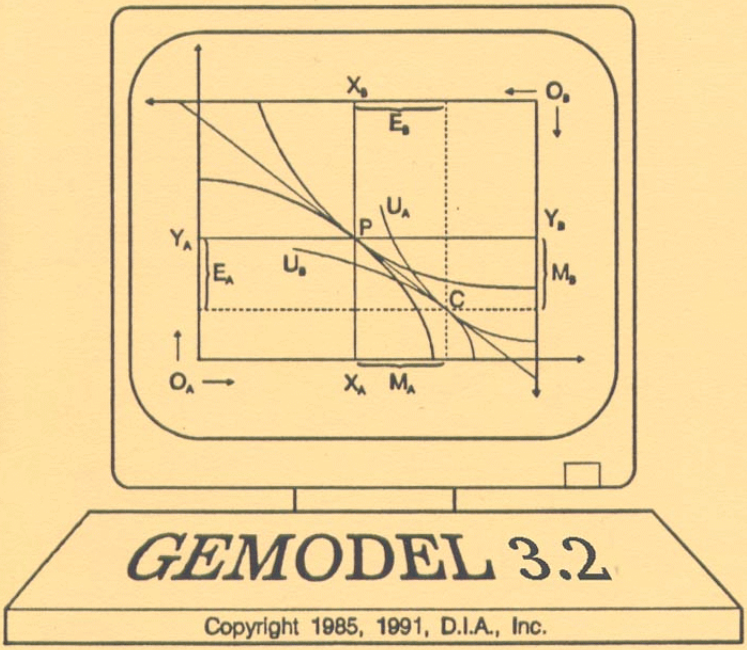


GEMODEL 3.2

CONTENTS

ABOUT THIS MANUAL

The manual is organized into 8 sections:

1. Installation, and loading instructions.

2. Pages alphabetically arranged by model features.

3. 15 **GEMODEL** "Explorations" that can be used as a tutorial to familiarize the reader with the capabilities of the software.

   The explorations are organized around major themes in economic theory and some of them involve multiple exercises.

4. A trouble-shooting guide and a listing of model symbols and equations.

The **GEMODEL** sections are followed by three other sections that refer to supporting data and software that may or may not have been included in your purchase order:

5. **GEDATA**, a set of files with data for and results of sample exercises in part 3 above.

6. **GEREPORT**, a computer program that compares simulation results.

7. **GESTATS**, a computer program that calibrates equation parameters to economic data.

8. Subject index

This manual can be printed on A5 paper.

INTRODUCTION

GEMODEL finds numerical solutions to non-linear economic models which can be used to illustrate principles of economics, including fundamental results of micro-economic theory, international trade, public finance, and welfare economics.

SYSTEM REQUIREMENTS

The GEMODEL software is supplied to run on a PC under WINDOWS XP or later versions of WINDOWS.

FEATURES

- Easy operation with a mouse on a graphical user interface.
- Solves either 3-factor, 3-industry or 2-factor, 2-industry models.
- Any model can be open or closed to international trade, international capital service flows, and to a labor/leisure choice.
- Solves single- and multi-country open-economy models. The number of countries may vary from one to nine.
- Simple menu and setup choices to delete and restore equations.
- Menu selection of policy parameters.
- Built-in default values of all policy variables and function parameters.
- Data entry in spreadsheets in a multiple-document interface with context-sensitive help.
- Automatic consistency check of the user's data input.

MODEL DESCRIPTION

GEMODEL solves systems of equations that describe closed or open economies. The equation system is designed to follow standard textbook assumptions so that the software can support courses in Intermediate Price Theory, Public Finance, International Trade, and Economic Development. The model is supplied with a maximum number of equations adequate for advanced courses. The number of equations can be reduced and the models can be simplified for elementary applications.

The wage rate is the standard of value and equal to one except in differential incidence experiments when a GNP deflator is applied to hold real tax revenue constant.

Individual utility is a nested function of goods and leisure. Leisure can be omitted from the utility functions and the demand for leisure equations can be deleted.

Industries employ capital and labor in two-sector models and also land in three-sector models. Factors are perfectly mobile between industries. Production functions can have constant or diminishing returns to scale. To assume diminishing returns amounts to assuming industry-specific factors beyond the 2 or 3 perfectly mobile ones. Production of intermediate inputs can be deleted and restored.

The economy can be open or closed to international trade and payments. The economy faces fixed world prices in a single-country model. World prices are endogenous in multi-country models. Imports are perfect substitutes for domestic products. There are no non-traded goods with the exception of capital services. Open economy simulations can be made with a closed as well as an open capital service account.

The user may input his own data or use default values provided. User data are tested for consistency prior to every run.

See page 1-6 for more detail on the variety of models that can be solved with GEMODEL. See page 7-14 for a tabular representation of the economic structure simulated with GEMODEL.

TO INSTALL GEMODEL

For the very first installation:

Insert the original GEMODEL in a CD or DVD drive. The installation should start automatically. If not seek and double-click on the SETUP.EXE file. Ignore Windows messages asking whether or not you wish to install this unrecognized software.

The installation program requests you to enter through the keyboard the the hard disk drive and folder on which you want to install the software, your name, and your address or institutional affiliation.

The installation finishes by making GEMODEL files with an icon for the executable files installed from the original disk.

Subsequent installations:

Subsequent installations proceed like the original one but without prompting you for your name and address.

*Installation instructions may change in the future. Consult the *.DOC files on your original diskette for up-to-date information.*

TO OPEN GEMODEL

Double-click the GEMODEL icon in *Program Files*.

Wait for a menu and spreadsheets to appear on screen.

CUSTOMER SUPPORT

In case of irreparable damage you may request a replacement disk by writing to

DIA Agency, Inc.
1879 Kingsdale Avenue
Ottawa, Ontario
K1T 1H9 CANADA

The charge for a replacement diskette is $35 (US). The original diskette and payment must be enclosed with the request for a replacement.

We can be reached by mail at the address above and by e-mail to

info@diaagency.ca

VARIETY OF MODELS IN GEMODEL

Two basic models have either 2 or 3 perfectly mobile primary factors employed with constant returns to scale, constant elasticity of substitution production functions to produce goods for a single consumer.

The two basic models can be multiplied exponentially by addition of other GEMODEL features. The number of models that the user may construct is doubled by adoption of any one of the following features:

diminishing returns to scale
taxes
demand for leisure
inter-industry transactions
2 to 19 consumers

Combinations of the above features represent 64 different closed-economy models. Another 64 models are available by opening any one of the closed models to commodity trade. Yet another 64 are possible by opening the open-economy models to international trade in capital services. These 192 model varieties can be multiplied further by running GEMODEL as a multi-country model.

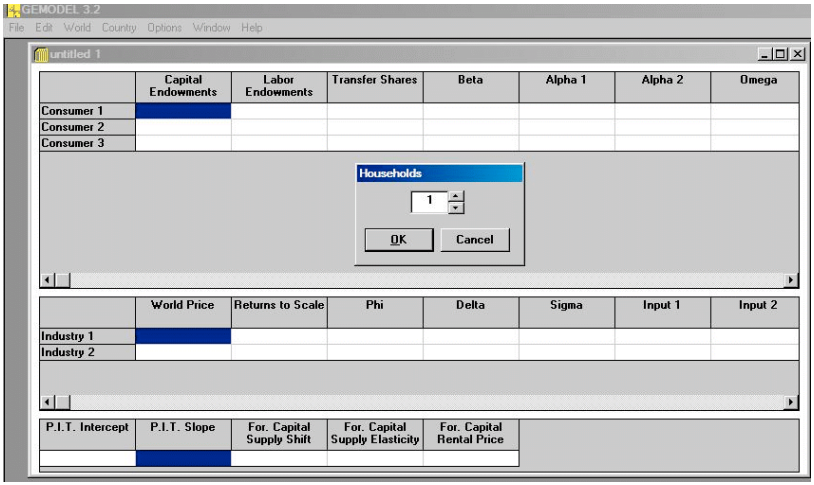
The number of model varieties can be increased again if one may regard 3-factor production functions that are CES at one level and Cobb-Douglas in the other as different from any of the basic functions. Note also that industry-specific factors need not be assumed in all sectors, that the tax structure can be more or less incomplete, and that one of three sectors need not partake in inter-industry relations.

Finally, total tax revenue can be either endogenous or exogenous. All tax rates are exogenous when revenue is endogenous. One or more tax rates are endogenous when revenue is exogenous.

PRACTICE RUNS

I. BUILD A ONE-COUNTRY MODEL

Start by building a bare-bones model of minimum complexity. Select **File|New** to create a window with three blank spreadsheets. Then select the smallest possible model dimensions: 2 industries, 1 household, no utility of leisure, no intermediate input transactions, no taxes, and no foreign capital service flows. Subsequent illustrations will show how to make most of these selections. The following illustration shows the selection of the number of households.



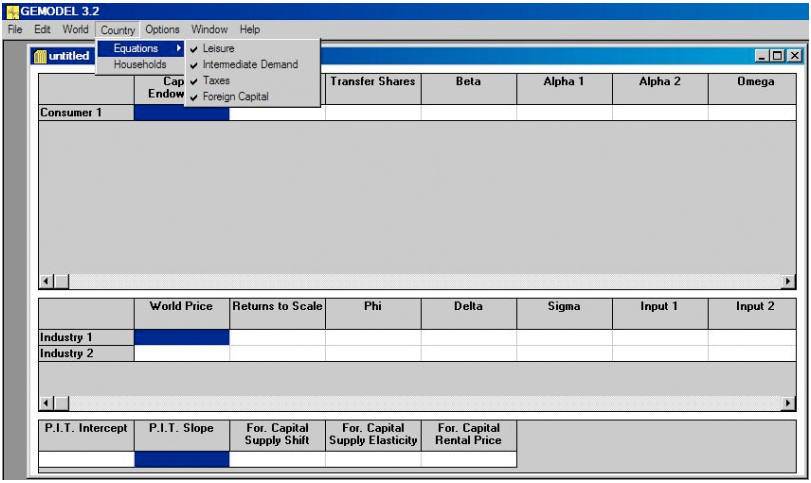
Select **Country|Households**. In the Households dialog box, type a 1 in the text box or use the scroll-bar to set the number of households to 1. Then click the **OK** button. The number of households that occupied three rows in the top spreadsheet will be reduced to one in a single row.

PRACTICE RUNS...

The number of industries in the above illustration is already 2. If it was three, then select **World|Model Dimensions** to set the number of industries to 2. This selection is made from the **World** menu because all countries in a GEMODEL multi-country world must have the same number of industries producing the given number of tradeable goods. To set the number of industries is the same as setting the number of tradeable goods.

With two industries and only one household the model has a minimum size but can still be simplified further. Simplify it by deleting equations. Select **Country|Equations** to delete (or reinstate deleted) equations as in the next illustration.

Intermediate demands and Taxes had already been deleted before the picture



was taken. One can see this by the absence of check-marks in the **Equations** menu and by the smaller size of the two lower spreadsheets from which the taxes and intermediate demand columns were eliminated.

PRACTICE RUNS...

Click on Leisure and on Foreign capital to delete also those equations. The model is now reduced to its most elementary form.

The screen now shows all cells and only the cells that need to be filled with data and parameters. The required data are household endowments of capital and labor. The parameters are utility function parameters, world prices of the 2 tradeable goods, and production function parameters. Select **File|Save As** to save the country data and parameters in a file on disk. There are various sources for data and parameters:

i) published models;
ii) calibration results;
iii) more or less arbitrary or experimental values.

Two published models, Shoven's version of the Harberger model and Shoven and Whalley's example in the Journal of Economic Literature can be loaded from files in the **GEDATA** set (see page 5-1).

Calibration results can be obtained by hand, by solving equations for their parameters given the variable values. Calibration results can be read from file if they had been produced by the GESTATS program (see pages 7-1 ff.).

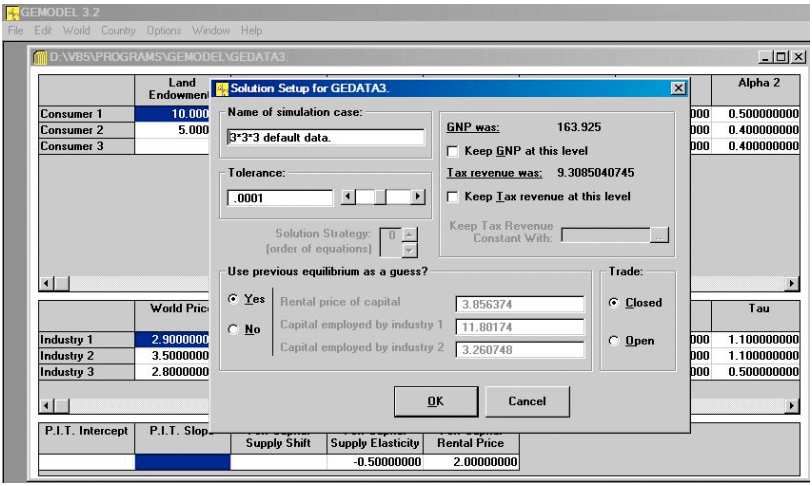
Any other values can be experimented with. Chances are that GEMODEL will either not attempt a solution but issue error messages and suggest corrections of the data and parameters, or GEMODEL will at least find a closed economy solution. That, indeed, is the first that should be attempted as there cannot be an open economy solution unless there also is a closed economy solution.

