Aggregate revenue from indirect taxes on investment (change)
delV3tax_cs	-132.46	Aggregate revenue from indirect taxes on households (change)
delV4tax_c	129.18	Aggregate revenue from indirect taxes on export (change)
delV5tax_cs		Aggregate revenue from indirect taxes on government (change)
employ_i	3.0134	Aggregate employment: wage bill weights
f1lab_io	-5.0000	Overall wage shifter
f1tax_csi		Uniform % change in powers of taxes on intermediate usa ..
f2tax_csi		Uniform % change in powers of taxes on investment
f2tot		Ratio, investment/consumption
f3tax_cs		Uniform % change in powers of taxes on household usage
f3tot	-0.7699	Ratio, consumption/ GDP
f4p_ntrad		Upward demand shift, collective export aggregate
f4q_ntrad		Right demand shift, collective export aggregate
f4tax_ntrad		Uniform % change in powers of taxes on nontradtnl exp ..
f4tax_trad		Uniform % change in powers of taxes on tradtnl exports
f5tax_cs		Uniform % change in powers of taxes on government usage
f5tot		Overall shift term for government demands
f5tot2		Ratio between f5tot and x3tot
invslack	10.3277	Investment slack variable for exogenizing aggregate inve ..
p0cif_c		Imports price index, C.I.F., local currency
p0gdpexp	-3.9143	GDP price index, expenditure side
p0gne	-3.7165	GNE price index
p0imp_c		Duty-paid imports price index, local currency
p0realdev	3.9143	Real devaluation
p0toft	-0.9360	Terms of trade
p1cap_i	-0.2640	Average capital rental
p1lab_io	-8.1999	Average nominal wage
p1lnd_i	7.6996	Average land rental
p1prim_i	-4.2968	Index of factor cost
p2tot_i	-3.5450	Aggregate investment price index
p3tot	-3.1999	Consumer price index
p4_ntrad	-2.6015	Price, collective export aggregate
p4tot	-0.9360	Exports price index, local currency
p5tot	-5.6293	Government price index
p6tot	-3.4744	Inventories price index
phi		Exchange rate, local currency/$world
q		Number of households
realwage	-5.0000	Average real wage
utility	0.0000	Utility per household
w0cif_c	0.3904	C.I.F. local currency value of imports
w0gdpexp	-2.4299	Nominal GDP from expenditure side
w0gdpinc	-2.4299	Nominal GDP from income side
w0gne	-3.7165	Nominal GNE
w0imp_c	0.3565	Value of imports plus duty
w0tax_csi	-0.0333	Aggregate revenue from all indirect taxes
w1cap_i	-0.2640	Aggregate payments to capital
w1lab_io	-5.1865	Aggregate payments to labour
w1lnd_i	7.6996	Aggregate payments to land
w1oct_i	-1.5509	Aggregate "other cost" ticket payments
w1prim_i	-2.7436	Aggregate primary factor payments
w2tot_i	-3.5450	Aggregate nominal investment
w3lux	-3.2790	Total nominal supernumerary household expenditure

contGDPExp	
Consumpti	
Investmen	
Governme	
Stocks	
Exports	1.5551
Imports	-0.0707

contGDPinc	
Land	
Labour	1.3734
Capital	
IndTax	0.1110
TechChan	

w3tot	-3.1999	Nominal total household consumption
w4tot	8.1579	Local currency border value of exports
w5tot	-5.6293	Aggregate nominal value of government demands
w6tot	-3.4744	Aggregate nominal value of inventories
x0cif_c	0.3904	Import volume index, C.I.F. weights
x0gdpexp	1.4844	Real GDP from expenditure side
x0gdpinc	1.4844	Decomposition of real GDP from income side
x0gne		Real GNE
x0imp_c	0.3565	Import volume index, duty-paid weights
x1cap_i		Aggregate capital stock, rental weights
x1lnd_i		Aggregate land stock, rental weights
x1prim_i	1.5532	Aggregate effective primary factor use
x2tot_i		Aggregate real investment expenditure
x3tot		Real household consumption
x4_ntrad	26.0153	Quantity, collective export aggregate
x4tot	9.0939	Export volume index
x5tot		Aggregate real government demands
x6tot		Aggregate real inventories
x0gdpfac	1.5532	Real GDP at factor cost (inputs) = x1prim_i

9 COM variables

	p0dom	p3_s	p4	x0com	x0dom	x0imp	x0loc	x3_s	x4
WoolMutton	1.5021	1.1401	0.3332	0.9986	3.1391		3.1391	-1.9353	-0.5297
GrainsHay	1.2414	-0.4645	0.1387	0.8683	2.6428	3.8277	2.6554	-1.2326	-1.3873
BeefCattle	4.8448	4.2138	4.2549	2.6700	2.0098	10.6924	2.0122	-3.2815	26.0153
OtherAgric	0.3458	-1.6605	-0.2220	1.7176	1.6625	1.7767	1.6674	-0.3580	2.2203
ForestFish	-1.8567	-2.2084	-2.0045	3.8996	1.4979	-0.7130	1.4397	-0.4689	20.0453
Mining	0.0979	-0.1185	-0.0996	1.6274	2.5019	2.1087	2.4219	-1.3842	0.9279
MeatDairy	-0.2781	-1.5744	-0.5068	2.1026	0.5493	0.2100	0.5413	-0.3733	5.0675
OthFoodPro	-1.4549	-2.2498	-1.7562	3.9293	0.7545	-0.3370	0.6012	-0.2413	16.1434
DrinksSmoke	-1.5909	-2.5885	-1.8778	2.2507	0.1510	-1.3245	0.0034	-0.1708	26.0153
Textiles	-0.9317	-2.7835	-1.6891	4.8892	3.5374	1.3295	2.6214	-0.2170	9.8180
ClothingFtw	-2.2027	-3.1636	-2.3067	4.6891	1.9543	-1.9803	0.4048	-0.0288	23.0674
WoodProds	-2.5674	-2.1913	-2.7811	4.5552	2.3569	-0.8517	1.7664	-0.5955	26.0153
PaperPrint	-2.7090	-3.2476	-2.9650	2.8345	2.1796	-1.0992	1.5775	-0.0172	26.0153
Petrol_CoalP	5.9224	3.1162	4.3932	2.4155	0.4099	2.8378	0.7830	-3.5010	26.0153
Chemicals	-0.7584	-3.1542	-1.2048	3.8831	2.5390	1.6699	2.2127	-0.0683	12.0477
RubberPlaste	-1.9364	-2.8835	-2.4322	4.0077	3.0268	0.7793	2.3103	-0.2165	26.0153
NonMetlMinr	-2.7355	-3.5239	-2.9592	1.6843	0.9817	-0.2693	0.8160	0.1340	26.0153
BasicMetals	-0.5153	-2.2933	-0.6055	4.3384	3.8631	3.0051	3.7427	-0.5396	5.0786
FabMetalPrd	-2.7677	-3.2519	-2.8857	3.4452	2.4259	-1.3961	1.8560	-0.0148	26.0153
TransportEq	-1.3702	-2.6196	-1.7611	4.5727	2.9883	-1.8885	0.9947	-0.4692	17.6106
OthMachnEc	-1.1225	-2.0923	-1.8862	4.7584	1.4475	0.8253	1.0633	-0.8445	18.8617
MiscManuf	-2.9937	-3.5543	-3.1889	3.2996	0.9935	-1.6853	0.3130	0.1507	26.0153
ElecGasWat	-2.0715	-2.0699	-2.0715	0.9396	0.9031	0.8898	0.9031	-0.6619	26.0153
Construction	-5.2748		-5.2748	-0.0920	-0.1000	0.6022	-0.0997	-1.7950	26.0153
Trade	-4.9010			1.0896	1.0896	1.9350	1.0896	-1.7950	26.0153
Repairs	-4.0062	-4.0054	-4.0062	1.0288	0.9688	1.4345	0.9699	0.3977	26.0153
Hotel_Cafe	-4.9805	-4.9644		0.7978	0.7978	1.1356	0.7987	0.9226	26.0153
Transport	-1.1695	-0.9291	-1.1695	2.7627	1.0093	-0.0597	0.8831	-1.8765	11.6952
CommunicSr	-2.3448	-2.2063	-2.3448	2.1751	0.9982	1.2286	1.0120	-0.5872	26.0153
FinanceInsur	-4.4551	-4.4180	-4.4551	1.4994	1.0553	1.4287	1.0624	0.6235	26.0153
OwnerDwelln	-3.2790	-3.2790		0.0000	0.0000		0.0000	0.0000	26.0153
PropBusSrvc	-4.4243	-4.3804	-4.4243	1.9749	1.3310	1.6093	1.3387	0.6029	26.0153
GovAdminDf	-5.2998	-5.2998	-5.2998	0.2834	0.1713		0.1713	1.1063	26.0153
Education	-7.3741	-7.0716	-7.3741	1.6230	0.5055	2.0379	0.5216	2.0762	26.0153
HealthComm	-6.0971	-6.0850	-6.0971	0.9358	0.9080	1.5025	0.9089	1.5361	26.0153
CultuRecrea	-4.6134	-4.5764	-4.6132	0.9347	0.8320	1.0445	0.8337	0.7103	26.0153
OtherService	-5.3936	-5.3655	-5.3936	0.9434	0.9244	1.8560	1.0722	1.1422	26.0153

9 IND variables

	employ	gret	p1cap	p1mat	p1prim	p1tot	p2tot	x1tot	x2tot
BroadAcre	8.8826	12.3877	9.5654	-1.0464	6.5268	2.5434	-2.8223	1.5193	4.7678
OtherAgric	6.7411	7.6052	5.2823	-1.0151	1.8471	0.3458	-2.3229	1.7176	1.6113
ForestFish	6.3069	6.0498	4.4139	-0.8442	-3.3861	-1.8560	-1.6358	3.9000	0.5847
Mining	6.3508	7.3644	4.5017	-1.6150	1.2794	0.0510	-2.8628	1.6111	1.4524
MeatDairy	3.4966	1.2418	-1.2066	1.0246	-5.3925	-0.2943	-2.4485	2.0929	-2.5886
OthFoodPro	7.3421	9.0473	6.4843	-1.4855	-1.3685	-1.4721	-2.5630	3.9264	2.5631
DrinksSmok	5.8840	6.1467	3.5681	-1.8931	-0.9017	-1.6143	-2.5785	2.2349	0.6486
Textiles	8.6614	11.5568	9.1230	-1.0643	-0.6366	-0.9617	-2.4338	4.8798	4.2193
ClothingFtw	6.6699	7.7306	5.1400	-1.2746	-4.2606	-2.1849	-2.5907	4.7003	1.6941
WoodProds	6.9188	8.2510	5.6377	-2.1303	-3.5110	-2.5734	-2.6133	4.5744	2.0375
PaperPrint	5.1975	4.4617	2.1952	-2.1635	-3.4600	-2.7196	-2.2665	2.8276	-0.4634
Petrol_CoalP	19.6408	33.0517	31.0817	0.0435	26.3493	5.8273	-1.9700	2.3662	18.4060
Chemicals	8.4067	11.1183	8.6135	-1.4720	0.8730	-0.7977	-2.5048	3.8702	3.9299
RubberPlast	6.8767	7.6602	5.5535	-1.6500	-2.4509	-1.9536	-2.1068	4.0022	1.6476
NonMetlMinr	3.3698	0.8935	-1.4602	-1.5957	-4.8129	-2.7448	-2.3537	1.6763	-2.8185
BasicMetals	8.8007	11.6122	9.4015	-0.9713	0.8177	-0.6033	-2.2107	4.2919	4.2559
FabMetalPrd	5.3134	4.8759	2.4269	-1.7654	-4.4799	-2.7499	-2.4490	3.4534	-0.1901
TransportEq	8.3726	11.0461	8.5453	-1.7514	-0.5667	-1.4063	-2.5008	4.5560	3.8823
OthMachnEq	8.4042	11.0723	8.6085	-1.4290	-0.8546	-1.2328	-2.4638	4.7315	3.8996
MiscManuf	4.8870	4.0463	1.5742	-1.8214	-5.0467	-2.9786	-2.4721	3.3104	-0.7376
ElecGasWat	3.8456	2.6094	-0.5086	-1.2882	-2.3820	-2.0786	-3.1180	0.9367	
Construction	-0.1935	-6.2460	-8.5869	-2.5507	-8.3935	-5.2636	-2.3409	-0.0967	
Trade	1.8606	-1.6275	-4.4786	-3.1487	-6.6581	-4.9007	-2.8511	1.0897	-4.4823
Repairs	2.3095	-0.7525	-3.5810	-1.8968	-5.4662	-4.0062	-2.8284	0.9426	-3.9048
Hotel_Cafe	1.1002	-2.2930	-5.9995	-2.6585	-7.5951	-4.9805	-3.7065	0.7978	-4.9216
Transport	6.2435	5.9280	4.2872	-1.0141	-1.2242	-1.1837	-1.6409	2.7557	0.5044
CommunicSr	4.8985	4.1126	1.5971	-1.9343	-2.6688	-2.4291	-2.5156	2.1329	-0.6938
FinanceInsur	3.1875	1.7889	-1.8249	-3.9042	-4.8251	-4.4537	-3.6138	1.5001	
OwnerDwelln	2.4948	2.0072	-3.2104	-3.4630	-3.2104	-3.2790	-5.2176	0.0000	
PropBusSrvc	3.3110	2.2611	-1.5778	-3.0428	-5.5973	-4.4243	-3.8389	2.0098	
GovAdminDf	0.3124	-3.7908	-7.5751	-3.3298	-8.1419	-5.2998	-3.7843	0.2834	
Education	1.7508	-0.7598	-4.6982	-3.0816	-7.9441	-7.3741	-3.9383	1.6230	
HealthComm	1.1257	-2.4200	-5.9484	-2.7378	-7.8201	-6.0971	-3.5284	0.9358	
CultuRecrea	1.5955	-1.3261	-5.0088	-2.8404	-6.8781	-4.6134	-3.6827	0.9347	-4.2834
OtherService	1.1119	-2.2079	-5.9761	-2.2298	-7.8629	-5.3936	-3.7682	0.9434	-4.8654

fandecomp((	LocalMarke	DomShare	Export	Total
WoolMutton	1.3077	0.0000	-0.3090	0.9986
GrainsHay	1.4862	-0.0071	-0.6108	0.8683
BeefCattle	1.9569	-0.0024	0.7155	2.6700
OtherAgric	1.5027	-0.0044	0.2194	1.7176
ForestFish	1.2533	0.0506	2.5957	3.8996
Mining	1.0763	0.0356	0.5155	1.6274
MeatDairy	0.3552	0.0052	1.7422	2.1026
OthFoodProd	0.4772	0.1216	3.3305	3.9293
DrinksSmoke	0.0031	0.1356	2.1120	2.2507
Textiles	2.0572	0.7188	2.1133	4.8892
ClothingFtw	0.3524	1.3488	2.9879	4.6891
WoodProds	1.6023	0.5356	2.4173	4.5552
PaperPrint	1.5342	0.5855	0.7148	2.8345
Petrol_CoalP	0.7217	-0.3439	2.0378	2.4155
Chemicals	1.8999	0.2802	1.7030	3.8831
RubberPlast	2.2117	0.6860	1.1101	4.0077
NonMetlMinr	0.7931	0.1610	0.7302	1.6843
BasicMetals	2.2792	0.0733	1.9859	4.3384
FabMetalPrd	1.7758	0.5452	1.1241	3.4452
TransportEq	0.8869	1.7775	1.9083	4.5727
OthMachnEq	0.8612	0.3112	3.5861	4.7584
MiscManuf	0.2841	0.6178	2.3976	3.2996
ElecGasWat	0.9018	0.0000	0.0378	0.9396
Construction	-0.0997	-0.0002	0.0079	-0.0920
Trade	1.0896	0.0000		1.0896
Repairs	0.9676	-0.0011	0.0624	1.0288
Hotel_Cafe	0.7987	-0.0009		0.7978
Transport	0.7382	0.1054	1.9190	2.7627
CommunicSr	0.9644	-0.0131	1.2238	2.1751
FinanceInsur	1.0435	-0.0070	0.4628	1.4994
OwnerDwelln	0.0000	0.0000		0.0000
PropBusSrvc	1.3038	-0.0075	0.6787	1.9749
GovAdminDf	0.1705	0.0000	0.1129	0.2834
Education	0.4988	-0.0154	1.1396	1.6230
HealthComm	0.9079	-0.0009	0.0288	0.9358
CultuRecreat	0.8303	-0.0017	0.1060	0.9347
OtherService	1.0714	-0.1477	0.0197	0.9434

SalesDecom	Interm	Invest	HouseH	Export	GovGE	Stocks	Margins	Total
WoolMutton	1.3185		-0.0108	-0.3090				0.9986
GrainsHay	1.5199		-0.0408	-0.6108				0.8683
BeefCattle	1.9974		-0.0429	0.7155				2.6700
OtherAgric	1.5739		-0.0756	0.2194				1.7176
ForestFish	1.4184	0.0062	-0.1206	2.5957				3.8996
Mining	1.1312	0.0031	-0.0225	0.5155				1.6274
MeatDairy	0.5109		-0.1505	1.7422				2.1026
OthFoodProd	0.6622		-0.0634	3.3305				3.9293
DrinksSmoke	0.1652		-0.0265	2.1120				2.2507
Textiles	2.7372	-0.0122	0.0510	2.1133				4.8892
ClothingFtw	0.6533		1.0479	2.9879				4.6891
WoodProds	2.1260	-0.0011	0.0129	2.4173				4.5552
PaperPrint	1.9991	0.0018	0.1188	0.7148				2.8345
Petrol_CoalP	1.2626		-0.8848	2.0378				2.4155
Chemicals	2.1720		0.0080	1.7030				3.8831
RubberPlast	2.8628	0.0019	0.0330	1.1101				4.0077
NonMetlMinr	0.9424		0.0117	0.7302				1.6843
BasicMetals	2.3537		-0.0012	1.9859				4.3384
FabMetalPrd	2.2676	0.0305	0.0229	1.1241				3.4452
TransportEq	1.4334	1.1346	0.0964	1.9083				4.5727
OthMachnEq	0.9501	0.2735	-0.0513	3.5861				4.7584
MiscManuf	0.5749	-0.1201	0.4472	2.3976				3.2996
ElecGasWat	1.0703		-0.1685	0.0378				0.9396
Construction	0.0351	-0.1350		0.0079				-0.0920
Trade	0.0550	0.0000					1.0346	1.0896
Repairs	0.7780		0.1884	0.0624				1.0288
Hotel_Cafe	0.3131		0.5261				-0.0414	0.7978
Transport	0.4168	0.0003	-0.2868	1.9190			0.7134	2.7627
CommunicSr	1.1179		-0.1667	1.2238				2.1751
FinanceInsur	0.8575		0.1685	0.4628			0.0106	1.4994
OwnerDwellr			0.0000					0.0000
PropBusSrvc	1.2773	-0.0095	0.0284	0.6787				1.9749
GovAdminDf	0.1530	0.0043	0.0132	0.1129				0.2834
Education	0.0145		0.4689	1.1396				1.6230
HealthComm	0.0614		0.8456	0.0288				0.9358
CultuRecreat	0.4321	0.0028	0.3937	0.1060				0.9347
OtherService	0.4282		0.4955	0.0197				0.9434

regx1tot(IND	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	1.5193	1.5193	1.5193	1.5193	1.5193	1.5193	1.5193	1.5193
OtherAgric	1.7176	1.7176	1.7176	1.7176	1.7176	1.7176	1.7176	1.7176
ForestFish	3.9000	3.9000	3.9000	3.9000	3.9000	3.9000	3.9000	3.9000
Mining	1.6111	1.6111	1.6111	1.6111	1.6111	1.6111	1.6111	1.6111
MeatDairy	2.0929	2.0929	2.0929	2.0929	2.0929	2.0929	2.0929	2.0929
OthFoodProd	3.9264	3.9264	3.9264	3.9264	3.9264	3.9264	3.9264	3.9264
DrinksSmoke	1.3911	2.0631	0.6452	6.4596	1.9863	0.8005	-0.5618	0.4174
Textiles	4.8798	4.8798	4.8798	4.8798	4.8798	4.8798	4.8798	4.8798
ClothingFtw	4.7003	4.7003	4.7003	4.7003	4.7003	4.7003	4.7003	4.7003
WoodProds	4.5744	4.5744	4.5744	4.5744	4.5744	4.5744	4.5744	4.5744
PaperPrint	2.8276	2.8276	2.8276	2.8276	2.8276	2.8276	2.8276	2.8276
Petrol_CoalP	2.3662	2.3662	2.3662	2.3662	2.3662	2.3662	2.3662	2.3662
Chemicals	3.8702	3.8702	3.8702	3.8702	3.8702	3.8702	3.8702	3.8702
RubberPlast	4.0022	4.0022	4.0022	4.0022	4.0022	4.0022	4.0022	4.0022
NonMetlMinr	1.6763	1.6763	1.6763	1.6763	1.6763	1.6763	1.6763	1.6763
BasicMetals	4.2919	4.2919	4.2919	4.2919	4.2919	4.2919	4.2919	4.2919
FabMetalPrd	3.4534	3.4534	3.4534	3.4534	3.4534	3.4534	3.4534	3.4534
TransportEq	4.5560	4.5560	4.5560	4.5560	4.5560	4.5560	4.5560	4.5560
OthMachnEq	4.7315	4.7315	4.7315	4.7315	4.7315	4.7315	4.7315	4.7315
MiscManuf	3.3104	3.3104	3.3104	3.3104	3.3104	3.3104	3.3104	3.3104
ElecGasWat	0.8667	1.0959	0.7493	1.1882	1.2347	1.2377	-1.2545	0.8934
Construction	-0.2027	0.1135	-0.2867	0.2371	0.3028	0.0395	-2.1661	-0.1770
Trade	0.9823	1.5479	0.8059	1.3758	1.1162	1.3015	-1.5787	0.2735
Repairs	0.8632	1.1705	0.7997	1.1866	1.1570	1.2369	-1.3728	0.7098
Hotel_Cafe	0.7323	1.0126	0.6497	1.0243	1.0051	0.9581	-1.1930	0.5200
Transport	2.7557	2.7557	2.7557	2.7557	2.7557	2.7557	2.7557	2.7557
CommunicSr	2.0530	2.3812	1.9547	2.3338	2.3521	2.3001	0.2783	1.8203
FinanceInsur	1.3998	1.7449	1.3171	1.7638	1.7617	1.7023	-0.6072	1.1603
OwnerDwell	-0.1123	0.3756	-0.2589	0.4348	0.4735	0.2835	-3.9702	-0.5249
PropBusSrvc	1.9484	2.2663	1.8203	2.2331	2.1206	2.1864	-0.0333	1.6446
GovAdminDf	0.2834	0.2834	0.2834	0.2834	0.2834	0.2834	0.2834	0.2834
Education	1.6073	1.6772	1.5863	1.6865	1.6911	1.6651	1.0536	1.5437
HealthComm	0.9004	1.0819	0.8387	1.0974	1.0622	1.0379	-0.4975	0.6987
CultuRecrea	0.8688	1.1576	0.7741	1.1662	1.1361	1.0847	-0.9982	0.6095
OtherService	0.8906	1.1444	0.8177	1.1210	1.0722	1.0508	-0.5408	0.6233

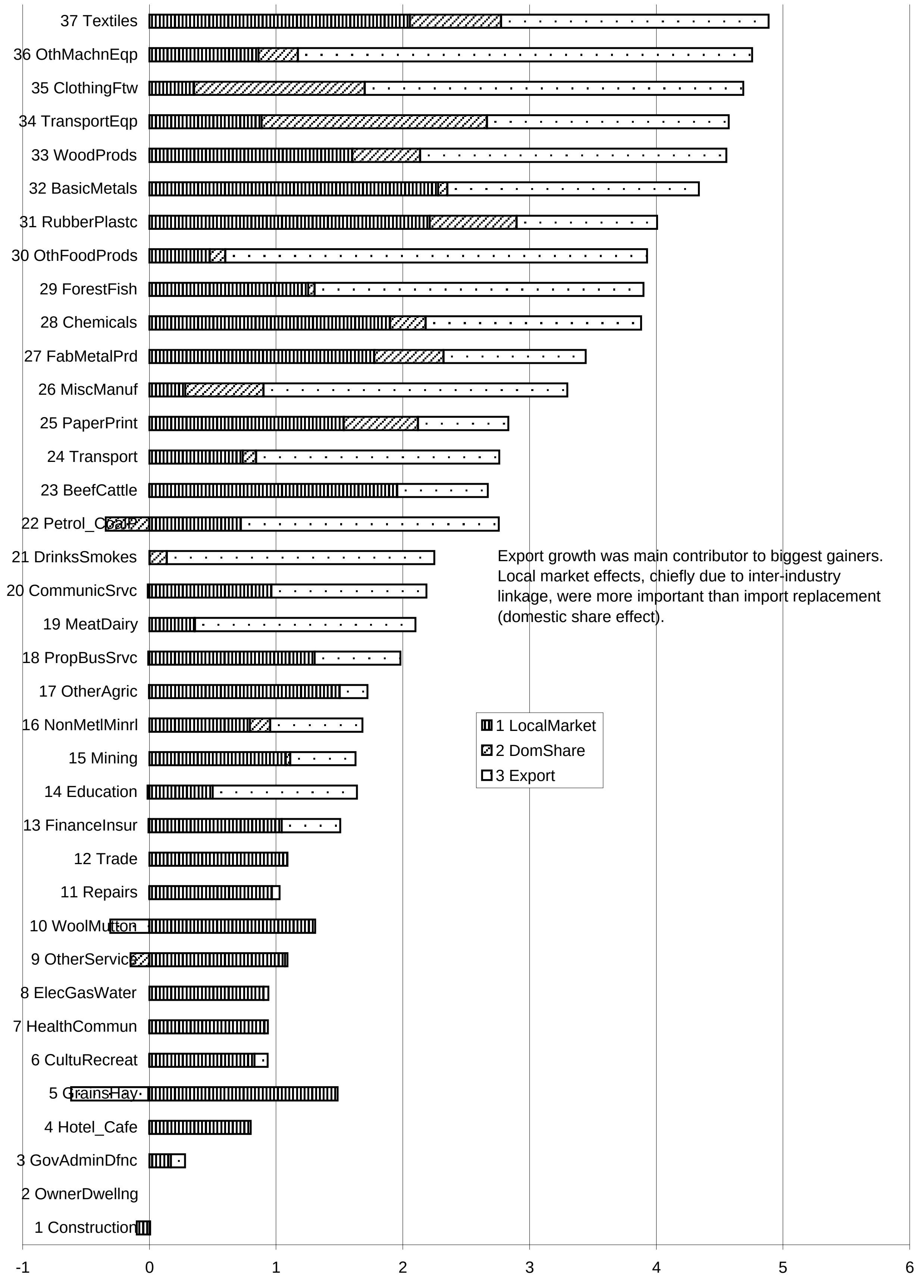
regadvantag	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	-0.0001	0.0002	0.0000	-0.0005	0.0001	0.0003	0.0005	-0.0008
OtherAgric	-0.0005	0.0006	0.0003	0.0019	-0.0012	0.0002	-0.0023	-0.0010
ForestFish	-0.0028	0.0000	0.0007	0.0022	-0.0011	0.0368	-0.0015	-0.0034
Mining	-0.0013	-0.0019	0.0005	-0.0008	0.0078	-0.0015	-0.0029	0.0056
MeatDairy	-0.0009	0.0007	0.0021	-0.0003	-0.0011	0.0023	-0.0044	-0.0043
OthFoodProc	-0.0011	0.0032	0.0112	-0.0082	-0.0101	0.0098	-0.0256	-0.0204
DrinksSmoke	-0.0043	-0.0008	-0.0069	0.0449	-0.0017	-0.0060	-0.0107	-0.0067
Textiles	-0.0031	0.0168	-0.0101	-0.0082	-0.0063	0.0175	-0.0146	-0.0146
ClothingFtw	0.0014	0.0068	-0.0025	-0.0028	-0.0076	-0.0108	-0.0099	-0.0117
WoodProds	-0.0007	-0.0007	0.0046	-0.0011	-0.0030	0.0114	-0.0067	-0.0086
PaperPrint	0.0016	0.0078	-0.0067	-0.0055	-0.0071	0.0161	-0.0102	-0.0168
Petrol_CoalP	0.0014	0.0017	0.0004	-0.0046	-0.0027	-0.0049	-0.0049	-0.0049
Chemicals	0.0048	0.0115	-0.0110	-0.0101	-0.0068	-0.0080	-0.0241	-0.0241
RubberPlast	-0.0014	0.0118	-0.0059	0.0008	-0.0072	-0.0104	-0.0146	-0.0140
NonMetlMinr	-0.0001	0.0001	0.0001	-0.0003	0.0002	0.0005	-0.0007	-0.0003
BasicMetals	0.0118	-0.0241	-0.0042	0.0080	0.0123	0.0383	-0.0379	0.0643
FabMetalPrd	-0.0012	0.0028	0.0028	-0.0025	-0.0003	-0.0031	-0.0171	-0.0101
TransportEq	-0.0211	0.0341	-0.0131	0.0660	-0.0271	-0.0008	-0.0400	-0.0377
OthMachnEq	0.0094	0.0147	-0.0215	0.0085	-0.0149	-0.0262	-0.0344	-0.0489
MiscManuf	-0.0008	0.0017	0.0003	0.0010	0.0000	-0.0032	-0.0057	-0.0071
ElecGasWat	-0.0022	0.0056	-0.0069	0.0092	0.0116	0.0107	-0.0840	-0.0024
Construction	-0.0078	0.0183	-0.0197	0.0229	0.0281	0.0098	-0.1826	-0.0066
Trade	-0.0129	0.0460	-0.0290	0.0288	0.0068	0.0216	-0.2415	-0.0624
Repairs	-0.0024	0.0056	-0.0041	0.0056	0.0057	0.0068	-0.0533	-0.0038
Hotel_Cafe	-0.0024	0.0048	-0.0036	0.0051	0.0058	0.0037	-0.0449	-0.0033
Transport	0.0088	-0.0036	0.0054	-0.0090	-0.0150	0.0069	-0.0358	0.0120
CommunicSr	-0.0020	0.0070	-0.0051	0.0053	0.0049	0.0046	-0.0578	-0.0091
FinanceInsur	-0.0069	0.0166	-0.0125	0.0174	0.0164	0.0137	-0.1463	-0.0207
OwnerDwelln	-0.0180	0.0344	-0.0269	0.0383	0.0528	0.0257	-0.3626	-0.0178
PropBusSrvc	-0.0045	0.0226	-0.0163	0.0165	0.0082	0.0142	-0.1687	-0.0315
GovAdminDf	0.0063	-0.0091	0.0145	0.0006	0.0275	0.0011	-0.2525	-0.0235
Education	-0.0007	0.0028	-0.0020	0.0034	0.0027	0.0022	-0.0340	-0.0043
HealthComm	-0.0040	0.0099	-0.0072	0.0107	0.0102	0.0070	-0.0946	-0.0113
CultuRecreat	-0.0016	0.0038	-0.0028	0.0040	0.0041	0.0026	-0.0344	-0.0034
OtherService	-0.0018	0.0041	-0.0028	0.0037	0.0040	0.0024	-0.0342	-0.0038

	regemploy_	regw1lab_i	regx1prim_i
NSW	2.9420	-5.2578	1.4920
VIC	3.2480	-4.9519	1.8088
QLD	2.8501	-5.3497	1.3754
SA	3.2850	-4.9148	1.8040
WA	3.3093	-4.8905	1.6485
TAS	3.1902	-5.0097	1.7445
ACT	0.5232	-7.6767	-0.5418
NT	2.6833	-5.5166	1.1957

