GEMODEL.PRO

for general equilibrium modelling

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INTRODUCTION

GEMODEL.PRO calibrates and solves large non-linear general equilibrium models. It is designed for use in research and policy analysis to simulate the impacts of a large number of tax rate and parameter changes on static equilibria and on adjustment paths to long-run equilibrium with myopic expectations. The software includes routines for easy data update, recalibration, and sensitivity analysis.

SYSTEM REQUIREMENTS

The GEMODEL.PRO software is supplied to run under *Windows*95 or better.

FEATURES

Easy, menu-driven operation.

Supplied ready to run by inclusion of sample data.

Two levels of government: federal and State/local.

Complete treatment of indirect taxes.

Explicit inclusion of depreciation in the cost of capital.

Detailed analysis of gross investment and saving.

Faithful reproduction of base case data.

Easy data update and recalibration.

Automatic consistency check of the user's data.

Output to screen, diskette file, or printer.

Designed specifically to process national accounts data.

MODEL DESCRIPTION

GEMODEL.PRO is a large, open economy model where export prices are endogenous.

Individual utility is a nested CES function of current consumption goods, current leisure, and of future consumption. Saving is derived from the demand for future consumption. Gross investment is derived from saving, from replacement of depreciated fixed capital, and from inventory change.

Industries employ capital and labour with constant elasticity of substitution and with constant returns to scale. Capital/labour ratios depend on the cost of capital relative to the cost of labour. The cost of labour depends on the wage of homogeneous Lalor and on industry-specific payroll taxes. The cost of capital includes taxes on the employment of capital (corporate income and property tax), depreciation, and the current cost of sales taxes on capital goods. Capital and labour are perfectly mobile across industries. The rate of return after all taxes is the same in all industries. Taxes are industry specific.

Industry outputs are used as intermediate inputs and in final demand. Intermediate inputs are distinguished by their domestic and foreign origins and treated as imperfect substitutes. Inputs of foreign origin include non-competing imports that can be modelled separately from competitive imports. Final demands are modelled in national accounting categories. Final demands by category are linear combinations of domestic products and imports. The proportions of domestic and foreign products depend on ratios of domestic and import prices. There can be simultaneous imports and exports of factor services. Foreign saving is either exogenous or endogenous.

A fairly complete system of federal and state/local taxes permits extensive analysis of tax policy. Disaggregation of revenue and expenditure by level allows simulation of second-best policies at one level of government given distortions imposed at the other level of government. The commodity tax margin base can be defined as a turnover tax base, a sales tax, or a value added tax. The tax base can be further defined as a destination base or an origin base. Personal income taxes can be linear or non-linear, and with deduction of saving and capital income. Separate definitions apply to each level of government.

See the section on the Accounting Framework on page 1-15 for more details on model structure and data.

BACK-UP COPIES

Back-up copies may be made for archival use by the purchaser of the software but not for use on more than one computer at a time.

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

DIA Agency, Inc.
1879 Kingsdale Avenue
Ottawa, Ontario

The charge for a replacement disk is US $ 35.00 plus postage. The original disk and payment must be enclosed with the request for a replacement disk.

TO OPEN GEMODEL.PRO

Click on *Start*, find the GEM_PRO.EXE file and double click its icon.

INSTALLATION

Double-click SETUP.EXE and follow instructions, including a selection of the destination folder.

On the first installation, the installation program presents a dialog box where you enter your name and institutional affiliation (company or university) or your address. Hyphens may not be used.

TEMPORARY FILES

GEMODEL.PRO aggregation and calibration require a large number of disk reads and writes. About 1 megabyte of space is needed in a folder for temporary files.

READ-ONLY FILES

All program and data files supplied to you may have been marked read-only to prevent accidental erasure. Data files can be copied to a different folder to be updated and written over.

SAMPLE DATA

The *Standard version* of GEMODEL.PRO is supplied with sample US data filed in a separate folder created by the installation software.

The *Professional* version also includes sample Canadian data in their own folder.