As for error messages, a common one is that the values of α for an indicated household do not add up to unity. Press the F1 key for help on parameter values while viewing a spreadsheet.

PRACTICE RUNS...

II. SOLVE THE ONE-COUNTRY MODEL

Select **World|Solve**. A Solution Setup dialog box such as that in the next illustration will appear if there are no errors in the data and parameters.



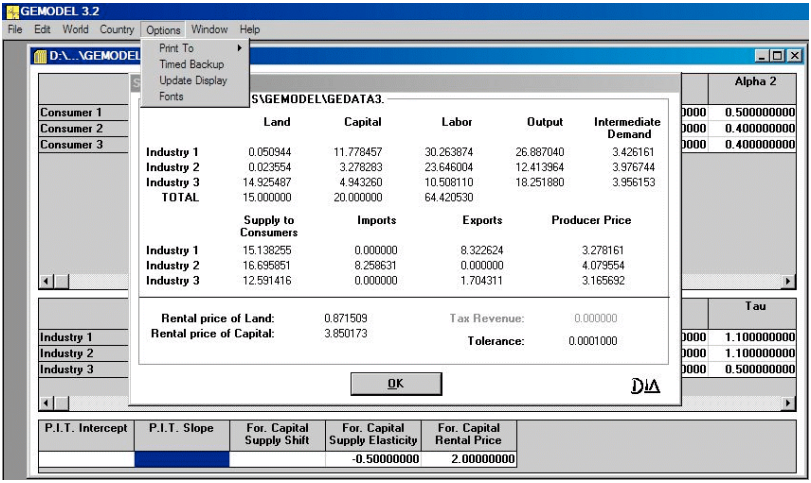
The illustration shows a solution setup for a practice run with the **Gedata3** file. GEMODEL offers *default selections* that the user can change by typing in text boxes, clicking a scroll-bar; clicking check-boxes, clicking radio buttons, and making menu selections. In the example above, the user has not changed the **name of the simulation case** and the error **tolerance**. Previously obtained equlibrium values will be used as **initial guesses** to start the iterative approach to a new equilibrium. The text boxes for insertion of guesses are disabled and can be enabled by clicking on **No**.

PRACTICE RUNS...

A closed economy solution is selected in the Trade frame. The choice of **Solution Strategy** becomes available when clicking on **Open**.

The user had changed rates of tax assessed on industries in the middle spreadsheet. The presence of tax rates enabled the **Keep Tax Revenue Constant** check-box. The illustrated tax menu pops up when this box is checked. The taxes on this menu are those found in the user's parameter set. Personal income tax rates being zero in the last of three spreadsheets, there is no personal income tax on the pop-up menu.

Click **OK** when satisfied with the Solution Setup. A solution updating screen may then appear, depending on the necessary number of iterations:



PRACTICE RUNS...

The updater screen has an **Abort** button that changes to **OK** when a solution is found. One reason to abort is when a message appears to the left of the button saying that a corner solution is being approached. Another reason is when variable values are oscillating without approaching an equilibrium. Select **Options|Update Display** to see all changes in all displayed variables as GEMODEL is searching for a solution. In the illustration above, this option is not checked. It was not selected because it seldom is necessary when solving a closed economy model.

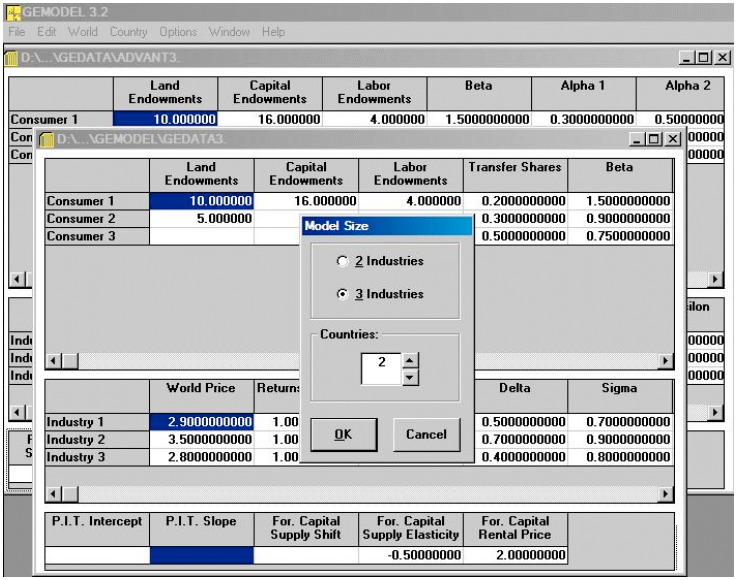
Click OK when available. GEMODEL will then display several screens with the equilibrium values of the variables. These other screens have a button bar for selection of results pages, for printing the results, and for closing the results and to return to the initial spreadsheets window.

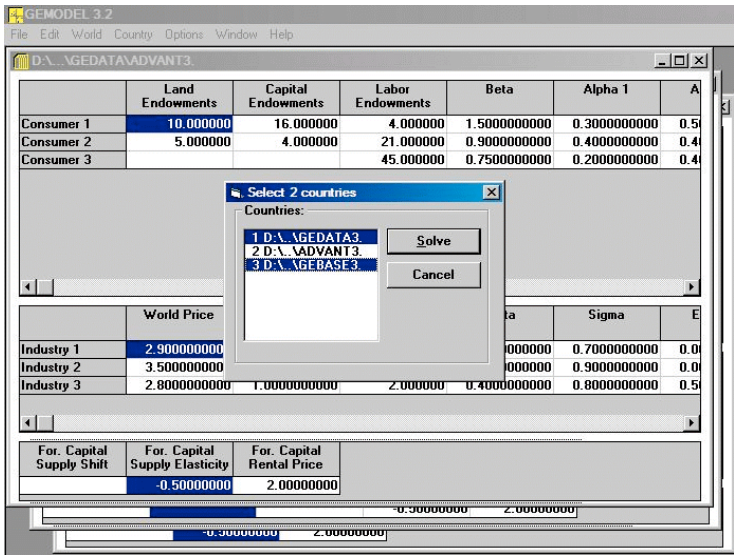
III. CREATING A MULTI-COUNTRY MODEL

Select **File|New** to create new spreadsheets, one for every country in the multi-country model (maximum 9). Then proceed as in part I above to dimension the models and to enter data and parameters. For best results, use consistent data that reflect a world trade equilibrium.

IV. SOLVING A TWO-COUNTRY MODEL

Select **World|Model Dimensions** to set the number of countries to two as in the next example. Click **OK** in the small dialog box. Select **World|Solve** and select the countries included in the model as shown in the second illustration. Click the **Solve** button. Solution Setup dialog boxes will appear, one for each country as in Part II above. The Updater screen will show the changing variable values for both countries alternating between them before revising world market prices. The iteration count on the Updater screen is a count of market price revisions. Clicking the Updater **OK** button causes a return to a country spreadsheet screen. Select **File|View Results** to view the equilibrium values of variables in the active country. Select the active country from the **Window** list. Select **File|History** to inspect the history of world market price revisions.


GEMODEL 3.2
File Edit World Country Options Window Help
D:\...\GEDATA\ADVANT3.
Land Endowments
Capital Endowments
Labor Endowments
Beta
Alpha 1
Alpha 2
Consumer 1
10.000000
16.000000
4.000000
1.5000000000
0.3000000000
0.5000000
D:\...\GEMODEL\GEDATA3.
Land Endowments
Capital Endowments
Labor Endowments
Transfer Shares
Beta
Consumer 1
10.000000
16.000000
4.000000
0.2000000000
1.5000000000
Consumer 2
5.000000
0.3000000000
0.9000000000
Consumer 3
0.5000000000
0.7500000000
Model Size
2 Industries
3 Industries
Countries:
2
OK
Cancel
World Price
Delta
Sigma
Industry 1
2.9000000000
0.5000000000
0.7000000000
Industry 2
3.5000000000
0.7000000000
0.9000000000
Industry 3
2.8000000000
0.4000000000
0.8000000000
P.I.T. Intercept
P.I.T. Slope
For. Capital Supply Shift
For. Capital Supply Elasticity
For. Capital Rental Price
-0.50000000
2.00000000


GEMODEL 3.2
File Edit World Country Options Window Help
D:\...\GEDATA\ADVANT3.
Land Endowments
Capital Endowments
Labor Endowments
Beta
Alpha 1
Consumer 1
10.000000
16.000000
4.000000
1.5000000000
0.3000000000
Consumer 2
5.000000
4.000000
21.000000
0.9000000000
0.4000000000
Consumer 3
45.000000
0.7500000000
0.2000000000
Select 2 countries
Countries:
1 D:\...\GEDATA3.
2 D:\...\ADVANT3.
3 D:\...\GEBASE3.
Solve
Cancel
World Price
Sigma
Industry 1
2.900000000
0.7000000000
Industry 2
3.500000000
0.9000000000
Industry 3
2.8000000000
1.0000000000
2.000000
0.4000000000
0.8000000000
For. Capital Supply Shift
For. Capital Supply Elasticity
For. Capital Rental Price
-0.50000000
2.00000000

ASCII FILES

GEMODEL simulation output can be directed to diskette ASCII files and to the printer.

Select **Options|Print To** to set the output destination.

AUTOMATIC BACKUP

Any file you are working on can be backed up automatically at timed intervals. Select **Options|Timed Backup** to change automatic back-up settings. A small dialog box appears when this selection is made. The dialog box has a checkbox, a text box, and a scroll bar. Click the checkbox to turn automatic backup off or on. When it is on or checked you can set a timed backup interval in minutes by typing in the text box or use the scrollbar to change the time interval.

CALCULATOR

The Calculator emulates an electronic calculator on screen.

Click the Calculator icon in the middle and at the bottom of the GEMODEL window.

Calculator results can be passed to GEMODEL spreadsheets. Click the **COPY** button of the calculator to pass the result to a clipboard. Then click the **CLOSE** button. Select a spreadsheet cell. Select **Edit|Paste** to pass the value in the clipboard to the GEMODEL spreadsheet cell.

CORNER SOLUTIONS

A corner solution is a solution where a variable is zero. GEMODEL has two important corners, one of which can be reached.

1. In an open economy, the world prices can be such that one industry must shut down. In that case, the production possibility curve and the straight line indicating the terms of trade meet at a point where they both cut an axis of the production possibility diagram. GEMODEL cannot find such a corner because one cannot solve for endogenous factor prices that are larger in number than the operating industries. This corner is more likely when there is a highly elastic foreign capital supply.

2. The corner GEMODEL can reach is where a consumer decides to supply no labor at all. This may happen when one of several consumers is richly endowed with land or capital and faces a high marginal personal income tax rate.

DATA INPUT

Select **World|Model Dimensions** to set the number of industries and countries. Select **Country|Number of Households** and to choose the included equations.

Use the spreadsheets to change data on screen. The number of spreadsheets and their sizes adjust to your choice of included or excluded equations, and to your choices for the number of industries and households. Some spreadsheets are larger than the current window. Use scroll bars to view the entire spreadsheet.

Use the mouse or cursor keys to move about the spreadsheets and focus on a data item that is to be changed. Type the new value and press the ENTER key or change the focus with the mouse. The value you type appears in a small window at the bottom left. Click the X mark to cancel the input. Click the check mark to confirm the input.

Dragging the mouse will highlight a number of cells that can be copied to the clipboard and pasted elsewhere using the **EDIT** menu.

DATA INPUT...

Your input is checked for consistency before every run. Inadmissible data values trigger error messages that suggest repair measures you can take by editing the data. Press the F1 key while viewing the data for information on the meanings of model parameters and the restrictions on them.

DATA INPUT FROM FILE

Select **File|Open** to pop up a drive list box, a directory list box, and a file list box. Click the **BROWSE** button to select an existing file from a list box or type a file name in the filename box.

When browsing, double click the drive box to change drives. Double-click a directory in the directory list box to change the current directory and to obtain a new list of available files in the file list box.

The files shown in the file list box are those whose names match a pattern indicated in the file specification box. Wildcards are allowed in the file specification box. Specify *.* to select from all files in the current directory. Specify GEDATA? to list GEDATA2, GEDATA3, and similarly named files.

DATA OUTPUT TO FILE

Select **File|Save** to save a file with the current file name. Select **File|Save As** to save data with a new file name. A file saved after a successful run can be opened to replicate the results without guessing or iteration.

A filename may be preceded by a drive designation and path. It may also be followed by a period and a 3-character extension. GEMODEL, GEDATA2, and GEDATA3 are reserved filenames that cannot be used. Neither may a filename end with the .RAW or .GEM extensions. These restrictions on filenames prevent the writing of GEMODEL simulation results over valuable files, including some created with GESTATS.

DEFAULT DATA

The default data files GEDATA2 and GEDATA3 can be used for immediate application of the software.

GEDATA2 is a two-industry data set. GEDATA3 is a three-industry data set.

Default data are modified by your own input. To get the default files you have to open the files after selection of **File|Open**.

Recently used files can be re-opened by clicking on one ofthe file names at the bottom of the **File** menu..

DO NOT UNDER ANY CIRCUMSTANCES DELETE THE DEFAULT DATA FILES. THESE FILES MUST ALWAYS REMAIN ON THE SAME FOLDER AS GEMODEL. THE DEFAULT DATA FILES ARE **GEDATA2** AND **GEDATA3**.