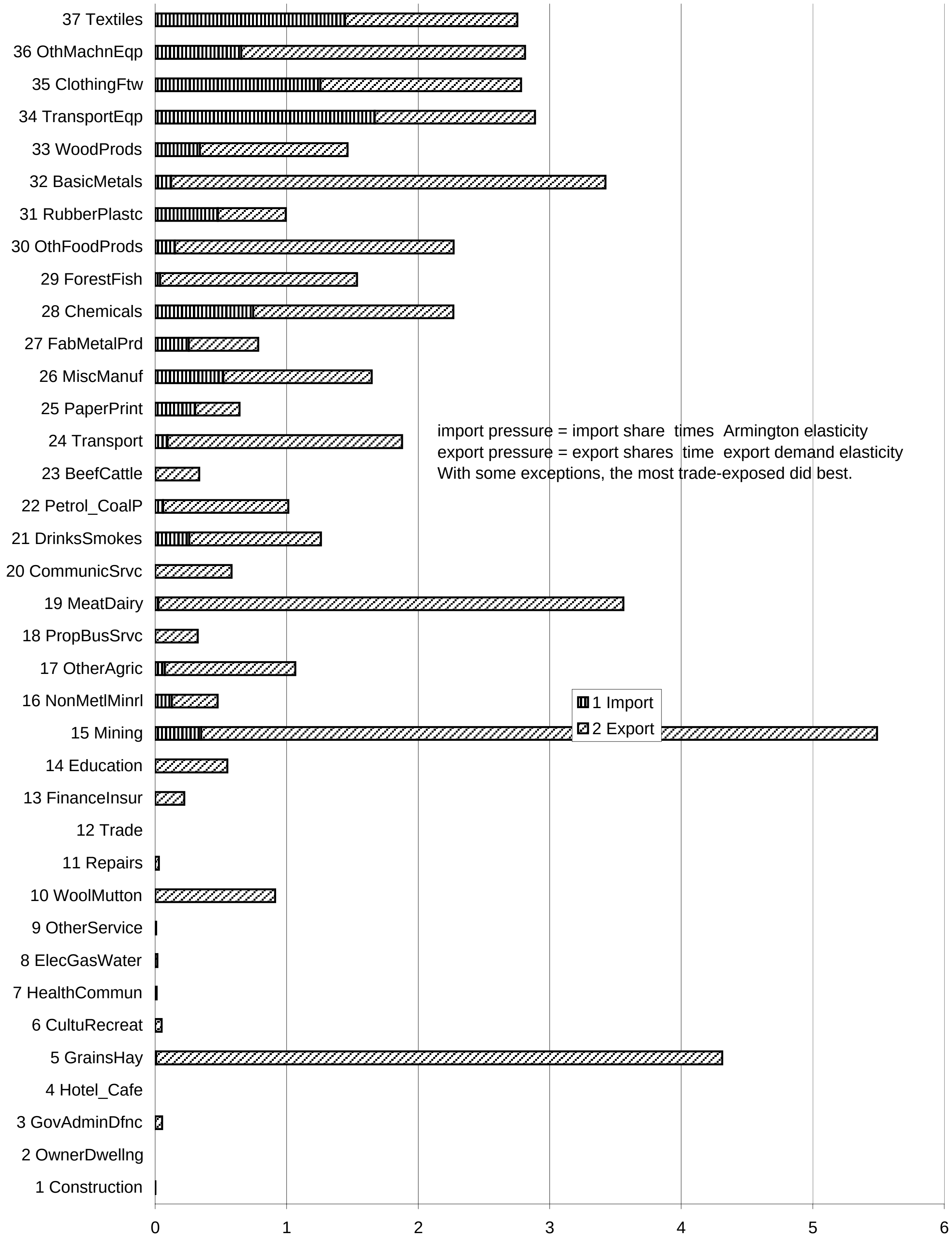
```
 ! Wage cut: DPSV shortrun closure
! Command file for ORANIG model: short-run closure

check-on-read elements = warn; ! very often needed
cpu=yes ; ! (Optional) Reports CPU times for various stages
log file = yes;  ! Optional
auxiliary files = oranig; ! needed by GEMSIM

! Solution method
!method = GRAGG ;
!steps = 2 4 6 ;
method = johansen; ! alternative to above

! Data and summary file
file basedata = basedata.har ;
updated file basedata =<cmf>.upd;
file summary  = summary.har;

! Closure

! Exogenous variables constraining real GDP from the supply side
exogenous  x1cap              ! all sectoral capital
           x1lnd              ! all sectoral agricultural land
           a1cap a1lab_o a1lnd
           a1prim a1tot a2tot  ! all technological change
           realwage ;          ! Average real wage

! Exogenous settings of real GDP from the expenditure side
exogenous  x3tot              ! real private consumption expenditure
           x2tot_i            ! real investment expenditure
           x5tot              ! real government expenditure on goods
           delx6 ;            ! real demands for inventories by commodity

! The demand curves of exports are fixed in both quantity and price axes
exogenous  f4p f4q              ! individual exports
           f4p_ntrad f4q_ntrad ; ! collective exports
! Exogenous foreign prices of imports ;
exogenous  pf0cif ;

! All tax rates are exogenous
exogenous  delPTXRATE f0tax_s  f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp
           f4tax_trad f4tax_ntrad f1oct ;

! distribution of government demands !
exogenous  f5 ;

! The nominal exchange rate is the numeraire
exogenous phi ;

! Number of households and their consumption preferences are exogenous
exogenous q a3_s ;

exogenous capslack; ! switch off aggregate capital constraint !

! Distribution of investment between industries
xSet EXOGINV  # 'exogenous' investment industries #
 (ElecGasWater
  PropBusSrvc
xSubset EXOGINV is subset of IND;
xSet ENDOGINV # 'endogenous' investment industries # = IND - EXOGINV;
exogenous finv1(ENDOGINV); ! investment linked to profits
exogenous finv2(EXOGINV);  ! investment follows aggregate investment
```

```
! Exogenous variables for regional extension
exogenous    freg1 freg2 freg3 freg4 freg5 freg6;
exogenous    rsum1 rsum2 rsum3 rsum4 rsum5 rsum6;


rest endogenous ;

verbal description =
 Wage cut: DPSV shortrun closure;

shock   realwage = -5 ;     ! real wage shift variable

→
```

Fan Decomposition sorted by output change (wagechart.xls)



Trade pressure sorted by output change (wagechart.xls)



Percentage Change Examples

bakcover.doc

Levels form	100*ordinary change	Percentage change
X	Xx	$x = 100\Delta X/X$
$3X$	$3Xx$	x
XY	$XY(x+y)$	$x+y$
X/Y	$(X/Y)(x-y)$	$x-y$
X^α	$X^\alpha(\alpha x)$	αx
$X+Y$	$Xx+Yy$	$(Xx+Yy)/(X+Y)$ $= S_x x + S_y y$ where $S_x = X/(X+Y)$, $S_y = 1-S_y$
In the examples below we assume *a vector of quantities X_i, total X.* *a vector of prices P_i, average P.* *a vector of values V_i, total V, such that $V_i = P_iX_i$, (thus $v_i = p_i+x_i$).* *that V = PX, (thus v = p+x).*		
Adding up quantities (rare)		
$X = \Sigma X_i$	$Xx = \Sigma X_i x_i$	$x = \Sigma S_i x_i$ where $S_i = X_i/X$
Adding up quantities with a common price P (frequent)		
$PX = P\Sigma X_i$	$PXx = \Sigma PX_i x_i$ or $Vx = \Sigma V_i x_i$ or $\Sigma V_i(x-x_i) = 0$	$x = \Sigma S_i x_i$ where $S_i = V_i/V$
Adding up values		
$V = \Sigma V_i$	$Vv = \Sigma V_i v_i$ or $V(p+x) = \Sigma V_i(p_i+x_i)$	$v = \Sigma S_i(p_i+x_i)$ where $S_i = V_i/V$
Decomposing value changes into indices of price and quantity change		
$V = \Sigma V_i$	$V(p+x) = \Sigma V_i(p_i+x_i)$	from $v = \Sigma S_i(p_i+x_i)$ price part: $p = \Sigma S_i p_i$ quantity part: $x = \Sigma S_i x_i$ so $v = p + x$
CES (no tech change)		
$X = CES(X_i)$		$x_i = x - \sigma(p_i-p)$ where $p = \Sigma S_i p_i$ implying $x = \Sigma S_i x_i$
CES (with tech change, a_i<0 for progress)		
$X = CES(X_i/A_i)$		$x_i-a_i= x - \sigma(p_i+a_i-p)$ where $p = \Sigma S_i(p_i+a_i)$ implying $x = \Sigma S_i(x_i-a_i)$
Ordinary change in a ratio		
$R = X/Y$	$Rr = 100\Delta R = (X/Y)(x-y)$ $100\Delta R = R(x-y)$	$100(\Delta R)/R = r = x - y$
$N = (X-M)/(X+M)$	$200(X+M)(X+M)\Delta N = 4MX(x-m)$	$200\Delta N = (1-N^2)(x-m)$

Section 9

AnalyseGE

■ Call for tariff cuts ■ Asian imports threat ■ Job loss fears

Grim future for textile industry

Jason Koutsoukis

Most of Australia's clothing and textile manufacturers face the prospect of being wiped out by Asian competitors within 10 years.

In a draft report on future assistance for the $9 billion sector, which employs about 70,000 workers, the Productivity Commission has warned that the industry is not able to compete against China, regardless of tariff barriers.

The commission recommended tariffs fall to 5 per cent on most TCF products in 2010, except for certain clothing and finished textiles which, it said, should not face a cut to 5 per cent tariffs until 2015.

But it said even if tariff barriers were maintained, most of Australia's 5000 firms would be unlikely to survive competition from China.

"There is now little if any productivity difference between Australian and efficient Chinese suppliers – the main source of import competition in the domestic market," the report said.

Presiding commissioner David Robertson said Australian firms could not compete against significantly lower labour costs.

"This means further migration of standardised, labour-intensive production offshore is inevitable," Mr Robertson said.

Business groups and union officials slammed the recommendation to lower tariffs, which they said would spell the end for local manufacturers and lead to more job losses. The federal government was advised to retain a key industry assistance scheme worth $140 million a year to manufacturers to ease the transition to lower tariffs.

Tariffs for the sector are already legislated to fall from 25 per cent to 17.5 per cent on clothing in 2005,

Continued page 4

From page 1

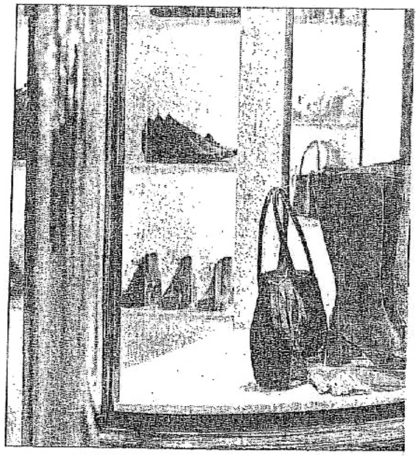
and from 15 per cent to 10 per cent for footwear, cotton sheeting and carpets, from 10 per cent to 5 per cent for sleeping bags and table linen.

Total assistance, including tariffs and direct grants and subsidies, now represents about $13,000 for each job.

The report said funding under a future assistance scheme should be maintained at about $140 million a year until 2009, and then halved for the following four years.

The federal Industry Minister, Ian Macfarlane, who will ultimately determine the shape of the final government position later this year, said the government was keen to get the balance right between tariff protection and direct assistance.

"The paper highlights the fundamental structural change the industry has undertaken in the last decade and rightly points out that this adjustment must continue," he said.



Textile, footwear and clothing manufacturers will face a battle

"The report correctly identifies a continuing role for government assistance, given acute pressure on various sectors of the industry, but doesn't definitively suggest what shape that support should take.

Assistant commissioner Philip Weickhardt said there were some parts of the industry that were internationally competitive, mainly in specialised areas, which could survive.

The Productivity Commission's recommendations are in line with what was expected by industry, although many thought tariffs could be maintained at 2005 levels for another decade.

The commission said tariffs cost consumers up to $1 billion a year in higher prices. But it recommended no crackdown on conditions and pay rates for outworkers, favouring a chance for a voluntary code of practice to work first.

Paul Orton, general manager for policy at Australian Business Ltd, which represents a large number of TCF employers in NSW, said there was no doubt lower tariffs meant pain for TCF companies.

"Some companies are going to ha[illegible] difficulty dealing with legislated tari[illegible] reductions in 2005, so further more rationalisation in the sector," he said. "While we are not opposed to TCF sector tariff cuts, we think matching the general tariff rate should happen only if our trading partners are doing the same.

"We note the economic modelling suggests negligible net national benefits from future tariff reductions, but if they are to occur, they must be accompanied by a structural adjustment program, so

"The commission said tariffs cost consumers up to $1 billion a year in higher prices."

we are pleased that the Productivity Commission is moving in that direction."

Mr Orton said any future structural adjustment program should be more accessible and focus more on innovation and export development.

"Given the lack of sophistication of smaller TCF businesses, we see a need for an businesses understand the global dynamics of the TCF market and that they have got appropriate plans in place to prosper in that environment," he said.

The national secretary of the TCF Union of Australia, Tony Woolgar, said the report's findings were no surprise. "We've lost 30,000 jobs in the last five years, and if we keep reducing tariffs, then that will continue," he said.

"This will spell the end of the industry. We just hope the federal government realises we can't move at that pace. We can't lead the world and try and convince them there is a level playing field when no other countries are doing what we are doing."

However, the national president of the Victorian-based Council of Textile Fashion Industries, Paul Cohen, said he was pleased the Productivity Commission had not provided a "do nothing, get nothing approach".

"There are some things in the report that soun[illegible]ttle different to what we would [illegible]deally but we will have to see m[illegible]e of the detail

Using AnalyseGE to examine an ORANI-G tariff cut simulation

Mark Horridge, W.J. Harrison and K.R. Pearson

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May 2004

Summary

General equilibrium modellers need to explain their results. A general equilibrium model has various main mechanisms that produce the results. The modeller is required to identify and quantify the mechanisms that are important for a particular simulation,

To analyse the results in this way, the modeller must bring together details of several different information sources: the equations of the model, the base data, consequences of that data such as totals and shares, and the simulation results (percentage changes or ordinary changes).

AnalyseGE is a software tool that assists modellers to move quickly between these different information sources. The AnalyseGE interface gives users "point and click" access to the equations of the model, the data, and the simulation results. In particular a modeller can click on any equation and ask the software to group the terms into different natural parts, and give the numerical values of each term. This greatly reduces the burden associated with analysing simulations, and offers the potential for significantly boosting the productivity of applied general equilibrium modellers.

This document illustrates the use of AnalyseGE by means of an example: a tariff cut simulation using the ORANI-G model. The example is presented as exercises for the reader to follow.

This document is divided into three parts:
- Part 1 contains sections 1 and 2,
- Part 2 contains section 3,
- Part 3 contains sections 4 to 12.

This is because the exercises in this document need about three Computer Lab sessions to complete, and the different parts correspond roughly to the three Lab sessions.

CLASS EXERCISES:

Throughout the document there are questions. Write your answer to the right of each question.

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1 Running the tariff cut simulation

The simulation shows the short-run effects of a reduction in the tariff on imported Clothing and Footwear. In the early 1980's, when ORANI was developed, Australian tariffs were higher than today, and tariff cut simulations were a major focus of ORANI work.

The details of the simulation are contained in the file TARFCUT.CMF. Briefly examine this file using TABmate:

What variable is shocked and by what value?

What type of closure is used?

Using TABmate, search through ORANIG.TAB and find the description (between # characters) of the shocked variable.

Now run the TARFCUT simulation using WinGEM.

When using WinGEM the first step is always to specify the location of the working directory. Choose:

File | Change both default directories

and check that the working directory is set to C:\GPWORK\ORANIG.

Let us review the three steps in running a simulation.

- Step 1 - Implement the model with TABLO
- Step 2 - Solve the equations of the model with GEMSIM
- Step 3 - View the results with ViewSOL

To carry out Step 1, choose

Simulation | TABLO Implement

A window for TABLO will appear. Click the Options menu item at the top of this TABLO window and select "Run from STI file". Then click on the ***Select*** button to select the name of the STI file, ORANIG.STI.

Click on the ***Run*** button.

Because we have not changed the TABLO Input file of the model, there is no need to run TABLO. However we have included this step for practice in running TABLO.

To carry out Step 2, choose

Simulation | GEMSIM Solve

Select the Command file for this simulation called TARCUT.CMF. Click on the ***Run*** button and wait until the simulation has finished.

To carry out Step 3, select the ***Go to ViewSOL*** button and look at the results of the simulation in the file TARFCUT.SL4.

1.1 A first look at the results using ViewSOL

First check that the right shock was applied—examine the variable ***t0imp***. Set the number of decimal places to 2. Then have a look at the imports vector ***x0imp***. Only two values are much different from zero.

What happened to imports of ClothingFtw?

What other import changed, and by how much?

Now have a look at the industry outputs, ***x1tot***.

What happened to output of ClothingFtw?

What happened to output of Textiles?

Can you see a pattern in the other industry outputs?

Summary: The results for “ClothingFtw” are as you would expect. You have decreased the tariff on Clothing and Footwear, so the imports of Clothing and Footwear increase and the domestic output of Clothing and Footwear decreases. We need to look more closely at “Textiles” to see what is causing the textiles results above.

1.1.1 The Fan Decomposition

The **Fan decomposition** variable ***fandecomp*** shows how the change in demand for a locally-produced commodity, say, textiles, may be divided between:

- local market effect: change in non-export demand for textiles *domestic plus imported*;
- domestic share effect: change in dom/imp ratio for textile demand.
- export effect: change in demand for textile exports

Examine the ***fandecomp*** variable and fill in the table below:

fandecomp	LocalMarket	DomShare	Export	Total
Textiles				
ClothingFtw				

Summary: You should see that, for Textiles, increased exports and weakened import competition failed to offset a shrinking local market, leading to a small output decline. For ClothingFtw, increases in both export and local demand were overwhelmed by increased import penetration, leading to a larger output decline.

1.1.2 Macro Variables

Now look at the **macro variables**. Macro variables are scalar variables that have just one component. Some of the macro variables are red (***x3tot, x2tot_I, x5tot, phi***). These red variables are exogenous in the simulation.

All the macro results except for the ***del…*** variables are percentage changes. Variables whose names start with ***del*** are ordinary changes.

Check whether all of the percentage changes in macro variables are less than one percent.

What variable is the numeraire in this simulation? The exchange rate (phi) or the CPI (p3tot)?

In ViewSOL you can copy the macro variables from the table shown on the screen into a spreadsheet. In the ViewSOL menu, select **Export | Copy** to copy the results to the clipboard. Next open the spreadsheet program Excel, and select the Excel menu item **Edit** | **Paste** to paste the values from the clipboard into Excel. You will see that ViewSOL has helpfully added the variable descriptions to the table.

If you are not sure what the asterisked variables are, search through the TAB file with TABmate to find the equations defining them.

Save the Excel file as TARFCUT.XLS in directory C:\GPWORK\ORANIG (but leave the file open).

Fill in the table of macro variables below.

Description	Variable	Value
Real household consumption	*x3tot*	
Real investment	*x2tot_i*	
Real government demands	*x5tot*	
Export volume	*x4tot*	
Import volume CIF	*x0cif_c*	
Real GDP	*x0gdpexp*	
Aggregate capital stock	*x1cap_i*	
Aggregate employment	*employ_i*	
Absorption price index*	*p0gne*	
GDP price index	*p0gdpexp*	
CPI	*p3tot*	
Exports price index	*p4tot*	
Real devaluation*	*p0realdev*	
Average nominal wage	*p1lab_io*	
Average real wage	*realwage*	
Contribution of BOT to real GDP	*contBOT*	
Terms of trade*	*p0toft*	
Change in aggregate tariff revenue	*delV0tar_c*	

1.1.3 Results relating to Clothing and Footwear

Next, in ViewSOL, change the combo box at top left (the 'filter' box) from "Everything" to "ClothingFtw". This causes ViewSOL to show only results that relate to the ClothingFtw sector. On the ViewSOL Contents page, double-click the first item: *Vector elements matching ClothingFtw*. You will see the ClothingFtw part of each vector variable. Again, use **Export..Copy** to paste these results into another Excel sheet within TARFCUT.XLS. These results will be handy later on. Again save (but do not close) the Excel file.

Summary: As expected, the tariff cut caused the ClothingFtw and Textiles industries to contract, and imports to increase—all bad for GDP. Yet, employment and real GDP expanded —why ? And why did imports of textiles go down? Next you will use AnalyseGE to investigate the simulation in more detail.

2 Investigating results, data, and equations with AnalyseGE

Start AnalyseGE running by returning to the GEMSIM window in WinGEM and clicking on the button ***Go to AnalyseGE.*** Click on the **Select/Change** button and select the Solution file **TARFCUT.SL4** . This may happen automatically if you are starting AnalyseGE from WinGEM.

This Solution file contains the results of the ORANI-G tariff cut simulation.

2.1 Some features of AnalyseGE

AnalyseGE has 3 forms (or windows).

- the TABmate form which contains the model's TABLO Input file[1] (in this case ORANIG.TAB[2]). AnalyseGE extracts the TAB file from the Solution file. Much of the analysis can be done by selecting and clicking on variables and equations in the TABLO Input file, as you will see below.
- the ViewHAR form (which will show the numerical results of various calculations) and
- the AnalyseGE form (which is the form shown each time AnalyseGE starts).

To see these other windows, you use the Menu item ***Front*** or ***AnalyseGE*** (if you are in the TABMate window).

2.2 The tariff shock and duty-paid import prices.

Go to the TABmate form (which is probably already the top one of the three forms associated with AnalyseGE). If not, select ***Front | Bring TABmate to the front***.

AnalyseGE makes it easy to see the values of any variable or coefficient.

To see the value of a variable *t0imp*, find the declaration of variable *t0imp* (for example, search using the Search menu). **Left-click** anywhere in the declaration of *t0imp*. Then **right-click** anywhere on the TABmate form.[3] A menu will appear. Select the option **Evaluate this Variable**. A ViewHAR window will appear to show the values of all components of variable t0imp.

Confirm that the right tariff was reduced.

To get back to the TABmate window, select menu item ***Front | Bring TABmate to the front*** from ViewHAR's main menu.[4]

To see the corresponding feature for Coefficients, go to the top of the TABmate form (click there) and then search for the declaration of coefficient **TARFRATE(c)**. Look at the formula for this coefficient. Left-click on **TARFRATE** in the Coefficient statement, and then **right-click** and select the menu option **Evaluate this Coefficient**. Again the ViewHAR window will appear, with values for TARFRATE.

---

[1] The TABLO Input file contains the equations of the model written in algebraic form.

[2] AnalyseGE may call this something like AN1.TAB. This file is put into a temporary directory after AnalyseGE extracts it from the Solution file.

[3] Your mouse has two (or possibly three) buttons. Left clicking uses the left-hand one, while right-clicking uses the right-hand one. In this document, we often just say "click" when we mean left-click. But we will not abbreviate "right-click".

[4] That is, first click on ***Front*** in the main menu, then select option ***Bring TABmate to the front*** from the menu which appears.

Write down the initial ad valorem tariff rate for ClothingFtw:

Note: the power of the tariff [t0imp] is defined as *one plus the ad valorem rate*.

Write down the initial power of the tariff for ClothingFtw:

Write down the percentage change in t0imp("ClothingFtw"):

Use the Windows calculator to compute the post-simulation power of the tariff for ClothingFtw:

Write down the post-simulation ad valorem rate:

You can also find the values of variables or coefficients from any equation or formula where they appear. To see this, return to the TABmate form, go to the top and then find the equation E_p0B . Left-click on the p0 term on left-hand side (for example, between the "p" and the "0"). Then right-click and select menu option Evaluate (selection or coeff/var at cursor). Again the ViewHAR form will appear and you will see the values of variable p0.

Write down the percentage change in p0("ClothingFtw","imp"):

Select menu item ***Front | Bring TABmate to the front*** to return to TABmate.

AnalyseGE lets you know which variables are exogenous and which are endogenous. Exogenous variables are coloured **red**; those not shocked are shown in italics and those shocked are bolded. Endogenous variables are **green** while variables which have been substituted out are coloured **grey** and shown in italics (which indicated that results are not available). If a variable has some components exogenous and some endogenous, the variable is coloured **purple**. Omitted variables are shown as red italics to indicate they have not been shocked. (However in the ViewHAR window, red just means that the value is negative.)

Summary: The ad valorem tariff rate fell from an initial value of 19.6% to 7.64% post simulation. This caused the basic price of imported ClothingFtw to fall by 10%.

2.3 Effect of the tariff cut on imports

Next we investigate the variable *x0imp*, aggregate imports. This variable appears in the next equation, E_delV0TAR. Click on *x0imp* and press the **Gloss** button at the top of TABmate.

A window appears, listing all statements in the TABLO file involving *x0imp*. The first mention defines the variable *x0imp*. The second mention is Equation E_x0imp, The name of the equation, "E_x0imp" suggest that this is the equation that explains variable x0imp. Line numbers are shown in red on the left side of the Gloss window. You can click on these red numbers to jump to that line. Use this method to jump to Equation E_x0imp. You should see:

```
Equation E_x0imp # Import volumes #
(all,c,COM)0.01*[TINY+V0IMP(c)]*x0imp(c)=sum{u,LOCUSER,delSale(c,"imp",u)};
```

The left hand side of this equation shows, for each commodity, the ordinary change in import volumes (measured at current prices). The right hand side shows how the total change in imports is split between various usage categories [Gloss on the set "LOCUSER" to see these categories].

Left-click on the *delSale* term on the right-hand side. Then **right-click** and select menu option **Evaluate (selection or coeff/var at cursor)**. Again the ViewHAR form will appear and you will see the values of variable delSale.

Above, ViewSOL told us that aggregate imports (*x0imp*) changed much only for 2 commodities: Textiles and ClothingFtw. The *delSALE* values show us which demanders are responsible for these changes.

Fill in the following delSale values:

delSale (c,"imp",u)	Intermediate	Household	Rest
Textiles			tiny
ClothingFtw			tiny

Summary: You should see that households account for most of the change in ClothingFtw imports. For textiles, most of the decrease is in intermediate use. Why did households increase their imports of ClothingFtw? [You will find out in the section 3.1.]

2.4 Strategy for remainder of analysis

In Part 2 of the ORANI-G tariff cut simulation, we will analyse more results for the ClothingFtw sector (section 3). Please find the document for Part 2 in your folder.

In Part 3 of the ORANI-G tariff cut simulation, we will

- analyse a few results for the Textiles sector (section 4).
- next, examine why some other industries expanded (section 5).
- last, comment briefly on macro results (section 6).

Using AnalyseGE to examine an ORANI-G tariff cut simulation

Part 2

In Part 2 of the ORANI-G tariff cut simulation, we will first, analyse more results for the ClothingFtw sector (section 3).

In Part 3 of the ORANI-G tariff cut simulation, we will

- analyse a few results for the Textiles sector (section 0).
- next, examine why some other industries expanded (section 5).
- last, comment briefly on macro results (section 6).

3 Analysing results for ClothingFtw

3.1 Import-domestic substitution : Household demand for ClothingFtw

In this section you will analyse why household demand for imports of ClothingFtw increased so much.

Go back to the TABmate window via the menu item ***Front | Bring TABmate to the front*** .

Again **Gloss** on delSale.and go to the following equation:

```
E_delSaleC (all,c,COM)(all,s,SRC)
delSale(c,s,"HouseH")=0.01*V3BAS(c,s)*x3(c,s);
```

V3BAS is a dollar amount while x3 is the percentage change in a quantity. Suppose that quantity units are determined by what one dollar will buy. Then V3BAS is also the initial quantity and the product V3BAS*x3 is 100 times the quantity change[5]. The 0.01 in the equation above cancels out this 100 and so the RHS is the quantity change (where one quantity unit is what one pre-simulation dollar will purchase).

For example, evaluate V3BAS, x3 and delSale for c=ClothingFtw and s=imp. A 9.12% increase in quantity x3 corresponds to a sales increase of 204.7 (delSale), from initial sales of 2243.2 (V3BAS).

Then **Gloss** on x3, and go to the following equation:

```
Equation E_x3  # Source-specific commodity demands #
(all,c,COM)(all,s,SRC)
x3(c,s)-a3(c,s) = x3_s(c) - SIGMA3(c)*[ p3(c,s)+a3(c,s) - p3_s(c) ];
```

The form of this CES demand equation is quite common in CGE modelling. The x3_s term on the right-hand side is the so-called "expansion effect". This dictates the increase in demand of each commodity from a given source, based on the overall increase in imp/dom composite for that commodity. If relative prices are unchanged, then this is the end of the story. The second term on the right-hand side of this equation is the "substitution effect". It captures the tendency to source products from the cheapest source. SIGMA3 is the elasticity of substitution between imported and domestic sources, and the negative of this value pre-multiplies the percentage change in the ratio of source-specific price to the average price. When one is conducting analysis of simulation results, it is often quite important to know how much of the change in import demand is due to the expansion effect, and how much is due to the substitution effect. The "intelligent" decomposition tool in AnalyseGE makes this easy to do.