KEYBOARD USES

Ctrl-A	Save the spreadsheet with a new name.
Ctrl-B	Freeze horizontal and vertical titles.
Ctrl-C	Copy selected data to the *Windows Clipboard*.
Ctrl-D	Delete spreadsheet rows or columns.
Ctrl-End	Change focus to the last cell on file.
Ctrl-F1	Open context-sensitive help contents.
Ctrl-H	Freeze column headings.
Ctrl-I	Insert new spreadsheet rows or columns.
Ctrl-N	Create a new spreadsheet.
Ctrl-O	Open a file.
Ctrl-R	Change the spreadsheet size (number of rows or columns)
Ctrl-S	Save the file with its current name.
Ctrl-T	Freeze row stubs.
Ctrl-U	Undo the last edit operation.
Ctrl-V	Paste data in the *Clipboard* to the selected range of cells.
Ctrl-X	Erase the data in the selected range of cells.
Shift-F4	Tile the open spreadsheets.
Shift-F5	Cascade the open spreadsheets.
Mouse click	To change a check-mark in a check box.
Tab	To access the next item on a form.
Shift-Tab	To access the previous item on a form.
Cursor	To change focus to a different cell.
Backspace	To erase the last character typed.
Enter	To confirm a cell edit.
	To confirm the choice of a file to open ro save.
Home	To change focus to the first cell on screen.
Ctrl-Home	To change the focus to cell (1,1).
End	To change the focus to the last cell on screen.

F1	Help.
F2	Open the tax margin window.
F3	Open the aggregation window.
F4	Open the calibration window.
F5	Open the simulation window.
F6	Open the simulation results window.
F9	Open an on-screen calculator.

TO OPEN A DATA FILE

Select a spreadsheet from the **Windows** menu or click **File|New** to open a new blank spreadsheet. Select **File|Open** from the Menu (See Figure 1.) Select the file type. The selct the folder where the data are saved, for example, GEM_PRO\US77. The select the file and press the ENTER key or double-click the selected file name.

MENUS

Menu options made available on the menu bar change as you change from one window to another.

To access a menu, press the **Alt** key and the key for the letter that is underlined in the menu's title.

Some menu options may be disabled until required information is entered in the open window.