DEFAULT VALUES

At different points in the program where when input is required the input prompt contains words or numbers written in boxes. These are default values that you may use. Simply click the OK button if you wish to use a default value instead of entering your own.

DELETION OF EQUATIONS

Deletion and reinstatement of equations are made at four places: the **NUMBER OF INDUSTRIES**, the **NUMBER OF HOUSEHOLDS**, the **EQUATIONS MENU** and in **SOLUTION SETUP**.

Deletion of an equation results also in deletion of equations, variables, and parameters that are associated with it. Deletion of taxes, for example, results in deletion of tax revenue and transfer payment equations and in the exclusion of all tax and transfer rates from demands and marginal conditions.

Numerical values of deleted variables and parameters are retained and restored on reinstatement.

Select **World|Model Dimensions** to switch from a one-country to a multi-country model and to change the number of production functions or industries. Select **Country|Households** to change the number of utility functions by changing the number of households.

The **Country|Equations** menu allows deletion or reinstatement of (1) intermediate input demands; (2) demands for leisure; (3) taxes; and (4) the foreign capital service supply. Clicking one of the options will toggle its state from included to deleted and back. Check-marked options are included in the equation system.

The number of equations is controlled during **SOLUTION SETUP** by choosing either a closed- or open-economy model. Foreign trade and the balance of payments equilibrium condition are deleted by choosing the closed-economy model. **SOLUTION SETUP** does not offer the closed economy option when a multi-country model has been chosen.

SOLUTION SETUP is the place to include or exclude two other equations: a quantity equation and a constraint on tax revenue together with an equation determining a rate of tax that meets the constraint. The quantity equation is included by choosing to hold nominal GNP constant. The endogenous tax rate equation is chosen and included after choosing to hold tax revenue constant.

DEMAND ELASTICITIES

The consumers' income elasticities of demand for goods are all unitary. The own-price elasticities are $S(\beta\text{-}1) - \beta$ and the cross-price elasticities are $R(\beta\text{-}1)$, where β is the elasticity of substitution in consumption and S and R are expenditure shares. S represents the proportion of disposable income spent on the good in question and R is the expenditure share of the other good with respect to which the cross-elasticity is measured.

DIFFERENTIAL INCIDENCE

Select **Keep Tax Revenue Constant** in SOLUTION SETUP to pop up a menu of taxes that may be used as instruments for the attainment of the previous level of real tax revenue. Select the tax instrument of your choice.

GEMODEL only adjusts the marginal rate when the Personal Income tax is chosen. The constant in the linear income tax function remains undisturbed unless you choose the head-tax as the instrument to achieve the given level of tax revenue. The last menu item **All** is usually your best choice. Choice of a narrower option may result in the appearance of this message:

You are adjusting taxes on a base that is either too narrow or too elastic.

Return to the spreadsheets where to inspect the current levels of tax rates. You may also attempt to solve again. On the next try you may change the tax used to maintain total revenue or insist on your previous choice.

If you insist on your previous choice you may--in certain cases--get this additional message:

Some tax rates cannot be raised further.

This message will appear in case not even a confiscatory tax will meet revenue requirements. In this case you must choose a different tax to meet the revenue goal.

See also the section on **TAX REVENUE IN DIFFERENTIAL INCIDENCE**.

DIMINISHING RETURNS

Assumption of diminishing returns to scale in GEMODEL has two consequences:

- it sharpens the curvature of production possibility curves; and
- it results in pure profits by pricing at marginal costs that exceed their corresponding average costs.

Pure profits accrue to owners of industrial capital. A corporate income tax in a GEMODEL with diminishing returns is thus both a distorting tax on the competitive return to capital and a non-distorting tax on pure profit.

The greater curvature of production possibilities achieved when assuming diminishing returns to scale in GEMODEL allows a more faithful numerical representation of the trade diagrams commonly found in textbooks. This increased curvature reduces the possibility that an industry will have to shut down when a closed economy is opened up to trade.[1]

DISPOSABLE INCOME

Individual disposable income after tax and transfers is

$$Disposable = -a + (1-t)Y + sT$$

where a is the constant in the linear income tax function, t is the marginal personal income tax rate, Y is the individual's income, s is the individual's share in transfer payments, and T is total government tax revenue.

[1] For an example of sharply diminishing returns to scale, see Ramón Clarete and J. Roumasset, "A Shoven-Whalley Model of a Small Open Economy: An Illustration with Philippine Tariffs," *Journal of Public Economics*, 32 (1987), 247-61. In their model, the sum of variable factor shares in Cobb-Douglas production functions ranges between 0.14 and 0.48.

ELASTICITY OF FOREIGN CAPITAL SERVICE SUPPLY

The elasticity of supply of foreign capital services is

$$E = -nx/(1-x)$$

where n is the elasticity parameter, $x = r/pe$,
r is the home-country rental price of capital not including any tax on the employment of capital (corporate income tax),
p is the rental price of capital abroad, and
e is the exchange rate.

E is positive if r is greater than pe (capital services are imported). E is negative if r is less than pe (capital services are exported). If r equals pe, capital services are neither imported nor exported. The elasticity can be increased by increasing the parameter n. Higher elasticities can be attempted to reduce international differentials in the price of capital in multi-country models.

EQUATIONS

GEMODEL is programmed to solve a complete model of maximum size: a model of nine countries, each with nineteen households and three industrial sectors. Households allocate labor to leisure and work. Sectors employ labor and internationally mobile capital. Production, consumption, and trade are subject to a variety of taxes. For each country, the equations in the complete model are

3 production functions;
3 demands for intermediate inputs;
19 utility functions;
1 government tax revenue equation;
19 individual disposable income equations;
1 supply of foreign capital services;
3 marginal cost pricing conditions;
1 full employment of labor condition;
1 full employment of capital condition;
1 full employment of land condition;
3 domestic market clearing equations;

EQUATIONS...

1 quantity equation;

plus derived marginal conditions and demand functions for factors, consumption goods, and leisure. Multi-country models include also world-market clearing conditions.

One cannot add equations but one can restore any that were deleted. Hundreds of different models are constructed by deletion of equations and by varying the number of sectors, households, and countries. Moreover, government tax revenue can be made exogenous and a tax rate or vector of tax rates can be designated as endogenous.

ERROR MESSAGES

Error messages may appear in message boxes on screen. Errors can arise from improper input responses (eg. alphabetical input where numerical is required) and, during iterations, by illegal attempts to arrive at a corner solution. Press the ENTER key or click the OK button to recover from such errors and return to the data and parameter spreadsheet.

Another type of error message can occur immediately after you select World|Solve. Your data are checked before a simulation is run. A message is displayed if any inconsistency or illegal parameter value is found. Click the OK button and make the required data change.

EXCHANGE RATE

The exchange rate in the open economy model is the price of foreign currency expressed in terms of domestic currency. It equals the ratio of money wages in the home country over money wages abroad, assuming factor price equalization and that the rest of the world has the same production functions. You can also interpret the exchange rate as a purchasing power ratio.

Doubling world market prices will cut the exchange rate in half.

EXIT FROM GEMODEL

The only exit is by selection of **File|Exit**.

FILE MENU

The options on the **FILE** menu are

- New country — To erase all data and start a new file.
- Open — To open a country file on disk.
- Save — To save a file without changing its name.
- Save As — To save a file with a new file name.
- Close Country — To close a country spreadsheet window.
- Print Country — To print the active spreadsheet data.
- History — To inspect price revisions in a multi-country model solution attempt.
- View Results — To display most recent simulation results.
- Print Results — To send results to an ASCII file or printer.
- Exit — To quit GEMODEL.

The **OPEN** and **SAVE AS** options open a drive list box together with a directory list box and a file list box.

The **VIEW** and **PRINT RESULTS** options become available after a simulation had been made.

FILE NAMES

GEMODEL filenames follow *Windows* file naming conventions

Filenames may be followed by a name extension and preceded by a path designation.

HELP

On-screen help explaining variables, model equations and menu options is available with the **HELP** menu and by pressing the F1 key.

HISTORY FILE

Iterative revisions of world prices and of world excess demands are stored in a diskette file named HISTORY. You will find this file on the current drive after either a successful or interrupted multi-country solution. The file can be displayed on screen by selecting **File|History**.

Inspection of the file may help to diagnose non-convergence problems.

INDIVIDUAL INCOME

Individual before-tax money income is

Income = (rental rate of capital) x (capital endowment)
+ (wage) x (labor supply)
+ (rent of land) x (land endowment)

where the rental rate of capital is after corporate income tax, the wage is after social security or payroll tax, and the rent of land is after property tax is paid.

Capital income includes a share of profits proportional to capital endowment whenever there are diminishing returns to scale.

Capital income includes a share in the excess of the domestic price over the world price of capital services whenever such services are imported.

Capital income includes a share in the excess of the world price over the domestic price of capital whenever such services are exported.

INITIAL GUESSES

WHY? Non-linear models are always solved iteratively. Initial guesses are needed to start an iteration process. The best guesses are the previous equilibrium values. Guesses can be changed during **SOLUTION SETUP** prior to iteration. The change in starting values can be skipped. Do this whenever you made only data changes.

WHEN would you have to make guesses? When you have put in substantially new data and run your new model for the very first time, especially when you changed the endowments or the numbers of industries and consumers. Then it is best to edit the default values for the amounts of capital used by the first n-1 industries and the after-tax rental price of capital shown in the **SOLUTION SETUP** window. The default values are looked up in the results for the latest model solution and are inappropriate after a large data change.

HOW? There are no general rules that govern your first guesses but there are ways to make bad guesses.

Do not input most capital in the industry whose product is least in demand. For example, if there should be two industries, 10 units of capital and one consumer, and if the αs in his utility function are

$$\alpha_1 = 0.3 \text{ and } \alpha_2 = 0.7$$

a good guess is . . . . . capital in industry 1 = 2
whereas a bad guess is . . . . . capital in industry 1 = 8
and a worse guess is . . . . . capital in industry 1 = 12

because 8 can be too much for an industry whose product has a low expenditure share parameter in the utility function and 12 is more than the capital endowment.

Less care is needed in guessing the rental rate of capital.

INPUT BOXES

Input numeric or alphabetic responses, depending on what is being requested. Click the **OK** button when available only when all data were entered or edited.

INTER-INDUSTRY RELATIONS

Every industry may demand intermediate inputs produced by other industries. If X_i is the intermediate use of the i-th commodity and Q_j is the gross output of the j-th industry, then

$$X_i = \sum_j a_{ij} Q_j$$

where a_{ij} is an input-output coefficient indicating how much of commodity i is used per unit of commodity j and $0 \le a_{ij} < 1$.

The net output available to meet demand is $Q_i - X_i$.

Deletion of inter-industry relations has the same effect as an increase in the total productivity of primary factors.

LARGE ECONOMY MODELS

Multi-country models are large open-economy models. The number of countries may vary from 2 to 9. World market prices of traded goods and capital services are endogenous. Thus a multi-country model can be used to find the effect that a tax change in the home country has on economic variables in the rest of the world. Small open-economy conditions in the home country can be approximated by making the factor endowments of the rest of the world very much larger than those of the home country.

LEISURE

In GEMODEL versions with a labor/leisure choice, the economic incomes of consumers exceed their disposable money incomes by the product of their leisure and the wage rate net of personal income tax. This tax distorts the demand for leisure and the supply of labor. The labor supplied equals the endowment less leisure demanded.

MARKET CLEARING

The model has market-clearing equations, one for each industry:

gross output = intermediate use + consumer demand + exports - imports.

Factor markets must clear as well. Industrial demand for land must equal the endowment in 3-sector models. Industrial demands for labor and household demands for leisure must equal the labor endowment. Industrial demands for capital services must equal the endowment plus an optional foreign supply available in open-economy models.

The market-clearing condition for multi-country equilibrium is that world net exports be zero. The sum of all exporting countries' exports equals the sum of all other countries' imports for every good and for optional international capital services.

MENU

Menus are available whenever they are visible and after clicking an OK button. Menu items are selected by clicking a highlighted item or by pressing the indicated hot keys.

MULTI-COUNTRY MODELS

Open several country files, each in a new window created with **File|New**. Reset the number of countries using the **World|Model Dimensions** menu option. Select **World|Solve.** GEMODEL will open a list box. Select countries from the list using Click and Ctrl-Click.

Select **File|Save As** to save the results for the active country in a file on disk. Select **File|View Results** to see the solution values for the active country. Select the active country from the **Window** list.

All countries in a multi-country model must have the same number of industries. Either more than one country or none must have an open foreign capital account.

The input files required by GEMODEL are best prepared using consistent trade data in calibrations made using GESTATS. GEMODEL is supplied with two multi-country model files named HOME and ROW. The HOME file is the same as GEDATA3 except that there are no taxes whatsoever. The ROW file differs from HOME only in the factor endowments. The simultaneous solution results in a trade pattern for HOME that is the reverse of the one obtained in the GEDATA3 single-country, small-open-economy model. Absence of taxes leads to factor price equalization in HOME and ROW (Stolper-Samuelson).

MULTIPLE EQUILIBRIA

Multiple equilibria can exist if factor endowments are unevenly distributed among consumers, consumers prefer goods whose production employs intensively the factors with which the consumers are most richly endowed, and if elasticities of substitution in production average out to less than unity. These conditions may cause multiple equilibria, some of which are unstable. If such multiple equilibria exist it may be impossible to find any one of them.