[5] If X is the initial quantity, delX is the change in X, and pX is the percentage change in X, then pX=100*delX/X. Hence X*pX=100*delX.

In order to decompose the RHS of the equation above, click anywhere on this equation in the TABmate form. Then right click and select menu item **Decompose Part of this Equation**. Then, in the "Type of Decomposition" form, select **RHS** (in the top box) to indicate that you are seeking to decompose the right hand side of this equation, select **Intelligent** (in the middle box) to indicate that you want AnalyzeGE to adopt the usual decomposition approach to this demand equation, select **First** (in the third box) to indicate that you want the decomposition toggle to come first in the ViewHAR file. and finally, click **Ok**. In the ViewHAR form which appears, make sure that the combo boxes read "All IntDec1", "ClothingFtw", and "All SRC".

Fill in the table below

	1 dom	2 imp
1 x3_s		
2 SIGMA3		
Total		

By definition, the expansion [x3_s] term is the same for both dom and imp ClothingFtw. In each case the substitution [SIGMA3] term is much more important. You can identify the separate parts of this. Use **Evaluate (selection or coeff/var at cursor)** to fill in the table below:

	x3 (c,“dom”)	x3 (c,“imp”)	x3_s	p3 (c,”dom”)	p3 (c,”imp”)	p3_s	SIGMA3	S3 (c,"imp")
ClothingFtw			*0.552*	*-0.746*	*-4.801*	*-2.378*	*3.537*	*0.402*

The composite (average dom/imp) price is defined in the next equation, E_p3_s. Omitting a3 taste change terms, the two equations of this CES nest read:

```
E_x3        x3(c,s)  =  x3_s(c) - SIGMA3(c)*[ p3(c,s)- p3_s(c) ];
E_p3_s      p3_s(c) =  sum{s,SRC, S3(c,s)*p3(c,s)};
```

For c = ClothingFtw, using values from the table above,

```
p3_s(c) =  sum{s,SRC, S3(c,s)*p3(c,s)}

p3_s(c) = 0.598 * (-.746)  + 0.402 *(-4.801) = -2.378
```

the price of ClothingFtw composite p3_s has decreased by –2.38 %,

```
x3(c,"dom") = x3_s(c) - SIGMA3(c) * [p3(c,"dom")-p3_s(c)]

x3(c,"dom") = 0.554 – 3.54*[-0.746 – (-2.378)] = 0.55 - 5.77 = -5.22
```

there is substitution away from the domestic good (-5.22 %), towards the imported good (9.12 %).

```
x3(c,"imp"  = x3_s(c) - SIGMA3(c) * [p3(c,"imp")-p3_s(c)]

x3(c,"imp") = 0.554 – 3.54 *[-4.801 – (-2.378)] = 0.55 + 8.57 = 9.12
```

We could substitute out the p3_s average price variable to get:

```
x3(c,"dom") = x3_s(c) - SIGMA3(c)*S3(c,"imp")[p3(c,"dom")-p3(c,"imp")]
x3(c,"imp") = x3_s(c) - SIGMA3(c)*S3(c,"dom")[p3(c,"imp")-p3(c,"dom")]
```

In each case the substitution term consists of the product of: the Armington elasticity, a share, and the percent change in the ratio of domestic to imported prices. In the first equation, the term SIGMA3(c)*S3(c,"imp") [called the "import pressure"] show that domestic producers are more vulnerable to import competition where both Armington elasticity and import share are larger.

Summary: For ClothingFtw, the household purchasers price has changed by –0.75% (domestic) and by -4.80% (imported). This causes the household demand x3 to change by –5.22% (domestic) and 9.12% (imported) via a substitution away from the domestic good to the imported good.

3.2 Explaining purchasers' prices: Household imports of ClothingFtw

In section 3.1, you might have wondered why the price of imported ClothingFtw to households, p3("ClothingFtw","imp") [= -4.8%] only fell by about half as much as the duty-paid price of imported ClothingFtw, p0("ClothingFtw","imp") [=-10%]. To understand why, Gloss on the variable p3 and go to the equation E_p3:

```
Equation E_p3 # Purchasers prices - households #
 (all,c,COM)(all,s,SRC)
  [V3PUR(c,s)+TINY]*p3(c,s) =
   [V3BAS(c,s)+V3TAX(c,s)]*[p0(c,s)+ t3(c,s)]
    + sum{m,MAR, V3MAR(c,s,m)*[p0dom(m)+a3mar(c,s,m)]};
```

The above equation states that the purchasers' price, p3, is composed of three components: basic values, consumption tax, and trade and transport margins. You can see (by colours) in AnalyseGE that, in this simulation, the variable a3mar (technical change) is exogenous and unshocked (ie, 0). Also the variable t3 (tax rate) is zero for all commodities c and sources s. To see why, Gloss on t3, go to equation E_t3 and note that the two variables on the RHS are both exogenous and unshocked. Thus, although it is formally endogenous, the variable t3 is zero "almost exogenously". Now go back to the equation E-p3 (shown above) in TABmate. You can ignore the a3mar and t3 terms in this simulation.

If we divided both sides in equation E_p3 by V3PUR+TINY we would get the percent change equation:

$$p3 = [1-S_m]p0 + S_m p_m$$

where S_m is the share of margins in purchasers price, and p_m is the average change in the cost of margins. **Intelligently decompose** the RHS of equation E_p3 to see that the second, margin, term contributes relatively little to the above. **Evaluate** p0dom in equation E_p3 above to see that margins prices decrease by only a small amount.

The conclusion of the above must be that, for imported ClothingFtw, the $[1-S_m]$ share must be around 0.5. To check this, Gloss on V3PUR and go to the formula defining it:

```
(all,c,COM)(all,s,SRC)
   V3PUR(c,s) = V3BAS(c,s) + V3TAX(c,s) + sum{m,MAR, V3MAR(c,s,m)};
```

Right click and select **Decompose the RHS of this Formula**. In ViewHAR, set the combo boxes to "All IntDec?", "ClothingFtw", "All SRC" and choose Column Shares.

Fill in the table below.

	1 dom	2 imp
V3BAS		0.471
V3TAX		
V3MAR		
Total	1.000	1.000

Thus, when you divide both sides of equation E_p3 by V3PUR+TINY, this equation for c=ClothingFtw and s=imp tells us that

p3("ClothingFtw","imp") = 0.474*p0("ClothingFtw","imp") + 0.526*SUM(m,MARG,p0dom(m))

Here p0("ClothingFtw","imp") is –10 and the SUM(m,MARG,p0dom(m)) term is small. Thus the margins share of 0.526 explains why p3("ClothingFtw","imp") is only about –4.8. This is an example where a share from the base data is vital in understanding the size of results.

Summary: Because of local distribution costs, a 10% fall in the duty-paid price of a Chinese teeshirt leads to just a 4.8% fall in the retail price. The detailed treatment of margins is distinctive of the ORANI type of CGE model—and quite important to simulation results. ORANI-G includes a data summary matrix summarizing the proportions of BAS, MAR, and TAX in purchasers' prices.

Search for and evaluate the SALEMAT2 matrix.
Set combos to "All COM", "All FLOWTYPE", "imp", "HouseH". Which commodity has the highest rate of distribution margin, and why?
What if you look at domestic commodities? [change “imp” to “dom”.]

3.3 Estimating household demand elasticities

In ORANI-G, intermediate, investment and government demands for composites (imp/dom combined goods) are insensitive to the prices of composites. For example, the Textiles industry will use composite ClothingFtw in proportion to Textiles output, regardless of composite-ClothingFtw price. For these users, the only substitution between commodities is import-domestic substitution. This is because the top nest in the intermediate demand nest is Leontief between composite commodities.[6]

Households, however, **do** substitute between composite commodities. As we saw, above, a fall in the price of composite ClothingFtw leads to a rise in household use (even though total household consumption x3tot is held fixed).

Use the changes in price and quantity to write down an estimate of the elasticity of household demand for ClothingFtw:

	x3_s	p3_s	demand elasticity = %x / %p	B3LUX
ClothingFtw	0.554	-2.378		

ORANI-G uses the linear expenditure system [LES] to model household demands. One way to think of LES is that demand for each composite good is split into two parts:

- a fixed or "subsistence" component representing necessities.
- a variable ("supernumerary") component representing luxuries.

The first part does not change, so its demand elasticity is zero. The second, supernumerary, part is modelled as Cobb-Douglas and so has a demand elasticitity near to -1. The total demand elasticity will be a share-weighted average of these two elasticities:

demand elasticity = (Fixed share) x 0 + (Luxury share) x -1

Above, the shares add to 1 and "Luxury share" is defined as:

[Value of supernumerary use of ClothingFtw]/[Value of all household use of ClothingFtw]

Therefore, the demand elasticity will be close to the [negative of the] value of the "Luxury Share". In the ORANI-G TAB file, this share corresponds to the coefficient B3LUX.

Search for and evaluate B3LUX("ClothingFtw") and fill the final column of the table above.

Is the value close to the previous estimate of demand elasticity?

Why are the two estimates not identical ? [hard]

---

[6] To see this, go to equation E_x1_s which is the equation for the Leontief top nest in the intermediate inputs demand theory. If you Evaluate terms you will see that x1tot(“Textiles”)=–0.232 and that x1_s(“ClothingFtw”,”Textiles”)=–0.232=x1_s(c,”Textiles”) for all other c, even though p1_s(“ClothingFtw”,”Textiles”)=–4.52 falls much more than p1_s(c,”Textiles”) for all other c.

3.4 Total demand for domestic ClothingFtw

We have seen in section 3.2 above that purchasers' prices of imported ClothingFtw to households fell directly as a result of the shock (even after taking account of margins). Of course the same happens for the purchasers' price of imported ClothingFtw used by firms. The amount of this fall can be understood using the equation E_p1 (which also involves margins).

We have seen in section 3.1 above that households substitute towards imported ClothingFtw, away from domestic ClothingFtw. This is because the shock has reduced the price of imported ClothingFtw.

For the same reason, firms (intermediate inputs) substitute towards imported ClothingFtw. There is an Armington nest in each case. For example, the equation for intermediate inputs x1 is E_x1:

```
Equation E_x1  # Source-specific commodity demands #
 (all,c,COM)(all,s,SRC)(all,i,IND)
  x1(c,s,i)-a1(c,s,i) = x1_s(c,i) -SIGMA1(c)*[p1(c,s,i) +a1(c,s,i) -p1_s(c,i)];
```

What about the other uses of imports of ClothingFtw? No ClothingFtw (imported or domestic) is used for capital creation, as the V2BAS values will show you. Also there is no change in government demands for ClothingFtw (domestic or imported) since total government demand x5tot is exogenous and fixed and there is no changes in government demands for the different commodities since the shifters f5 are exogenous and not shocked. Thus we can concentrate on intermediate and household demands.

Suppose for the moment that total demand for composite ClothingFtw remains approximately unchanged. Then, since more imports and less domestic are used for intermediate inputs and households, you can see that total demand for imported ClothingFtw will increase and total demand for domestic ClothingFtw must fall.

To see the sizes of the changes, search for the variable delSale and Evaluate it. Set the combo boxes to ClothingFtw/All SRC/All DEST.

Complete the following table (in which we ignore the columns which are all zero):

delSale ClothingFtw	Interm	HouseH	Export	Total
dom				
imp	48.3	204.7	0	253.0
Total	–14.3		78.8	90.6

These are changes in the dollar value. As expected from the discussion above, intermediate and household demand drop significantly[7] for the domestic commodity but increase for the imported commodity.

The only use of ClothingFtw we have not considered above is exports. The table above shows that exports (only the domestic is exported, the imported commodity cannot be re-exported in this model) do increase, but not by sufficient to offset the other declines. [You will look more closely at the size of this export increase in section 3.7 below.] Thus total demand for domestic ClothingFtw decreases. To see that another way, look at the value of x1tot("ClothingFtw") = -3.5%.

[7] To see the corresponding base values for which the delSales are changes, look at the values of the Coefficient SALEMAT2. Set the combo boxes to ClothingFtw/Basic/All SRC/All SALECAT2. For example, the pre-simulation basic value of sales of ClothingFtw is 4621 (from the SALEMAT2 values) and the change is –162.5 (from the delSALES results). Note that this ratio –162.5/4621 equals –0.0351 which is exactly the x1tot("ClothingFtw") result of –3.51 percent.

3.5 Why did domestically-produced ClothingFtw get cheaper ?

So far we have seen that the tariff cut caused imported ClothingFtw to become cheaper (relative to domestically-produced ClothingFtw) so that users switched from domestic to imported. However, the domestic price of ClothingFtw also decreased—this moderated the price difference between domestic and imports, and helped to protect demand for the domestic product.

Find and evaluate the variable p0 (basic prices) and fill in the two values below.

	s=dom	s=imp
p0("ClothingFtw",s)		

3.5.1 Relation between commodity prices and industry costs

The price of the domestic ClothingFtw *commodity* is nearly equal to the output price of the ClothingFtw *industry*, p1tot.

What is the value of the output price for the industry, p1tot ?

The two prices [p1tot, p0("dom")] would be identical if:

(a) all ClothingFtw commodity was made by the ClothingFtw industry; *and*

(b) the ClothingFtw industry made *only* the ClothingFtw commodity.

These conditions are only approximately satisfied. To check them, find and evaluate the MAKE matrix. Use ViewHAR's shares view to answer these 2 questions:

What fraction of ClothingFtw commodity is made by the ClothingFtw industry?

What fraction of ClothingFtw industry output is ClothingFtw commodity?

In compiling Input-output tables, most statistical bureaus build up industry statistics from facts about "establishments", eg individual factories. The factories are grouped according to the commodity that they *mainly* produce. As a result, we often find that "Textiles" factories produce as well a little ClothingFtw, while "ClothingFtw" factories produce as well a little Textiles. Small off-diagonal MAKE entries result from this statistical procedure.[8]

The main equations connecting industry prices to commodity prices are shown below:

```
Formula
 (all,i,IND) MAKE_C(i) = sum{c,COM, MAKE(c,i)};
Equation E_x1tot # Average price received by industries #
 (all,i,IND) p1tot(i) = sum{c,COM, [MAKE(c,i)/MAKE_C(i)]*pq1(c,i)};
Equation
 E_pq1  # Each industry gets the same price for a given commodity #
 (all,c,COM)(all,i,IND) pq1(c,i) = p0com(c);
```

Summary: You can see that if the ClothingFtw industry made *only* the ClothingFtw commodity, the share [MAKE(c,i)/MAKE_C(i)] would = 1, and so the prices p1tot and p0com for ClothingFtw would be identical.

Conclusion: We will have explained why domestically-produced ClothingFtw becomes cheaper if we explain why the output price p1tot(“ClothingFtw”) decreases. We do this in section 3.6 below.

[8] The ORANI-G data is based on an original commodity/industry input-output table. Often statistical bureaus will adjust the IO data to eliminate off-diagonal MAKE values, so producing an industry/industry or commodity/commodity IO table. In that case the MAKE matrix is perfectly diagonal (ie, redundant), so that the industry/commodity distinction vanishes.

3.6 Why did the output price p1tot("ClothingFtw") decrease?

In the absence of technological change, the output price of each industry, p1tot, can be expressed as a cost-share-weighted average of the price of each industry input. ORANI-G contains an equation, E_p1cst, which computes this average input cost.

Find the equation E_p1cst.

```
Equation E_p1cst  (all,i,IND) p1cst(i) =  [1/V1CST(i)]*[
  sum{c,COM,sum{s,SRC,  V1PUR(c,s,i)*p1(c,s,i)}}
                     +  V1OCT(i)    *p1oct(i)
                     +  V1CAP(i)    *p1cap(i)
                     +  V1LND(i)    *p1lnd(i)
           + sum{o,OCC, V1LAB(i,o)  *p1lab(i,o)}];
```

Evaluate the p1cst variable and check that

p1cst("ClothingFtw") = p1tot("ClothingFtw") = ?

Now left-click within equation E_p1cst, then right-click. Select **Decompose Part of this Equation**. This time click on **Complete** (rather than Intelligent) and, as previously, select RHS and Toggle first. The complete decomposition shows the contributions of each variable. The decomposition shond in ViewHAR shows you how each category of input price contributes to the total change, p1cst.

Fill in the table below:

ClothingFtw	contribution
1 p1	
2 p1oct	
3 p1cap	
4 p1lnd	
5 p1lab	
Total p1cst	

You should see that p1 (material inputs) and p1cap (capital rentals) are much the largest contributors.

3.6.1 Breaking down the reduction in intermediate input prices?

You can use AnalyseGE to see which material inputs contributed to the negative p1 contribution. Return to the TABmate form and select with your mouse the expression *V1PUR(c,s,i)*p1(c,s,i)* .[9] Now **right-click** and select menu option Evaluate (selection or coeff/var at cursor). Again the ViewHAR form will appear and you will see the values of the expression *V1PUR(c,s,i)*p1(c,s,i)*.

Set the combo boxes to All COM/All SRC/ClothingFtw.

The numbers you see now are *dollar contributions* from price changes to total cost [ie, if they were divided by V1CST(i), they would show components of the percent change in p1cst]. Set ViewHAR to show *matrix shares* (the whole matrix adds to one) so you will see the share of each commodity and source in the whole p1 contribution.

[9] That is, left-click just to the left of the "V" in **V1PUR** and drag with your mouse until all of this expression is highlighted. [In fact, you don't have to be quite this precise since AnalyseGE knows where words start and end. So, for example, you could achieve the same by clicking just left of the U in V1PUR(c,s,i) and dragging only to the right of the 1 in p1(c,s,i).]

What share of the p1 contribution comes from price change in domestic ClothingFtw?

What share of the p1 contribution comes from price change in imported ClothingFtw?

- You should see that the largest matrix share corresponds to imported ClothingFtw. Thus cheaper clothing imports significantly reduce costs for the domestic clothing industry as well competing with it [these imports are probably semi-finished garments from Asia].
- The next biggest matrix share corresponds to domestic ClothingFtw. That is, cheaper domestic ClothingFtw also contributes significantly to cost reduction—implying that the industry is a customer of itself ! This is quite usual, especially when data has fewer (more aggregated) sectors[10].
- The other large matrix share corresponds to domestic Textiles. As you will see and explain later (see section 4.1), the price of domestic Textiles falls. This reduces the costs in the ClothingFtw industry since that industry uses significant intermediate inputs of domestic Textiles.

What share of ClothingFtw sales go to the ClothingFtw industry? [Hint: V1BAS/SALES[11]]

3.6.2 Why did the capital rental p1cap("ClothingFtw") decrease?

Above we saw that more than half of the reduction in input costs for ClothingFtw came from reduced capital rentals (p1cap).

In this shortrun closure of ORANI-G industry capitals stocks are fixed, and profits are a residual item. The CES between capital and labour in the production function implies a "declining marginal product of labour"—labour is less productive as the L/K ratio rises. Conversely, as output falls with K fixed, L (and thus L/K) must fall by more than output, so labour becomes more productive. You will confirm these assertions below.

To see this search for the equation E_p1cap. You should see equations like:

```
Equation
E_x1lab_o  # Industry demands for effective labour #
 (all,i,IND) x1lab_o(i) = x1prim(i) - SIGMA1PRIM(i)*[p1lab_o(i)-p1prim(i)];
E_p1cap    # Industry demands for capital #
 (all,i,IND) x1cap(i) = x1prim(i)-SIGMA1PRIM(i)*[p1cap(i)-p1prim(i)];
E_p1prim   # Effective price term for factor demand equations #
 (all,i,IND) V1PRIM(i)*p1prim(i) = V1LAB_O(i)*p1lab_o(i)+V1CAP(i)*p1cap(i);
```

Above, technical change variables and demands for land are omitted as irrelevant to this example.

Why is land irrelevant here? [Hint: Decompose RHS of formula for V1PRIM]

For which industries would land be relevant?

[10] The phenomenon of own-sales can lead to puzzling results. In Australian technical jargon, an industry which buys significant amounts of its own product is said to be "up-itself".

[11] You can evaluate this share by going to the AnalyseGE form (bring that to the Front). Click on the **Clear** button. Then enter
`V1BAS(“ClothingFtw”,”dom”,”ClothingFtw”)/SALES(“ClothingFtw”) ;`
(don’t forget the semi-colon at the end) into the memo. Then click **Evaluate**. You will see the answer. [You can use the memo on the AnalyseGE form to evaluate expressions if you cannot do this conveniently from the TABmate window.]

3.6.2.1 Rewriting the equations for factors

If you divide Equation E_p1prim by V1PRIM, it can be written [dropping subscripts] as

p1prim = SL.p1lab_o + SK.p1cap

where SL is the share of labour in factor costs (V1LAB_O/V1PRIM) and SK is the share of capital in factor costs (V1CAP/V1PRIM).

If you subtract E_p1cap from E_x1lab_o, you get

x1lab_o - x1cap = –SIGMA1PRIM.[p1lab_o – p1cap]

With some manipulation,[12] the first equation becomes

x1prim = SL.x1lab_o + SK.x1cap

The three equations have become

x1prim = SL.x1lab_o + SK.x1cap

p1prim = SL.p1lab_o + SK.p1cap

x1lab_o - x1cap = –SIGMA1PRIM.[p1lab_o – p1cap]

3.6.2.2 The short run equations for factors

With no change in x1cap, we can drop the x1cap terms so these equations become:

(a) x1prim = SL.x1lab_o

(b) p1prim = SL.p1lab_o + SK.p1cap

(c) x1lab_o = –SIGMA1PRIM.[p1lab_o – p1cap]

With output (=x1prim) and wages (p1lab_o) given, we see that:

(i) From (a), if output falls 1%, employment must fall more than 1% [=1/SL]

(ii) From (c), if employment falls, p1cap must fall relative to p1lab_o. p1lab_o is linked to the CPI, so does not change much. Therefore p1cap must fall.

(iii) From (b) if p1cap falls, p1prim (price of value-added) must also fall.

This explains why the capital rental p1cap("ClothingFtw") falls in your simulation.

You know that capital stocks (x1cap) and technology are fixed in that simulation.

You have also seen (and explained—see section 3.4 above) that (domestic) output x1tot of ClothingFtw falls by about 3.5%.

But x1prim is equal to x1tot since there is no technical change (see equation E_x1prim). Thus x1prim("ClothingFtw") falls by about 3.5% and so, from (i) and (ii) above, it follows that p1cap("ClothingFtw") must fall.

---

[12] First substitute the second equation into E_x1lab_o which becomes

x1lab_o = x1prim – SIGMA1PRIM*[p1ab_o – SL*p1lab_o – SK*p1cap]
= x1prim – SIGMA1PRIM*[(1-SL)*p1lab_o – SK*p1cap]
= x1prim – SIGMA1PRIM*SK*[p1lab_o – p1cap] (a1)

since 1–SL=SK. Similarly,

x1cap = x1prim – SIGMA1PRIM*SL*[p1cap – p1lab_o] (a2).

If you add SL times (a1) to SK times (a2) you see that, since SL + SK =1

SL*x1lab_o + SK*x1cap = SL*x1prim + SK*x1prim = x1prim

3.6.2.3 Estimating how much p1cap("ClothingFtw") falls

What's more, the equations above give a pretty good estimate as to how much this price must fall. Suppose for the minute that p1lab_o does not change. [This is not correct, as the figures in the work-sheet below show. However it is true that the p1lab_o is small.[13]]

Then, from (a):

x1lab_o = (1/SL)*x1prim=(1/SL)*(–3.5).

Then, (c) above can be rewritten as

p1cap = x1lab_o/SIGMA1PRIM + p1lab_o.

Ignoring the tiny p1lab_o change, we get:

p1cap = x1lab_o/SIGMA1PRIM = (1/SL)*(–3.5)/SIGMA1PRIM.

The SL value is about 0.7 (this is easily calculated from the base data) and the SIGMA1PRIM value for ClothingFtw is 0.5 (as is easily seen from AnalyseGE). This gives the rough estimate that

p1cap("ClothingFtw") = (1/0.7)*(–3.5)/0.5 = –10.

This is very close to the exact result of –10.171 (see the worksheet below).

Fill in the worksheet below to validate equations (a) to (c) above. Your Excel sheet with industry results may save time. For the Factor shares SL and SK, find and evaluate the coefficient FACTOR, then use ViewHAR's shares view.

SL = labour share	
SK = 1 - SL	
x1cap	
x1lab_o	
RHS(a) = SL.x1lab_o + SK.x1cap	
LHS(a) = x1prim	
x1tot	
p1lab_o	
p1cap	
RHS(b) = SL.p1lab_o + SK.p1cap	
LHS(b) = p1prim	
SIGMA1PRIM	
RHS(c) = -SIGMA1PRIM * [p1lab_o-p1cap]	
LHS(c) = x1lab_o	

[13] In this closure (where realwage is fixed), wage rates p1lab_o move with the consumer price index p3tot. Given that the only shock here is to a relatively small industry (ClothingFtw accounts for only about 2.5% of GDP), you can see without any detailed analysis that the effect on p3tot must be small compared to the approximately 10% fall in p1cap which is explained in the text.

Since p1lab_o moves with p3tot, the explanation of p1lab_o results relies on the explanation of the macro results for this simulation, which is given later in section 6. Contrast that to the explanation of the p1cap results which, in this shortrun closure, is very much a micro (rather than macro) story, as the text here shows.

Checking calculations such as that above are very often done when developing or extending a model to ensure that the equations are working properly. If the single-step, Johansen, solution method is used, we expect good agreement between LHS and RHS of linearized equations. Agreement is usually pretty good (but not exact) for results from multi-step [non-linear] solution methods.

Summary: Output (x1tot) of ClothingFtw has changed by –3.5%, resulting in a change in labour input (x1lab_o) of –4.97% since capital is fixed (x1cap). The price of capital (p1cap) changes by –10.1% (which is roughly equal to x1lab_o/SIGMA1PRIM). [Note that the price of labour (p1lab_o) only changes by –0.2%, a small amount.]

3.6.3 Slope of the shortrun supply schedule

Consider the shortrun (that is, capital stocks are fixed) and suppose that there is no technical change (which is true in your simulation).

Suppose that output x1tot falls (as it did for ClothingFtw – see section 3.4 above). Now x1prim is equal to x1tot since there is no technical change (see equation E_x1prim). Hence x1prim falls. From point (i) in section 3.6.2, employment x1lab_o must fall by more than x1tot and x1prim. From point (ii) in that section, p1cap must fall by more than p1lab_o. From point (iii), p1prim must also fall. A fall in p1prim causes the output price p1tot to fall. Thus, in the shortrun, when there is no technical change, if the output x1tot falls, so does the price p1tot.

This correlation between output and price implies *an upwardly sloping shortrun supply schedule*. You could obtain this positive relation between output and price by using (c) to eliminate x1lab_o and then (b) to eliminate p1cap from equation (a) above.

In your simulation, output (x1tot) of ClothingFtw has fallen by 3.5%, resulting in a fall in labour input (x1lab_o) of 4.97% since capital is fixed (x1cap). The price of capital (p1cap) falls by 10.1% (which is roughly equal to x1lab_o/SIGMA1PRIM). This causes the price of value-added (p1prim) to fall by 3.1%. The output price p1tot falls by about 1.4%. This confirms the upwardly sloping shortrun supply schedule in your simulation.

The following section is optional and maybe omitted.

3.6.4 Movements OF the supply curve and ALONG the supply curve

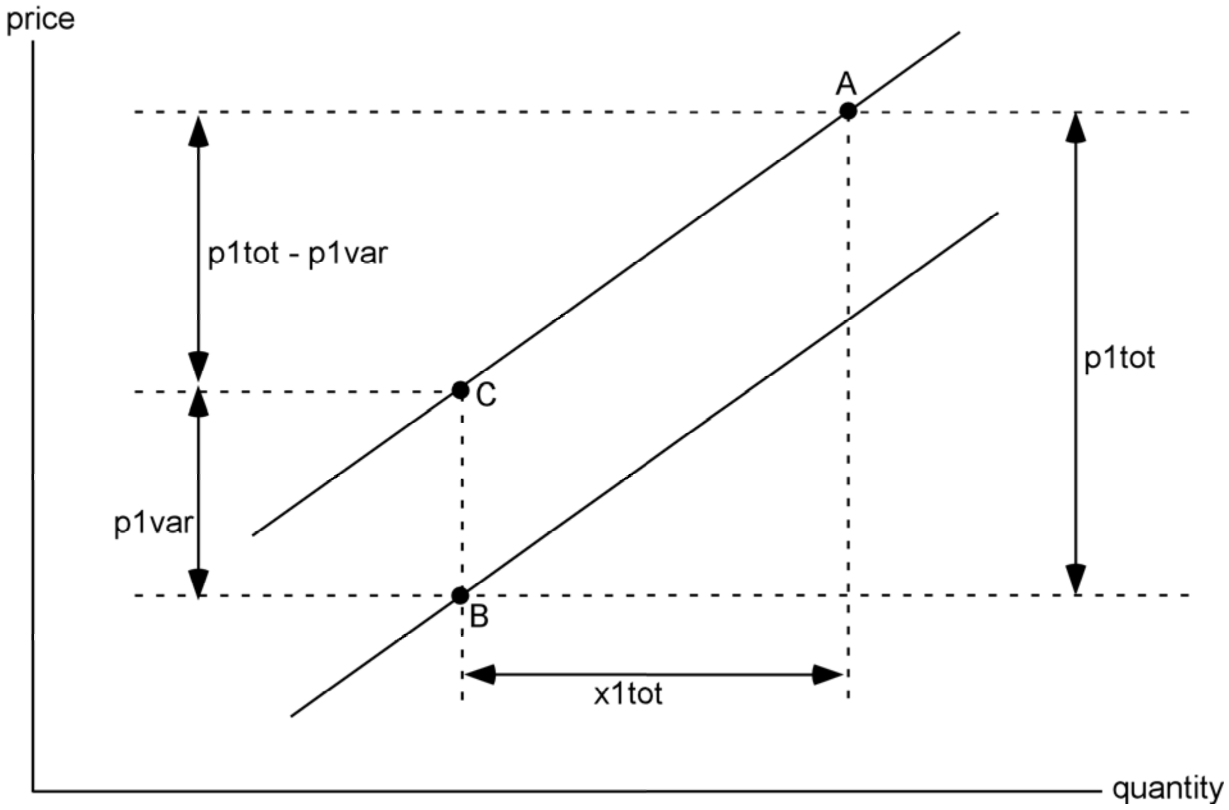
Appendix J of the ORANI-G document (Horridge, *2003)* has a full derivation of the short-run supply elasticity. The formula given there is computed by the SUPPLYELAST coefficient in the ORANI-G TAB file. Find and evaluate this coefficient.