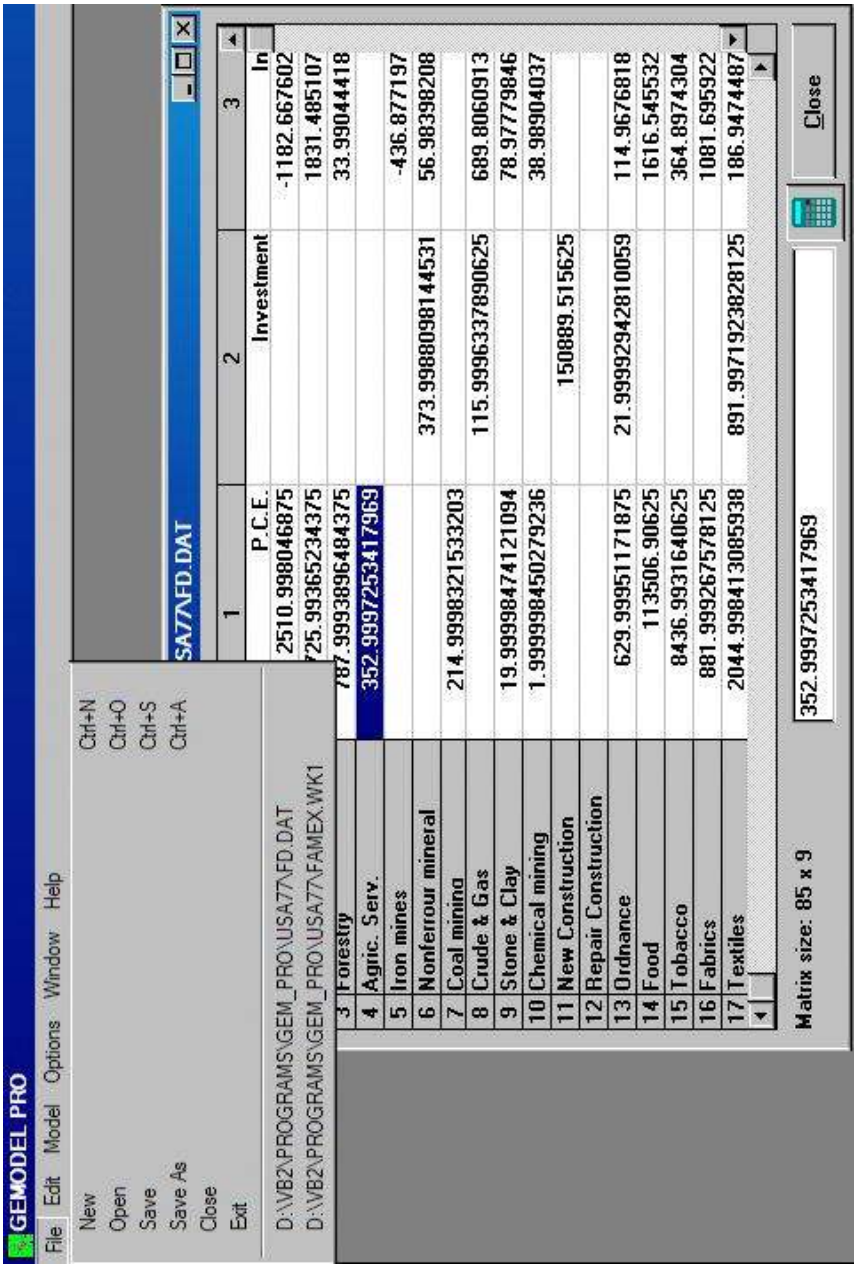


Figure 1: A spreadsheet under the Main Menu.

DATA ENTRY

Data are entered on a new blank spreadsheet or by editing an existing one (see Figure 1). Editing existing data means the loss of old data.

Prevent the loss of data. Create a new folder and copy the old data to the new folder.

Select the spreadsheet from the **Windows** menu or create a new one with **File|New**.

Use cursor keys to select the active spreadsheet cell. Click on a fixed title to select an entire row or column. Click on scroll-bars to view data to the right or left, above or below those shown on screen

Enter new data in the active cell by typing the new value.

Every column must have a heading. Enter column headings only in row 0.
Every row must have a stub. Enter row stubs only in column 0.

Save the file in the new data folder.

Keep data for different countries or time periods in different folders. All data folders contain files that have identical names. Name folders in ways that distinguish data sets.

See the section on the **Calculator** (page 10-14) for further spreadsheet uses.

FILE FORMATS

GEMODEL.PRO can write files in the following formats:

ASCII	*.DIF	for interchange with EXCEL and similar applications.
	*.DAT	required for aggregation and calibration.
	*.TXT	suitable for transfer to *IO&SAM for Windows.*
binary	*.WK1	suitable for transfer to older *QuattroPro* or *Excel*.

GEMODEL.PRO can read files in the following formats:

ASCII	*.DIF	created by EXCEL and similar applications.
	*.DAT	required for aggregation and calibration.
	*.TXT	suitable for transfer from *IO&SAM for Windows.*
	*.AGG	suitable for inspection of aggregation results.
	*.SQR	suitable for inspection of some calibration results.
binary	*.WK1	suitable for transfer from older *QuattroPro* or *Excel*.

DATA FILE STRUCTURE

Data are filed as matrices. Each matrix is filed in three separate files: one for the numerical data, the other two for column and row headings.

All files are ASCII text files. The alphabetical files of row and column headings can be edited with any text editor such as *Wordpad* and *Notepad*. Edit to correct typographical errors or to translate original sample data supplied in English to your language.

Never edit the numerical entries at the top of an alphabetical file. These entries must equal matching entries in matching numerical files.

Various data matrices share common row and column headings. That is why the number of alphabetical files is less than 2 times the number of numerical matrix data files.

The following files contain all data:

Matrix:	*Headings:*	*Stubs:*
MAKE.DAT	COMMODTY.DAT	INDUSTRY.DAT
USE.DAT	INDUSTRY.DAT	COMMODTY.DAT
PCE.DAT	PCECAT.DAT	COMMODTY.DAT
FD.DAT	FINALCAT.DAT	COMMODTY.DAT
CFT.DAT	INDUSTRY.DAT	COMMODTY.DAT
MARGINS.DAT	MARGCAT.DAT	COMMODTY.DAT
FAMEX.DAT	HHCAT.DAT	PCECAT.DAT
ENDOW.DAT	HHCAT.DAT	ENDOWCAT.DAT
TAXES.DAT	INDUSTRY.DAT	TAXCAT.DAT

GEMODEL.PRO **does not accept any other data file names**. Data for other countries and time periods belong in other folders.