NON–CONVERGENCE

Two typical causes of non-convergence are that guesses are too far from equilibrium or that one industry must shut down to reach a corner solution.

A CORNER SOLUTION IS APPROACHED

This problem arises in open-economy models when the production possibilities have little curvature and the world price ratio is very different from the closed economy relative price.

The problem is recognized on screen by the output of one of the industries becoming steadily smaller during iterations. Click the **ABORT** button to interrupt iterations and return to the spreadsheet. Change data in ways that avoid corner solutions.

Possible data changes: increase the world price of the good in question, increase its final demand (change α's), increase the intermediate demand (change technical coefficients), reduce productivity (φ), reduce taxes on the product.

Consider deletion of inter-industry relations to increase the curvature of the production possibilities.

Some action is required because there must be as many industries as endogenous prices!

GUESSES ARE TOO FAR FROM EQUILIBRIUM VALUES

Start from the previous equilibrium whenever possible. Use a modified closed economy equilibrium as the initial guess for an open economy simulation. If the closed economy relative price of good 1 exceeds the world price then reduce the initial guess of capital allocated to industry 1 in the closed economy. See also the section on **INITIAL GUESSES**.

Far-off guesses result in an excessive number of iterations. Iterations will eventually stop. If you are convinced that an equilibrium exists, start over from the previous "equilibrium," in which case the computer will continue from where it left off, but with a new iteration count.

NUMÉRAIRE

GEMODEL can run with either of two numéraires: the wage or the GNP deflator. The choice is available when tax revenue is endogenous. The choice is made during **SOLUTION SETUP** by clicking on a checkbox. This choice does not exist in differential incidence analysis when nominal GNP is held constant during deflation of nominal tax revenue.

NUMERIC INPUT

- Use the spreadsheets to change data on screen.
- Input no more than 16 significant figures.
- Input tax rates as decimals (eg. for a 6% tax you would enter .06).

ONE-COUNTRY, SMALL OPEN ECONOMY MODELS

A troubling characteristic of a small open economy model is that it can easily crash into a corner solution. This happens when the world price ratio is very different from any of the possible closed-economy price ratios, especially when the closed-economy price ratios fall within a narrow range. They do this when the production possibility curve or surface is very flat. The curvature of production possibilities can be increased by: (a) deletion of inter-industry relations, (b) increasing the difference in factor intensities among the industries, (c) reduction of elasticities of factor-substitution, (d) reduction of the degree of returns to scale in production.

Further difficulties are created by tariffs. Proper price signals must be given for resource allocation to domestic industries. Industries that compete with imports must be made to face world prices plus tariffs, whereas export industries face world prices without tariffs. The identification of export- and import-competing industries is simultaneous to the resource allocation. This simultaneous identification problem obviously does not exist when all tariffs are zero because in that case one knows before-hand that all industry selling prices (producer prices) equal world market prices. The problem does arise, however, when some tariffs are positive, and it is greater when duty rates are high.

OSCILLATION

Solution values oscillate when GEMODEL repeatedly displays the same values the updater window. Click the **ABORT** button when this happens to interrupt iterations or let GEMODEL reach a maximum iteration count. Typical causes of oscillation are:

World price ratios are too close to closed economy price ratios

Rounding errors in prices determine what is exported and imported. An import good becomes an export good, again an import good, and so on (but you will not see this if you suppress display during iterations.)

Equality of price ratios may happen with tariffs included or excluded. Compare closed economy prices with world prices including and excluding import duties.

Comparative advantage changes between iterations

Oscillation shows in the total quantity of capital and labor employed. International capital flows change comparative advantage back and forth between iterations and the algorithm can therefore not find the equilibrium direction of trade. Possible repair: reduce the elasticity and/or scalar of the capital flow.

High elasticity in the labor/leisure choice causes changes in labor supply and comparative advantage between iterations. Reduce the elasticity parameter (ω).

The tolerance level is too low

Rounding errors keep the algorithm from recognizing a solution that it finds. The error tolerance should not be so low that the computer will not declare a solution unless all figures are correct. You recognize this situation when the iterative revisions made on screen do not result in appreciable changes in *any* of the displayed figures.

Wrong solution strategy

Oscillation can be avoided in some multi-country models with international capital services by changing the solution strategy.

Consult also the sections on **PRECISION** and **TOLERANCE**.

PARAMETER RESTRICTIONS

Keyboard input of various function parameters is subject to restrictions. Press the F1 key while viewing the data to see the restrictions.

GEMODEL will check prior to every run whether the model parameters obey their respective restrictions.

PRECISION

GEMODEL uses 16 significant figures but does not display all of them. Do not make keyboard data input of more than 16 significant figures.

The precision of simulation results can be increased by reduction of the tolerance level, but do not push it so low that rounding errors keep the computer from recognizing a solution.

The precision of simulation results depends also on the initial guesses. The solution obtained is always a point in the neighborhood of the true solution. Which point is reached depends on initial conditions and tolerance. Thus it is virtually impossible to replicate previous results without using exactly the same data, initial guesses, and tolerance level.

PRICE OF INTERNATIONAL CAPITAL SERVICES

Capital is imperfectly mobile. The elasticity of foreign capital supply is finite. The supply responds to the difference between the domestic and world market prices of capital services. The domestic price in the importing country exceeds the world price. The excess accrues pro-rata to domestic capitalists in proportion to their capital endowments. The world price exceeds the domestic price in the exporting country. The premium earned by exporting capital services accrues to owners in proportion to their capital endowments. The domestic price is the marginal value product of capital less any tax on the employment of capital (or corporate income tax).

PRINTER OUTPUT

Select **Options|Print To|Printer**. Select **File|Print Country Data** to print the data in the active country window. Select **File|Print Results** to print latest resultsof simulation with the data in the active window or click the **Print** button while viewing the output screens.

QUANTITY EQUATION

The quantity equation is such that factor prices are adjusted to hold GNP constant. Factor and product prices are adjusted so that real income at market prices is constant. The adjustment helps to highlight the effect of tax policy on prices but is meaningful only if you do not change factor endowments.

ROBUSTNESS

No algorithm is guaranteed to solve all models. Some models have no solution. Other models have a solution that the algorithm cannot find. Open economy models can be less easy to solve than closed ones. The following are typical cases in which the algorithm may not find a solution:

- redistributions of income to several consumers cause aggregate demands to violate the weak axiom of revealed preference,
- the solution requires that one industry shut down,
- world price ratios are too close to the closed economy price ratio,
- comparative advantage changes between iterations,
- guesses are too far from equilibrium values,
- the tolerance level is too low.

For more on these cases, see the sections on **NON-CONVERGENCE** and **OSCILLATION**.

GEMODEL does not declare a solution that does not exist or cannot be found with the selected error tolerance.

SOLUTION SETUP

Whenever you choose to solve a model, the computer will first take you through a solution setup routine before proceeding to the solution.

A number of data fields, checkboxes and option buttons appear on screen during the solution setup. They are about whether you want to

- simulate an open or closed economy,
- input guesses or start from previous equilibrium,
- hold real tax revenue and nominal GNP constant,
- change the solution strategy,
- suppress display during iterations,
- change the tolerance.

The extent of the available options depends on the list of included equation and on tax parameter values. For this reason, the setup routine must be run through every time. Click the **OK** button when all setup choices are correct. Click the **CANCEL** button to return to the data spreadsheet.

SOLUTION STRATEGY

This section applies only if your model has a variable supply of foreign capital.

When there is a variable supply of foreign capital, it may be advantageous to change the order of equations, depending on parameter configurations and on the nature of the policy experiment.

A choice of 3 solution strategies involving different equation orderings may appear on the solution setup form. The default option is 0. You would normally leave it as it is. You may also select either option 1 or 2. The latter may speed up those simulations which cannot be expected to result in an appreciable change in the after-tax rental price of capital or in the amount of foreign capital employed.

SPEED

GEMODEL solutions are obtained quickly but the time taken depends on the error tolerance level. Thus one can trade accuracy for speed, but sometimes you can get both.

To get both speed and accuracy, run your model several times, starting with a large tolerance level and then working down toward a small one. This technique is particularly effective with open economy models.

More speed is gained by suppressing the display of revised guesses during iteration. Deselect **Options|Udpate Display** to suppress the display whenever you are confident that a solution will be reached.

SUPPRESS DISPLAY DURING ITERATION

Suppression of the display of revised guesses during iteration speeds up the solution. The choice to suppress display is made by deselecting **Options|Update Display**. Click **UPDATE DISPLAY** to toggle the check mark between on and off. Iterative variable revisions will not be updated if the check mark is off.

Suppress the display whenever you are sure that there is a solution, which is most likely when running closed economy models.

Some updated results will still be displayed to allow you to spot oscillations such as would occur when the tolerance level is too low.

TAX RATES

All GEMODEL tax rates are ad-valorem rates.

Most rates are expressed as rates on tax-exclusive value but there are two exceptions to this rul:.

The import duties are at rates on duty-paid value.

The marginal personal income tax rate is on before-tax income.

TAX REVENUE IN DIFFERENTIAL INCIDENCE

When you choose to hold real tax revenue constant for a differential incidence analysis, the computer will adjust tax and subsidy rates to reach a revenue target. The choice is made in **SOLUTION SETUP** by clicking a checkbox.

You do not choose the level of revenue, only whether you want to reach it or not. You have a choice of taxes adjusted to reach the target revenue. A menu of taxes pops up when you check the checkbox. The taxes on the menu are those for which you have specified non-zero tax rates on the spreadsheet or in data files.

The target level is the last one to have been reached without having been fixed. Once you fixed a level of tax revenue it remains in memory until you disable this option.

When you save a data file on disk, the file will contain the tax revenue reached on your last run. This will be available as a target level the next time you run GEMODEL with the same data.

The tax revenue displayed during iteration is a nominal amount without inflation adjustment. It is different from the figure finally displayed in the fourth output screen. The final figure is deflated by the new GNP deflator.

TOLERANCE

What is it? Iteration ceases when a computed solution deviates from the true solution by a small amount. This amount is determined by an error tolerance chosen during **SOLUTION SETUP**.

The tolerance level specified during **SOLUTION SETUP** is a relative value and seldom needs to be less than 0.001.

How does one choose a tolerance level? The choice involves a trade of speed for accuracy. If you are interested in speed, then choose a large tolerance (0.01 or greater). Enter 0.001 or less if you want accuracy. Accuracy is most crucial in open economy models.

The computer will show one or both of two diagnostic messages if the tolerance is too large: it may tell you that the balance of payments surplus or deficit is too large a percentage of GNP or that GNP deviates from GNE. You may decide that these errors are small enough to be neglected or run again with a smaller tolerance.

Solution values will oscillate if the tolerance is too small.

While displaying revised guesses the computer will keep showing the same figures instead of moving on to a solution. Click the **ABORT** button and run again using this "previous equilibrium" as your guess with a larger tolerance.

GEMODEL does not accept input of a tolerance value that is too small *a priori*.

Iterative solutions are a bit like shooting at a stretching target: if you want to hit the bull's eye you must set a low tolerance. If you set a high tolerance, you can hit any point in an enlarged target area.

GEMODEL EXPLORATIONS IN PRICE, TRADE, AND TAXATION THEORIES

Exercises in this chapter are a sample of GEMODEL's uses that demonstrate its versatility. 13 single-country exercises and 2 multi-country exercises illustrate basic lessons in Economics and introduce users to general equilibrium models. Exercise solutions should be saved on disk for use in other exercises. Make 4 base case data files and save them on disk. Call these files GEBASE1, GEBASE2, GEBASE3, and GEBASE4. The first 3 are solutions to closed economy runs. GEBASE4 is a solution to a single-country, open economy run. All 4 require that real tax revenue and GNP be allowed to find their new levels, using the wage rate as numéraire.

To make GEBASE1:

Open GEDATA2.
Delete leisure, inter-industry transactions, and taxes.
Set the number of consumers to 1.
Solve as a closed economy model.
Return to **FILE MENU** and **SAVE AS** file GEBASE1.

To make GEBASE2:

Open GEDATA2.
Delete leisure. Set the number of consumers to 2.
Using spreadsheets, change the transfer payment shares to 0.1 for consumer 1 and 0.9 for consumer 2.
Set the marginal personal income tax rate to 0.3.
Solve and then save as GEBASE2.

To make GEBASE3:

Open GEDATA3. Delete leisure and taxes.
Solve and save as GEBASE3.

To make GEBASE4:

Open GEDATA3.
Set the capital import function scalar to 10.
Solve as an open economy model and save as GEBASE4.

A GEDATA disk with the GEBASE files and exercise solutions is available from DIA Agency, Inc., as well as GEREPORT, a program that compares files, prints out numerical deviations between them, and computes Hicksian measures of welfare change (see pages 5-1 and 6-1).

EXPLORATION No. 1

CHANGE FACTOR ALLOCATIONS IN AN EDGEWORTH BOX

The point of this exercise is to verify that, given factor endowments and production functions, a shift in consumer tastes towards the capital-intensive good will make all industries employ more labor per unit of capital. Also, the relative price of capital will rise.

Open GEBASE1 and select **World|Solve**

During **SOLUTION SETUP**:

Rename your simulation Base Case as, for example, "Edgeworth Box Base Case."[2]

Choose a closed economy run.
Use the previous equilibrium values as a guess.
Leave the tolerance level at its default value.
Suppress display during iteration.