Which industry has most elastic short-run supply? and why ?

Which industry has least elastic short-run supply? and why ?

In using the SUPPLYELAST values we must remember that the shortrun supply curve moves up and down according to the average change in variable [non-capital] costs, p1var. In the diagram below, the initial state is A, and the final state is B. Between A and B there is a price change, p1tot, and a quantity change, x1tot. The movement from A to B consists of a movement *along* the supply curve, A⇒C, and a movement *of* the supply curve C⇒B. In price space, the downward shift of the supply curve is measured by p1var. If we want to estimate the slope of the supply curve along the section CA as a ratio, Δquantity/Δprice, we must subtract the supply shift p1var from the total price change p1tot:

elasticity CA = x1tot/(p1tot-p1var)



Find the equation for variable p1var which calculates average variable costs. Then fill in the table below, for the industry ClothingFtw .

SUPPLYELAST	
x1tot	
p1tot	
p1var	
x1tot/[p1tot-p1var]	

The last line above, "x1tot/[p1tot-p1var]" estimates the supply elasticity from simulation results.

How close are the 2 estimates of short-run supply elasticity ?

Why are the two numbers not identical [hint: up-itself] ?

3.7 Why did exports of ClothingFtw increase ?

You saw in section 3.4 above that exports of ClothingFtw increase. You will explain this in this section.

Check to find how much exports of ClothingFtw increased.

Find the equation in ORANIG.TAB which "explains" exports x4. [Hint. Gloss on x4 and look for an equation with x4 on the LHS. When you find it, are you surprised at the name?]

In fact there are two equations explaining exports, one for the commodities in the set TRADEXP and one for the commodities in the set NTRADEXP.

Gloss on TRADEXP to find out about that set. You will see

```
Set TRADEXP # Individual export commodities # = (all,c,COM: IsIndivExp(c)>0.5);
```

This is the set of commodities whose exports are determined individually. They are sometimes called the traditional export commodities. They are usually commodities whose exports are substantial.

To see which commodities are in this set TRADEXP, bring the AnalyseGE form to the front (via the **Front** menu). Select menu item ***View | Sets, Subsets, Variables, Coefficients*** . You will see a list of the sets (under the **Sets** tab on the form shown). Run down these sets until you see TRADEXP and click on it. The members of this set are then shown.[14]

Is ClothingFtw in the set TRADEXP?

Since ClothingFtw is in the set TRADEXP, demand for its exports is explained by equation E_x4A (rather than equation E_X4B). Close the sets form and go back to the TABmate form (via the **Front** menu). Look at the equation E_x4A. You should see

```
Equation E_x4A  # Individual export demand functions #
(all,c,TRADEXP) x4(c) - f4q(c) = -ABS[EXP_ELAST(c)]*[p4(c) - phi - f4p(c)];
```

Note that the variables f4p and phi are exogenous and not shocked.

How can you tell this? What does that mean about their values?

Hence this equation says that

```
x4("ClothingFtw") = -ABS[EXP_ELAST("ClothingFtw")]*p4("ClothingFtw")
```

This connect exports x4 to a price p4 and an elasticity EXP_ELAST.

What is the value of EXP_ELAST("ClothingFtw")?

Hence you can see that

```
x4("ClothingFtw") = -10*p4("ClothingFtw")
```

Thus you will understand why exports of ClothingFtw increased (and by how much) when you understand why the export price p4 fell (and by how much). You look at this in subsection 3.7.1 below. You will complete the explanation of exports in subsection 3.7.2 below.

---

[14] Another way of checking to see the elements of TRADEXP is to look at the values of the Coefficient IsIndivExp which determines the set. These values are read from the BASEDATA file. To see the values, search for IsIndivExp and evaluate. Note that the value for ClothingFtw is 1. This means that ClothingFtw is in TRADEXP since the value is larger than 0.5.

3.7.1 The export price p4 of ClothingFtw

What happens to the export price p4 of ClothingFtw?

What would you expect to influence the export price of ClothingFtw?

Firstly, the basic price p0(“ClothingFtw”,”dom”). Secondly any export taxes or subsidies. Thirdly, the cost of getting exports from the factory to the port (that is, margins). You will see how all of these are involved in the equations shown below.

Find the equation which “explains” the price p4. As you would expect, this is equation E_p4 which says:

```
Equation E_p4 # Zero pure profits in exporting #
 (all,c,COM)  [V4PUR(c)+TINY]*p4(c) =
   [V4BAS(c)+V4TAX(c)]*[pe(c)+ t4(c)]
    + sum{m,MAR, V4MAR(c,m)*[p0dom(m)+a4mar(c,m)]};
```

This connect p4 to another export price pe, to export taxes t4 and to margins (the last term).

To find about pe, look at equation E_x0dom which says

```
Equation E_x0dom  # Supply of commodities to export market #
 (all,c,COM) TAU(c)*[x0dom(c) - x4(c)] = p0dom(c) - pe(c);
```

Find the values of the Coefficient TAU. In fact they are all zero, so that this equation simply says that pe(c) is equal to p0dom(c) for all commodities c.

Finally, in this chain of price connections, find the equation which “explains” p0dom. This is the simple equation E_p0dom which says

```
Equation E_p0dom  # Basic price of domestic goods = p0(c,"dom") #
 (all,c,COM) p0dom(c) = p0(c,"dom");
```

Hence you can see that

```
pe(“ClothingFtw”) = p0dom(“ClothingFtw”) = p0(“ClothingFtw”,”dom”)
```

Thus equation E_p4 can be rewritten as

```
(all,c,COM)  [V4PUR(c)+TINY]*p4(c) =
  [V4BAS(c)+V4TAX(c)]*[p0(c,”dom”)+ t4(c)]
   + sum{m,MAR, V4MAR(c,m)*[p0(m,”dom”)+a4mar(c,m)]};
```

which makes the expected connection between p4 and domestic prices, export taxes and margins clear.

Decompose the equation E_p4 (Intelligent decomposition). Complete the table below for ClothingFtw.

V4BAS	
V4MAR	
Total	

Thus the first term in the equation above is the main reason for the fall in p4 for ClothingFtw.

You know that the basic price of ClothingFtw has fallen and why (see section 3.5). Nothing has happened to export taxes t4 in this simulation so they are all zero. [You can check that by evaluating t4. A look at equation E_t4A will make it clear why t4 is zero here.]

Suppose for the minute that nothing much happens to the prices p0dom(m) of the margins commodities. [If you evaluate those, you will see that this is not a bad assumption.] Then, dividing the equation above by V4PUR+TINY and setting t4 and p0dom(m) to zero, the equation becomes

```
p4(c) = {[V4BAS(c)+V4TAX(c)]/[V4PUR(c)+TINY]}*p0(c,”com”)
```

You can find out about this share by glossing on V4PUR and going to the formula for V4PUR. [It is at about line number 193.] **Decompose the RHS** of this formula. For ClothingFtw you will see that the above share is equal to 0.92. Thus, approximately,

p4(“ClothingFtw”) = 0.92*p0(“ClothingFtw”,”dom”) = 0.92*(-1.42) = -1.31

which, if you evaluate the LHS, is a pretty good approximation to the result.

This explains why p4(“ClothingFtw”) falls and by how much.

Summary. The export price p4 for ClothingFtw falls because the basic price of domestically-produced ClothingFtw falls. How much p4 falls can be calculated from the fall in p0 and knowledge of the non-margins share in V4PUR.

3.7.2 Why exports of ClothingFtw increase and by how much

In section 3.7, you saw that

```
x4(“ClothingFtw”) = -10*p4(“ClothingFtw”)
```

(where the “-10” is the value of the elasticity EXP_ELAST).

In section 3.7.1 above, you explained why p4(“ClothingFtw”) fell and by how much.

Given that p4 falls by about –1.31%, it is clear that exports x4 must increase by about 10 times that, namely by about 13.1%. [The exact result is 13.16%.]

3.7.3 Tariff simulation Part 3

Please find the document for Part 3 in your folder.

In Part 3 of the ORANI-G tariff cut simulation, we will

- analyse a few results for the Textiles sector (section 4).
- next, examine why some other industries expanded (section 5).
- last, comment briefly on macro results (section 6).

Using AnalyseGE to examine an ORANI-G tariff cut simulation

Part 3

In Part 3 of the ORANI-G tariff cut simulation, we will

- analyse a few results for the Textiles sector (section 4).
- next, examine why some other industries expanded (section 5).
- last, comment briefly on macro results (section 6).

4 Why did Textiles output shrink?

This ends our analysis of ClothingFtw. Next we turn to the other industry which is most affected by the shock, namely Textiles. As you saw in section 1.1 above, the output of Textiles industry x1tot("Textiles") falls by 0.23%. Here you will explain this effect.

The reason for the fall in Textiles output is quite different to that for the fall in ClothingFtw output. In the case of ClothingFtw, output falls because households and firms substitute away from the domestic commodity to the imported commodity (as you saw in section 3.1 above). But there is no such substitution in the case of Textiles.

To check that, look at the x3("Textiles","dom") and x3("Textiles","imp") results.

The SalesDecomp variable breaks down the percent change in output between main sources of demand.

Find and evaluate SalesDecomp and fill in the table below:

SalesDecomp("textiles")	
Interm	
HouseH	
Export	
Total[15]	-0.28

You should see that although export and household demand contribute positively to demand, the overall output change is dominated by a large fall in intermediate demand.

Investigate further by looking at the values of the SALEMAT2 Coefficient, which shows the sales of each commodity. Here it is convenient to work with Basic values, so set the combo boxes to Textiles/Basic/All SRC/All SALECAT2.

Which category is the main user and what percent of use goes there?

Which firm uses most of Textiles and what percentage of intermediate usage does it take?
[Hint. Look at V1BAS and set combos to Textiles/dom/All IND. Take column shares.]

Thus 0.386*0.53 (about 20%) of total sales of Textiles goes to the ClothingFtw industry. The output of the ClothingFtw industry (x1tot) contracts by 3.5% (see section 3.4). The ClothingFtw industry uses a fixed share of composite Textiles (since top nest is Leontief – see equation E_x1).

[15] You will see that SalesDecomp adds up to commodity output x0dom, which (due to MAKE multiproduction) is not quite the same value as industry output, x1tot.

From this information, how much would you expect the fall of 3.5% in output of ClothingFtw to decrease the demand for Textiles?

In fact total demand for Textiles does not fall by as much since household demand is up by a little (0.08%) and exports are up significantly (1.2%) on a significant base. [Look at the x3 and x4 results. To see the export base, look at SALEMAT2 as above to see that 21.5% of Textiles is exported.]

You will see in section 4.1 below that the price of domestic Textiles falls.

Given this information about the price of domestic Textiles, which earlier section contains the argument which explains why exports of Textiles increase?

The FanDecomp variable breaks down the percent change in output between three main causes.

fanDecomp("textiles")		
LocalMarket	-0.70	change in non-export demand for textiles *domestic plus imported*
DomShare	0.15	change in dom/imp ratio for textile demand
Export	0.27	change in demand for textile exports
Total	-0.28	

The DomShare effect is positive because the domestic price of Textiles fell, so enabling import-substitution. The LocalMarket effect shows the effect of demand change *ignoring the just-mentioned price effect*, so that the LocalMarket fall is larger than the corresponding Interm and HouseH components in SalesDecomp. You can see, therefore, that the Textile price fall was quite important in moderating the fall in Textile demand.

4.1 Why did domestically-produced Textiles get cheaper?

What happens to the basic price p0(“Textiles”,”dom”) of domestic Textiles?

Why does the price of domestically-produced Textiles fall?

Your first guess may be that the Textiles industry uses significant amounts of the cheaper ClothingFtw imports.

What percentage of total intermediate usage by the Textiles comes from imported ClothngFtw?

So the Textiles industry using cheaper imports of ClothingFtw is not the reason.

You saw in section 4 above that demand for domestically-produced Textiles falls. Thus the price must also fall because of the upwardly sloping shortrun supply curve – see section 3.6.3 above.

5 Which industries gained, and why?

This completes our look at the Textiles industry. Now we turn to the results for the other industries. Table 1 below shows some of the main results for each sector, together with important features of each sector that might explain the results. You could gather all the numbers for such a table using AnalyseGE. Most of the numbers relate to commodities but the last two columns relate to industries. For all but the first 3 sectors, commodities and industries are nearly equivalent.

The first column shows x0com, output of commodities. Outside the TCF sectors, these are all positive, though gains in the bottom third of the table are small. The next 3 columns show how the x0com change may be split between 3 causes: overall increase in local demand (LocalMarket), replacement of imported by domestic goods (DomShare), and and increase in exports. Most of the x0com increases are due to the LocalMarket and Export effects; DomShare contributes little.

The next 3 columns report coefficient values. EXPSHR is the share of output which is exported; IMPSHR is the share of imports in the local market; and INDIVEXP has the value 1 if that commodity faces its own export demand curve. Where INDIVEXP=0, commodity exports share a common export demand curve (ie, they all move together).

The first industry column, p1var, shows the change in short-run variable costs (which exclude rents to capital and land). These are all negative, with a tendency to larger falls at the bottom of the table. Last are the industry short-run supply elasticities.

Different sectoral characteristics and input-output linkages between sectors lead to a complicated pattern of sectoral results. Neverthess, there *is* a pattern, as follows.

The industries may be divided into 2 main groups: *traded* and *non-traded*. Traded industries are those which have a larger export share [EXPSHR] or face significant import competion [IMPSHR]. In Table 1, most of the exporters are in the top 2/3 of the Table, whilst import-competition is concentrated in the middle 1/3. These traded sectors tend to expand. The last third of the industries are basically non-traded and sell mainly to final demand; their output changes little.

In this simulation, the main components of absorption (household, government, investment) are fixed, so the main opportunities for expansion are to increase exports, to replace imports, or to sell more to other industries. To achieve either of the first two (increase exports, replace imports) it is necessary to reduce output prices. This is possible because of the generalized fall in input costs (p1var). The effect of the general cost reduction appears in Figure 1 below as downward shift in all industry supply curves.

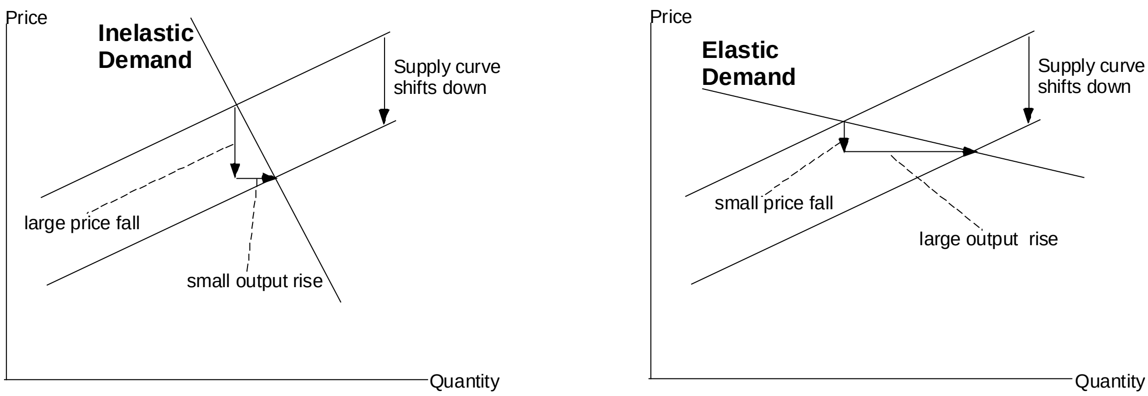


Figure 1. Effects of reduced input costs

Non-traded industries, which face inelastic demand, tend to pass on cost decreases to their customers. Export-oriented industries expand their output instead. Sectors facing significant import competition also expand. The effect of demand elasticity is shown in the two panes of Figure 1, representing two different sectors. The supply schedule of each sectors shifts down, representing the effect of decreased input costs. In the left-hand pane, depicting a non-traded sector, inelastic demand allows the cost increase to be passed on without much output drop. The right-hand pane depicts a trade-exposed sector. There, elastic demand causes output to rise more, and price to fall less, than in the left-hand pane.

In summary, most output expansion is caused by increased exports, driven by lower costs. Some sectors expand by selling more to exporting sectors: for example, BeefCattle is drawn along by rising exports of MeatDairy; or BasicMetals sells more to other manufacturing industries.

Table 1: Summary of sectoral outputs and characteristics

	Output	Fan decomposition			Coefficients				Variable cost	
Commodity	x0com	Local Market	Dom Share	Export	EXPSHR	IMPSHR	INDIV EXP	Industry	p1var	SUPPLY ELAST
WoolMutton	0.00	-0.05	0.00	0.05	0.58	0.00	1.00			
GrainsHay	0.03	0.04	0.00	-0.01	0.44	0.01	1.00			
BeefCattle	0.07	0.05	0.00	0.02	0.03	0.00	0.00	BroadAcre	-0.06	0.21
OtherAgric	0.04	0.03	0.00	0.01	0.10	0.04	1.00	OtherAgric	-0.08	0.35
ForestFish	0.11	0.02	0.00	0.09	0.13	0.03	1.00	ForestFish	-0.10	2.19
Mining	0.05	0.03	0.00	0.02	0.56	0.20	1.00	Mining	-0.10	0.29
MeatDairy	0.05	-0.03	0.00	0.09	0.34	0.02	1.00	MeatDairy	-0.02	3.81
OthFoodProds	0.11	0.00	0.00	0.10	0.21	0.14	1.00	OthFoodProds	-0.08	2.00
DrinksSmokes	0.06	-0.01	0.00	0.07	0.08	0.10	0.00	DrinksSmokes	-0.08	1.04
Textiles	-0.28	-0.70	0.15	0.27	0.22	0.41	1.00	Textiles	-0.12	2.18
ClothingFtw	-3.52	0.15	-5.37	1.70	0.13	0.39	1.00	ClothingFtw	-0.54	4.02
WoodProds	0.13	0.04	0.01	0.08	0.09	0.18	0.00	WoodProds	-0.10	3.13
PaperPrint	0.06	0.02	0.02	0.02	0.03	0.18	0.00	PaperPrint	-0.11	1.45
Petrol_CoalP	0.06	0.01	-0.01	0.06	0.08	0.15	0.00	Petrol_CoalP	-0.01	0.31
Chemicals	0.09	0.02	0.01	0.06	0.14	0.38	1.00	Chemicals	-0.08	1.46
RubberPlastc	0.09	0.03	0.03	0.04	0.04	0.32	0.00	RubberPlastc	-0.10	2.00
NonMetlMinrl	0.05	0.02	0.01	0.02	0.03	0.13	0.00	NonMetlMinrl	-0.09	1.43
BasicMetals	0.13	0.06	0.00	0.06	0.39	0.14	1.00	BasicMetals	-0.06	1.87
FabMetalPrd	0.10	0.04	0.02	0.04	0.04	0.15	0.00	FabMetalPrd	-0.12	2.79
TransportEqp	0.13	0.02	0.05	0.05	0.11	0.41	1.00	TransportEqp	-0.09	1.95
OthMachnEqp	0.12	0.01	0.01	0.10	0.19	0.62	1.00	OthMachnEqp	-0.09	1.68
MiscManuf	0.09	-0.01	0.03	0.08	0.09	0.25	0.00	MiscManuf	-0.14	2.98
ElecGasWater	0.01	0.01	0.00	0.00	0.00	0.00	0.00	ElecGasWater	-0.11	0.23
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Construction	-0.12	1.08
Trade	0.06	0.06	0.00	0.00	0.00	0.00	0.00	Trade	-0.15	1.42
Repairs	0.02	0.02	0.00	0.00	0.00	0.00	0.00	Repairs	-0.13	0.59
Hotel_Cafe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Hotel_Cafe	-0.14	2.81
Transport	0.07	0.01	0.00	0.06	0.16	0.12	1.00	Transport	-0.10	0.74
CommunicSrvc	0.05	0.01	0.00	0.04	0.05	0.06	0.00	CommunicSrvc	-0.13	0.61
FinanceInsur	0.03	0.01	0.00	0.01	0.02	0.02	0.00	FinanceInsur	-0.17	0.68
OwnerDwellng	0.00	0.00	0.00	0.00	0.00	0.00	0.00	OwnerDwellng	-0.12	0.00
PropBusSrvc	0.05	0.03	0.00	0.02	0.03	0.03	0.00	PropBusSrvc	-0.15	1.43
GovAdminDfnc	0.01	0.00	0.00	0.00	0.00	0.00	0.00	GovAdminDfnc	-0.16	11.94
Education	0.04	0.00	0.00	0.04	0.04	0.01	0.00	Education	-0.20	7.19
HealthCommun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	HealthCommun	-0.18	3.73
CultuRecreat	0.01	0.00	0.00	0.00	0.00	0.01	0.00	CultuRecreat	-0.14	1.63
OtherService	0.00	0.01	0.00	0.00	0.00	0.16	0.00	OtherService	-0.16	5.00

Questions:

Why did Hotel_Cafe output not increase?

Why did OwnerDwellng output not increase?

Why is the LocalMarket component of DrinksSmokes and MeatDairy negative?

5.1 Why did industry costs decrease?

We saw above that reduced input costs were responsible for expansion in non-TCF sectors. Where did this cost reduction come from? Since ClothingFtw sells mainly to households it is not obvious how cheaper shoes will reduce other sectors' costs.

The chief mechanism by which cheaper TCF (both domestic and imported) leads to cost reductions elsewhere is via the assumption that wages for all sectors are indexed to the CPI. This works as follows:

(a) Cheaper TCF reduces the CPI directly; we call this the *impact effect*.

(b) Wages everywhere go down with the CPI.

(c) Reduced wages reduce costs (and output prices) for all the other sectors.

(d) Generalized reduction in output prices further reduces both the CPI and all sectors input costs: we call this the *second-round effect*.

(e) The further reduction in the CPI reduces all wages........go back to (c).

The general equilibrium effect will be produced by an endless repetition of steps (c) to (e).

To measure the impact effect of cheaper TCF on the CPI, find the appropriate equation:

```
E_p3tot # Consumer price index #
  p3tot = sum{c,COM, sum{s,SRC, [V3PUR(c,s)/V3TOT]*p3(c,s)}};
```

What is the value of p3tot?

Next select and **Evaluate** the phrase above "[V3PUR(c,s)/V3TOT]*p3(c,s)" to see the contributions of each commodity (dom and imp) to the CPI change.

What is the total contribution to the final change in p3tot from Textiles and ClothingFtw, domestic and imported (add 4 numbers together)?

You should see that the direct or impact effect of cheaper TCF is responsible for just over half the CPI change.

Assertion: The remaining drop in the CPI is due to second-round effects [steps (c) to (e) above].

How can we test the assertion above? One way would be to reason as follows. A 1% direct reduction in the CPI will reduces wages 1%. Let S be the share of wages in GDP. The 1% wage reduction will cause costs generally *and the CPI* to fall by S%. So CPI and wages fall by another S%. This in turn reduces costs by S^2%, and so on. The total eventual reduction in the CPI would be:

$$1 + S + S^2 + S^3 + \text{........} = T\%$$

We can add up the infinite series by noting:

$$ST = S + S^2 + S^3 + S^4 + \text{....} = T - 1$$

So $T = 1/[1-S]$

Find and evaluate the coefficient INCGDP. What is the share of wages in GDP, S?

So what is T?

You should find that the total effect T is just under double the initial 1% CPI rise. This means that indirect or second-round CPI falls will be slightly less than half the impact effect—which agrees with the assertion above.

A second approach would be to use the model to estimate the second round effects of wage indexation. In a later session you will use the model to simulate the effects of a wage cut. The results will show that a nominal wage cut of 8.2 % is associated with a CPI fall of 3.2 %: the CPI fall is 0.39 times the wage fall. With indexation in place, the CPI drop would cause a further 3.2% fall in wages leading to another 0.39*3.2% drop in the CPI, ... and so on. Since 1/[1-0.39] = 1.64, we can deduce that a tariff cut which directly caused a 1% reduction in the CPI, would indirectly cause (via wage indexation and input-output linkages) an eventual 1.64% reduction in the CPI. Again the total effect is nearly double the impact effect, consistent with the assertion above.

Summary: the benefits of the tariff cut arise mainly[16] from the effect of the tariff cut on the CPI, and on the link between the CPI and wages. If we dropped the wage indexation assumption, or we reduced tariffs on goods sold mainly to some other final demander (say, investment) we would not expect to see expansion in the other sectors.

Our argument, that lower wages are the main cause of non-TCF expansion seems to explain why p1var fell more for the nontraded industries at the bottom of Table 1: for these industries labour accounts for a larger share of costs.

Find and evaluate the coefficient COSTMAT (use *row shares* in ViewHAR). Are the nontraded industries really more labour-intensive?

But is labour-intensity the whole story? Find the equation for p1var:

```
Equation E_p1var  # Short-run variable cost price index #
 (all,i,IND)
  p1var(i) = [1/V1VAR(i)]*[V1MAT(i)*p1mat(i) + V1LAB_O(i)*p1lab_o(i)];
```

and evaluate the materials cost index p1mat. You should see that it also falls more for the non-traded industries.

Decompose the RHS of equation E_p1var to find out whether wages (p1lab_o) or materials (p1mat) make the bigger contribution to reduced input costs for non-traded sectors? for traded sectors?

[16] A small amount of ClothingFtw is sold directly to other industries, so providing another route for cheaper ClothingFtw to benefit other sectors.

6 Macro results

We will not analyse macro results at length here, since results analysis from the macro point of view is the focus of a later exercise: analysis of a wage-cut simulation. Nevertheless, AnalyseGE can make a useful contribution.

What happened to real GDP?

Which expenditure aggregates contributed to this change?

Exports

Imports

Now find equation E_x0gdpinc and decompose the RHS by variable

How much did employment and taxes respectively contribute to real income-side GDP?

employment contributed:

taxes contributed:

of taxes, tariffs contributed:

You should see that 2/3 of the increase comes from the employment gain[17], and most of the remainder from the tariff revenue contribution. The tariff term is a rough[18] measure of the allocative gain from the tariff reduction—the source of welfare gain in formal trade theory. Against this we must posit the welfare loss arising from terms-of-trade deterioration, in this case arising only from the reduced prices paid for Australian exports.

To find the terms-of-trade loss as a percent contribution to GDP, **Bring AnalayseGE to Front**, clear the expression box, type in "`V4TOT*p4tot/V0GDPEXP;`" (don't forget semicolon) and press the **Evaluate** button.

What is the terms-of-trade loss as a percent contribution to GDP?

How does the terms-of-trade loss compare with the allocative efficiency gain?

6.1.1 Sector-specific shocks have tiny macro effects

Sometimes it is embarasssing to report the tiny GDP % effects that result from shocks to one small sector. To avoid this, you can report results, not in per cent terms, but in base-period-dollars-worth. For example, **Bring AnalayseGE to Front**, clear the expression box, and type in:

```
0.01*sum{i,ind:employ(i)<0, employ(i)*V1LAB_O(i) };
```

Then press the **Evaluate** button.

This gives the value[19] of employment losses. What is it?

Use a similar method to find value of employment gains. What is it?

---

[17] According to economists, this is not a real welfare gain, since it requires extra work: always a curse.

[18] The true "Harberger triangle" is actually just half the expression calculated by AnalyseGE. The problem is that AnalyseGE is using the initial tariff level to calculate allocative gain; it should be using a level between the larger initial and the smaller final. See Appendix 1.

[19] It gives the value in base-period-currency units. The initial data is measured in million 93-4 dollars.

7 What if we did not use Johansen's method?

The simulation described above used Johansen's method [specified in TARFCUT.CMF]. This computes a first-order linear approximation to the true model solution. An advantage [from the point of view of AnalyseGE] is that the linear equations in the TAB file are satisfied accurately by the [approximate] variable solution values.

Change the solution method in TARFCUT.CMF to Gragg 2,4,6 steps, save the modified file as TARFCUTG.CMF and rerun the sim. Repeat the analysis above. You will see that, though the linear equations are not satisfied exactly (as they were above), they are still very close to being satisfied, and the analysis can proceed essentially as in the Johansen case.

Section 11 (Appendix 1) explains why you should not expect the linearised equations to be satisfied exactly by an accurate solution (for example, one obtained with Gragg 2,4,6 steps).

8 Other features of AnalyseGE

Although we have illustrated AnalyseGE with the ORANI-G model, the software is completely general-purpose. It can be used to assist with the analysis of any simulation carried out using Release 7.0 (or later) of GEMPACK.

AnalyseGE is fully documented via the Help file which accompanies it. You can find details there about several features we have introduced only briefly in this paper.

The main function of AnalyseGE is to assist with calculations involving data and/or simulation results. The main way of doing such calculations is via the TABmate form, as has been illustrated in the sections above.

Sometimes you may want to carry out calculations which cannot be initiated from the TABmate form, and sometimes the calculations initiated from the TABmate form turn out to be not quite what you want. In such cases it is possible to enter the formulas you want in the memo on the AnalyseGE form. The syntax is very similar to that in TABLO Input files (though AnalyseGE often allows you to omit quantifiers). Full details of this way of initiating calculations can be found in the Help file supplied with AnalyseGE. [Note that when AnalyseGE carries out a calculation initiated from the TABmate form, the corresponding formulas etc are always visible in the memo on the AnalyseGE form after the calculation has been completed. You can look here to check exactly what was calculated, and also to get a good idea as to the sorts of formulas etc that can be entered into that memo.]

The **View** menu on the AnalyseGE form is often useful. This lets you view

- the Command file used for the simulation. This contains the full instructions for the simulation, including the closure and shocks.
- the Sets, Subsets, Variables and Coefficients in the model.
- the Stored-input file used to condense the model when running TABLO (if condensation was carried out).

In fact Release 7.0 (or later) of GEMPACK stores the Command file, the TABLO file (which you see in the TABmate window) and the Stored-input file used to run TABLO on the Solution file. AnalyseGE recovers them from there.