FILE TYPES

GEMODEL.PRO uses data files, tax margin files, aggregation parameter files, assumption files, simulation input files, and simulation output files. The files are distinguished by names and name extensions. A group of files is specific to a country and year and should be kept in a folder created specifically for that country and year.

Data files have the name extension .DAT. The sub-group of data files includes the files listed on the previous page and a file created during the aggregation process, called PRECALIB.CFF. *There must be only one PRECALIB.CFF file in each file group in a folder.*

Tax margins by commodity and use are filed with the name extension *.DAT. File INDIRECT.TAX contains federal and State/local indirect tax system specifications. Other files with the name extensions of .TAX and .XAT contain assumed indirect tax exemptions.

Industry, personal consumption expenditure and household aggregation parameters are saved in INDUSTRY.AGG, PCE.AGG and HH.AGG.

Elasticity assumptions made during calibration are saved in files with any name chosen by the user and with the name extension .CAL. *There can be any number of .CAL files in a group*, each containing alternative assumptions.

Files with model equivalent tax rates and parameters are saved after calibration for input to simulation and after a successful simulation to save simulation results. These files can have any name chosen by the user and carry the name extension .PRO. *There can be any number of .PRO files in a group.*

Simulation results can also be saved in .PRO text files for for comparison of results by GEMODEL.PRO's **COMPARE RESULTS** module.

See chapter 3 about files used in dynamic simulations with the *Professional Version* of GEMODEL.PRO

CHANGING THE SIZE OF A DATA FILE

The maximum file size is 126 rows by 126 columns. The 85-industry US input-output tables leave 38 rows and 41 columns free. Free rows and columns can be used to expand file size and accommodate larger tables. Press **Ctrl-R** to expand a spreadsheet.

GEMODEL.PRO saves all rows and columns that have a heading or stub, even blank ones No blank rows or columns are allowed in *.DAT files. Press **Ctrl-D** to delete blank rows andcolumns or press **Ctrl-R** to reset the file size to include only meaningful data rows and columns..

EXTENDING DATA FILES

Press **Ctrl-R** keys to extend the spreadsheet up to 126 rows ad 126 columns. This size is adequate for a 126-industry, 123 commodity USE matrix. Note, however, that such large numbers of industries and commodities cannot be retained in the *standard version* of the model. Select HELP|ABOUT to find the currently allowed numbers of industrialsectors, household consumption goods, and households.

Moreover, the calibration routines expect certain files in given sizes. These are

TAXES	exactly 7 rows, up to 126 columns.
FD	exactly 9 columns, up to 123 rows.
PCE	up to 123 rows, 126 columns.
FAMEX	up to 123 rows, 126 columns.
ENDOW	exactly 6 rows, up to 126 columns.

CALCULATOR

A calculator that emulates an electronic calculator on screen in available in many GEMODEL.PRO windows.

Click the Calculator icon or press **F9** to open the calculator. While working on a spreadsheet, the calculator opens with the active cell value.

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

See page 4-4 about the use of a different calculator for computation of model shocks.

THE ACCOUNTING FRAMEWORK

This section gives an overview of the model, of the model's data, and of how the data fit into a social accounting framework.

Figure 2 on the next page represents a social accounting matrix. There are eleven accounts: commodities (C), industries (I), consumer goods (E), households (HH), firms (F), governments (G), indirect taxes (T), factors (W), fixed capital formation (K), inventory change (A) and the rest of the world (ROW). Every account is balanced. Credits to an account are recorded in a column; debits in a row. Every row sum equals the corresponding column sum. The sums over the indirect tax and factor income rows, plus the trade balance B equals gross domestic product. However, this sum equals gross national product if the commodity and industry accounts include accounts for a *rest of the world* special industry and a *rest of the world* special commodity.