Inspect the results. Note that industry 1 is the capital-intensive one. Also make note of the rental price of capital.

Click the **CLOSE** button to return to the spreadsheets.
Increase the consumer's taste for good 1 by raising α_1 from 0.3 to 0.7. At the same time, reduce α_2 from 0.7 to 0.3.

Solve again. Call this simulation case "Swapped alphas."

Has the price of capital increased and has L/K increased in both industries?

Save the result as EDGEWBOX.[1]

[2] You can, of course, enter any title you wish. These are only suggested titles and filenames which were used in the making of the **GEDATA** diskette.

EXPLORATION No. 2

THE SHAPE OF THE PRODUCTION POSSIBILITY CURVE

Given the endowments and production functions, see how much closed-economy relative prices change when consumer tastes shift and the equilibrium point moves along the production possibility curve.

Open GEBASE1. Change δ_1 to 0.3. This change increases the difference in factor intensity between industries 1 and 2 and puts more curvature into the production possibility curve.

Solve the closed economy model. Note the producer prices of goods 1 and 2 and their ratio. Note also the ratio in which goods 1 and 2 are produced. Save the results as PPCURVE.

Change the αs in the consumer's utility function. Set α_1 to 0.7 and α_2 to 0.3.

Solve the closed economy again. Call this simulation "Swapped alphas." Note the new product prices. Save the results as PPCURVE2.

The price ratio changed very little. Production possibility curves do not have much curvature. A consequence of lack of curvature is that an industry may have to shut down if the economy is opened up to international trade at terms of trade that are very different from the closed economy price ratio.

DIMINISHING RETURNS

Open GEBASE1 and change the production functions by setting the degree of returns to scale to 0.9 in both industries. Save the file as GEBASE1.DIM.

Repeat the above exercise and save as PPCURVE.DIM and PPCURVE2.DIM. You should now find that a change in tastes causes a greater change in prices or that the production possibility curve has more curvature.

EXPLORATION No. 3

THE SHAPE OF THE UTILITY POSSIBILITY CURVE

Given the endowments, production functions, tastes, and tax rates, change the consumers' shares in transfer payments to find at least two points of a utility possibility curve.

Open GEBASE2.

Solve the closed economy model. Note each consumer's utility level.

Change transfer payment shares from (0.1, 0.9) to (0.9, 0.1).

Solve the closed economy model again. Call this simulation "Swapped transfer shares." Note the new utility levels. Save the results as UPP.

EXPLORATION No. 4

COMPARATIVE ADVANTAGE I

Run comparable closed and open economy simulations and observe the change in welfare.

Open PPCURVE.

Run the closed economy model. Note the consumer's utility level and the product prices.

Change world prices to (0.42, 1.0).

Solve the open economy. Make note of the new utility level and save the results as ADVANT2.

Change world prices to (0.4, 1.06). Solve the open economy model again. Note the changes in trade flows and the utility level. Save the results as ADVANT22.

EXPLORATION No. 5

COMPARATIVE ADVANTAGE II

Run comparable closed and open economy simulations and observe the change in welfare.

Verify that the owner of the factor used intensively in the export industry gains from trade.

Open GEBASE3.

Solve the closed economy model. Note the consumers' utility levels and the product prices.

Solve the open economy. Make note of the new utility levels and save the results as ADVANT3.

Consumer 1, who owns most of the capital employed intensively in the largest export industry, is the one who gains from trade.

Use the GEREPORT program to compare GEBASE3 with ADVANT3 and compute the Hicksian compensating and equivalent variations that estimate the gains from trade.

EXPLORATION No. 6

FREE TRADE

Run comparable open economy simulations with and without a tariff and observe the change in welfare.

Verify that the owner of the factor used intensively in the export industry gains from free trade.

Open ADVANT3.

Set the tariff on good 2 at 0.03. Solve the open economy model. Note the consumers' utility levels and the product prices.

Compare the results with those previously obtained with the ADVANT3 file and save the new results as PROTECT.

DIMINISHING RETURNS

Open ADVANT3 again. Change the production functions by setting the degree of returns to scale to 0.9 in every industry. Save the file as ADVANT3.DIM.

Repeat the above exercise and save to PROTECT.DIM.

Check whether diminishing returns to scale in production increase the gains from free trade or the losses from protection.

EXPLORATION No. 7

THE RYBCZYNSKI THEOREM

Increase the capital endowment of an open economy and verify that the capital-intensive industry expands, the labor-intensive industry contracts, and the amount of capital employed by the labor-intensive industry decreases.

Open ADVANT2. Use the spreadsheets to change the consumer's capital endowment from 16 to 17. Solve the open economy.

Compare the results to those previously obtained with the ADVANT2 file and save the new results as RYBCZY2.

The theorem does not hold under diminishing returns[3]. Factor prices do not remain constant when the supply of one factor is increased. Moreover, both industries expand when factor intensities are close and substitution elasticities are large.

Open ADVANT2 again.

Edit production function parameters of both industries:

- set returns to scale to 0.9 and 0.9,
- set deltas to 0.5 and 0.55,
- set sigmas to 1.5 and 2.0.

Solve the open economy model.

Increase capital from 16 to 17.

Solve again.

The output of the first industry should have increased from 0.2056 to 0.212. The other output should rise from 6.72 to 6.95.

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[3] See Sakari Ylönen, "Factor Demand and Substitution Under Decreasing Returns to Scale. An application to the Rybczynski Theorem," *Scandinavian Journal of Economics*, 89(2), 1987, pp. 206-209.

EXPLORATION No. 8

THE WELFARE COST OF A TAX

Compare the levels of welfare obtained when a given amount of revenue is obtained either by a sales tax on one good or by a uniform sales tax on all goods.

Open GEBASE1.

Set the sales tax on good 1 at 0.2 (20 percent).

Solve the closed economy and note the consumer's utility level. Save the results as SALESTAX.

Set sales taxes equal to 0.06 on both goods 1 and 2. Solve the closed economy again. In **SOLUTION SETUP** choose the option to hold tax revenue constant by clicking on the corresponding check box. Choose the sales tax as your instrument for revenue-neutrality.

Note the new utility level. Verify that you did indeed get the same amount of tax revenue. Inspect the new tax data on the spreadsheets. Note how GEMODEL adjusted the revenue-neutral tax rates. Are they still 0.06? Save the results as SALESTAX.UNI.

EXPLORATION No. 9

FACTOR PRICE DISTORTIONS

Verify that the welfare cost of raising a given level of revenue is greater when a factor tax is used than when a product tax is imposed.

Open SALESTAX. Set all sales taxes back to zero.

Set the corporate income tax on industry 1 to 0.3 (thirty percent.)

Solve the closed economy model, holding tax revenues constant. Use the corporate income tax as your revenue-neutrality instrument.

Has utility decreased in comparison to the non-uniform sales tax experiment?

Go back to the spreadsheets and view the tax data. The corporate income tax rate of industry 1 is over 90 percent of net after-tax income (over 45 percent of before-tax income). Such a high rate was required to maintain tax revenue because corporate income is a narrower tax base than sales.

The after-tax income of capital fell by about two thirds of the corporate income tax revenue. The incidence of this tax is also on labor.

Save the results as CIT.

DIMINISHING RETURNS

Open SALESTAX again. Change the production functions by setting the degree of returns to scale to 0.9 in both industries. Save the result as SALESTAX.DIM.

Repeat the above exercise and save the simulation results as CIT.DIM.

Verify that the welfare cost of a corporate income tax is smaller when this tax falls on pure profits that result from diminishing returns to scale.

EXPLORATION No. 10

INCOME TAXES

Verify that a personal income tax is equivalent to a uniform sales tax when the labor supply is exogenous.

Open SALESTAX.UNI. Set sales taxes back to zero. Set the marginal personal income tax rate to 0.06 on the last data screen.

Solve the closed economy holding tax revenue constant. Let income tax be the instrument to hold revenue constant. Save the results as PIT.

There should be no difference between SALESTAX.UNI and PIT except for:

- the deliberate differences in tax structure,
- factor and product prices should be higher in the PIT experiment,
- consumer prices should be lower in the PIT experiment

The differences in prices are so that GNP including sales taxes is equal to GNP without sales taxes. Recall that GNP is held constant during differential incidence experiments and that GNP equals factor income plus indirect tax revenue.

EXPLORATION No. 11

THE MODEL IS REAL

Verify that there is no money illusion in GEMODEL.

Open GEBASE4. Solve the open economy and make a note of the results, especially prices and the exchange rate.

Simulate inflation in the rest of the world: double foreign commodity prices and the rental price of capital abroad. Solve the open economy again without taking the option of holding tax revenue constant. Note that the exchange rate is cut in half and that the differences in other variables are in the nature of rounding errors. Save the result as REALGE.

EXPLORATION No. 12

TAXES AS A DETERMINANT OF TRADE[4]

The Heckscher-Ohlin trade model assumes — *inter alia* — that prices are not distorted by taxes. This assumption can be removed to show that taxes can have a greater influence on the pattern of trade than factor endowments.

1. Open GEDATA3.
2. Delete equations for: (*a*) leisure and (*b*) foreign capital.
3. Edit the data:
   - set all taxes to zero
   - set import duties to zero
   - set the marginal personal income tax rate to 0.2.
4. Solve the open economy model and find this result:

	IMPORTS	EXPORTS
INDUSTRY 1	0	9.765
INDUSTRY 2	8.856	0
INDUSTRY 3	0	0.956

5. Edit the data:
   - set the rate of corporate income tax on industry 1 to 0.2.
6. Solve the open economy. Hold tax revenue constant letting the personal income tax rate adjust.
7. Note the new result:

	IMPORTS	EXPORTS
INDUSTRY 1	7.257	0
INDUSTRY 2	0	5.225
INDUSTRY 3	0	0.985

   The rent of land rises above the wage rate. Relative to the wage rate, the price of capital (after tax) falls by 35 percent.

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[4] See James R. Melvin, "Commodity Taxation as a Determinant of Trade," *Canadian Journal of Economics*, Vol. III, No. 1 (Feb. 1970), pp. 62-78.

EXPLORATION No. 13

PERVERSE FACTOR TAXES[5]

Factor taxes can cause perverse price responses to demand shifts under some parameter configurations. The price of good 1 can fall when the demand for it increases sharply. Two examples:

1. Open GEDATA2.
2. Dimension the model to 2 industries, 1 consumer.
3. Delete leisure, inter-industry transactions, and foreign capital.
4. Edit data:
   - set σ's to 1.1 in both industries
   - δ_1 to 0.5
   - δ_2 to 0.6
   - capital tax in industry 1 to 0.6
   - all other taxes to 0
5. Set
   - α_1 to 0.3
   - α_2 to 0.7.
6. Solve the closed economy, letting revenue and GNP change.
7. Note inputs, outputs, and prices.
   Use the calculator to find the price ratio p_1/p_2 and also Q_1/Q_2.
8. Edit data again: set α_1 to 0.8, α_2 to 0.2.
9. Repeat steps 6 and 7. Note that p_1/p_2 was reduced although Q_1/Q_2 was increased. This is the perverse price response. It appears, however, only in the third decimal.
10. Edit data again:
    - reduce σ's to 0.7
    - set the capital tax in industry 1 to 0.4
    - set the labor tax in industry 2 to 0.1.
11. Repeat steps 5 to 9.

---

[5] See Horst Herberg and Murray Kemp, "Factor market distortions, the shape of the locus of competitive outputs, and the relation between product prices and equilibrium outputs," in *Trade, Balance of Payments and Growth*, ed. J. Bhagwati, R. W. Jones, R. A. Mundell, and J. Vanek, North-Holland, 1971, pp. 22-48.

EXPLORATION No. 14

THE WORLD'S LOSS FROM A TARIFF

Find how a home country tariff changes welfare at home and in the rest of the world.

1. Open the file named HOME.
2. Reinstate taxes to impose a tariff on good 1 equal to 0.03.
3. Delete equations for foreign capital.
4. Save the new file with the name HOME.T.
5. Open file ROW, delete foreign capital, and save with filename ROW.T (i.e. Rest Of World facing Tariff).
6. Select **World|Model Dimensions**.
7. Leave the number of industries and households at 3.
8. Set the number of countries to 2.
9. Select **World|Solve**.
10. Use the mouse and the Control key to select HOME.T and ROW.T country files.
11. Retain default values for inputs, prices, and tolerance.
12. Wait for the solution and save the country files.
13. Compare the solution for HOME.T with that for ROW.T. Find:

    - a welfare gain in HOME smaller than the loss in ROW,
    - an increase in the price of capital services in HOME, a decrease in ROW,
    - a reduction in world trade volumes.

    The welfare gain to HOME is due to terms-of-trade effects of a tariff in a large-country model, even though ROW has many times more land, labor, and capital than HOME.

The solution is saved in HOME.T and ROW.T on the GEDATA disk.

EXPLORATION No. 15

SECOND-BEST INVESTMENT BEHIND TARIFF WALLS

A tariff stimulates factor flows. The new flows diminish the damage done by the tariff.

1. Open the file named HOME.T.
2. Reinstate foreign capital.
3. Save the new file with name HOME.KT.
4. Open the ROW.T file. Reinstate foreign capital and save ROW.KT.
5. Repeat steps 6 to 9 of Exploration 14.
6. Use HOME.KT and ROW.KT for two-country file input.
7. Repeat steps 11 to 13 of Exploration 14. Find:

    - A smaller gain of aggregate welfare in HOME and a smaller loss in ROW although there remains a net loss (measured by EV in base equalized factor prices),
    - a small export of capital services from ROW to HOME in response to the factor price differential.