When a TABLO-generated program or GEMSIM from Release 7.0 of GEMPACK carry out a simulation, they create a so-called **SLC file** as well as the usual Solution file. This SLC (Solution Coefficient values file) contains the pre-simulation values of all Coefficients from the TABLO Input file. In particular this contains essentially a copy of the pre-simulation data read (as well as the values of Coefficients whose values are obtained from this pre-simulation data via formulas).

Together the Solution and SLC files provide a very strong audit trail for the simulation. They contain the TABLO Input file for the model, the Command file, the Stored-input file used to run TABLO, and all the pre-simulation data.

This paper has introduced AnalyseGE in the context of a simulation with ORANI-G. You can also find a hands-on introduction to AnalyseGE in the context of a simulation with GTAP (Hertel, 1997) in Pearson *et al* (2002).

9 Installing AnalyseGE on your computer

The AnalyseGE files (including the Solution files for the application described in this paper) can be downloaded from the Web from address

http://www.copsmodels.com/gpange.htm

Follow the instructions there to install AnalyseGE on your computer.

Note that you will not be able to use AnalyseGE to assist in the analysis of your own applications unless you have Release 7.0 (or later) of GEMPACK installed, since AnalyseGE can only be used with Solution files produced by this release (or later releases) of GEMPACK.

10 Conclusion

In this paper we have introduced the capabilities of AnalyseGE.

You can use AnalyseGE to calculate any formula involving simulation results, pre-simulation data and Coefficients of the model. The main way of initiating such calculations is via the TABmate form, however you can also use the memo on the AnalyseGE form (see section 8).

As outlined in section 8, the Solution and SLC files form a strong audit trail for any simulation.

We hope that this software is able to assist modellers analyse their simulation results. For experienced modellers, we hope that it will make them more efficient in their analysis of GE simulations – thereby enabling them to delve more deeply into the mechanisms underlying the results. For non-modellers, we hope that, by making such analysis easy and rewarding, economists will be increasingly drawn back to the fundamental equations of the model, thereby discouraging "confabulation" and encouraging sound analysis.

11 Appendix 1 : Why linearized equations are not satisfied exactly

The linearized equations of the model are not always satisfied exactly when you look at them using AnalyseGE. We explain why in detail in this appendix. This is a more technical section and some readers may prefer to skip it.

In the Johansen (one-step) simulation TARFCUT.SL4, the equations are all satisfied exactly. However here the solution is only an approximate solution of the non-linear equations in the ORANI-G model.

If you carry out a multi-step solution as in TARFCUTG.SL4 as described in section 7 where Gragg's method is used and there is a 2, 4, 6 step solution followed by extrapolation, you will find that the linearized equations are not satisfied exactly. However, the resulting solution satisfies the non-linear equations much better than the simple one-step solution TARFCUT.SL4.

11.1 Linearization of a product

Some equations are obtained by linearizing a levels equation which contains a product. An example is the equation E_x3lux

```
Equation  E_x3lux # Luxury demand for composite commodities #
  (all,c,COM) x3lux(c) + p3_s(c) = w3lux + a3lux(c);
```

In the levels this can be written

X3LUX_L(c) * P3_S_L(c) = W3LUX_L* A3LUX_L(c);

Open TARFCUTG.SL4 in AnalyseGE and search for the Equation E_x3lux. Right click on this equation and select Decompose Part of this Equation. Select Whole Equation and click OK. Look at the results for the ClothingFtw commodity.

x3lux	= 2.337862	
p3_s	= -2.451745	
w3lux	= 0.171201	This is actually (– w3lux)
a3lux	= 0	
Total	= 0.057318	

The Total shows the difference between the LHS of the equation and the RHS. You can see that the linearized equation is not satisfied exactly.

Suppose, for simplicity, that all the levels values are 1, then, in the levels, after the simulation (for ClothingFtw):

X3LUX_L = 1 + 2.337862/100 = 1.02337862 P3_S_L = 1 - 2.451745/100 = 0.97548255

W3LUX_L = 1 - 0.171201/100 = 0.99828799 A3LUX_L = 1.0

X3LUX_L * P3_S_L = 0.99828799

W3LUX_L * A3LUX_L = 0.99828799

So that **post-simulation,** the levels equation is satisfied exactly.

The exact equation is in terms of the percentage changes in the levels values:

(1 + x3lux/100) (1 + p3_s/100)	= (1 + w3lux/100)(1 + a3lux/100)	Exact
x3lux + p3_s + x3lux*p3_s/100	= w3lux + a3lux + w3lux*a3lux/100	Exact
x3lux + p3_s	= w3lux + a3lux	Linearized

You do not want to satisfy the linearized equations in the final solution because what you are trying to satisfy is the (exact) non-linear equations (and you can't have it both ways).

11.2 Shares vary

Other equations in the TABLO Input file contain shares (or other Coefficients). Typically the values of these shares or coefficients change between the pre-simulation data base and the post-simulation one. An example is the equation E_prim which we looked at in section 2.9.2 above.

```
E_p1prim   # Effective price term for factor demand equations #
 (all,i,IND) V1PRIM(i)*p1prim(i) = V1LAB_O(i)*p1lab_o(i)+V1CAP(i)*p1cap(i);
```

which we saw was

x1prim = SL.x1lab_o + SK.x1cap

where SL and SK are shares of labour and capital in factor costs.

Evaluate the LHS and the RHS of the equation E_p1prim for "ClothingFtw" using AnalyseGE

LHS = -4383.334

RHS = -217.511 - 4094.278   = -4311.789

There are two reasons for this difference. Firstly the shares SL and SK vary across the simulation. Secondly, the linearized equation is only an approximate version of the underlying levels equation for the price part of this CES nest.

Note that the linearized equation would not be satisfied exactly if we used post-simulation values for the shares or even an average of pre- and post-simulation values (though the discrepancy would be less in the latter case).

11.3 General comments

You should not expect the linearized equations to be satisfied exactly when looked at in AnalyseGE. Normally you can expect them to be satisfied sufficiently well that the values obtained via AnalyseGE are useful in explaining simulation results.

You may be puzzled as to how GEMPACK is able to obtain arbitrarily accurate solutions of the underlying levels equations of the model even though it seems only to use the linearized equations. The answer is partly that the update statements in the TABLO Input file ensure that each time a small part of the shock is applied, the data values and shares are recalculated. A more detailed intuitive explanation can be found in section 3.12 of the GEMPACK manual, *How Johansen and multi-step solutions are calculated.* A more technical and complete explanation can be found in Pearson (1991).

12 References

Harrison, W.J. and K.R. Pearson (1996), 'Computing Solutions for Large General Equilibrium Models Using GEMPACK', Computational Economics, vol. 9, pp.83-127. [A preliminary version was Impact Preliminary Working Paper No. IP-64, (June 1994), pp.55.]

Hertel, Thomas W. (ed) (1997), *Global Trade Analysis: Modeling and Applications*, Cambridge University Press.

Horridge, J.M.(2003), *ORANI-G: A Generic Single-Country Computable General Equilibrium Model,* downloadable from www.copsmodels.com/oranig.htm.

Pearson K.R. (1991), 'Solving Nonlinear Economic Models Accurately via a Linear Representation', *Impact Preliminary Working Paper* No. IP-55, Melbourne (July), pp.39.

Tarfsim.ppt 1

Tariff Simulation

with AnalyseGE

2

The old way of examining results

ViewSOL

- can compare several simulation results
- can view all results for a particular sector, or all macros
- quick

paired with ViewHAR

- to examine original data file
- to examine SUMMARY file

3

AnalyseGE

- **shows variable values AND coefficient values, in the context of equations**
- **shows ALL coefficient values not just those in input or SUMMARY files,**
- **can show contributions to changes in LHS variables**

$$Y = F(A,B,C)$$

$$\Delta Y = F_A \Delta A + F_B \Delta B + F_C \Delta C$$

$$y = S_A a + \underline{S_B b} + S_C c$$

contribution of b
to percent change y

4

Tariff Cut

- **Reduced price of imported ClothingFtw**
- **Purchaser's price ClothingFtw only fell half as much as basic imported price -- reason is margins**
- **Import price drop caused Households (main user) to substitute from domestic ClothingFtw**
- **Output domestic ClothingFtw fell, so ....**
- **Price domestic ClothingFtw fell also [short-run supply schedule is upward sloping], implying**
- **Sharp fall in p1cap ClothingFtw [residual]**
- **Reduced price domestic ClothingFtw allowed exports to rise**

5

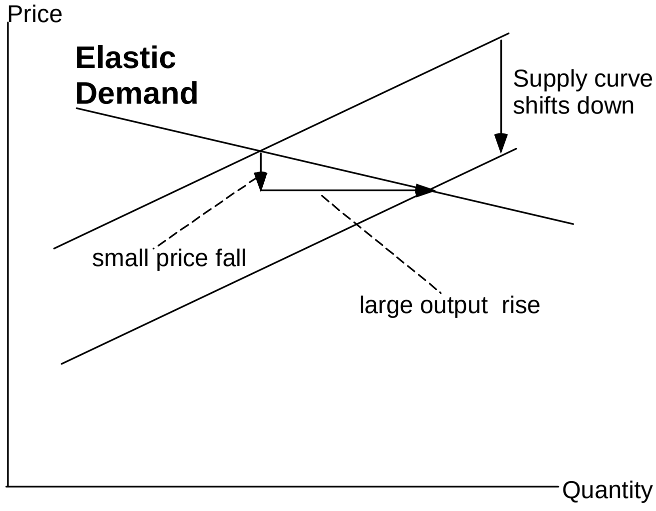
Textiles

- Major customer is ClothingFtw
- Output domestic ClothingFtw fell, so ....
- Demand for Textiles fell

6

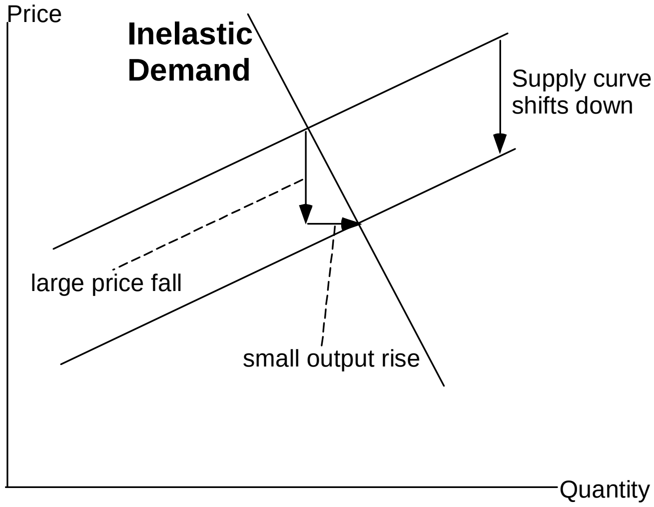
Other Sectors

- A general fall in the price level reduces input costs
- Exporters and import-competers expand output



Other Sectors

- A general fall in the price level reduces input costs
- Non-Traded sectors pass on the savings



Why the generalized price fall?

A circle [spiral] of price reductions:

- Cheaper imported & domestic ClothingFtw reduce CPI
- CPI down so wages down
- Wage reduction reduces costs to all sectors
- So all prices down
- So CPI down...so wages down

Macro results

Expendituture side GDP

- **with C, I, G fixed gain came from trade balance**
  - **Exports up, imports down**
- **Real devaluation**

Income side GDP

- **most gain came from employment expansion**
- **but a little came from "allocative" gain**

Terms of trade loss was similar to "allocative" gain

END

! ClothingFtw tariff cut: DPSV shortrun closure

Macro	Variables	
capslack		Slack variable to allow fixing aggregate capital
contBOT	0.0331	Contribution of BOT to real expenditure-side GDP (change)
delB	0.0002	(Nominal balance of trade)/{nominal GDP} (change)
delV0tar_c	-223.48	Aggregate tariff revenue (change)
delV0tax_csi	-257.60	Aggregate revenue from all indirect taxes (change)
delV1PTX_i		Ordinary change in all-industry production tax revenue (change)
delV1tax_csi	5.92	Aggregate revenue from indirect taxes on intermediate (change)
delV2tax_csi	-0.62	Aggregate revenue from indirect taxes on investment (change)
delV3tax_cs	-10.05	Aggregate revenue from indirect taxes on households (change)
delV4tax_c	3.98	Aggregate revenue from indirect taxes on export (change)
delV5tax_cs		Aggregate revenue from indirect taxes on government (change)
employ_i	0.0492	Aggregate employment: wage bill weights
f1lab_io		Overall wage shifter
f1tax_csi		Uniform % change in powers of taxes on intermediate usa ..
f2tax_csi		Uniform % change in powers of taxes on investment
f2tot		Ratio, investment/consumption
f3tax_cs		Uniform % change in powers of taxes on household usage
f3tot	-0.0570	Ratio, consumption/ GDP
f4p_ntrad		Upward demand shift, collective export aggregate
f4q_ntrad		Right demand shift, collective export aggregate
f4tax_ntrad		Uniform % change in powers of taxes on nontradtnl exp ..
f4tax_trad		Uniform % change in powers of taxes on tradtnl exports
f5tax_cs		Uniform % change in powers of taxes on government usage
f5tot		Overall shift term for government demands
f5tot2		Ratio between f5tot and x3tot
invslack	0.2195	Investment slack variable for exogenizing aggregate inve ..
p0cif_c		Imports price index, C.I.F., local currency
p0gdpexp	-0.1902	GDP price index, expenditure side
p0gne	-0.1805	GNE price index
p0imp_c	-0.3256	Duty-paid imports price index, local currency
p0realdev	0.1902	Real devaluation
p0toft	-0.0463	Terms of trade
p1cap_i	-0.0542	Average capital rental
p1lab_io	-0.2141	Average nominal wage
p1lnd_i	0.1804	Average land rental
p1prim_i	-0.1350	Index of factor cost
p2tot_i	-0.0982	Aggregate investment price index
p3tot	-0.2141	Consumer price index
p4_ntrad	-0.0824	Price, collective export aggregate
p4tot	-0.0463	Exports price index, local currency
p5tot	-0.1661	Government price index
p6tot	-0.2655	Inventories price index
phi		Exchange rate, local currency/$world
q		Number of households
realwage		Average real wage
utility	0.0000	Utility per household
w0cif_c	0.2180	C.I.F. local currency value of imports
w0gdpexp	-0.1571	Nominal GDP from expenditure side
w0gdpinc	-0.1571	Nominal GDP from income side
w0gne	-0.1805	Nominal GNE
w0imp_c	-0.0679	Value of imports plus duty
w0tax_csi	-0.5203	Aggregate revenue from all indirect taxes
w1cap_i	-0.0542	Aggregate payments to capital
w1lab_io	-0.1649	Aggregate payments to labour
w1lnd_i	0.1804	Aggregate payments to land
w1oct_i	-0.1818	Aggregate "other cost" ticket payments
w1prim_i	-0.1096	Aggregate primary factor payments
w2tot_i	-0.0982	Aggregate nominal investment
w3lux	-0.1673	Total nominal supernumerary household expenditure

contGDPExp	
Consumpti	
Investmen	
Governme	
Stocks	
Exports	0.0726
Imports	-0.0395

contGDPinc	
Land	
Labour	0.0224
Capital	
IndTax	0.0106
TechChan	

w3tot	-0.2141	Nominal total household consumption
w4tot	0.3780	Local currency border value of exports
w5tot	-0.1661	Aggregate nominal value of government demands
w6tot	-0.2655	Aggregate nominal value of inventories
x0cif_c	0.2180	Import volume index, C.I.F. weights
x0gdpexp	0.0331	Real GDP from expenditure side
x0gdpinc	0.0331	Decomposition of real GDP from income side
x0gne		Real GNE
x0imp_c	0.2577	Import volume index, duty-paid weights
x1cap_i		Aggregate capital stock, rental weights
x1lnd_i		Aggregate land stock, rental weights
x1prim_i	0.0254	Aggregate effective primary factor use
x2tot_i		Aggregate real investment expenditure
x3tot		Real household consumption
x4_ntrad	0.8237	Quantity, collective export aggregate
x4tot	0.4243	Export volume index
x5tot		Aggregate real government demands
x6tot		Aggregate real inventories
x0gdpfac	0.0254	Real GDP at factor cost (inputs) = x1prim_i

9 COM variables

	p0dom	p3_s	p4	x0com	x0dom	x0imp	x0loc	x3_s	x4
WoolMutton	-0.0375	-0.0377	-0.0496	-0.0040	-0.1200		-0.1200	-0.0568	0.0789
GrainsHay	0.0299	-0.0127	0.0018	0.0297	0.0673	0.0989	0.0676	-0.0677	-0.0181
BeefCattle	0.1168	0.1006	0.1016	0.0732	0.0519	0.2612	0.0520	-0.1173	0.8237
OtherAgric	-0.0018	-0.0459	-0.0146	0.0447	0.0336	0.0062	0.0325	-0.0269	0.1460
ForestFish	-0.0668	-0.0705	-0.0683	0.1114	0.0264	-0.0984	0.0231	-0.0424	0.6833
Mining	0.0027	-0.0027	-0.0030	0.0450	0.0660	0.0566	0.0641	-0.0721	0.0283
MeatDairy	-0.0211	-0.0478	-0.0258	0.0545	-0.0521	-0.0648	-0.0524	-0.0262	0.2579
OthFoodPro	-0.0467	-0.0613	-0.0528	0.1053	0.0066	-0.0293	0.0015	-0.0249	0.4849
DrinksSmoke	-0.0544	-0.0790	-0.0596	0.0571	-0.0107	-0.0636	-0.0159	-0.0218	0.8237
Textiles	-0.2404	-0.1346	-0.2152	-0.2804	-0.7003	-1.1694	-0.8949	-0.0143	1.2506
ClothingFtw	-1.4166	-2.3777	-1.3158	-3.5155	-5.9966	9.6823	0.1779	0.5519	13.1584
WoodProds	-0.0694	-0.0573	-0.0736	0.1342	0.0636	-0.0234	0.0476	-0.0602	0.8237
PaperPrint	-0.0917	-0.0878	-0.0940	0.0623	0.0408	-0.0768	0.0192	-0.0435	0.8237
Petrol_CoalF	0.1544	0.0832	0.1155	0.0635	-0.0011	0.0663	0.0093	-0.1371	0.8237
Chemicals	-0.0338	-0.0799	-0.0427	0.0937	0.0387	-0.0051	0.0223	-0.0479	0.4273
RubberPlast	-0.0686	-0.0770	-0.0766	0.0937	0.0612	-0.0487	0.0262	-0.0495	0.8237
NonMetlMinr	-0.0776	-0.0864	-0.0812	0.0494	0.0270	-0.0176	0.0211	-0.0443	0.8237
BasicMetals	-0.0161	-0.0566	-0.0184	0.1269	0.1091	0.0800	0.1051	-0.0606	0.1546
FabMetalPrd	-0.0982	-0.0886	-0.0984	0.1007	0.0680	-0.0775	0.0463	-0.0431	0.8237
TransportEq	-0.0394	-0.0648	-0.0481	0.1271	0.0841	-0.0581	0.0260	-0.0729	0.4809
OthMachnEc	-0.0361	-0.0524	-0.0526	0.1242	0.0300	0.0062	0.0153	-0.0818	0.5256
MiscManuf	-0.1159	-0.0981	-0.1155	0.0936	0.0195	-0.1198	-0.0159	-0.0379	0.8237
ElecGasWat	-0.1046	-0.1046	-0.1046	0.0144	0.0132	0.0152	0.0132	-0.0344	0.8237
Construction	-0.1457		-0.1457	-0.0031	-0.0034	0.0109	-0.0034	-0.0916	0.8237
Trade	-0.1174			0.0643	0.0643	0.0562	0.0643	-0.0916	0.8237
Repairs	-0.1373	-0.1373	-0.1373	0.0175	0.0156	0.0498	0.0156	-0.0164	0.8237
Hotel_Cafe	-0.1513	-0.1508		-0.0022	-0.0022	0.0083	-0.0022	-0.0090	0.8237
Transport	-0.0372	-0.0295	-0.0372	0.0742	0.0158	-0.0225	0.0113	-0.1100	0.3719
CommunicSr	-0.0863	-0.0812	-0.0863	0.0476	0.0093	0.0147	0.0096	-0.0471	0.8237
FinanceInsur	-0.1504	-0.1491	-0.1504	0.0280	0.0136	0.0276	0.0139	-0.0100	0.8237
OwnerDwellr	-0.1673	-0.1673		0.0000	0.0000		0.0000	0.0000	0.8237
PropBusSrvc	-0.1305	-0.1292	-0.1305	0.0516	0.0309	0.0352	0.0310	-0.0208	0.8237
GovAdminDf	-0.1616	-0.1616	-0.1616	0.0068	0.0032		0.0032	-0.0031	0.8237
Education	-0.1981	-0.1899	-0.1981	0.0392	0.0033	0.0132	0.0034	0.0124	0.8237
HealthComm	-0.1854	-0.1850	-0.1854	0.0042	0.0033	0.0141	0.0034	0.0097	0.8237
CultuRecrea	-0.1540	-0.1522	-0.1539	0.0076	0.0043	0.0014	0.0042	-0.0083	0.8237
OtherService	-0.1668	-0.1660	-0.1668	0.0027	0.0021	0.0270	0.0060	-0.0007	0.8237

9 IND variables

	employ	gret	p1cap	p1mat	p1prim	p1tot	p2tot	x1tot	x2tot
BroadAcre	0.2140	0.2904	0.2138	-0.0383	0.1406	0.0436	-0.0766	0.0366	0.1192
OtherAgric	0.1756	0.1997	0.1371	-0.0422	0.0476	-0.0018	-0.0626	0.0447	0.0594
ForestFish	0.1806	0.1932	0.1470	-0.0533	-0.0763	-0.0668	-0.0462	0.1117	0.0551
Mining	0.1756	0.2147	0.1370	-0.0601	0.0479	0.0013	-0.0777	0.0445	0.0693
MeatDairy	0.0911	0.0356	-0.0319	0.0115	-0.1410	-0.0217	-0.0675	0.0545	-0.0490
OthFoodPro	0.1966	0.2504	0.1791	-0.0510	-0.0312	-0.0473	-0.0714	0.1051	0.0928
DrinksSmoke	0.1492	0.1572	0.0842	-0.0636	-0.0291	-0.0550	-0.0730	0.0567	0.0313
Textiles	-0.4130	-0.9724	-1.0401	-0.0974	-0.5747	-0.2402	-0.0677	-0.2327	-0.7142
ClothingFtw	-4.9800	-10.1023	-10.1742	-0.6395	-3.1554	-1.3819	-0.0719	-3.5094	-6.7400
WoodProds	0.2035	0.2649	0.1929	-0.0645	-0.0762	-0.0699	-0.0721	0.1345	0.1024
PaperPrint	0.1146	0.0768	0.0151	-0.0749	-0.1096	-0.0920	-0.0618	0.0623	-0.0217
Petrol_CoalP	0.5164	0.8731	0.8186	-0.0002	0.6942	0.1519	-0.0545	0.0622	0.5038
Chemicals	0.2029	0.2621	0.1917	-0.0499	0.0049	-0.0348	-0.0704	0.0934	0.1005
RubberPlast	0.1605	0.1642	0.1069	-0.0613	-0.0799	-0.0702	-0.0573	0.0934	0.0359
NonMetlMinr	0.0987	0.0485	-0.0168	-0.0533	-0.1149	-0.0779	-0.0653	0.0491	-0.0404
BasicMetals	0.2568	0.3607	0.2994	-0.0332	0.0490	-0.0194	-0.0612	0.1252	0.1656
FabMetalPrd	0.1572	0.1672	0.1003	-0.0831	-0.1040	-0.0975	-0.0669	0.1022	0.0379
TransportEq	0.2324	0.3191	0.2507	-0.0549	-0.0022	-0.0407	-0.0684	0.1265	0.1382
OthMachnEq	0.2192	0.2913	0.2243	-0.0472	-0.0225	-0.0400	-0.0670	0.1234	0.1198
MiscManuf	0.1440	0.1416	0.0739	-0.1111	-0.1212	-0.1161	-0.0678	0.0975	0.0210
ElecGasWat	0.0592	-0.0088	-0.0957	-0.0519	-0.1245	-0.1047	-0.0869	0.0144	
Construction	-0.0050	-0.1603	-0.2241	-0.0791	-0.2191	-0.1454	-0.0638	-0.0025	
Trade	0.1097	0.0853	0.0054	-0.1053	-0.1232	-0.1174	-0.0800	0.0643	-0.0161
Repairs	0.0376	-0.0614	-0.1389	-0.0854	-0.1696	-0.1373	-0.0775	0.0154	-0.1130
Hotel_Cafe	-0.0031	-0.1144	-0.2203	-0.0921	-0.2158	-0.1513	-0.1059	-0.0022	-0.1479
Transport	0.1677	0.1657	0.1212	-0.0401	-0.0268	-0.0376	-0.0445	0.0740	0.0369
CommunicSr	0.1072	0.0673	0.0002	-0.0696	-0.0931	-0.0881	-0.0671	0.0467	-0.0280
FinanceInsur	0.0605	0.0069	-0.0931	-0.1285	-0.1500	-0.1495	-0.1000	0.0285	
OwnerDwell	0.0156	-0.0383	-0.1830	-0.1188	-0.1830	-0.1673	-0.1446	0.0000	
PropBusSrv	0.0872	0.0671	-0.0397	-0.1079	-0.1456	-0.1305	-0.1068	0.0530	
GovAdminDf	0.0075	-0.0922	-0.1992	-0.1262	-0.2127	-0.1616	-0.1069	0.0068	
Education	0.0423	-0.0177	-0.1295	-0.1118	-0.2080	-0.1981	-0.1119	0.0392	
HealthComm	0.0051	-0.1062	-0.2039	-0.1302	-0.2124	-0.1854	-0.0978	0.0042	
CultuRecrea	0.0130	-0.0857	-0.1882	-0.1065	-0.2034	-0.1540	-0.1025	0.0076	-0.1290
OtherService	0.0032	-0.1023	-0.2078	-0.1048	-0.2132	-0.1668	-0.1055	0.0027	-0.1400

fandecomp(C	LocalMarke	DomShare	Export	Total
WoolMutton	-0.0500	0.0000	0.0460	-0.0040
GrainsHay	0.0379	-0.0002	-0.0080	0.0297
BeefCattle	0.0506	-0.0001	0.0227	0.0732
OtherAgric	0.0292	0.0011	0.0144	0.0447
ForestFish	0.0201	0.0029	0.0885	0.1114
Mining	0.0285	0.0008	0.0157	0.0450
MeatDairy	-0.0344	0.0002	0.0887	0.0545
OthFoodProd	0.0012	0.0040	0.1000	0.1053
DrinksSmoke	-0.0146	0.0049	0.0669	0.0571
Textiles	-0.7023	0.1527	0.2692	-0.2804
ClothingFtw	0.1549	-5.3747	1.7044	-3.5155
WoodProds	0.0431	0.0145	0.0765	0.1342
PaperPrint	0.0187	0.0210	0.0226	0.0623
Petrol_CoalP	0.0085	-0.0095	0.0645	0.0635
Chemicals	0.0191	0.0141	0.0604	0.0937
RubberPlast	0.0250	0.0335	0.0351	0.0937
NonMetlMinr	0.0205	0.0057	0.0231	0.0494
BasicMetals	0.0640	0.0025	0.0604	0.1269
FabMetalPrd	0.0443	0.0208	0.0356	0.1007
TransportEq	0.0232	0.0518	0.0521	0.1271
OthMachnEq	0.0124	0.0119	0.0999	0.1242
MiscManuf	-0.0144	0.0321	0.0759	0.0936
ElecGasWat	0.0132	0.0000	0.0012	0.0144
Construction	-0.0034	0.0000	0.0003	-0.0031
Trade	0.0643	0.0000		0.0643
Repairs	0.0156	-0.0001	0.0020	0.0175
Hotel_Cafe	-0.0022	0.0000		-0.0022
Transport	0.0094	0.0038	0.0610	0.0742
CommunicSr	0.0091	-0.0003	0.0387	0.0476
FinanceInsur	0.0136	-0.0003	0.0147	0.0280
OwnerDwelln	0.0000	0.0000		0.0000
PropBusSrvc	0.0302	-0.0001	0.0215	0.0516
GovAdminDf	0.0032	0.0000	0.0036	0.0068
Education	0.0032	-0.0001	0.0361	0.0392
HealthComm	0.0033	0.0000	0.0009	0.0042
CultuRecreat	0.0042	0.0000	0.0034	0.0076
OtherService	0.0060	-0.0039	0.0006	0.0027