The first column of commodity supply includes industry outputs (MAKE), indirect commodity tax margins, withdrawals from inventory (WI), and imports. The commodities are distributed to intermediate use (USE), personal consumption expenditure (PCE), gross government consumption expenditure (GGCE), fixed capital formation (CFT), inventory accumulation (IA), and exports (X). Industries purchase intermediate inputs, pay indirect business taxes besides commodity tax margins, and they distribute gross value added to owners of factors. Value added is gross by inclusion of depreciation.

Value added is distributed to households in proportion to their endowments (ENDOW). The gross profit of firms is exhausted by corporate income tax (CIT), capital consumption allowance (CCA), and net inventory accumulation (a). Firms could make distributions to households from behind a corporate veil. The veil was removed and individual ownership of corporate shares is reflected in the endowments. Household income is spent on goods (FAMEX), personal income tax (PIT) and on net accumulation (SAVING).

Government revenue consists of personal income tax (PIT), corprate income tax (CIT), transfers from other levels of home government, and indirect tax collections. The revenue is disposed of by government consumption, transfers to households, inter-government transfers, and accumulation.

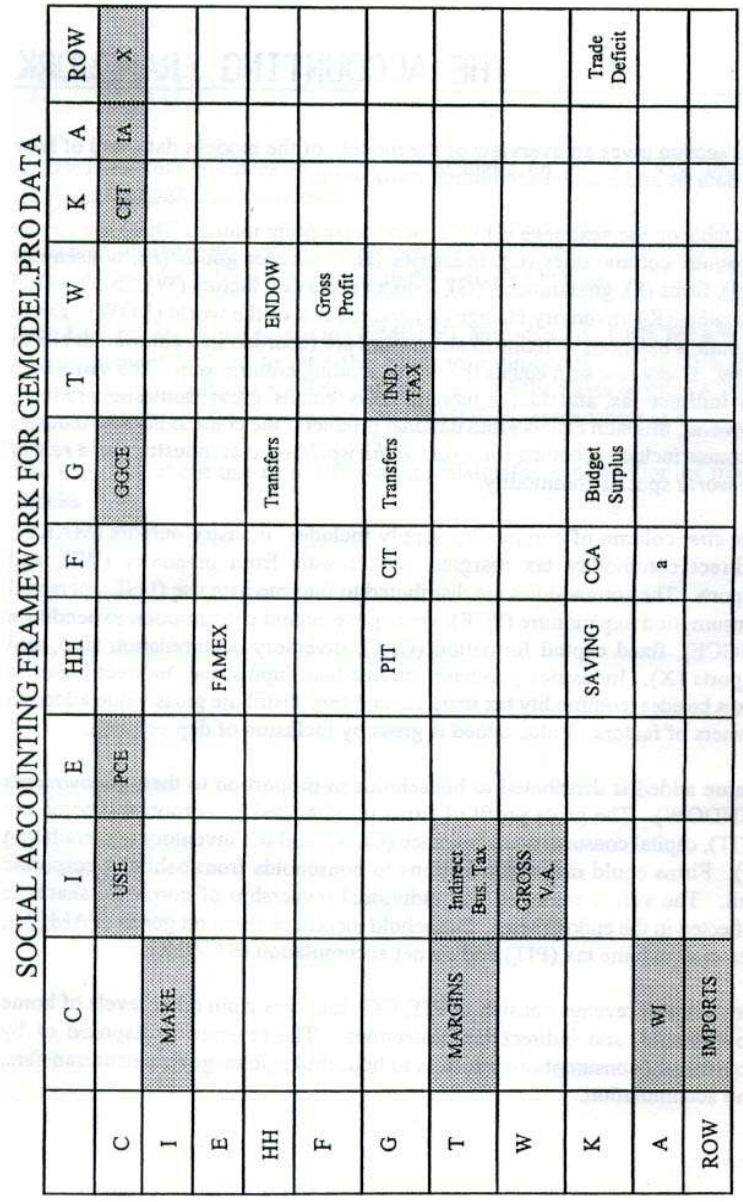


Figure 2: A schematic social accounting matrix.

...THE ACCOUNTING FRAMEWORK

The GEMODEL.PRO data are derived from national accounts, input-output tables, and other sources. The shaded cells in the social accounting matrix represent matrices or vectors derived from national and input-output accounts. Unshaded, capitalized cells are derived from census, survey, and income tax data. Remaining, lower-case cells are computed by GEMODEL.PRO. Shaded cells serve as benchmarks to which the remaining cell values are adjusted.