    The loss inflicted on ROW by the HOME country tariff on the capital-intensive good is reduced by ROW's ability to export capital to HOME.

The solution is filed in HOME.KT and ROW.KT on the GEDATA disk.

MODEL SYMBOLS[1]

a	constant term in the linear personal income tax
a_{ji}	input coefficient (j^{th} input per unit of i^{th} product)
A_{ji}	intermediate use of good j in production of good i
c	foreign capital supply shift parameter
D_i	final demand by residents
e	exchange rate (domestic price of foreign currency)
E_i	exports of the i^{th} industry product
F	net foreign capital service inflow
g	foreign capital supply elasticity parameter
$\underline{h}$	rent of land after tax
K_j	capital endowment of the j^{th} resident
$\underline{K}_i$	capital input to industry i
L_j	labor endowment of the j^{th} resident
L_i	labor input to industry i
M_i	imports of the i^{th} good
m	number of resident consumers
n	number of industries
N_j	leisure of the j^{th} consumer
p_i	producer price of the i^{th} good
q_i	world market price expressed in foreign currency
Q_i	industry gross output
R	total tax revenue
r	after-tax rental rate of capital
s_j	j^{th} consumer's share in total transfer payments
t_{hi}	rate of tax on land rent of industry i
t_i	retail sales tax rate
t_{ji}	rate of sales tax on intermediate inputs

[1] For a single-country model. Add country subscripts for the multi-country model.

t_{ki} rate of tax on industry profits

t_{li} payroll tax rate

t_{mi} import duty rate

t_y marginal personal income tax rate

$\underline{T}_i$ land used by industry *i*

T_j j^{th} consumer's land endowment

U_i individual utility

v_i rate of other commodity taxes net of subsidies

w wage rate

W total transfer payments

X_{ji} demand for the i^{th} good by the j^{th} consumer

Y_j taxable personal income

Z_j disposable income of the j^{th} consumer

α_{ji} j^{th} consumer's expenditure share parameter for the i^{th} good

β_j elasticity of substitution of consumption between goods

γ_j leisure demand share parameter

δ_i factor income distribution parameter

ε_i land rent distribution parameter

θ_i land substitution parameter

π rental price of capital abroad, in foreign currency

ρ_i factor substitution parameter

σ_i elasticity of substitution of capital for labor

τ_i elasticity of substitution of land for capital and labor

υ_i degree of returns to scale for industry *i*

φ_i industry productivity parameter

ψ_i profits of industry *i*

Ψ total profits of all industries

ω elasticity of substitution of leisure for goods and services

Variables	Number
A_{ji}	n^2
D_i	n
e	1
E_i	n
F	1
h	1
K_i	n
L_i	n
M_i	n
N_j	m
p_i	n
Q_i	n
r	1
R	1
U_j	m
w	1
W	1
X_{ji}	nm
Y_j	m
T_i	n
Z_j	m
ψ_i	n
	$n^2 + 9n + nm + 4m + 7$

Also q_i , π in the multi-country model.

PARAMETERS

Assumed	Calibrated	
a	a_{ji}	t_{mi}
g	$\bar{c}$	v_i
t_y	$\bar{K}_j$	α_{ji}
β_j	$\bar{L}_j$	γ_j
π	s_j	δ_i
σ_i	t_i	ε_i
ω_j	t_{ji}	θ_i
τ_i	t_{ki}	ρ_i
υ_i	t_{li}	ψ_i

PARAMETER RESTRICTIONS

$a_{ji} \geq 0$, $\sum_{j=1}^{n} a_{ji} < 1$

$c \geq 0$

$g < 0$

$m \in \{1, 2, \ldots, 18, 19\}$

$t_{mi} < 1$

$\alpha_{ji} > 0$, $\sum_{i=1}^{n} \alpha_{ji} = 1$

$0 \leq \gamma_j < 1$

$0 < \upsilon_i \leq 1$

$0 < \epsilon_i < 1$

$\phi_i > 0$

$\sigma_i > 0$

$n \in \{2, 3\}$

$\beta_j > 0$

$\omega_j > 0$

$\tau_i > 0$

$\sum_{j=1}^{m} s_j = 1$

GEMODEL EQUATIONS[2]

Production functions (CES case)

in 2-sector models $$Q = \phi\left(\delta L^{-\rho} + (1-\delta)K^{-\rho}\right)^{-\frac{\upsilon}{\rho}}$$

in 3-sector models $$Q = \phi\left\{(1-\epsilon)\left[\left(\delta L^{-\rho} + (1-\delta)K^{-\rho}\right)^{-\frac{1}{\rho}}\right]^{-\theta} + \epsilon T^{-\theta}\right\}^{-}$$

where $\sigma = 1/(1+\rho)$ and $\tau = 1/(1+\theta)$.

Utility functions (CES) $$U = \left\{(1-\gamma)^{\frac{1}{\omega}}\left[\left(\sum_{i=1}^{n}\alpha_i^{\frac{1}{\beta}}X_i^{-\kappa}\right)^{-\frac{1}{\kappa}}\right]^{-\nu} + \gamma^{\frac{1}{\omega}}N^{-\nu}\right\}^{-\frac{1}{\nu}}$$

where $\kappa = 1/\beta - 1$ and $\nu = 1/\omega - 1$.

Supply of foreign capital services $$F = c\left[1 - \left(\frac{r}{\pi e}\right)^{g}\right]$$

Producer prices $$p_i = \frac{\left[w(1+t_{li})L_i + r(1+t_{ki})K_i + h(1+t_{hi})T_i\right]}{Q_i\upsilon_i}$$

$$+ v_i\, p_i + \sum_{j=1}^{n} p_j\,(1+t_{ji})\,a_{ji}$$

$$= \frac{eq_i}{(1-\quad)} \text{ if } M_i > 0$$

Balance of payments $$\sum_{i}^{n} p_i E_i - e\sum_{i} q_i M_i - e\pi F = 0$$

Final demands by residents $$D_i = Q_i + M_i - E_i - \sum_{j} A_{ij}$$

---

[2] In the single-country model unless otherwise noted.

Industry profits

$$\psi_i = \left[r(1 + t_{ki})K_i + w(1 + t_{li})L_i + h(1 + t_{hi})T_i \right] \left(\frac{1 - \upsilon_i}{\upsilon_i} \right)$$

$$\Psi = \sum \frac{\psi_i}{1 + t}$$

Personal income

$$Y_j = w(\bar{L}_j - N_j) + h\bar{T}_j + r\bar{K}_j + \frac{\left[(r - e\pi)F + \Psi\right]\bar{K}_j}{\sum_i^m \bar{K}_i}$$

Government revenue

$$R = \sum_{i=1}^{n} [rt_{ki}K_i + \frac{\psi_i t_{ki}}{1 + t_{ki}} + ht_{hi}T_i + wt_{li}L_i +$$

$$+ p_i t_i D_i + \frac{eq_i t_{mi} M_i}{1 - t_{mi}} + p_i v_i Q_i] +$$

$$+ \sum_{i=1}^{n}\sum_{j=1}^{n} p_j t_{ji} A_{ji} + \sum_{j=1}^{m} (a + t_y Y_j)$$

Transfer payments $W = R$

Personal disposable income if $Y_j > 0$ $Z_j = -a + (1 - t_y)Y_j + s_j W$

else $Z_j = s_j W$

Consumer demands

$$X_{ji} = \frac{\alpha_{ji} Z_j}{\left[(1 + t_i)p_i\right]^{\beta_j} \sum_{i=1}^{n} \alpha_{ji} \left[(1 + t_i)p_i\right]^{1 - \beta_j}}$$

Intermediate demands $A_{ij} = a_{ij}Q_j$

Sub-utility (CES case) $S_i = \left(\sum_{j=1}^{n} \alpha_{ij}^{\frac{1}{\beta_i}} X_{ij}^{1-\frac{1}{\beta_i}} \right)^{\frac{\beta_i}{\beta_i - 1}}$

Marginal condition on labor/leisure choice

$$\frac{N_i}{S_i} = \left(\frac{\gamma_i}{1 - \gamma_i} \right) \left(\frac{Z_i}{(1 - t_y) w S_i} \right)^{\omega_i}$$

$N_i < \bar{L}_i \quad \forall\ i \in \{1, 2, \ldots, m\}$

Market equilibria

$$D_i = \sum_{j=1}^{m} X_{ji} \quad \forall\ i \in \{1, 2, \ldots, n\}$$

$$F + \sum_{j=1}^{m} \bar{K}_j = \sum_{i=1}^{n} K_i$$

$$\sum_{j=1}^{m} \bar{T}_j = \sum_{i=1}^{n} T_i$$

$$\sum_{j=1}^{m} (\bar{L}_j - N_j) = \sum_{i=1}^{n} L_i$$

also in simultaneous solution for *m* countries

$$\sum_{j=1}^{m} F_j = 0$$

$$\sum_{j=1}^{m} (M_{ij} - E_{ij}) = 0 \quad \forall\ i \in \{1, 2, \ldots, n\}$$

Gross national product $\text{GNP} = \sum_{j=1}^{m} Z_j$

IN CASE OF TROUBLE

Every effort was made to check and debug the GEMODEL routines thoroughly. If, however, you find errors or unexplainable failures to converge, then follow this procedure:

1. Make a fresh start.

2. Review your data and model parameters:
   are the elasticities "too high"?
   is the production possibility curve too "flat"?
   are world prices forcing a corner solution?
   are world prices too close to closed economy prices?
   can capital flows and leisure demands change comparative advantage?

3. Review your initial guesses:
   are the capital input guesses too far from a plausible equilibrium allocation?
   is the tolerance too small or too large?

4. Record the type of error and the point where it occurs.

5. Send a copy of your data and your report of the error to

   DIA Agency, Inc.
   1879 Kingsdale Avenue
   Ottawa, Ontario
   K1T 1H9
   CANADA

We can also be reached at our Web site:

info@www.DIAagency.ca

Your time and effort will be appreciated. Please allow six weeks for a reply.

GEDATA

The GEDATA diskette contains the following data files:

A. For GEMODEL exercises:

1. GEBASE1
2. GEBASE2
3. GEBASE3
4. GEBASE4
5. EDGEWBOX
6. PPCURVE
7. PPCURVE2
8. UPP
9. ADVANT2
10. ADVANT22
11. ADVANT3
12. PROTECT
13. RYBCZY2
14. SALESTAX
15. SALESTAX.UNI
16. CIT
17. PIT
18. REALGE
19. PPCURVE.DIM
20. PPCURVE2.DIM
21. ADVANT3.DIM
22. PROTECT.DIM
23. SALESTAX.DIM
24. CIT.DIM
25. HOME
26. ROW
27. JEL84

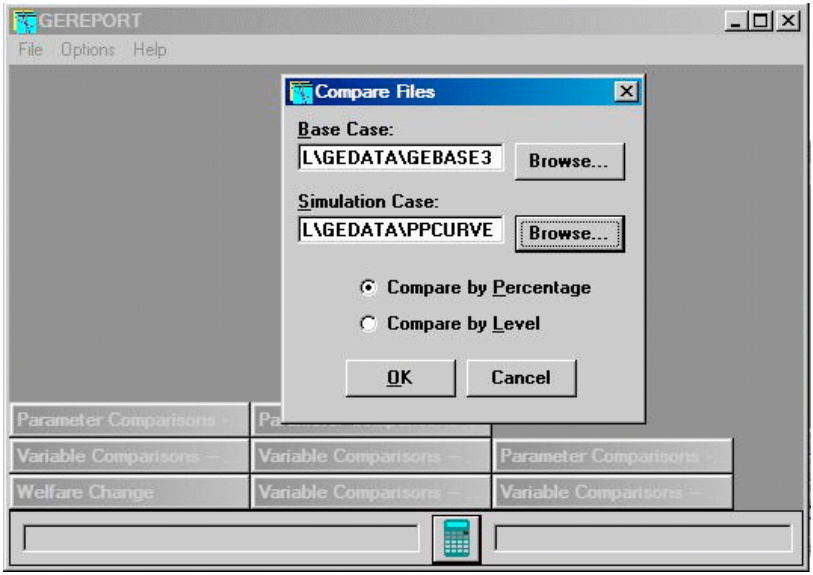
B. For GESTATS:

1. CALIBRE.RAW a sample RAW data file
2. CALIBRE.GEM a sample calibrated file
3. HARBERG.RAW Harberger model data

With the exception of the *.RAW files, all the above files can be read by GEMODEL and GEREPORT. The *.RAW files are for input to GESTATS.

The HARBERG.RAW file contains case 5 in John B. Shoven, "The Incidence and Efficiency Effects of Taxes on Income from Capital," *Journal of Political Economy*, 84 (6), Dec. 1976, pp. 1261-1284. In this file, sector 2 is the corporate sector (X in Shoven) and sector 1 is unincorporated (Y in Shoven). Elasticity assumptions are those on page 1272 and in panel B of Table 4. Make a calibrated HARBERG.GEM file and run it through GEMODEL. You should be able to reproduce results in the third-last column of the table on page 1277 of Shoven by equalizing the capital tax rates on both sectors. An equal-yield replacement will result in the 9.2% increase in sector X capital shown in Shoven's Table 5 under the Scarf Algorithm results. HARBERG.RAW assumes a single consumer. See Shoven's footnote 7 on page 1278.