SalesDecom	Interm	Invest	HouseH	Export	GovGE	Stocks	Margins	Total
WoolMutton	-0.0497		-0.0003	0.0460				-0.0040
GrainsHay	0.0399		-0.0022	-0.0080				0.0297
BeefCattle	0.0520		-0.0015	0.0227				0.0732
OtherAgric	0.0354		-0.0050	0.0144				0.0447
ForestFish	0.0339	0.0005	-0.0114	0.0885				0.1114
Mining	0.0303	0.0001	-0.0012	0.0157				0.0450
MeatDairy	-0.0235		-0.0106	0.0887				0.0545
OthFoodProc	0.0168		-0.0116	0.1000				0.1053
DrinksSmoke	0.0043		-0.0141	0.0669				0.0571
Textiles	-0.5700	0.0007	0.0197	0.2692				-0.2804
ClothingFtw	-1.3566		-3.8633	1.7044				-3.5155
WoodProds	0.0587	0.0000	-0.0010	0.0765				0.1342
PaperPrint	0.0418	0.0001	-0.0021	0.0226				0.0623
Petrol_CoalP	0.0331		-0.0341	0.0645				0.0635
Chemicals	0.0409		-0.0076	0.0604				0.0937
RubberPlast	0.0621	0.0001	-0.0036	0.0351				0.0937
NonMetlMinr	0.0266		-0.0004	0.0231				0.0494
BasicMetals	0.0666		-0.0002	0.0604				0.1269
FabMetalPrd	0.0640	0.0013	-0.0003	0.0356				0.1007
TransportEq	0.0405	0.0366	-0.0021	0.0521				0.1271
OthMachnEq	0.0252	0.0062	-0.0072	0.0999				0.1242
MiscManuf	0.0151	0.0020	0.0005	0.0759				0.0936
ElecGasWat	0.0220		-0.0087	0.0012				0.0144
Construction	0.0008	-0.0042		0.0003				-0.0031
Trade	0.0017	0.0000					0.0626	0.0643
Repairs	0.0233		-0.0078	0.0020				0.0175
Hotel_Cafe	0.0084		-0.0052				-0.0055	-0.0022
Transport	0.0118	0.0000	-0.0182	0.0610			0.0196	0.0742
CommunicSr	0.0222		-0.0134	0.0387				0.0476
FinanceInsur	0.0159		-0.0027	0.0147			0.0002	0.0280
OwnerDwelln			0.0000					0.0000
PropBusSrvc	0.0314	-0.0003	-0.0010	0.0215				0.0516
GovAdminDf	0.0039	-0.0007	0.0000	0.0036				0.0068
Education	0.0003		0.0028	0.0361				0.0392
HealthComm	-0.0020		0.0053	0.0009				0.0042
CultuRecreat	0.0093	-0.0004	-0.0046	0.0034				0.0076
OtherService	0.0024		-0.0003	0.0006				0.0027

regx1tot(IND	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366
OtherAgric	0.0447	0.0447	0.0447	0.0447	0.0447	0.0447	0.0447	0.0447
ForestFish	0.1117	0.1117	0.1117	0.1117	0.1117	0.1117	0.1117	0.1117
Mining	0.0445	0.0445	0.0445	0.0445	0.0445	0.0445	0.0445	0.0445
MeatDairy	0.0545	0.0545	0.0545	0.0545	0.0545	0.0545	0.0545	0.0545
OthFoodPro	0.1051	0.1051	0.1051	0.1051	0.1051	0.1051	0.1051	0.1051
DrinksSmok	0.0281	0.0383	0.0129	0.1979	0.0625	0.0271	-0.0091	0.0218
Textiles	-0.2327	-0.2327	-0.2327	-0.2327	-0.2327	-0.2327	-0.2327	-0.2327
ClothingFtw	-3.5094	-3.5094	-3.5094	-3.5094	-3.5094	-3.5094	-3.5094	-3.5094
WoodProds	0.1345	0.1345	0.1345	0.1345	0.1345	0.1345	0.1345	0.1345
PaperPrint	0.0623	0.0623	0.0623	0.0623	0.0623	0.0623	0.0623	0.0623
Petrol_CoalF	0.0622	0.0622	0.0622	0.0622	0.0622	0.0622	0.0622	0.0622
Chemicals	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934
RubberPlast	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934	0.0934
NonMetlMinr	0.0491	0.0491	0.0491	0.0491	0.0491	0.0491	0.0491	0.0491
BasicMetals	0.1252	0.1252	0.1252	0.1252	0.1252	0.1252	0.1252	0.1252
FabMetalPrd	0.1022	0.1022	0.1022	0.1022	0.1022	0.1022	0.1022	0.1022
TransportEq	0.1265	0.1265	0.1265	0.1265	0.1265	0.1265	0.1265	0.1265
OthMachnEq	0.1234	0.1234	0.1234	0.1234	0.1234	0.1234	0.1234	0.1234
MiscManuf	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975	0.0975
ElecGasWat	0.0090	-0.0077	0.0223	0.0333	0.0480	0.0519	-0.0130	0.0504
Construction	-0.0116	-0.0324	0.0088	0.0212	0.0433	0.0421	-0.0247	0.0432
Trade	0.0572	0.0564	0.0677	0.0775	0.0878	0.0995	0.0308	0.0760
Repairs	0.0089	-0.0022	0.0228	0.0321	0.0456	0.0515	-0.0146	0.0439
Hotel_Cafe	-0.0080	-0.0204	0.0053	0.0149	0.0289	0.0304	-0.0243	0.0290
Transport	0.0740	0.0740	0.0740	0.0740	0.0740	0.0740	0.0740	0.0740
CommunicSr	0.0402	0.0288	0.0537	0.0628	0.0788	0.0809	0.0268	0.0766
FinanceInsur	0.0211	0.0069	0.0376	0.0487	0.0658	0.0685	0.0050	0.0631
OwnerDwelln	-0.0110	-0.0408	0.0172	0.0347	0.0664	0.0693	-0.0400	0.0683
PropBusSrvc	0.0481	0.0373	0.0595	0.0687	0.0786	0.0842	0.0249	0.0752
GovAdminDf	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
Education	0.0376	0.0334	0.0417	0.0442	0.0488	0.0492	0.0335	0.0489
HealthComm	-0.0001	-0.0119	0.0107	0.0173	0.0284	0.0316	-0.0081	0.0296
CultuRecrea	0.0018	-0.0106	0.0149	0.0249	0.0391	0.0410	-0.0127	0.0385
OtherService	-0.0022	-0.0124	0.0090	0.0169	0.0284	0.0324	-0.0088	0.0293

regadvantag	NSW	VIC	QLD	SA	WA	TAS	ACT	NT
BroadAcre	0.0000	-0.0001	0.0000	0.0002	0.0000	-0.0001	-0.0002	0.0003
OtherAgric	-0.0001	0.0001	0.0000	0.0002	-0.0001	0.0000	-0.0003	-0.0001
ForestFish	-0.0001	0.0000	0.0000	0.0001	0.0000	0.0014	-0.0001	-0.0001
Mining	-0.0004	-0.0006	0.0002	-0.0003	0.0026	-0.0005	-0.0010	0.0019
MeatDairy	0.0000	0.0000	0.0001	0.0000	-0.0001	0.0001	-0.0002	-0.0002
OthFoodProc	0.0000	0.0001	0.0004	-0.0003	-0.0003	0.0003	-0.0009	-0.0007
DrinksSmoke	-0.0001	-0.0001	-0.0002	0.0015	0.0000	-0.0002	-0.0003	-0.0002
Textiles	0.0002	-0.0013	0.0008	0.0006	0.0005	-0.0014	0.0011	0.0011
ClothingFtw	-0.0015	-0.0076	0.0028	0.0032	0.0086	0.0121	0.0112	0.0132
WoodProds	0.0000	0.0000	0.0002	0.0000	-0.0001	0.0004	-0.0002	-0.0003
PaperPrint	0.0000	0.0002	-0.0002	-0.0002	-0.0002	0.0005	-0.0003	-0.0005
Petrol_CoalP	0.0001	0.0001	0.0000	-0.0002	-0.0001	-0.0002	-0.0002	-0.0002
Chemicals	0.0001	0.0003	-0.0003	-0.0003	-0.0002	-0.0002	-0.0007	-0.0007
RubberPlaste	0.0000	0.0003	-0.0002	0.0000	-0.0002	-0.0003	-0.0004	-0.0004
NonMetlMinr	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0001	-0.0001	-0.0001
BasicMetals	0.0004	-0.0009	-0.0002	0.0003	0.0004	0.0014	-0.0014	0.0023
FabMetalPrd	-0.0001	0.0001	0.0001	-0.0001	0.0000	-0.0001	-0.0007	-0.0004
TransportEq	-0.0007	0.0011	-0.0004	0.0022	-0.0009	0.0000	-0.0013	-0.0013
OthMachnEq	0.0003	0.0005	-0.0007	0.0003	-0.0005	-0.0008	-0.0011	-0.0015
MiscManuf	0.0000	0.0001	0.0000	0.0000	0.0000	-0.0001	-0.0002	-0.0003
ElecGasWat	-0.0002	-0.0009	0.0003	0.0007	0.0012	0.0015	-0.0011	0.0014
Construction	-0.0006	-0.0017	0.0007	0.0015	0.0029	0.0028	-0.0021	0.0029
Trade	-0.0006	-0.0008	0.0004	0.0013	0.0018	0.0034	-0.0034	0.0004
Repairs	-0.0002	-0.0004	0.0002	0.0004	0.0007	0.0008	-0.0007	0.0006
Hotel_Cafe	-0.0002	-0.0004	0.0002	0.0004	0.0007	0.0007	-0.0005	0.0007
Transport	0.0004	-0.0001	0.0002	-0.0004	-0.0006	0.0003	-0.0014	0.0005
CommunicSr	-0.0002	-0.0005	0.0002	0.0004	0.0008	0.0010	-0.0006	0.0008
FinanceInsur	-0.0005	-0.0015	0.0006	0.0013	0.0023	0.0027	-0.0016	0.0021
OwnerDwelln	-0.0011	-0.0033	0.0014	0.0029	0.0051	0.0058	-0.0037	0.0052
PropBusSrvc	-0.0004	-0.0013	0.0005	0.0012	0.0021	0.0026	-0.0024	0.0016
GovAdminDf	0.0001	-0.0001	0.0002	0.0000	0.0004	0.0000	-0.0037	-0.0003
Education	0.0000	-0.0003	0.0002	0.0003	0.0003	0.0005	-0.0003	0.0004
HealthComm	-0.0003	-0.0009	0.0004	0.0008	0.0015	0.0017	-0.0009	0.0015
CultuRecrea	-0.0001	-0.0003	0.0001	0.0003	0.0005	0.0005	-0.0004	0.0005
OtherService	-0.0001	-0.0003	0.0001	0.0003	0.0005	0.0006	-0.0003	0.0005

	regemploy_	regw1lab_i	regx1prim_i
NSW	0.0422	-0.1719	0.0193
VIC	0.0236	-0.1905	0.0049
QLD	0.0599	-0.1542	0.0335
SA	0.0709	-0.1432	0.0441
WA	0.0908	-0.1234	0.0548
TAS	0.0926	-0.1215	0.0627
ACT	0.0241	-0.1901	0.0051
NT	0.0920	-0.1221	0.0559

```
! Command file for ORANIG model: short-run closure

check-on-read elements = warn; ! very often needed
cpu=yes ; ! (Optional) Reports CPU times for various stages
log file = yes;  ! Optional
auxiliary files = oranig; ! needed by GEMSIM

! Solution method
!method = GRAGG ;
!steps = 2 4 6 ;
method = johansen; ! alternative to above

! Data and summary file
file basedata = basedata.har ;
updated file basedata =<cmf>.upd;
file summary  = summary.har;

! Closure

! Exogenous variables constraining real GDP from the supply side
exogenous  x1cap              ! all sectoral capital
        x1lnd              ! all sectoral agricultural land
        a1cap a1lab_o a1lnd
        a1prim a1tot a2tot  ! all technological change
        realwage ;         ! Average real wage

! Exogenous settings of real GDP from the expenditure side
exogenous  x3tot              ! real private consumption expenditure
        x2tot_i            ! real investment expenditure
        x5tot              ! real government expenditure on goods
        delx6 ;            ! real demands for inventories by commodity

! The demand curves of exports are fixed in both quantity and price axes
exogenous  f4p f4q              ! individual exports
        f4p_ntrad f4q_ntrad ; ! collective exports
! Exogenous foreign prices of imports ;
exogenous  pf0cif ;

! All tax rates are exogenous
exogenous  delPTXRATE f0tax_s  f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp
        f4tax_trad f4tax_ntrad f1oct;

! distribution of government demands !
exogenous  f5 ;

! The nominal exchange rate is the numeraire
exogenous phi ;

! Number of households and their consumption preferences are exogenous
exogenous q a3_s ;

exogenous capslack; ! switch off aggregate capital constraint !

! Distribution of investment between industries
xSet EXOGINV  # 'exogenous' investment industries #
 (ElecGasWater
  PropBusSrvc

xSubset EXOGINV is subset of IND;
xSet ENDOGINV # 'endogenous' investment industries # = IND - EXOGINV;
exogenous finv1(ENDOGINV); ! investment linked to profits
exogenous finv2(EXOGINV);  ! investment follows aggregate investment
```

```
! Exogenous variables for regional extension
exogenous    freg1 freg2 freg3 freg4 freg5 freg6;
exogenous    rsum1 rsum2 rsum3 rsum4 rsum5 rsum6;

rest endogenous ;

verbal description =
 ClothingFtw tariff cut: DPSV shortrun closure;

shock  t0imp("ClothingFtw")= -10;
```

→

	Size	Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export*	Government	Stocks
	Size	← I →	← I →	← H →	← 1 →	← 1 →	← 1 →
Basic Flows domestic	↑ C ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Basic Flows imported	↑ C ↓	V1BAS	V2BAS	V3BAS		V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					
Production Tax	↑ 1 ↓	V1PTX					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported,

O = Number of Occupation Types

M = Number of Commodities used as Margins

H = 1: Number of Household Types

* Note: Export column is for domestic goods only.

	Make Matrix	
Size	← I →	Total
↑ C ↓	MAKE	= sales row totals
Total	=col total absorptn	

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

ORANI-G flows database

Section 10

Other topics

Lab Exercise: Adding new behaviour to the ORANI-G model

W.J. Harrison and Mark Horridge

Centre of Policy Studies

April 2003

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This exercise requires the additional file NEW.BIT.

1. Introduction

ORANI-G is a generic model which is designed to be used with a variety of national databases. Usually, country-specific versions of the model include some additional equations (and perhaps data) describing country-specific behaviour. For example, the basic ORANI-G model does not include equations modelling tourism exports. Indeed, foreign visitors' purchases of hotel rooms, meals, and airfares are often not consistently reported in input-output tables. If you wanted to build a CGE model of a country which relied heavily on tourism, you would need to add equations and data describing tourist demand to the basic ORANI-G framework.

Particular modelling projects also call for new equations and data. Suppose you want to know by how much an increase in electricity prices will reduce industrial electricity demand. According to the basic ORANI-G model, all intermediate demands are Leontief—they move in proportion to industry outputs. The Leontief assumption would have to be modified if you wanted to capture the effects of price-induced electricity savings.

In short, it will often be useful or necessary to add equations and data to the core model. This exercise aims to lead you through that process.

2. Linking household consumption to post-tax income

Like the original version of ORANI, ORANI-G makes no explicit link between household incomes and household spending. Two reasons are:

- The input-output table underlying the database includes indirect (commodity) taxes but has no data about direct taxes or transfers between household and government. Thus the IO table tells us the value of household spending, but not of household disposable income.

- Originally, ORANI was part of a suite of 4 models: BACHUROO (demographics/population), MACRO (quarterly macro model), SNAPSHOT (long-run CGE), and ORANI (short-run CGE). ORANI's role was to predict detailed sectoral shortrun effects. The MACRO model was to predict the values of major expenditure aggregates (like consumption and investment). ORANI was rather under-developed from the macro standpoint.

The lack of macro detail sometimes raises questions. For example, in the tariff cut simulation that you studied earlier, employment (and the purchasing power of total wage payments) rose, yet household consumption was fixed. Should not increased earnings have boosted consumption? Again, reduction of tariffs reduced government tax receipts, suggesting (since government spending was fixed) a move towards government budget deficit. Should not some other tax be raised to cover the lost tariff revenue?

Answering these criticisms, Peter Dixon and others argued that fiscal or monetary policy (raising taxes or interest rates), not modelled by ORANI, could be used in the short run to manipulate or stabilize aggregate demand. Thus, if an ORANI simulation showed employment to increase whilst consumption was held constant, we could presume that the government must be raising income taxes [unseen by ORANI]. Higher income taxes could meet the tariff revenue shortfall, and at the same time explain how consumption failed to rise with employment.

The aim of this exercise is to make some of these mechanisms more explicit. In particular we wish to specify that:

- primary factor incomes are subject to direct (income) tax;
- household disposable income is *proportional* to [primary factor income *less* direct tax].
- government income is *proportional* to [direct taxes + indirect taxes].
- labour supply depends on *post-tax* real wages.

Please note that above, we say "proportional" rather than "equal". A complete accounting treatment should include transfers between households, government and the ROW [rest of the world]. Pension payments (from government to households) and repatriated profits (from factors to ROW) are two important examples. If we measured *all* of the payments between firms, households, government and ROW, we would have enough data to construct a complete Social Accounting Matrix [SAM][1]. That is beyond the scope of this exercise. Nevertheless, the simple addition to the model framework of direct taxation allows us to make predictions of changes in household disposable income and government revenue, and perhaps could improve our simulations of the effects of tariff reduction.

2.1. Relevant parts of the existing model

First we review existing variables, coefficients and equations which we may use in our modification. Open TABmate, and search for and Gloss on the following items:

Description	Coefficient	Variable
Aggregate revenue from all indirect taxes	V0TAX_CSI	w0tax_csi
Nominal total household consumption	V3TOT	w3tot
Aggregate primary factor payments	V1PRIM_I	w1prim_i
Average real wage	n/a	realwage

[1] A SAM is a diagram enforcing the rule of double-entry book-keeping: every cash flow goes from one agent to another agent. It is a square table with matching row and column labels listing various agents (firms, factors, household, government, ROW, savings/investment). Cell(i,j) of the SAM shows the payment made to agent i by agent j. Row and column sums of the matrix must match—since the income of agent k must equal her [expenditure+saving]. If we have an input-output table, we have 90 or 95% of the numbers needed to construct a SAM.

2.2. New equations, variables and coefficients

We aim to define the following new relations (in levels):

(a) VDIRTAX = DTAXRATE*V1PRIM_I flat rate income tax

(b) VINCPTAX = V1PRIM_I - VDIRTAX income after tax

(c) VTAXTOT = VDIRTAX + V0TAX_CSI total tax revenue

(d) V3TOT = F3INC*VINCPTAX consumption function

(e) REALWAGEPT = REALWAGE*[1-DTAXRATE] post-tax real wage

using the following new coefficients and variables: All the new variables are percent change variables[2].

Description	Coefficient	Variable
Revenue from direct taxation	VDIRTAX	wdirtax
Rate of direct tax	DTAXRATE	dtaxrate
Post-tax factor income	VINCPTAX	wincptax
Sum of income and commodity tax revenue	VTAXTOT	wtaxtot
Ratio: [household consumption]/[post-tax factor income]	F3INC	f3inc
Average post-tax real wage	REALWAGEPT	realwagePT

Translating formulae (a) to (e) above into percent change form, we get the equations:

(a') wdirtax = w1prim_i + dtaxrate

(b') VINCPTAX*wincptax = V1PRIM_I*w1prim_i - VDIRTAX*wdirtax

(c') VTAXTOT*wtaxtot = VDIRTAX*wdirtax + V0TAX_CSI*w0tax_csi

(d') w3tot = wincptax + f3inc

(e') VINCPTAX*realwagePT = VINCPTAX*realwage - VDIRTAX*dtaxrate

Can you see how we derived Equation (e')? First we split:

(e) REALWAGEPT = REALWAGE*[1-DTAXRATE] into two equations:

REALWAGEPT = REALWAGE*V and V=[1-DTAXRATE]

giving percent change forms:

realwagePT = realwage + v

and Vv=-DTAXRATE*dtaxrate or v=-[DTAXRATE/V]*dtaxrate

Substituting the equation for v back into the first of the above equations, we get:

realwagePT = realwage -[DTAXRATE/V]*dtaxrate

or realwagePT = realwage -[DTAXRATE/(1-DTAXRATE)]*dtaxrate

It is customary for coefficients of percent change equations to be expressed in terms of flows (ie, values) which are stored on the data file. To achieve this we multiply top and bottom of the square bracketed term above by V1PRIM_I, thus:

[DTAXRATE/(1-DTAXRATE)] = [V1PRIM_I*DTAXRATE/(V1PRIM_I-V1PRIM_I*DTAXRATE)]

Using (a): VDIRTAX = DTAXRATE*V1PRIM_I the above becomes:

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[2] If there was any chance that the income tax rate could be zero or negative, we would have to define it as an ordinary change variable. Unfortunately such a possibility seems remote in Australia.

= [VDIRTAX/(V1PRIM_I-VDIRTAX)]

Using (b): VINCPTAX = V1PRIM_I - VDIRTAX the above becomes:

= [VDIRTAX/(VINCPTAX)]

The entire equation now becomes:

realwagePT = realwage -[VDIRTAX/(VINCPTAX)]*dtaxrate

Multiplying through by VINCPTAX we get[3]:

VINCPTAX*realwagePT = VINCPTAX*realwage - VDIRTAX*dtaxrate

Notice that some of the percent change variables (eg, f3inc, dtaxrate) do not appear as coefficients in the percent change equations. This is quite normal. The new coefficients that we actually need are: VDIRTAX, VINCPTAX and VTAXTOT. If we read the value of VDIRTAX from the data file we can compute VINCPTAX via formula (b) and VTAXTOT via formula (c).

Box 1 below shows the new material that must be added at the bottom of the TABLO input file. We start by defining three new coefficients and six new variables. One new coefficient, VDIRTAX, is read from file; the others are calculated by two formulae.

The equations are the same as (a') to (e') above. The only new point is the system of naming the equations. Each equation name consists of "E_", followed by the name of the new variable which that equation explains[4]. The five new equations will endogenize the corresponding five new variables—leaving one variable—dtaxrate—to be exogenous. With dtaxrate exogenous, the five new equations will compute values for the five new variables—without affecting results for any other variables. Hence, even though we have added new equations we can still replicate solutions computed using the original model[5]. Only when we exogenize f3inc and endogenize the original variable x3tot, will the new equations have a system-wide effect.

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[3] You can mentally verify (e') as follows: with tax rates fixed (dtaxrate=0) a 1% rise in realwage must lead to a 1% rise in realwagePT -- so the coefficients on realwage and realwagePT should be the same. The left-hand term equals 100 times the ordinary change in post-tax income. With realwage fixed (=0), the term VDIRTAX*dtaxrate equals equals 100 times the ordinary change in income tax revenue.

[4] This way of creating equation names is used by the TABmate **Tools...Closure** command, which attempts to automatically work out a closure (ie, list of variables not explained by any equation).

[5] The capacity to replicate the solutions obtained with the original, un-enhanced model, is an important checking device. See Appendix I of the ORANI-G document: *Formal Checks on Model Validity; Debugging Strategies*.

Box 1: Addition to bottom of TABLO input file [see file NEW.BIT]

```
Coefficient
 VDIRTAX  # Revenue from direct taxation #;
 VINCPTAX # Post-tax factor income #;
 VTAXTOT  # Sum of income and commodity tax revenue #;
Variable
 wdirtax  # Revenue from direct taxation #;
 dtaxrate # % Change in ad valorem direct tax rate #;
 wtaxtot  # Sum of income and commodity tax revenue #;
 wincptax # Post-tax factor income #;
 f3inc    # Ratio: [household consumption]/[post-tax factor income] #;
 realwagePT   # Average post-tax real wage #;

Read   VDIRTAX from file BASEDATA header "DTAX";
Update VDIRTAX = wdirtax;
Formula
 VINCPTAX = V1PRIM_I - VDIRTAX;
 VTAXTOT  = VDIRTAX + V0TAX_CSI;

Equation
E_wdirtax # Revenue from direct taxation #
 wdirtax = w1prim_i + dtaxrate;

E_wincptax # Post-tax factor income #
 VINCPTAX*wincptax = V1PRIM_I*w1prim_i - VDIRTAX*wdirtax;

E_wtaxtot # Sum of income and commodity tax revenue #
 VTAXTOT*wtaxtot =  VDIRTAX*wdirtax + V0TAX_CSI*w0tax_csi;

E_f3inc # Household consumption proportional to post-tax factor income #
 w3tot = wincptax + f3inc;

E_realwagePT # Average post-tax real wage #
 VINCPTAX*realwagePT = VINCPTAX*realwage - VDIRTAX*dtaxrate;
```

2.3. Adding new statements to the TABLO input file

The next step is to make new versions of the TAB, STI and CMF files. In Explorer:

- make a copy of ORANIG.TAB named ORANIGDT.TAB (DT=direct tax)
- make a copy of ORANIG.STI named ORANIGDT.STI
- make a copy of TARFCUT.CMF named TARFCUT1.CMF

Start TABmate directly (no need for WinGEM at this stage) and open ORANIGDT.TAB. You have to add the contents of Box 1 at the bottom of the TAB file. To help you, we have supplied the Box 1 contents in a text file, NEW.BIT. Open this file, and copy the entire contents into the bottom of ORANIGDT.TAB. Then press the **TABLO Check** button.

You will discover that there are two or three errors or typos in the newly added equations—this is quite normal! TABmate underlines each error in red[6]. If you click on the underlined text, an error message appears in the panel at the bottom[7]. The "Next" button at the top (marked with a red cross) takes you to the next error. Study the error messages and the correct equations in Box 1 above and attempt to fix the problems. Then press **TABLO Check** again. Continue till you see the message "No errors found".

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[6] More precisely, TABmate underlines where a problem is noticed. Sometimes the real error is in a line nearby.

[7] The error message at bottom vanishes after 4 seconds, but will return if you click the bottom panel.

2.4. Creating new STI and CMF files

Without closing the TAB file, press the button **TABLO STI** and **Edit** the file ORANIGDT.STI. Use **Search...Replace** to change every occurrence of ORANIG into ORANIGDT. Then save and close the STI file.

Back at the TAB file, again press the button **TABLO STI** but this time choose **Run**. This causes TABLO to "implement" the model, that is, to produce GSS and GST files which GEMSIM can use. After a short wait a success message should appear. Click OK, and close the TAB file.

Open the file TARFCUT1.CMF and use **Search...Replace** to change every occurrence of ORANIG into ORANIGDT. Then find the lines:

```
! All tax rates are exogenous
exogenous  delPTXRATE f0tax_s  f1tax_csi f2tax_csi f3tax_cs f5tax_cs t0imp
           f4tax_trad f4tax_ntrad f1oct ;
```

and add in "dtaxrate" just before the last semicolon above. The line above should now read:

```
           f4tax_trad f4tax_ntrad f1oct dtaxrate;
```

Save the CMF file and close TABmate. As explained previously, by making dtaxrate exogenous (but not f3inc) we aim to replicate our previous TARFCUT simulation. We will "swap" f3inc with x3tot at a later stage.

2.5. Adding new data to the BASEDATA input file

We next must add the new input data for VDIRTAX to a new header DTAX on the input data file. According to ABS publication 5206.0, *National Income, Expenditure and Product*, June Quarter 1997, Table 33, in 1993-94 total direct taxes on income summed to 66,383 million dollars.

Start ViewHAR and open the BASEDATA file, BASEDATA.HAR.

Can you see the Edit menu item at the top of ViewHAR? If not, choose **File..Use advanced, editing, menu**, and the Edit menu should appear[8].

Select **Edit...Create New Header**. In the window which appears, enter in:

- *Header Type:* Real [RE]
- *4 Character header:* DTAX
- *Default value:* 0.0
- *Coeff name:* VDIRTAX
- *Long Name:* Revenue from direct taxation
- *No of Dimensions[9]:* 0

Select **OK**. A new header DTAX should appear at the bottom of the Contents page. Double-click on this line to examine its contents. You should see a single number, 0.0.

Right-click on the zero—an edit box appears—type in 66383 and click the green tick-mark button[10]. The title bar at the top of ViewHAR will now show that the file has changed. Choose **File..Save** to save your changes.

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[8] ViewHAR can run in either *read-only* or in *editing* mode. Editing mode offers the full set of menu options, while the read-only menus are simpler and do not allow files to be modified. Read-only is the default. The File menu lets you switch between the two modes.

[9] According to GEMPACK, a matrix has 2 dimensions, a vector has 1 dimension, and a scalar (single number) has 0 dimensions.

[10] You can also paste in whole matrices of numbers from Excel, using the **Import...Paste** command.

2.6. Check simulation: TARFCUT1

Start WinGEM and use ***File | Change both default directories*** to ensure that the working directory is C:\GPWORK\ORANIG.

Choose **Simulation...GEMSIM Solve** and **Select** the command file TARFCUT1.CMF[11]. Click **Run**. After a short while, you should get a success message[12]—click **Go to ViewSOL**, and examine the macro variables in TARCUT1.SL4. If possible, use ViewSOL to open the original solution TARFCUT.SL4 that you computed in previous days[13]. You should see that the results are the same. However, some useful new variables have been computed: f3inc, realwagePT, wincptax, wdirtax and wtaxtot. To see the results for these new variables, select tarfcut1 (rather than tarfcut) in the second drop-down menu ("Choose which solution to view") in ViewSOL. Then, on the page containing results for **macros,** you will see **n.a.** (not available) for these new variables in the tarfcut column of results.

Looking at the macro results for TARFCUT1 (also in Table 1 below), we see:

- price indices p3tot and p0gdpexp fell by about 0.2%. Total tax revenue (wtaxtot) fell by more than this, so that its real value fell (because tariff revenue declined). Total tax revenue also fell more than the nominal value of government demands (w5tot) suggesting that the government budget deficit might be increasing.
- although employment (employ_i) rose by 0.05%, real household consumption was fixed. The ratio f3inc (= household spending/factor income) fell by -0.1%.

Both features of the simulation seem problematic. Would employment rise so much if the government maintained tax revenue by increasing some other tax? Would exports still increase if newly employed people spent some of their earnings? The next simulation addresses these questions.

[11] You might wonder how GEMSIM knows which model to use: ORANIG or ORANIGDT?. The information is contained in the TARFCUT1.CMF, in the line: "auxiliary files=ORANIGDT;". This tells GEMSIM to use the files ORANIGDT.GSS and ORANIGDT.GST which you created earlier in TABmate (by pressing TABLO STI button).

[12] The Accuracy Summary with smiling faces does not appear this time because this was a single-step, Johansen computation. GEMSIM can only judge accuracy by comparing results from, say, 2-step, 4-step, and 6-step computations.

[13] Set the "Choose which solution to view" combo box at top middle ViewSOL to read "TARFCUT1", to ensure that you see values for new variables.