The user can assemble the data in a balanced social accounting matrix and thus guarantee completeness and consistency of data. However, the GEMODEL .PRO approach provides some advantages and allows some deviation from the social accounting approach. Storage space is economized and computation time is reduced by treating each matrix partition separately. The balancing of accounts derived from separate sources is done internally and automatically. Conceptual differences with the social accounting approach are in the treatment of public investment, of inventories and of imports.

Public investment excluded from the CFT matrix in the US national income and product accounts and input-output accounts is included in government commodity demand. GEMODEL.PRO makes the government contribution of surplus to the capital account equal to zero in a model of the US economy. Any current account deficit is funded by transfer payments.

There is no row of withdrawals from inventory in GEMODEL.PRO's com-modity supply columns. Only the net value of inventory change is recorded in the *A* column. Imports do not have shares in the total commodity market. Competitive imports have a share in the supply of commodities for home use but no share in commodity supply for export. Non-competing imports are recorded separately.

Non-competing imports can be recorded in the imports row and in industry columns. From there they are moved into the USE matrix and placed in a special non-competing imports commodity row while keeping them in the same columns. The commodity row is balanced by recording total use of the commodity in the MAKE matrix cell at the intersection of the commodity column with the row for the special non-competing imports industry. The industry row is balanced by recording the same total use in the special industry column and in the imports row beneath the USE matrix. Thus total imports in the imports row remain unchanged.