JEL84 is for input to GEMODEL and holds the data in Table 1 of John B. Shoven and John Whalley, "Applied General Equilibrium Models of Taxation and International Trade: An Introduction and Survey," *Journal of Economic Literature*, XXII(3), September 1984, 1007-51.


GEREPORT
File Options Help
Compare Files
Base Case:
L\GEDATA\GEBASE3
Browse...
Simulation Case:
L\GEDATA\PPCURVE
Browse...
Compare by Percentage
Compare by Level
OK
Cancel
Parameter Comparisons
Variable Comparisons
Variable Comparisons
Parameter Comparisons
Welfare Change
Variable Comparisons
Variable Comparisons

GEREPORT

TO INSTALL THE PROGRAM:

GEREPORT is installed in the same directory as GEMODEL if you purchased both programs and installed them from the same original diskette.

If you had purchased GEREPORT separately then install it following the same procedure as with GEMODEL and install it in the same directory.

TO LOAD THE PROGRAM:

Double-click the GEREPORT icon in the GEMODEL program group of *WINDOWS*.

TO USE THE PROGRAM:

Select **File|Compare**. A dialog box pops up where you enter the names of two files or choose the files by browsing through directories. Click one of two radio buttons in the same dialog box to choose comparison by percentage change or by change in level. Click the **OK** button when all choices are correct.

Use the **Options** menu to select printing of results to file or printer.
Click the calculator icon at the bottom of the window to call a pop-up calculator.

RESTRICTIONS ON INPUT FILES:

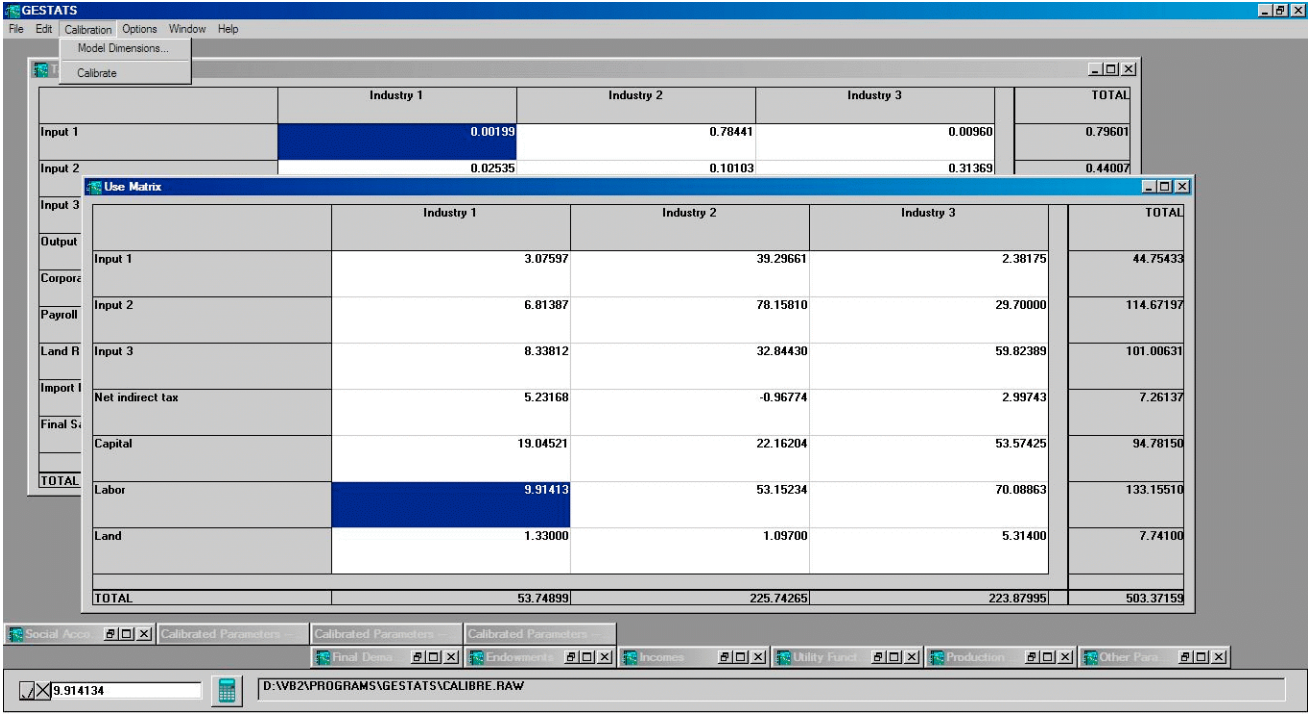
The files must have been saved with GEMODEL or as GESTATS calibrated files. To be comparable, the files must have

- equal numbers of industries
- equal numbers of consumers
- the labor/leisure choice either included or excluded in both files.

OUTPUT:

Output consists of deviations of the simulation result from the base case. Compensated and equivalent variations and the marginal cost of taxes are also displayed.

Click the **NEXT** button to see the next output page. Click the **CLOSE** button to return to the **MENU**.


GESTATS
File Edit Calibration Options Window Help
Model Dimensions...
Calibrate
Use Matrix
Industry 1 Industry 2 Industry 3 TOTAL
Input 1 0.00199 0.78441 0.00960 0.79601
Input 2 0.02535 0.10103 0.31369 0.44007
Input 3 8.33812 32.84430 59.82389 101.00631
Output
Corpora
Payroll
Land R
Import I
Final Sa
TOTAL
Input 1 3.07597 39.29661 2.38175 44.75433
Input 2 6.81387 78.15810 29.70000 114.67197
Input 3 8.33812 32.84430 59.82389 101.00631
Net indirect tax 5.23168 -0.96774 2.99743 7.26137
Capital 19.04521 22.16204 53.57425 94.78150
Labor 9.91413 53.15234 70.08863 133.15510
Land 1.33000 1.09700 5.31400 7.74100
TOTAL 53.74899 225.74265 223.87995 503.37159
Social Accts
Calibrated Parameters
Calibrated Parameters
Calibrated Parameters
Final Dema...
Endowments
Incomes
Utility Functi...
Production ...
Other Para...
9.914134
D:\VB2\PROGRAMS\GESTATS\CALIBRE.RAW

TO INSTALL GESTATS

GESTATS is installed in the same directory as GEMODEL if you purchased both programs and installed them from the same original diskette. If you had purchased GESTATS separately then install it following the same procedure as with GEMODEL and install it in the same directory.

TO LOAD GESTATS

Double-click the GESTATS icon in the GEMODEL program group of WINDOWS.

REQUIREMENTS TO RUN GESTATS

To run GESTATS you need eight tables of economic data and elasticity assumptions. The tables are dimensioned following choices made on dialog boxes called from the **CALIBRATION** menu. The tables or worksheets accessed from the **WINDOW** menu are (with optional items in *italics*):

1. Primary inputs by industry and *intermediate inputs by industry* .
2. Direct taxes on primary inputs by industry.
   Indirect taxes on intermediate inputs by commodity and by industry .
3. Final demands by households and by industry.
4. Household factor endowments and labor supply by household.

(Details by household in tables 3 and 4 and differences between labor endowments and labor supplies are optional.)

5. *Income tax payments and transfers received by households.*
6. assumed elasticities of substitution in production, by industry
   degree of returns to scale, by industry
7. elasticities of substitution in consumption, by consumer
   elasticities of substitution of income for leisure
   uncompensated price-elasticities of demand for one of n outputs (n = 2 or 3), by household
8. income-tax function parameters (constant and slope)
   elasticity of supply of foreign capital services.

(The last is required only if capital endowment differs from capital input to industry net of corporate income tax.)

AGGREGATION

Many of your primary data are in input-output tables. Input-output tables can be square, industry-by-industry tables, or they can be rectangular, commodity-by-industry tables. The presentation varies from one country to another. This manual assumes that you use tables that follow the United Nations recommendation of commodity-by-industry tables. A complete set of tables consists of Make, Use, Final Demand, and Margins. These have to be aggregated to 2 or 3 industries and squared to conform to the industry-by-industry dimension of GEMODEL. The following steps accomplish aggregation and squaring:

1. Add industry rows in the Make matrix until they are reduced in number to 2 or 3.
2. Add industry columns in the Use matrix until they are reduced in number to 2 or 3.
3. Convert the Make matrix into a Market Share matrix by dividing each row by the column sums.
4. Multiply Market Share by Use, Market Share by Final Demands, and Market Share by the indirect tax column of the Margins table.

CONSISTENCY CHECKS

GESTATS checks your data for various conditions. Calibration stops if any one of these conditions is not met:

GNE equals GNP.
Full employment of labor and land.
Personal expenditure equals personal disposable income.
Personal income equals market value of factor supplies.
Tax revenue equals transfer payments.
All inputs must be non-negative.
Labor supply must be equal to or less than labor endowment.
Either all consumers have some leisure or none has any.
Income tax payments must be less than personal income.
Corporate income tax payments must be less than value added by capital.
Social security tax payments must be less than value added by labor.
There may be no import duty revenue from products of export industries.
Elasticity assumptions must obey the parameter restrictions on p. 4-4.
The degree of returns to scale in any industry must not be so small that pure profits would exceed the recorded capital income.

DATA FILES

GESTATS lets you save two types of files: raw data and model-equivalent, calibrated data. For better recognition of any of these files on disk, GESTATS will save them only if you name them in ways which correspond to their contents. GESTATS uses RAW and GEM as filename extensions to designate raw and calibrated files, respectively. These extensions are automatically appended to your 8-character filenames. You do not need to type them in.The sample files on the diskette are called CALIBRE.

When saving calibrated data, GESTATS saves two files with the same name: one of variable levels and assumptions with the RAW name extension, another with model parameters and coefficients saved with GEM name extension. Select **Options|Timed Backup**.

FINAL DEMAND

Final Demand is domestic demand for consumption and capital goods. The goods supplied to households are industry outputs. Data can be transferred from your source to the GESTATS final demand table if the source data are classified by household and by industry output.

Household expenditure data are seldom classified by industry output. Let S be a survey of consumer expenditure matrix with national accounts expenditure categories in the rows and household groups in the columns. Find a matrix C, the expenditure by household and industry.

Input-output tables contain an industry-by-commodity Make matrix V and a commodity-by-category final demand matrix E. The vector of industry output is $q = V^T i$ and the industry market shares are $D = V\hat{q}^{-1}$ where the hat (^) denotes diagonalization. Final demand for industry products is $H = DE$. Final demand by category is $h = H^T i$. Industry shares in final demand are $F = H\hat{h}^{-1}$. A matrix of industry by household demand is then $C^T = FS$. If D has 2 or 3 industry rows and S has 1 to 19 household columns then C has dimensions compatible with GESTATS. For this static model, S should have a row of saving that balances a column of investment in E.

FINAL DEMANDS FOR PRIMARY FACTORS

GEMODEL has no equations for this type of demand. If the data show that such a demand exists, one can deal with it in one of two ways:

- Eliminate the final demands for primary factors by excluding the quantities involved from endowments and from consumer demands. Analytically, this amounts to a change in the origin of the economy's production possibility surface.[1]

  Numerically, the result is that computed GDP, GNP, and GNE will be reduced by an amount equal to the gross of tax value of excluded primary factor services. One can always add this back, if necessary, after revaluation according to new, simulated factor prices.

- Let one of the model industries use only primary factors in such quantities as are in final demand. This avoids elimination of primary factors at the cost of further aggregation of activities in the Make and Use tables.

GOVERNMENT

To model a government sector, let government be the n^{th} consumer ($n \leq 19$). Multiply the Market Share matrix by the Government Final Demand column to get government demand by industry.

Make transfers to government equal to its expenditure on goods. Set government income and income tax payments to zero.

See above about government as a source of final demand for primary inputs.

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[1] See Richard A. Musgrave, *The Theory of Public Finance*, New York: McGraw-Hill, 1959, p. 125, for the assumption that the production possibility curve represents the output left for consumers after government has satisfied its needs.

IMPORT DUTIES

A traded good can be imported and exported at one and the same time. In such a case of "cross hauling," net imports equal total imports less exports. Given a duty rate, duty revenue is a function of total imports. Given the revenue, the duty rate per unit of net import is higher than the actual rate on gross imports. If a country imports 10 Fiats and exports 8 Renaults and the tariff revenue from duty on auto imports is 100 Fr. then the small open-economy model duty on net imports of only 2 cars is 50 Fr. per car.

GEMODEL is a small-open-economy model. In such a model, a traded good is either imported or exported. No "cross-hauling" is allowed. GEMODEL tariff revenue is derived from duties on net imports. Given net imports and the actual duty revenue, GESTATS computes duty rates that are higher than the actual rates.

The import duty revenue derived from commodities that are both imported and exported should be zero whenever net exports are positive.

Your import duty data are derived from tariffs on gross imports. To apply such data in the small open-economy model you may distribute the revenue from import duties on commodities of which your country is a net exporter over the commodities of which there are net imports. An alternative is to re-estimate the tariff revenue as the yield of nominal duties on net imports. In the above example, write the revenue from auto tariffs down to 20 Fr. Government accounts can be balanced by adding 80 Fr. to sales tax revenue.