Table 1: Selected macro results from simulations TARFCUT1 and TARFCUT2

Description	Name	TARFCUT1	TARFCUT2
Contribution of BOT to real expenditure-side GDP (change)	contBOT	0.033	0.004
Aggregate tariff revenue (change)	delV0tar_c	-223.471	-223.127
Aggregate revenue from all indirect taxes (change)	delV0tax_csi	-257.626	-256.345
% Change in ad valorem direct tax rate	dtaxrate	**0.000**	0.441
Aggregate employment: wage bill weights	employ_i	0.049	-0.008
Overall wage shifter	f1lab_io	0.000	0.094
Ratio: [household consumption]/[post-tax factor income]	f3inc	-0.105	**0.000**
GDP price index, expenditure side	p0gdpexp	-0.190	-0.114
Terms of trade	p0toft	-0.046	-0.028
Average nominal wage	p1lab_io	-0.214	-0.057
Consumer price index	p3tot	-0.214	-0.151
Average real wage	realwage	**0.000**	0.094
Average post-tax real wage	realwagePT	0.000	**0.000**
C.I.F. local currency value of imports	w0cif_c	0.218	0.211
Nominal GDP from expenditure side	w0gdpexp	-0.157	-0.109
Nominal GDP from income side	w0gdpinc	-0.157	-0.109
Aggregate revenue from all indirect taxes	w0tax_csi	-0.520	-0.518
Revenue from direct taxation	wdirtax	-0.110	0.386
Aggregate nominal value of government demands	w5tot	-0.16615	-0.05776
Post-tax factor income	wincptax	-0.110	-0.149
Sum of income and commodity tax revenue	wtaxtot	-0.285	**0.000**
Aggregate payments to labour	w1lab_io	-0.165	-0.065
Nominal total household consumption	w3tot	-0.214	-0.149
Import volume index, C.I.F. weights	x0cif_c	0.218	0.211
Real GDP from expenditure side	x0gdpexp	0.033	0.005
Real household consumption	x3tot	**0.000**	0.002
Export volume index	x4tot	0.424	0.247
Aggregate real government demands	x5tot	**0.000**	**0.000**

Note: Above, exogenous values are shown bold.

2.7. Second simulation: TARFCUT2

Next you change the closure to activate the new equations so that they affect all parts of the model.

From WinGEM use **File...Edit File** to open TARFCUT1.CMF in TABmate. Then use TABmate's **File Save As** to save the CMF with a new name, TARFCUT2.CMF.

We wish to make 3 closure changes:

- hold constant the average post-tax real wage (realwagePT) instead of the average pre-tax real wage (realwage). In other words, make labour supply respond to *post-tax* real wages.
- hold constant the sum of income and commodity tax revenue (wtaxtot) instead of the direct tax rate (dtaxrate). In other words, income taxes will increase to make up for lost tariff revenue.
- hold constant the propensity to consume post-tax factor income (f3inc) instead of aggregate real household consumption (x3tot). In other words, make household consumption follow post-tax income.

These changes are summarized in the table below:

Table 2: Closure swaps for TARFCUT2.CMF

Description	Name	tarfcut1	tarfcut2
Average real wage	realwage	exogenous	
Average post-tax real wage	realwagePT		exogenous
% Change in ad valorem direct tax rate	dtaxrate	exogenous	
Sum of income and commodity tax revenue	wtaxtot		exogenous
Real household consumption	x3tot	exogenous	
Ratio: [household consumption]/[post-tax factor income]	f3inc		exogenous

In file TARFCUT2.CMF just after the line "rest endogenous;" add in the following 3 lines:

```
! old exogenous = new exogenous

swap realwage=realwagePT ; ! closure swaps for tarfcut2
swap dtaxrate=wtaxtot ;
swap x3tot=f3inc ;
```

Then find the line:

```
verbal description = ORANIG: ClothingFtw tariff cut, DPSV shortrun closure;
```

and change it to:

```
verbal description = ORANIGDT: ClothingFtw tariff cut, modified closure;
```

Then save TARFCUT2.CMF and close TABmate.

From WinGEM, choose **Simulation...GEMSIM Solve** and **Select** the command file TARFCUT2.CMF. Click **Run**. After a short while, you should get a success message—click **Go to ViewSOL**, and examine the macro variables in TARCUT2.SL4. If it is not already visible, also open the previous solution TARFCUT1.SL4. You should see that most of the results are different. You could **Export** the macro results from ViewSOL to Excel to produce a table much like Table 1.

Comparing the macro results for simulations TARFCUT1 and TARFCUT2, we see:

- in TARFCUT2 income taxes must rise to keep tax revenue constant. [Note: dtaxrate rises by nearly half a percent. 0.5% would mean that an initial tax rate of 25% became 25.125% -- not 25.5%]. With post-tax real wages fixed, the income tax rise means that the pre-tax wage must rise. This makes firms less keen to employ. Consequently.....
- employment (employ_i) rises by less in TARFCUT2. Consequently.....
- real GDP (x0gdpexp) rises by less in TARFCUT2
- consumption (x3tot) rises a little in TARFCUT2. Because more of the [smaller] GDP increase is diverted to domestic use.....
- exports (x4tot) increase less in TARFCUT2, and so....
- the terms of trade loss (p0toft) is less in TARFCUT2.

The more realistic macro closure of TARFCUT2 greatly reduces the employment and output gains from the tariff cut.

2.8. A caveat

If you examine the w5tot, x5tot and wtaxtot rows of the TARFCUT2 simulation, you might notice that while real government spending (x5tot) and nominal tax receipts (wtaxtot) were fixed, the nominal value of government demands declined. Therefore, the government must be moving towards budget surplus. The TARFCUT2 simulation is *revenue-neutral* but not *budget neutral*. Another aspect of the same phenomenon is that in TARFCUT2 we have two exogenous variables measured in $A (phi and wtaxtot). Therefore, a shock to the numeraire (phi) would have real effects. We could fix the [tiny] problem in various ways, perhaps defining a new variable, *real tax collection* (rtaxtot), given by the percent change equation:

rtaxtot = wtaxtot - p5tot

and holding rtaxtot fixed instead of wtaxtot. We would then find that w5tot and wtaxtot moved together, and our model would again be money-neutral (numeraire shocks would have no real effects).

Neweq.ppt

Adding new behaviour

Adding direct taxation and post-tax wages

The addition may be deactivated

- **can replicate original simulation results, but with new variables calculated**
- **with closure swap, the new behaviour is switched ON**
- **added several new variables, but only one data item**
- **incremental approach: gradually build a more complicated simulation**

Original simulation

- W/CPI fixed: real prod wage falls, employment rises.
- moved households towards budget surplus:
  [wage income up, consumption fixed]
- moved government towards budget deficit:
  lost tariff revenue not replaced
- employment gains linked to fixed PRE-tax real wage

New simulation

- links household spending to income
- replaces tariff revenue with income tax rise
- links employment to POST-tax real wage
- chokes off employment and GDP gains

E_wdirtax # *Revenue from direct taxation #*
wdirtax = w1prim_i + dtaxrate

E_wincptax # *Post-tax factor income #*
VINCPTAX*wincptax = V1PRIM_I*w1prim_i - VDIRTAX*wdirtax

E_wtaxtot # *Sum of income and commodity tax revenue #*
VTAXTOT*wtaxtot = VDIRTAX*wdirtax + V0TAX_CSI*w0tax_csi

E_f3inc # *Household consumption proportional to post-tax factor income #*
w3tot = wincptax + f3inc   x3tot

E_realwagePT # *Average post-tax real wage #*
VINCPTAX*realwagePT=
VINCPTAX*realwage -VDIRTAX*dtaxrate

Comparison

	TARF1	TARF2
dtaxrate	**0**	**+0.44**
wtaxtot	**-0.29**	**0**
realwagePT	**0**	**0**
realwage	**0**	**0.09**
employ_i	**+0.05**	**-0.01**
realgdp	**+0.03**	**+0.01**
f3inc	**-0.10**	**0**
x3tot	**0**	**0.002**
x4tot	**+0.42**	**0.25**

REGIONAL MODELLING

REGIONAL MODELLING

- Intense interest in regional results
- Policies which are good for nation but bad for one region may not be politically feasible
- The ideal: we tell what will happen to employment and house prices in each electorate

The Sledgehammer Approach: Model

Simply add a regional subscript (or two) to each variable and data.

1 reg	ORANI-G	V1BAS(c,s,i)	size 37 x 2 x 35
8 reg	MMRF	V1BAS(c,s,i,r)	size 37 x 9 x 35 x 8

2 sources (s in ORANI-G); 9 sources (s in MMRF); 8 locations (r)

known as: Bottom-up approach

Database has grown by factor of [9/2]*8 = 36

Number of variables also 36 times bigger

Solve time and memory needs move with SQUARE of model size.

So model needs 1000 times as much memory and takes 1000 times longer to solve.

The Sledgehammer Approach: Data

$$\text{Data Productivity} = \frac{\text{(no of numbers in model data)}}{\text{(no of numbers supplied by ABS)}}$$

1 reg	ORANI-G	Data Productivity = 5
8 reg	MMRF	Data Productivity = 5*36 = 180

Beyond ordinary imaginative power !

Poor quality:	regional input-output tables
Crippling lack:	inter-regional trade matrix
Can only get:	a few regional vectors (industry employment, some final demands by commodity)

The Sledgehammer Approach: Results

5

Voluminous: many matrices, often 3 dimensional

Hard to analyse and report

The Sledgehammer Approach: Summary

6

Desirable --- but very costly.

But TERM reduces the cost somewhat .. see later.

A simpler approach

7

Modest data requirements: no trade matrix

Same technology each region. reasonable !

Same prices each region.

National factor markets

Add one regional subscript to quantity variables

National supply side, regional demand side.

effect of car tariff cut on Victoria

We can simulate:

- **regional effects of national shocks** ← effect of car tariff cut on Victoria
- **regional effects of regional demand shocks** ← effect of Olympic Games on Sydney

but not

- **effects of region-specific supply side shocks**

Queensland abolishes payroll tax

A simpler approach: Cost Benefit Analysis

8

Compared to MMRF/Sledgehammer:

70% of the benefit

10% of the cost

The simple approach: intuition

9

Value-added by region and sector

Growth rates from national model

	North	Central	South	Total	%
Rice	30	40	3	73	2.50
Gold	10	60	0	70	9.00
Other	60	100	27	187	3.00
Total	100	200	30	330	

Which region does best?

Central, because it specializes most in producing gold (the fastest-growing industry).

Assumption: gold sector grows at same rate in each region.

The simple approach: arithmetic

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Specialization: Sector shares in regional value-added

	North	Central	South	%
Rice	30	20	10	2.50
Gold	10	30	0	9.00
Other	60	50	90	3.00
Total	100	100	100	
%	3.45	4.70	2.95	4.16
Advantage	-0.71	0.54	-1.21	

Regional Advantage = Regional GDP %change minus national GDP %change

Regional GDP %change

National GDP %change

gdp = x1prim_i = GDP at factor cost

The simple approach: consistent with national model results

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We assumed:
each sector grows at national rate in every region.

Therefore, if we added changes in regional outputs for each sector, the sum would be equal to national change in output for that sector.

So regional results are consistent with national results.

The simple approach: doubt sets in

12

Output, employment and income grew faster in Central.

But we assumed:
each sector grows at national rate in every region.

Surely demand for haircuts grows faster in Central (because income grew more).

Therefore, output of haircut industry grows faster in Central than elsewhere (because haircuts must be consumed where they are produced).

We need local multiplier effects.

Revision of the simple approach

Two sorts of industry:

LOCAL industries: demand must be mainly satisfied locally (ie, local production must follow local demand).

NATIONAL industries: grow everywhere at national rate (local production follows national demand).

Regional household consumption follows regional wage income.

Revised simple approach: benefits

Introduces strong regional multiplier effect:

Gold output up

More wage income in Central

more consumption in Central

more demand for LOCAL commodities

LOCAL industries in Central grow more than national average

Wage income in Central up even more

Even more consumption..............and so on

Strong regional multiplier because:

a few local service industries account for a large share of the economy.

Local Industries in OZDAT934.HAR

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DrinksSmokes
ElecGasWater
Construction
Trade
Repairs
Hotel_Cafe
CommunicSrvc
FinanceInsur
OwnerDwellng
PropBusSrvc
Education
HealthCommun
CultuRecreat
OtherService

Many small regions would mean fewer local commodities

Revised simple approach = ORES = LMPST

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ORES: ORANI regional equation system
LMPST : Leontief, Morgan, Polenske, Simpson, Tower (1965)
also called: Top-down regional extension
as opposed to: Bottom-up regional model (MMRF)

See Green Book, Chapter 6 (tough)

REGIONAL MODELLING

17

- **Top-down method with minimal data requirements**
- **Necessary data**
  - base year data for each industry showing regional shares in value added (or output)
  - base year data for local commodities only, showing regional shares in investment demand, in consumption demand, in government demand and in international (export) demand

REGIONAL MODELLING

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- **Do not need regional data for input-output coefficients**
  - it is assumed that the economy-wide input/output coefficients relating to commodity supply and industry costs apply at the regional level
- **Do not need data on inter-region trade**
  - for local commodities, trade is assumed to be zero
  - for national commodities, inter-state trade is irrelevant to working out the allocation of output across regions.
- **Results obtained for percentage changes in aggregate and industry output and employment by region**

REGIONAL MODELLING: METHODOLOGY

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- **Step 1: Allocate industries into one of two groups**
  - ***National*** **industries produce commodities that are extensively traded across regions**
    - **e.g., most agricultural, mining and big manufacturing industries**
  - ***Local*** **industries produce commodities that are essentially not traded across regions**
    - **e.g., some service industries and most industries producing perishable items such as bread and fresh milk for consumption**
- **In Australian model, 27/112 industries are local, but that 27 represent over 60 per cent of value added in most regions.**

REGIONAL MODELLING: METHODOLOGY

20

- **National industries**
  - **output in region r assumed to be independent of region r's demand**
  - **default assumption is that percentage change in output for national industry j in region r (x(j,r)) is the same as the national-level percentage change (x(j)), i.e.,**

    $$x(j,r) = x(j), \quad \text{for all } j \text{ and } r$$

  - **always must conform to the constraint that**

    $$\sum_r S(j,r)\, x(j,r) = x(j)\,, \quad \text{for all } j$$

    where the sum is across regions and S(j,r) is the share of region r in national output of industry j

    Exogenous (↑ S(j,r))

REGIONAL MODELLING: METHODOLOGY

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- **Local industries**
  - output of local commodity i in region r must meet demand for commodity i in region r
  - demand for local commodity i in region r includes
    - intermediate and investment demand for i by local industries and national industries located in r
    - regional household demand for i
    - government demand for i in r
    - and if i is a margin commodity, the usage of i in facilitating commodity flows in region r

Local Industries in OZDAT934.HAR

22

DrinksSmokes	ElecGasWater
Construction	Trade
Repairs	Hotel_Cafe
CommunicSrvc	FinanceInsur
OwnerDwellng	PropBusSrvc
Education	HealthCommun
CultuRecreat	OtherService

REGIONAL MODELLING: METHODOLOGY

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- **For local commodities, household consumption in region r is related to income generated in r**
  - **this gives rise to regional multiplier effects**
  - **if a region has an over-representation of national industries that have large percentage increases in output, then the effect on aggregate real value added in that region is multiplied through a relatively large increase in regional income and hence a relatively large increase in household consumption of local commodities.**

REGIONAL MODELLING: OUTPUTS

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- **Regional output and employment by industry**
- **Aggregate regional output and employment**
- **Regional advantage matrix**
  - **decomposes the difference between percentage change in region r's real value added (x(r)) and the percentage change in national real GDP (x) into contributions made by each industry**

REGIONAL MODELLING: OUTPUTS

- Regional advantage formula

```
x(r)- x = SUM_OVER_IND {  [S(j,r)-S(j)] * [x(j)-x]
                  +   S(j,r) * [x(j,r)-x(j)]  }
```

where S(j) is the share of industry j in national value added

S(j,r) is the share of industry j in region r value added

x(j) is the percentage change in national output of j

Derivation in TAB file

REGIONAL MODELLING: OUTPUTS

- Regional advantage formulae tells us which industries are making a positive contribution to the differential, x(r) - x.
- Industry j makes a positive contribution (is a strength) of region r if:
  - its output increases by more than real GDP (x(j) > x) and its share in region r is larger than its share in the national economy (S(j,r) > S(j)) or
  - its output increases by less than real GDP (x(j) < x) and its share in region r is less than its share in the national economy (S(j,r) < S(j)) or
  - its output in region r increases by more than its national output (x(j,r) > x(j))

Recipe for Regional Success

27

Winning regions:

Have more than their share of faster growing industries

AND/OR

Have less than their share of slower growing or contracting industries

Loser regions:

Specialize in slower growing or contracting industries

AND/OR

Have less than their share of faster growing industries

More doubts

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If we allow growth rates of local industries to differ between regions, how we be sure that those regional outputs are consistent with the national model?

Answers:

(a) We can check that they do add up properly.

(b) Green Book, Chapter 6 proves that they MUST add up properly (but yields little insight).

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Key assumptions in DPSV proof

Same industry technology in all regions, means:
National demands for inputs are unaffected whether (growth in) production takes place in NSW or Tasmania.

LES: Same marginal budget shares in all regions means:
National household demands are unaffected whether income is spent in NSW or Tasmania.

Region shares in other final demands are exogenous.

Initially, each region is self-sufficient (or nearly so) in each local commodity.

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Still more doubts

Industry technology is NOT the same in all regions. For example, in Victoria, electricity industry uses brown coal, but in South Australia they burn oil or gas.

Partial Solution: in National model, split electricity industry into 8 parts, corresponding to each region, with different input requirements. Victorian electricity industry will use coal, SA industry will use oil/gas.

Regional shares of the 8 industries will locate:

100% of the "Vic" electricity industry in Victoria

100% of the "SA" electricity industry in South Australia, etc

If we did this for EVERY sector we would be back to MMRF.

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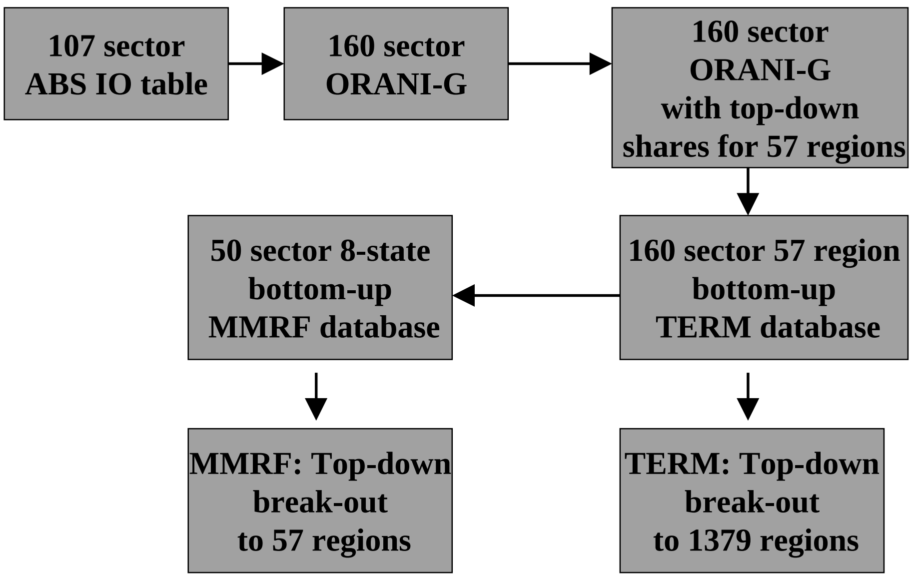
From Top-Down to Bottom-up

- **The top-down model is the indispensable first step in constructing or understanding a bottom-up regional model.**
- **The regional output shares and final demand shares needed by the top-down model are the main data input used to construct the bottom-up database.**
- **In building the database, we assume (by default) that industry technology is the same across regions, and inter-regional trade volumes are inversely related to distance.**
- **The assumptions are crude, but more reasonable if we work with very many (detailed) sectors.**

32

CoPS data process



TERM - a leaner bottom-up model

33

- TERM is a bottom-up model like MMRF but:
  - for given number of regions/sectors solves far faster.
  - allows us to have more regions/sectors and still solve in reasonable time. For example 50 regions/sectors is feasible.
- Very useful where:
  - we model BRIC countries with 30-50 provinces/states (Brazil, Russia, India, China).
  - smaller regions are needed to track natural features such as climatic zones or river watersheds.
  - Supply-side constraints are specific to small regions (Sydney housing).

TERM - how it solves faster

34

- A different data structure: compared to MMRF, data matrices have fewer subscripts.
- eg, for Australian goods, TERM has one trade matrix size: COM*SrcREG*DestREG
- MMRF has one such matrix for EACH industry and final user.
- TERM data assumes that every Sydney wine user gets (say) 30% of their wine from Hunter Valley.
- MMRF could allow government wine users to drink more Hunter wine (than other Sydney users). But in practice, we rarely have data to support this idea.

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The End

Condensing ORANIG

This is done by running program TABLO taking inputs from the Stored-input file ORANIG.STI

Two of the equations in ORANIG.TAB are:

```
Equation    E_t1
   # power of tax on sales to intermediate #
  (All,c,COM)(All,s,SRC)(All,i,IND)
  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;

Equation E_p1 # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*{p0(m,"dom")+a1mar(c,s,i,m)});
```

Two of the instructions in Stored-input file ORANIG.STI are

(1) omit variable a1mar,
(2) use equation E_t1 to substitute out variable t1.

We look at the effect of these on the equation E_p1. [These actions have similar effects on the other equations of the model.]

1. Omit variable a1mar

Equation E_p1 becomes

```
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*[p0(c,s)+ t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*{p0(m,"dom")});
```

Variable **a1mar(c,s,i,m)** has 37(COM) x 2(SRC) x 35(IND) x 4(MAR) =10,360 components. So omitting it omits 10360 exogenous variables from the system to be solved.

Only omit variables which are to be **exogenous and not shocked** in the simulations you intend to carry out.

2. Use equation E_t1 to substitute out variable t1

Equation E_p1 becomes

```
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
    [p0(c,s)+  {f0_tax(c) + f1tax_csi} ]
+ Sum(m,MAR,V1MAR(c,s,i,m)*{p0(m,"dom")});
```

For the Australian version, there are 37(COM) x 2(SRC) x 35(IND) = 2590 equations in the E_t1 block of equations, and variable **t1(c,s,i)** has the same number of components. So substituting out variable t1 removes 2590 equations and 2590 endogenous variables from the system to be solved.

Only substitute out (or backsolve for) variables which are to be **endogenous** in the simulations you intend to carry out.

Backsolve or Substitute

If you want to see the values of a variable that is substituted out, you can use **backsolve** instead of **substitute** in your condensation file. This means that, in the solving the set of equations, the variable is substituted out so that the set of equations is smaller. After solving the equations, the backsolve equation is used to calculate the values of the backsolved variable t1. In using the program AnalyseGE to look at your results, you can click on backsolved variables and see their values but you cannot see the variables that have been substituted out.

In substituting out variable **t1** using equation **E_t1**, the lines in your condensation file are

```
s
t1
E_t1
```

To backsolve for variable t1, change the “s” to a “b”

```
b
t1
E_t1
```

ORANIG Before and After Condensation

Before condensation ORANIG (using the data BASEDATA.HAR) has **272,647** endogenous variables.

After the condensation in ORANIG.STI there are only **3092** endogenous variables. A further **17,120** are backsolved for.

More details and examples

For more details about condensation (including omitting, substituting out and backsolving for different variables), see the 'Condensing models' Chapter 14 of the GEMPACK manual.

Condense.ppt

CONDENSATION

```
Equation    E_t1
# power of tax on sales to intermediate #
  (All,c,COM)(All,s,SRC)(All,i,IND)
  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;

Equation E_p1
  # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
        [p0(c,s)  +  t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*
        {p0(m,"dom")+ a1mar(c,s,i,m)});
```

1

OMISSION

Omit variable a1mar

(must be exogenous and not shocked)

```
Equation E_p1
  # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
        [p0(c,s)  +  t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*
        {p0(m,"dom")+a1mar(c,s,i,m)});
```

2

OMISSION

a1mar has 10,360 components

37(COM) x 2(SRC) x 35(IND) x 4(MAR)

Removes 10,360 exogenous variables

```
Equation E_p1
  # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
        [p0(c,s)  +  t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*
        {p0(m,"dom")    });
```

3

SUBSTITUTION

Use equation E_t1 to substitute out variable t1

Variable t1 must be endogenous

```
Equation    E_t1
# power of tax on sales to intermediate #
  (All,c,COM)(All,s,SRC)(All,i,IND)
  t1(c,s,i)  = f0tax_s(c) + f1tax_csi;

Equation E_p1
  # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
        [p0(c,s)  +  t1(c,s,i)]
+ Sum(m,MAR,V1MAR(c,s,i,m)*{p0(m,"dom")});
```

4

SUBSTITUTION

There are 2590 = 37(COM) x 2(SRC) x 35(IND) equations in the E_t1 block.

Substituting out variable t1 removes 2590 equations and 2590 variables.

```
Equation E_p1
  # purchasers prices - producers #
(All,c,COM)(All,s,SRC)(All,i,IND)
[V1PUR(c,s,i)+TINY]*p1(c,s,i) =
  [V1BAS(c,s,i)+V1TAX(c,s,i)]*
   [p0(c,s)  +  f0tax_s(c) + f1tax_csi]
+ Sum(m,MAR,V1MAR(c,s,i,m)*
        {p0(m,"dom")});
```

5

CONDENSATION

- Before condensation ORANIG (using OZDAT934.HAR) has 271,224 endogenous variables (ie equations) and 32,393 exogenous variables
- After condensation in ORANIG.STI, there are only 3,069 endogenous variables (ie, equations) and 2,731 exogenous variables

6

CONDENSATION STI file

```
o       ! Omit following variables
a1
a1oct
a1mar
a1_s
 ! End of those to be omitted
s         ! Substitute (Results not available)
t1        ! Variable to be substituted
E_t1      ! Use this equation
b         ! Backsolve (Results available)
p1lab
E_p1lab
```

TABLO Implement **|** *Options* **|** *Run from STI file*

7

The end

8

Percentage Change Examples

Levels form	100*ordinary change	Percentage change
X	Xx	$x = 100\Delta X/X$
$3X$	$3Xx$	x
XY	$XY(x+y)$	$x+y$
X/Y	$(X/Y)(x-y)$	$x-y$
X^α	$X^\alpha(\alpha x)$	αx
$X+Y$	$Xx+Yy$	$(Xx+Yy)/(X+Y)$ $= S_x x + S_y y$ where $S_x = X/(X+Y)$, $S_y = 1-S_y$
In the examples below we assume *a vector of quantities X_i, total X.* *a vector of prices P_i, average P.* *a vector of values V_i, total V, such that $V_i = P_iX_i$, (thus $v_i = p_i+x_i$).* *that V = PX, (thus v = p+x).*		
Adding up quantities (rare)		
$X = \Sigma X_i$	$Xx = \Sigma X_i x_i$	$x = \Sigma S_i x_i$ where $S_i = X_i/X$
Adding up quantities with a common price P (frequent)		
$PX = P\Sigma X_i$	$PXx = \Sigma PX_i x_i$ or $Vx = \Sigma V_i x_i$ or $\Sigma V_i(x-x_i) = 0$	$x = \Sigma S_i x_i$ where $S_i = V_i/V$
Adding up values		
$V = \Sigma V_i$	$Vv = \Sigma V_i v_i$ or $V(p+x) = \Sigma V_i(p_i+x_i)$	$v = \Sigma S_i(p_i+x_i)$ where $S_i = V_i/V$
Decomposing value changes into indices of price and quantity change		
$V = \Sigma V_i$	$V(p+x) = \Sigma V_i(p_i+x_i)$	from $v = \Sigma S_i(p_i+x_i)$ price part: $p = \Sigma S_i p_i$ quantity part: $x = \Sigma S_i x_i$ so $v = p + x$
CES (no tech change)		
$X = CES(X_i)$		$x_i = x - \sigma(p_i-p)$ where $p = \Sigma S_i p_i$ implying $x = \Sigma S_i x_i$
CES (with tech change, a_i<0 for progress)		
$X = CES(X_i/A_i)$		$x_i-a_i= x - \sigma(p_i+a_i-p)$ where $p = \Sigma S_i(p_i+a_i)$ implying $x = \Sigma S_i(x_i-a_i)$
Ordinary change in a ratio		
$R = X/Y$	$Rr = 100\Delta R = (X/Y)(x-y)$ $100\Delta R = R(x-y)$	$100(\Delta R)/R = r = x - y$
$N = (X-M)/(X+M)$	$200(X+M)(X+M)\Delta N = 4MX(x-m)$	$200\Delta N = (1-N^2)(x-m)$

Section 11

Group Projects

SIMULATION EXERCISES WITH ORANI-G

GROUP I *Problem:*

- The government has decided that it must improve its budgetary position immediately by $4000 million. It has made an election commitment not to raise taxes and has decided to cut government consumption expenditure. Treasury officials have asked you to model the short-run effects of this policy.

GROUP II *Problem:*

- Treasury officials are now worried about the long-run effects of the cut to government expenditure outlined above in group I's problem. They have asked you to model the long-run effects of the policy.

GROUP III *Problem:*

- The government believes that it has policies of microeconomic reform, which if implemented, can improve all-primary-factor productivity across all industries by one per cent. The Productivity Commission has asked you to model the short-run effects of the policy.

GROUP IV *Problem:*

- The Productivity Commission has asked you to model the long-run effects of the microeconomic reform policies outlined above for group III.

GROUP V *Problem:*

- An academic economist suggests that an increase in real aggregate absorption, coupled with a reduction in real wages, could be used, in the short-run, to stimulate employment by 5%, without harming the balance of trade. He further claims that the economic stimulus would be fairly evenly distributed between sectors and regions. Use the ORANI-G model to test this suggestion. What would happen to the government budget deficit?

GROUP VI *Problem:*

- The government decides to lift all restrictions on the import or use of genetically modified plants in Australia. The result is that Australian exports of agricultural and food products become less attractive to our EU and Japanese customers. In fact, export demand curves for affected products move down by a uniform 5%. Model the long-run effects of this change.

ALL GROUPS ARE TO USE THE GRAGG 2-4-6 SOLUTION METHOD.

Each group should prepare a Powerpoint file for presentation on Friday. During the presentation each member of the group should speak for some of the time. You could break the presentation into topics, each delivered by one group member. Topics might include:

- Experiment setup: policy background, closure, shocks.
- Main mechanisms at work in the results
- Macro results
- Sectoral results: winners and losers
- Explaining some mysterious feature of results
- Regional results
- Effects of making some alternative assumption
- Summary

Each presentation should last for 25 minutes, with 5 minutes for questions.

Hints for your presentation

- Avoid unusual fonts, striking backgrounds, or comical animations, which might compete with your message.
- Remember that you can only fit small tables on a Powerpoint slide.
- Include the whole of your group presentation in a single Powerpoint file.

SPECIAL INSTRUCTIONS FOR GROUPS

GROUP I

Problem:

- The government has decided that it must improve its budgetary position immediately by $4000 million. It has made an election commitment not to raise taxes and has decided to cut government consumption expenditure. Treasury officials have asked you to model the short-run effects of this policy.