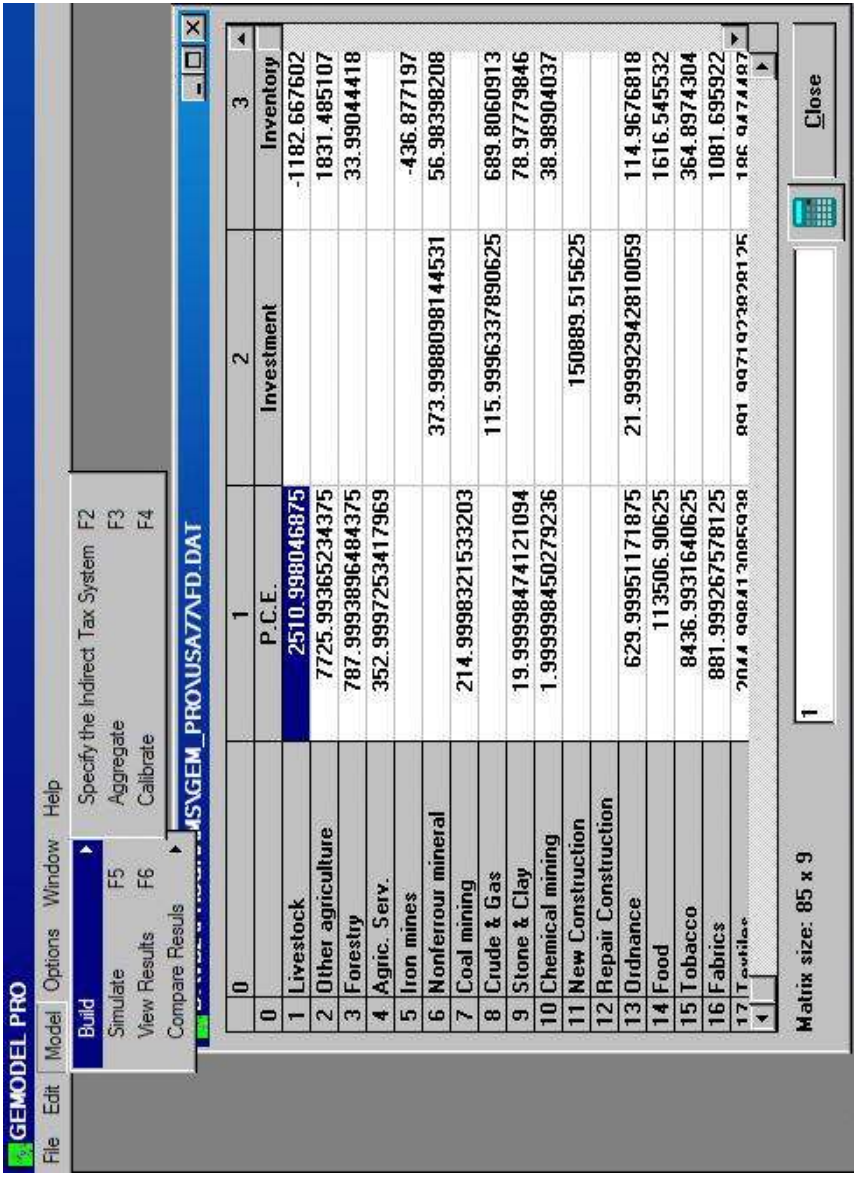


Figure 3: The Model Menu

THE NORMAL FLOW OF WORK

1. Enter or edit data. Save data in files. See pages 1-9 and 2-3.

2. Describe the base case indirect tax system. See page 2-18

2. Aggregate industries, personal expenditure categories, and households. See page 2-21.

4. Enter elasticity assumptions. See page 2-26.

5. Make a "no policy change" simulation to test the calibration. See 2-31.

6. Enter policy or parameter changes. See page 2-31, 4-28.

7. Toggle tax policy instruments on or off and choose an error tolerance. See page 2-36, 4-27.

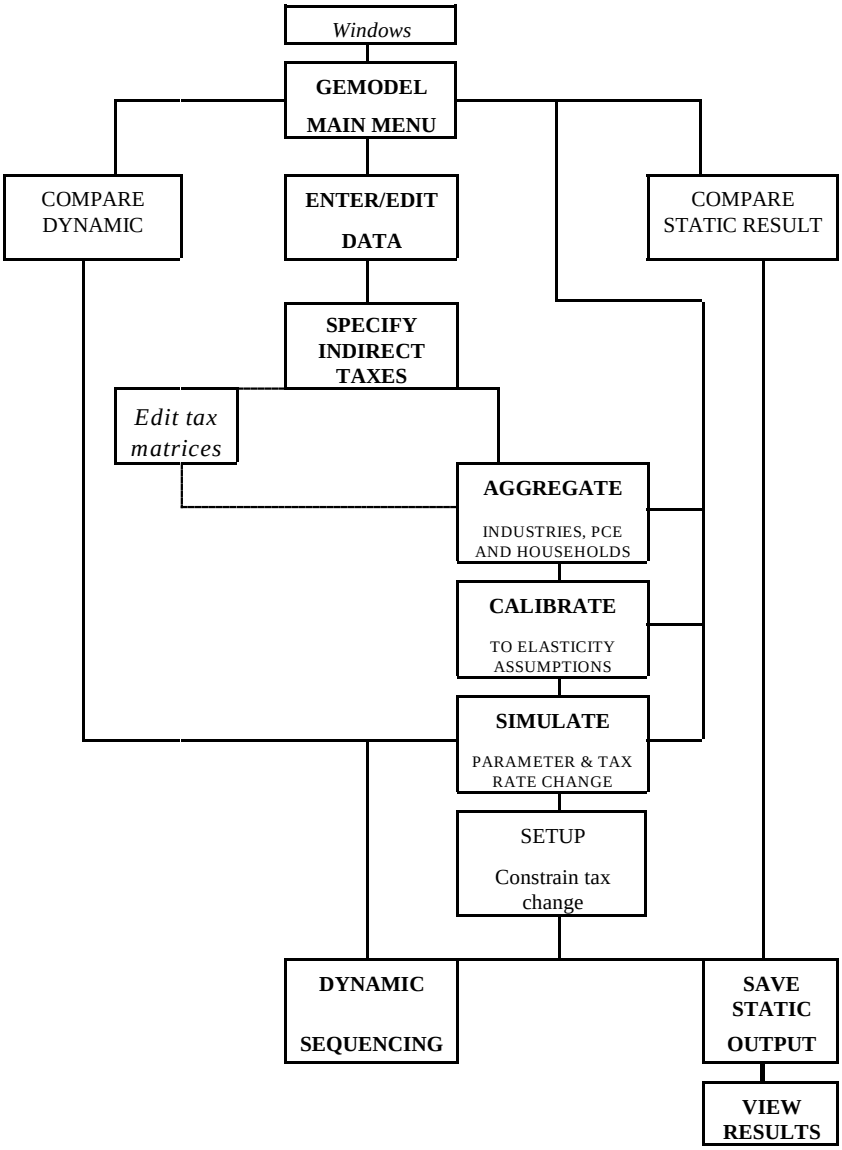
8. Solve the model. See page 2-35, 2-36.