INCOME TAXES AND TRANSFERS

Choose constant and slope parameters of an income tax revenue function that best fit your data on tax payments by household.

Income-tax data by household are unlikely to reflect faithfully the marginal tax rates in your country's income-tax schedule.

There are many reasons (household characteristics, legal complexity, avoidance) for deviation of survey data on household tax payments from taxes due according to income-tax schedules.

GESTATS adjusts for these deviations. It treats the deviations of income-tax payments from scheduled payments as supplementary transfers. The result of this adjustment is that your simulations will reflect the effect of factor price changes through the marginal tax rate instead of the average tax rates.

INDIRECT TAXES

Your main source of indirect tax data is the indirect tax row in the value added section of the Use table. The revenues in this row are derived from many sources: sales transactions in intermediate inputs, taxes on gross output, property taxes, and other indirect taxes. The simplest treatment of these taxes is to retain them as one aggregate tax on gross output. See the section on **OTHER VALUE ADDED**. Consult also the sections on **SALES TAXES** and **PROPERTY TAXES** if you wish to treat various taxes separately.

OTHER VALUE ADDED

Entries in the Other Value Added row are indirect taxes on gross output. Other Value Added is the row of indirect taxes less subsidies in the Use matrix, less a row of sums of taxes on intermediate transactions, less a row of taxes on industry deliveries to final demand. See the section on **SALES TAXES** for the calculation of the latter two rows.

OVERFLOW ERROR

Overflow and underflow errors occur when the results of computations fall outside the range for floating-point numbers allowed by the computer.

The powers in non-linear production and utility functions can cause this type of error. The error can be corrected by re-scaling variables, e.g. by expressing all dollar amounts in billions instead of millions.

PROPERTY TAXES

The national accounts treat property taxes as an indirect tax. You can retain this treatment by leaving property taxes in the Other Value Added row, as indirect taxes on gross output.

Property taxes can also be treated as taxes on the employment of capital. Estimates of property tax revenue by industry can be deducted from the indirect tax row in the Use table and distributed over rows of tax on land and on reproducible capital. The tax on reproducible capital is included in CALIBRE.RAW and CALIBRE.GEM with the corporate income tax.

SALES TAXES

Taxes on sales to intermediate and final demand can be disaggregated from the indirect tax row in the Use table. The disaggregation requires an estimation of indirect tax rates.

Sales tax rates may be obtained by dividing the indirect tax column in the Margins table by the sum of the row totals on the Use and Final Demand tables. Multiplication of these rates by cells in the Use and Final Demand tables gives revenues from sales taxes on intermediate and final transactions. Column sums of revenue from sales taxes on intermediate and final demands are deducted from indirect tax revenue by industry. The residual is Other Value Added or indirect tax on gross output.

Exclude Use from the sales tax base if the country you model has a value added or retail sales tax that exempts inputs.

In input-output tables, U is a commodity by industry Use matrix, E is a commodity by expenditure category final demand matrix, and r is a vector of sales tax revenue or margins. The vector of taxable commodity sales is $q = Ui + Ei$. Sales tax rates are $t = \hat{q}^{-1}r$. Commodity by activity matrices of revenue from sales taxes on inputs and on consumption are then $\hat{t}U$ and $\hat{t}E$. Tax revenues by industry are $i^T D\hat{t}U$ and $D\hat{t}Ei$. These results can be deducted from the indirect tax row of the Use table to leave only output taxes in the Other Value Added row of the tax collections table.

Revenue from sales taxes on final demand should be included in expenditure by household and industry.

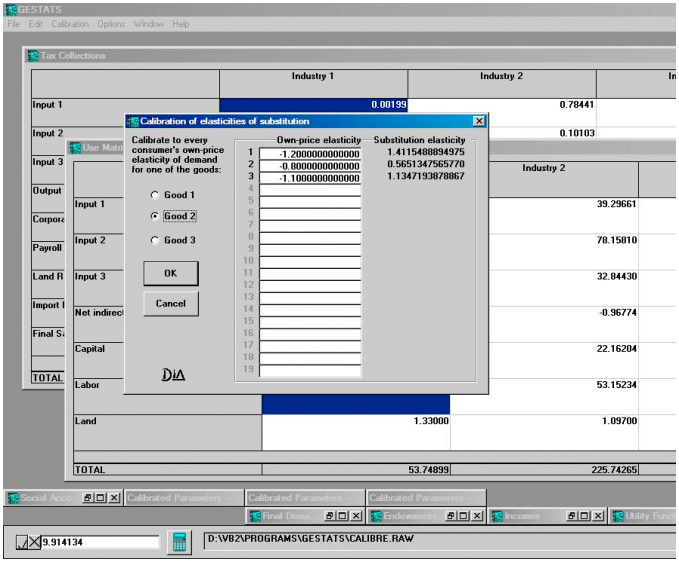
UNALLOCATED AND NON-COMPETING IMPORTS AND EXPORTS

Unallocated and non-competing imports and exports usually represent small amounts. You should eliminate them from your tables as there is no place for them in GEMODEL. Adjust your row and column totals accordingly.

UTILITY FUNCTION CALIBRATION

There are two ways to calibrate the parameters of the lower, commodity nest of a utility function. One way is to specify the elasticity of substitution. The elasticity of substitution must always be entered in the **BETA** column of the elasticities spreadsheet.

The other way is to enter the own-price elasticity of demand for one of the goods. This second alternative is available in a dialog box that appears after you choose to calibrate.



Click a commodity radio button to choose the good for which you want to enter pre-determined own-price elasticities of demand. GESTATS will then calculate and display the implied elasticities of substitution and will update them every time you edit a price elasticity.

Click the other radio buttons to see what price elasticities of demand for the other goods are implied by your choice of price elasticities of demand for any one good. Click the **OK** button when all price elasticities of demand are satisfactory.

WORKSHEETS

The tables on the following pages are sample worksheets. The data in these tables represent the economy of Canada in 1980. The industries are agriculture and mining, manufacturing and construction, and services and real estate. The consumers are low-income households, high-income households, and consolidated federal, provincial, and local governments.

Units of output are chosen so that producer prices are $1 billion. The units of output produced by the industries are 53.7, 225.7, and 223.9. Value added is only 235.7. The other 267.6 units are intermediate products and indirect taxes.

Every cell in the Use matrix is greater than the corresponding cell in the tax matrix. Factor taxes (of 18.7, 4.8, and 2.4) sum to 25.9. Indirect taxes are import duties (3.4), sales taxes (12.3), and taxes on intermediate transactions (33.2 - 25.9 = 7.3). Total indirect taxes are thus 23. Adding value added to this revenue gives GDP (259).

Direct taxes equal the factor taxes plus personal income tax (following A. C. Harberger, the property tax is treated as similar to the corporate income tax). Total tax revenue equals transfers.

Factors are also measured in units that fetch a $1 billion price. Personal income is the sum of the capital and land endowments plus labor supply. The values in the labor supply row are smaller than the labor endowments.

The total endowments of land and labor supply equal the value added by these factors, less tax. These factors are employed fully.

The capital employed exceeds the endowment by approximately 6 units. Six units of capital income are earned by non-residents. Disposable income and total expenditure are therefore only equal to 253 (GDP - 6). How the expenditure is divided over the three industries is a matter of indifference to GESTATS. The program makes GEMODEL's small country assumption: that any difference between final demand and net output can be disposed of or filled in the world market and at exogenous prices. It so happens that only good 2 is imported and therefore GESTATS would balk if there was any revenue from import duties on goods 1 and 3.

The data are stored in the CALIBRE.RAW file on your GEMODEL diskette. Press F1 for **HELP** while viewing this file or while entering your own data.

USE MATRIX

	INDUSTRY 1	INDUTRY 2	INDUSTRY 3	TOTAL
INPUT 1	3.075970	39.296610	2.381746	44.754326
INPUT 2	6.813872	78.158100	29.700000	114.671972
INPUT 3	8.338122	32.844300	59.823890	101.006312
OTHER V.A.	5.231680	-0.967741	2.997433	7.261372
CAPITAL	19.045210	22.162040	53.574250	94.781500
LABOR	9.914134	53.152340	70.088630	133.155104
LAND	1.330000	1.097000	5.314000	7.741000
TOTAL	53.748988	225.742649	223.879949	503.371586

TAX COLLECTIONS

	INDUSTRY 1	INDUSTRY 2	INDUSTRY 3	TOTAL
INPUT 1	0.001994	0.784413	0.009599	0.796007
INPUT 2	0.025347	0.101027	0.313694	0.440069
INPUT 3	0.366392	1.853511	1.630868	3.850771
OUTPUT TAX	4.837947	-3.706693	1.043271	2.174525
CORPORATE	2.762726	5.319000	10.631890	18.713616
PAYROLL	0.239260	2.047760	2.560660	4.847680
LAND RENT	0.200000	0.153000	2.018000	2.371000
IMPORT DUTY	0.000000	3.369436	0.000000	3.369436
FINAL SALES	0.012570	11.771310	0.502637	12.286518
TOTAL	8.446236	21.692764	18.710619	48.849619

FINAL DEMANDS

	INDUSTRY 1	INDUSTRY 2	INDUSTRY 3	TOTAL
CONSUMER 1	1.407092	38.415990	34.911690	74.734772
CONSUMER 2	2.494082	88.126550	72.550270	163.170902
CONSUMER 3	0.106792	3.904550	11.139230	15.150572
TOTAL	4.007966	130.447090	118.601190	253.056246

ENDOWMENTS

	LAND	CAPITAL	LABOR	LABOR INCOME
CONSUMER 1	1.463800	20.379131	46.797000	21.495024
CONSUMER 2	3.906200	50.150070	148.566300	106.812432
CONSUMER 3	0.000000	0.000000	0.000000	0.000000
TOTAL	5.370000	70.529201	195.363300	128.307424

INCOMES

	INCOME	INCOME TAX	TRANSFERS	DISPOSABLE
CONSUMER 1	43.337580	1.521523	32.918340	74.734397
CONSUMER 2	160.868700	30.700850	33.003082	163.170932
CONSUMER 3	0.000000	0.000000	15.150572	15.150572
TOTAL	204.206280	32.222373	81.071994	253.055901

ELASTICITIES OF SUBSTITUTION IN CONSUMPTION

	COMMODITIES	LEISURE
CONSUMER 1	1.500000	0.100000
CONSUMER 2	0.900000	0.100000
CONSUMER 3	0.750000	0.100000

ELASTICITIES OF SUBSTITUTION IN PRODUCTION

	LAND	K FOR L	SCALE
INDUSTRY 1	0.500000	0.600000	0.900000
INDUSTRY 2	0.600000	0.700000	0.900000
INDUSTRY 3	0.550000	0.500000	0.900000

OTHER CONSTANTS

P.I.T. INTERCEPT	-9.238361
P.I.T. SLOPE	0.248272
FOREIGN CAPITAL RENTAL PRICE	0.800000
FOR. CAPITAL ELASTICITY PARAMETER	-4.805740
SUPPLY ELASTICITY	2.499999

A SOCIAL ACCOUNTING FRAMEWORK

	Ind. 1	Ind. 2	Ind. 3	Good 1	Good 2	Good 3	Capital	Labor	Land
Industry 1				53.749					
Industry 2					225.743				
Industry 3						223.880			
Good 1	3.076	39.297	2.382						
Good 2	6.814	78.158	29.700						
Good 3	8.338	32.844	59.824						
Capital	19.045	22.162	53.574						
Labor	9.914	53.152	70.089						
Land	1.330	1.097	5.314						
Other ind. tax	5.232	-0.968	2.997						
Final sales tax				0.013	11.771	0.503			
Import duty									
Transfers							18.714	4.848	2.371
Household 1							20.379	21.495	1.464
Household 2							50.150	106.812	3.906
Household 3									
Imports					7.605		5.539		
TOTAL	53.749	225.743	223.880	53.762	245.119	224.383	94.782	133.155	7.741

With the exception of elasticity assumptions, the data for GESTATS are partitions of a larger social accounting matrix. A social accounting matrix is shown on this and the next page. Credits to accounts are recorded in columns. Rows show debits to accounts. The accounts balance and thus any row sum equals the corresponding column sum. The number of accounts is smaller than the usual number in social accounting. The accounts not relevant to a static model have been eliminated. There is no accounting for saving and investment. Investment expenditure is included in household demand for goods. There also are no accounts for government and firms.

FOR GEMODEL DATA

Other indirect tax	Final sales tax	Import duty	Transfers	Househ. 1	Househ . 2	Househ. 3	Exports	TOTAL
								53.749
								225.743
								223.880
				1.407	2.494	0.107	4.999	53.762
				38.416	88.127	3.905		245.119
				34.912	72.550	11.139	4.775	224.382
								94.782
								133.155
								7.741
								7.261
								12.287
							3.369	3.369
7.261	12.287	3.369		1.521	30.701			81.072
			32.918					76.256
			33.003					193.872
			15.151					15.151
								13.144
7.261	12.287	3.369	81.072	76.256	193.872	15.151	13.144	

Firms are assumed to distribute all their income to households and thus have no income and expenditure of their own. Government expenditure is assimilated to household expenditure. The only government activities modeled in GEMODEL are taxation and transfer payments.

The social accounting framework is recommended as one that assures consistency of the data. Social accounting data are easily transferred to GESTATS tables. In that process, final demand and income tax data are transposed.

SUBJECT INDEX

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