Your section boss (who has no experience in CGE modelling) has declared your task to be relatively straightforward and has left no specific instructions. However, he has boasted to other section heads about the job you are doing and claims that you can help group II with calibrating the shock to government consumption expenditure. So be prepared to liaise with this group on the calculation of the shock.

SPECIAL INSTRUCTIONS FOR GROUPS

GROUP II

Problem:

- Treasury officials are now worried about the long-run effects of the cut to government expenditure outlined above in group I's problem. They have asked you to model the long-run effects of the policy.

You need to devise a long-run closure. There are a number of possibilities. Usually, we think how various macro economic variables (on the supply side and demand side of GDP) might be determined. Below are details of the long-run closure that you should use.

SUPPLY SIDE

Labour market

In the long run, it is often argued that aggregate employment is determined by demographic variables, participation rates and the natural rate of unemployment.1 These variables are unrelated to government expenditure. In simulations with fixed employment in the long run, the real wage rate must be free to adjust.

Capital formation

Because we are concerned with the long run, we wish to allow for capital relocation effects in our simulations. For example, in simulating the effects on the metal products industry of cuts in government expenditure, we wish to allow the metal products industry's capital stock to deviate from its basecase level. To allow for capital mobility, we assume that industry rates of return on capital do not deviate from their basecase levels. Initially, the change in government spending will put varying pressures on rates of return in industries. We assume that these cause a change in capital formation sufficient to keep rates of return at their initial levels.

We can justify the rate of return/capital stock assumptions by appealing to small country arguments. With no restrictions on international flows of financial capital, Australian industries face perfectly elastic supply-of-funds schedules in the long run.

DEMAND SIDE

Investment

We assume that, in the long-run solution year, the percentage deviation from base in industry j’s investment is the same as the percentage deviation in industry j’s capital

---

[1] The assumption that, in the long run, the national employment level is determined by population growth, labour force participation rates and the natural rate of unemployment, is the standard steady-state (ie., long-run) assumption of most modern macroeconometric models.

stock. With no restrictions on the supply of investment funds at the given rates of return, it is possible that the nation-wide level of capital formation will change. Therefore, if we tie investment in each industry to changes in industry's capital formation, it is possible (when aggregating across industries) that the nation wide level of investment has changed. This means we need to endogenise the aggregate level of investment. Typically, the swap is with the *invslack* variable.

Trade balance and private consumption expenditure

One assumption that can be made is our shocks have no long-run effects on the trade balance. That is, we assume that national expansions in income are matched by national expansions in absorption (GNE). Hence, the trade balance will be exogenous.

With the trade balance and government expenditure exogenous, investment determined by capital formation and GDP determined by the supply side of the economy, private consumption expenditure is residually determined (ie., it must be set endogenously).

Calibrating the shock to government expenditure

You have heard that another section (group I) has been given the job of running the same simulation as you in a short-run closure. Their life is easier than yours because they didn't have to develop a new closure. Your section boss has told you to liaise with the other section on the shock. (Hint: check their answer!).

SPECIAL INSTRUCTIONS FOR GROUPS

GROUP III

Problem:

- The government believes that it has policies of microeconomic reform, which if implemented, can improve all-primary-factor productivity across all industries by one per cent. The Productivity Commission has asked you to model the short-run effects of the policy.

Below are some suggestions that may help you in interpreting the results.

MACROECONOMIC RESULTS

1. As a first guess, you might expect that a one per cent increase in all-primary-factor-saving technical change would increase GDP by one per cent. Check the results to see what's happened to GDP.

2. You will have noticed that GDP has not changed by one per cent. We now try to understand why. What effect do you expect the technological change to have on employment? Hint: The real wage and the capital stock are both fixed. If we improve the technology of the economy (holding capital fixed), what will be the initial pressure on the marginal productivity of, and hence the real wage of, the existing (pre-shock) workforce? Verify your answer from the results.

3. From the changes to the employment and technology, can you verify the change in GDP?

4. Given the changes in GDP and the assumptions governing domestic absorption, what must happen to the foreign trade balance?

5. How is the trade balance being changed? By higher imports or lower exports or by some combination?

6. What would you expect to happen to the prices of domestically produced goods relative to foreign goods?

INDUSTRY RESULTS

7. Look at the industry results. Note some of the outstanding effects.

8. In your analysis of the macro economy, you will have noticed a move towards trade surplus. The movement to trade surplus required as improvement in international competitiveness, ie., a reduction in domestic costs relative to foreign prices. In analysing the fortunes of various industries, it is useful to bear in mind the influence of the change in international competitiveness.

SPECIAL INSTRUCTIONS FOR GROUPS

GROUP IV

Problem:

- The Productivity Commission has asked you to model the long-run effects of the microeconomic reform policies outlined above for group III.

You need to devise a long-run closure. There are a number of possibilities. Usually, we think how various macro economic variables (on the supply side and demand side of GDP) might be determined. Below are details of the long-run closure that you should use.

SUPPLY SIDE

Labour market

In the long run, it is often argued that aggregate employment is determined by demographic variables, participation rates and the natural rate of unemployment.2 In simulations with fixed employment in the long run, the real wage rate must be free to adjust.

Capital formation

Because we are concerned with the long run, we wish to allow for capital relocation effects in our simulations. For example, in simulating the effects on the metal products industry of productivity changes, we wish to allow the metal products industry's capital stock to deviate from its basecase level. To allow for capital mobility, we assume that industry rates of return on capital do not deviate from their basecase levels. Initially, the productivity changes will put varying pressures on rates of return in industries. We assume that these cause a change in capital formation sufficient to keep rates of return at their initial levels.

We can justify the rate of return/capital stock assumptions by appealing to small country arguments. With no restrictions on international flows of financial capital, Australian industries face perfectly elastic supply-of-funds schedules in the long run.

DEMAND SIDE

Investment

We assume that, in the long-run solution year, the percentage deviation from base in every industry j's investment is the same as the percentage deviation in industry j's capital stock. With no restrictions on the supply of investment funds at the given rates of return, it is possible that the nation-wide level of capital formation will change. Therefore, if we tie investment in each industry to changes in industry's capital formation, the nation wide level of investment is determined. This means we need to

[2] The assumption that, in the long run, the national employment level is determined by population growth, labour force participation rates and the natural rate of unemployment, is the standard steady-state (ie., long-run) assumption of most modern macroeconometric models.

endogenise the aggregate level of investment. Typically, the swap is with the *invslack* variable.

Trade balance and consumption expenditure

One assumption that can be made is our shocks have no long-run effects on the trade balance. Hence, the trade balance will be exogenous; and national expansions in income are matched by national expansions in absorption (GNE=C+I+G). With I determined we need to specify how the residual change in C+G is shared between C and G. We suggest that you assume that real household and real government consumption move together (ie, x5tot=x3tot). You will need to work out the closure trick to do this.

MACROECONOMIC RESULTS

1. As a first guess, you might expect that a one per cent increase in total factor productivity would increase GDP by one per cent. Check the results to see what's happened to GDP.

2. You will have noticed that GDP has not changed by one per cent. We now try to understand why.

What effect do you expect the technological change to have on the demand for capital? Hint: The rental rate of capital and the national employment are both fixed. If we improve the technology of the economy (holding employment fixed), what will be the initial pressure on the marginal productivity of, and hence the real rate of return on, the existing (ie., pre-shock) capital stock? Verify your answer from the results.

3. From the changes to capital and technology, can you verify the change in GDP?

4. What is happening to aggregate investment?

5. Why has export demand increased? What is causing imports to change?

INDUSTRY RESULTS

6. Look at the industry results. Note some of the outstanding effects.

Here are some hints in interpreting the industry results. (i) The effect of the productivity improvement decreases costs (ceteris paribus). However, in our interpretation of the macro results, we noticed that the real wage had risen. (ii) Industries with more elastic demand and supply curves will experience greater fluctuations in activity (for a given change in costs or demand) than industries with less elastic demand and supply curves.

SPECIAL INSTRUCTIONS FOR GROUPS
GROUP V

Problem:

- An academic economist suggests that an increase in real aggregate absorption, coupled with a reduction in real wages, could be used, in the short-run, to stimulate employment by 5%, without harming the balance of trade. He further claims that the economic stimulus would be fairly evenly distributed between sectors and regions. Use the ORANI-G model to test this suggestion. What would happen to the government budget deficit? How much of the employment growth is due to the wage shock, and how much due to the increase in real absorption ?

An increase in real absorption will stimulate employment while having a negative effect of the trade balance, delB. On the other hand, a cut in real wages will have a positive effect on both employment and delB. So there must be some combination of increased spending and wage cut which stimulates employment by 5%, without harming the balance of trade. But what combination?

We can think of this as a "two instrument, two target" problem. Using a linear approximation to the ORANI-G model we could write:

0 = delB = A1.x0gne + B1.realwage

5 = employ_i = A2.x0gne + B2.realwage

Here, A1, B1, A2 and B2 are elasticities. For example, B2 is the elasticity of employment with respect to the real wage. You could obtain numerical values for B1 and B2 by running a short-run closure experiment (Johansen, to save time) where the real wage was increased by 1%. Values for A1 and A2 would come from a short-run experiment where x0gne was increased by 1%. With numerical values for A1, B1, A2 and B2 one could solve the 2 simultaneous equations to obtain estimates for the appropriate x0gne and realwage shocks.

A second approach might be to alter the standard closure so that:

- employ_i is exogenous instead of realwage
- delB is exogenous and x0gne is endogenous

and then shock employ_i by 5% [using Gragg 2-4-6]. The solution would yield appropriate x0gne and realwage values which could then be used as exogenous shocks for a second simulation that uses a short-run closure in which x0gne and realwage are exogenous.

Hint: successfully implementing this simulation will give your understanding of the function of shift variables a good workout. The main question you will need to answer is: how can real private consumption spending, real investment spending, and real government consumption spending all be made to move together? Since inventory demands are a negligible share of GNE, you should simply retain the standard short-run treatment in which inventory demands (delx6) are exogenous.

To discover how much of the employment growth is due to the wage shock, and how much due to the x0gne shock, use the the GEMPACK "subtotals" feature. An instructor can show you how to do this (it's quite easy).

To see what would happen to the government budget deficit, you could use the new equations and variables about direct taxation added during a previous lab.

SPECIAL INSTRUCTIONS FOR GROUPS

GROUP VI

Problem:

- The government decides to lift all restrictions on the import or use of genetically modified plants in Australia. The result is that Australian exports of agricultural and food products become less attractive to our EU and Japanese customers. In fact, export demand curves for affected products move down by a uniform 5%. Model the long-run effects of this change.

You will be using a similar closure to Groups 2 and 4, so study the instructions for those groups, and pick their brains if you find the results puzzling.

You should move export demand curves down 5% for the following commodities:
WoolMutton GrainsHay BeefCattle OtherAgric MeatDairy OthFoodProds

In the standard BASEDATA.HAR data file the commmodity BeefCattle is marked as belonging to the "collective" export group. For this simulation, it will be more convenient to assume that this commodity faces its own individual export demand curve. Make a copy of BASEDATA.HAR called BASEDATAa.HAR and modify BASEDATAa.HAR so that BeefCattle is removed from the "collective" export group. In the CMF, specify the the modified HAR file as input for your simulation.

Analyzing the results

Some industries gain from the fall in food export demands -- why ? [Hint: Reverse Dutch disease]. Some regions also gain -- why? Can you explain why household consumption fell by more than real GDP?

	Size	Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export*	Government	Stocks
	Size	← I →	← I →	← H →	← 1 →	← 1 →	← 1 →
Basic Flows domestic	↑ C ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Basic Flows imported	↑ C ↓	V1BAS	V2BAS	V3BAS		V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Other Costs	↑ 1 ↓	V1OCT					
Production Tax	↑ 1 ↓	V1PTX					

C = Number of Commodities

I = Number of Industries

S = 2: Domestic,Imported,

O = Number of Occupation Types

M = Number of Commodities used as Margins

H = 1: Number of Household Types

* Note: Export column is for domestic goods only.

Size	Make Matrix ← I →	Total
↑ C ↓	MAKE	= sales row totals
Total	=col total absorptn	

Size	Import Duty ← 1 →
↑ C ↓	V0TAR

ORANI-G flows database

Section 12

GEMPACK and
Course Evaluation

Installing Executable-image GEMPACK prior to laptop course

We ask that you install GEMPACK on your laptop prior to the course. This will save time during the course, and might identify problems which your own IT support could help fix.

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1. Preparing for the installation

Download Executable-Image GEMPACK from http://www.copsmodels.com/gpeidl.htm

That page mentions a longer install document, GPinstall.pdf, but you should follow these shorter instructions.

1.1 System Requirements

- A Laptop PC running Windows XP, Vista or Windows 7/8.
- At least 500 MB free hard disk space on drive C:
- 1 GB memory (RAM) or more
- The laptop must be able to "open a DOS box" [Start...Run..."cmd"]. Occasionally system administrators configure PCs to prevent this.

To install the software, you will need "Administrator" or "Power User" access rights. If your laptop belongs to, or was configured by, your organization's IT section, you may only have limited or "Standard User" access rights. In that case an Administrator password may be needed to install GEMPACK. This could mean that someone from your organization's IT section has to be present during the install.

1.2 Installation location and managing existing installations

The installer program will install GEMPACK into the folder **C:\GP**.

It is possible that your computer already has an installation of GEMPACK in **C:\GP**.

We prefer that you use the latest Executable-image GEMPACK as downloaded from the GEMPACK website. This is because parts of the course exercises may have been written to accompany this particular version of the software.

Please check whether you already have a folder **C:\GP**. If so then

rename the existing C:\GP folder to C:\GPOLD.

Do this now. This preserves the existing installation of GEMPACK, and any other files in this folder, for the duration of the course. When the course is finished you can return your computer to its previous state by deleting the course C:\GP directory, and then renaming C:\GPOLD to C:\GP.

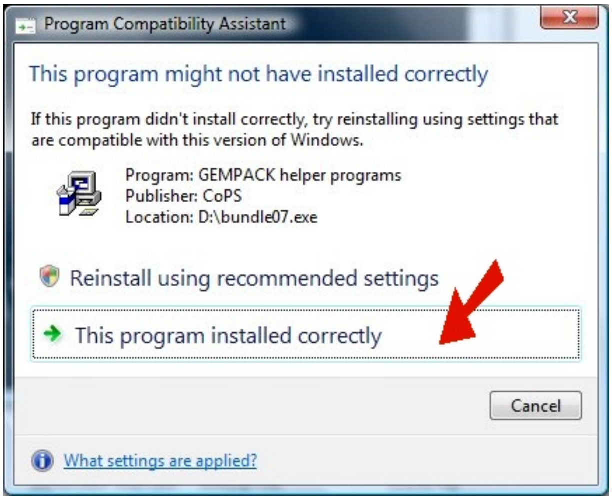
2. Installing Executable-Image GEMPACK

2.1 Installation

Locate the installer program and follow the steps below.

1. From Windows Explorer or My Computer, double-click the installer EXE. It may have a name such as **gpei-11.0-install.exe**.
2. Under Vista and perhaps under XP, a warning window will appear. You may need to supply an Administrator password to continue.
3. The installer program will begin.
4. **Licence Agreement**. To agree to the copyright conditions click *I agree* then click Next.
5. **Destination location**. Please accept the suggested C:\GP directory, and click Next.
6. **Changes to your PATH and Environment.** We ask that you agree to the suggested changes to the PATH and GPDIR variables, and click Next.
7. **Selecting a GEMPACK licence file.** If you have your course CD then *Browse* and select the **.gem** file on your CD. If you do not have your course CD then you do not need to do anything; a temporary licence will be created for you. Click Next to continue.
8. **Ready to begin installation.** This window displays your installation choices. Review your choices, click Back to make corrections. When you are ready click Next to begin the installation.
9. **Finished.** The program signals that Installation is finished. Just click Finish.

Sometimes, just after installation, Windows shows a warning message similar to that below:



You should just click "This program installed correctly" as indicated above.

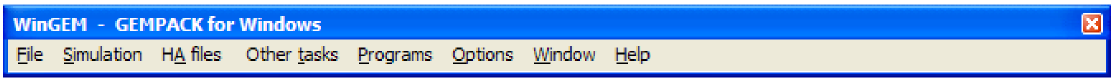
2.2 Folder permissions

Users need full access (read, write, and delete) to the GEMPACK installation folder C:\GP. If you performed the installation above in section 2.1 using the user account which will be used at the course then you have sufficient access, and you don't need to change permissions on C:\GP. If you performed the installation using an administrator level account that will **not** be used at the course, please ensure that the user account to be used at the course has full access to the C:\GP folder. One way to do this is to give the USERS group full access to C:\GP.

3. A Quick Test of the GEMPACK installation

This section leads you through a 5 minute test of your installation. We strongly recommend that you perform this test.

Start WinGEM by double clicking the WinGEM icon on your desktop. WinGEM starts as a taskbar across the top of your desktop:

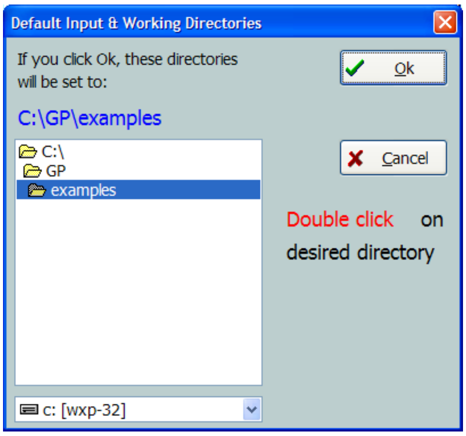


3.1 How to check your GEMPACK licence

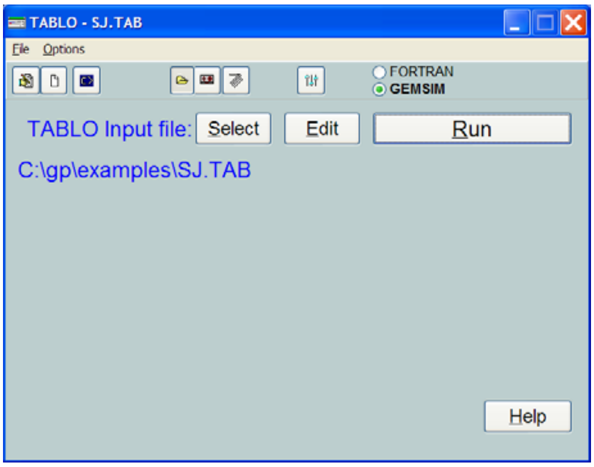
Go to the *Options→Check GEMPACK licence* menu item. You should see a window appear with a text box containing the details of the expiring 3-month licence created by the install program. If a window appears reporting that the file C:\GP\licen.gem could not be found then for some reason the licence file was not copied or made during the installation. Try installing again, then again try the *Check GEMPACK licence*.

3.2 How to run a quick simulation

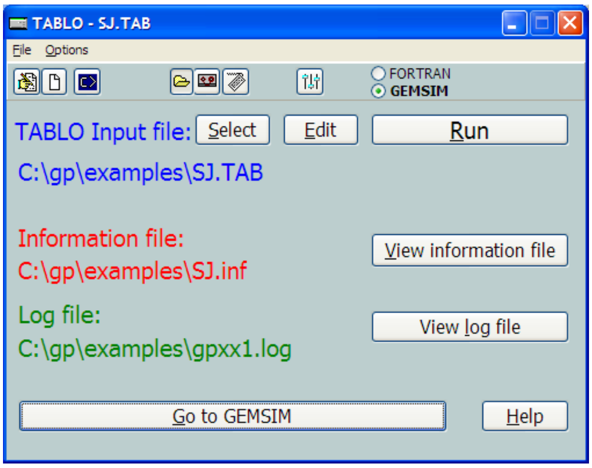
Go to the WinGEM menu *File → Change both default directories*, and in the window that appears, double-click to navigate through the folders until the blue directory path reads C:\GP\examples. Click OK.



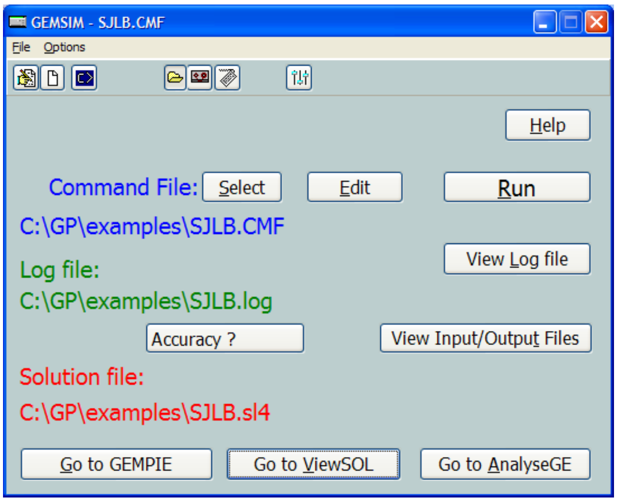
Return to the WinGEM taskbar and select the *Simulation → TABLO Implement* menu item. The TABLO window will appear. Check that the GEMSIM option (near top right) is selected. Now click on the *Select* button and open the SJ.TAB file from amongst those that are listed. The window should now look like this.

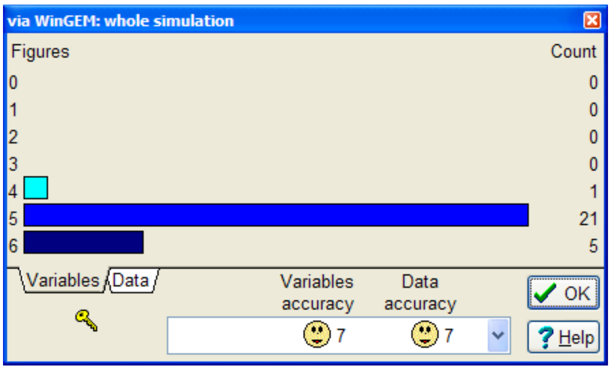


Now click on the *Run* button and after a few seconds some more buttons will appear in the TABLO window. Click on the *Go to GEMSIM* button, see below. (If instead an “Error running Tablo” window appears, go on to the troubleshooting section below.)



In the GEMSIM window which appears click the *Select* button and open the file SJLB.CMF. Now click on the *Run* button, and after a few seconds you will see some more buttons appear on the GEMSIM window and another new window will appear containing a bar chart and two smiley faces, see below. (If instead you see an error message appears, go on to the troubleshooting section below.)





If you got this far then your quick simulation test is successful. Well done! Take a moment to look at your desktop and discover the new program icons there.

4. If there is a problem

If you encounter a problem during the installation, please follow these steps:

- Re-read these instructions and install GEMPACK again. If there is still a problem ...
- Try the "quick fix" mentioned in the next subsection. If that doesn't help ...

- Study the full install document, gpinstall.pdf (downloadable from http://www.copsmodels.com/gpeidl.htm), and follow the procedure suggested there. Still no luck ...
- Send an email to **support@gempack.com** carefully describing your problem. If possible attach the diagnostic file which you can produce using ViewHAR . In ViewHAR, go Help....About/Diagnostics and press the Diagnostics button. A diagnostic file should be displayed, which you can save or copy to the clipboard.

4.1 A quick fix

Various problems sometimes occur if the TEMP or USER folders have very long names or contain spaces or non-english characters. The latter might occur if your username contains non-english characters, or if you are running an Asian version of Windows. The following remedy does no harm and can often fix puzzling problems.

1. Create a folder C:\TEMP (if it does not exist already).
2. Create a folder C:\GPKEEP (if it does not exist already).
3. Set the User Environment variable called TMP to be C:\TEMP .
4. Set the User Environment variable called TEMP to be C:\TEMP .
5. Create a User Environment variable called GPKEEP and set it to C:\GPKEEP .
6. Reboot.

You can set User Environment variables as follows:

1. For XP, right click on *My Computer* and select *Properties* | *Advanced* | *Environment Variables.*
   For Vista, select in turn: *Control panel* | *Classic view* | *System* | *Advanced system settings* | *Environment Variables*.
2. Edit the User Environment variable TMP to be C:\TEMP. Edit the User Environment variable TEMP to be C:\TEMP. Make a New environment variable called GPKEEP with value C:\GPKEEP .

For (much) more detail, please see GEMPACK document GPD-7.

5. Notes on Course GEMPACK installation

Course participants receive the latest Limited Executable-Image Version of GEMPACK. The Limited Executable-Image Version allows the full range of modelling tasks (building new models or modifying existing models), but models are limited to those that can be implemented and solved within about 32 megabytes of memory. This is large enough for many medium-sized models (including all course exercises) but not sufficient for large models. For larger models, you would need one of the more expensive alternatives:

- Source Code version of GEMPACK and a Fortran compiler, or
- Unlimited Executable-Image Version of GEMPACK.

Some course participants may have access at work to the Source Code version of GEMPACK. In that case, they should NOT install the Limited Executable-Image GEMPACK *at work* without first consulting experienced colleagues.

The simplified installation instructions in this document are rather rigid: eg, you *must* install in C:\GP. After the course, you could install GEMPACK on your office and home PC, following the detailed instructions in document GPD-7 -- which allow more flexibility. To install GEMPACK, you may need Administrator or Power User privileges.

6. Upgrading the temporary licence

The trial edition of the Limited Executable-Image Version of GEMPACK comes with a temporary licence lasting 3 months from the download date -- long enough to complete the training course. In addition:

- Usually course participants will receive (either beforehand by email, or on arrival at the course) a course-specific licence lasting 12 months from the start of the course.

- Occasionally, participants are entitled to receive their own permanent individual licence for the Limited Executable Image Version of GEMPACK. In this case, the price is included in the course fee. You would get the licence by emailing a request *after the course* to the GEMPACK Business Manager at sales@gempack.com. Your request should mention: the date and place of the course; your own full name; the name and address of your organization; and your preferred email address.

Practical GE Modelling Course Questionnaire

We would appreciate feedback on the course.

For each question, please give a rating between 1 and 5 where

1=poor and 5=excellent

Comments are welcome.

Part A. Course Content

Question 1. How do you rate the lectures on ORANI-G ?

Your Rating (1-5):

Comments:

Question 2. How do you rate the computing lab sessions on ORANI-G?

Your Rating (1-5):

Comments:

Question 3. How do you rate the first (introductory) simulation?

Your Rating (1-5):

Comments:

Question 4. How do you rate the wage cut simulation?

Your Rating (1-5):

Comments:

Question 5. How do you rate the tariff cut (AnalyseGE) simulation?

Your Rating (1-5):

Comments:

Question 6. How do you rate the group projects on ORANI-G?

Your Rating (1-5):

Comments:

Question 7. How do you rate the course as a whole? Would you have liked more or less of theory, GEMPACK exercises in the Lab, economic analysis of simulations or time for group projects?

Your Rating (1-5):

Comments:

Part B. Logistics

Question 8. How do you rate the meals?

Your Rating (1-5):

Comments:

Question 9. How happy were you to be left to find food on your own?

Your Rating (1-5):

Comments:

Question 10. How do you rate the other logistical and administrative organization of the course?

Your Rating (1-5):

Comments:

Question 11.

(a) Did you work through the MINIMAL material prior to the course?

(a) If you did, did you find it useful?

Comments:

<u>Part C. General Feedback</u>

Question 11. What was the worst thing about the course?

Question 12. What was the best thing about the course?

Question 13. How strongly, if at all, would you recommend the course to colleagues? (Please circle one of the responses below.)

1 = Not at all

2 = Somewhat

3 = Strongly

4 = Very strongly

Comments:

Question 14. Is there one thing that you could suggest that would make an improvement to the course?

Thank you for taking the time to give us this feedback.

Have you any other comments about the course?

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Percentage Change Examples

Levels form	100*ordinary change	Percentage change
X	Xx	$x = 100\Delta X/X$
$3X$	$3Xx$	x
XY	$XY(x+y)$	$x+y$
X/Y	$(X/Y)(x-y)$	$x-y$
X^α	$X^\alpha(\alpha x)$	αx
$X+Y$	$Xx+Yy$	$(Xx+Yy)/(X+Y)$ $= S_x x + S_y y$ where $S_x = X/(X+Y)$, $S_y = 1-S_y$
In the examples below we assume *a vector of quantities X_i, total X.* *a vector of prices P_i, average P.* *a vector of values V_i, total V, such that $V_i = P_iX_i$, (thus $v_i = p_i+x_i$).* *that V = PX, (thus v = p+x).*		
Adding up quantities (rare)		
$X = \Sigma X_i$	$Xx = \Sigma X_i x_i$	$x = \Sigma S_i x_i$ where $S_i = X_i/X$
Adding up quantities with a common price P (frequent)		
$PX = P\Sigma X_i$	$PXx = \Sigma PX_i x_i$ or $Vx = \Sigma V_i x_i$ or $\Sigma V_i(x-x_i) = 0$	$x = \Sigma S_i x_i$ where $S_i = V_i/V$
Adding up values		
$V = \Sigma V_i$	$Vv = \Sigma V_i v_i$ or $V(p+x) = \Sigma V_i(p_i+x_i)$	$v = \Sigma S_i(p_i+x_i)$ where $S_i = V_i/V$
Decomposing value changes into indices of price and quantity change		
$V = \Sigma V_i$	$V(p+x) = \Sigma V_i(p_i+x_i)$	from $v = \Sigma S_i(p_i+x_i)$ price part: $p = \Sigma S_i p_i$ quantity part: $x = \Sigma S_i x_i$ so $v = p + x$
CES (no tech change)		
$X = CES(X_i)$		$x_i = x - \sigma(p_i-p)$ where $p = \Sigma S_i p_i$ implying $x = \Sigma S_i x_i$
CES (with tech change, a_i<0 for progress)		
$X = CES(X_i/A_i)$		$x_i-a_i = x - \sigma(p_i+a_i-p)$ where $p = \Sigma S_i(p_i+a_i)$ implying $x = \Sigma S_i(x_i-a_i)$
Ordinary change in a ratio		
$R = X/Y$	$Rr = 100\Delta R = (X/Y)(x-y)$ $100\Delta R = R(x-y)$	$100(\Delta R)/R = r = x - y$
$N = (X-M)/(X+M)$	$200(X+M)(X+M)\Delta N = 4MX(x-m)$	$200\Delta N = (1-N^2)(x-m)$