9. Inspect the results and store them for later analysis. See page 2-38.

10. Compare results with the base case. See page 2-41.

The first five steps do not have to be repeated until your next data update. You will therefore usually start at step 6.

THE NORMAL FLOW OF WORK



WHAT DATA MUST BE FILED?

The following files must be in the data folder at all times:

Numeric files	*Alphabetical files*
1. USE. DAT	10. COMMODTY.HDG
2. MAKE.DAT	11. INDUSTRY.HDG
3. FD.DAT	12. FINALCAT.HDG
4. PCE.DAT	13. PCECAT.HDG
5. CFT.DAT	14. TAXCAT.HDG
6. TAXES.DAT	15. MARGCAT.HDG
7. MARGINS.DAT	16. HHCAT.HDG
8. FAMEX.DAT	17. ENDOWCAT.HDG
9. ENDOW.DAT	18. PERSTAX.HDG
	19. VA.HDG

Each numerical file is discussed on a separate page and under its name. The description of required input-output data on the following pages assumes a rectangular, commodity-by-industry input-output system. See page 2-5 if your input-output data are symmetric, industry-by-industry or commodity-by-commodity.

The files you create are the *.DAT files. The *.HDG files are created by GEMODEL.PRO to save column headings and row stubs common to one or more *.DAT files whenever you choose to save numerical data in *.DAT files.

... WHAT DATA MUST BE FILED?

USE.DAT

USE.DAT has industries (named in INDUSTRY.DAT) in the columns and commodities (named in COMMODTY.HDG and VA.HDG) in the rows.

There must be three more rows than columns. The last three rows after the *n*th commodity row must contain

Value added by labour	in row n+1
Net indirect taxes by industry	in row n + 2
Value added by capital	in row n + 3

in exactly that order. Aggregation and calibration routines expect data in this order.

The columns show the value of commodities and primary factors used by each industry. The use is measured in its dollar level, not in ratio to gross output.

Industries may include *dummy industries*, that is activities such as Scrap production that do not employ primary factors and that do not exist in the real world but are an artifact of input-output accounting to route commodities of uncertain origin.

Industries may include *special industries* such as a rest-of-the world sector and households.
Points to remember in case you file foreign data:

Include imports in intermediate use. If necessary, add an imports matrix to a matrix of intermediate use of domestic products.

Intermediate use is at producers' prices including import duties on imports for intermediate use and all other indirect taxes on intermediate use.

The net indirect tax row includes all indirect taxes and subsidies on intermediate and final use and all real property taxes.

... WHAT DATA MUST BE FILED?

MAKE.DAT

The Make matrix shows the values of the commodities produced by each industry. Industries are in the rows (named in INDUSTRY.HDG) and commodities are in the columns (named in COMMODTY.HDG).

Some rows and columns can be zero in the original source. If that is the case, then insert a 1 on the diagonal at the intersection of equally named rows and columns.

Example: in the US Make table, insert a 1 in cell (80,80), non-competing imports.

Counter-example: leave blank the cell at the intersection of the Scrap row with the Scrap column.

Reason: Every cell in the Make matrix will later be divided by the corresponding column sum to obtain the industries' market shares but one cannot divide by zero.

Points to remember:
The *n* Make matrix columns must correspond one by one to first *n* rows in the Use matrix.
The *m* Make matrix rows must correspond one by one to first *m* columns in the Use matrix.

In case you file foreign data:
Foreign Make matrices may need transposing in case they are published (as in Canada) with industries in the columns and commodities in the rows.

In case of symmetric input-output data:
Your data may be symmetric, industry-by-industry or commodity-by-commodity. No Make matrix is included in symmetric input-output tables. However, GEMODEL.PRO expects a Make matrix in every case. The requirement of a Make matrix can be satisfied by filing an identiy matrix (with 1 on the main diagonal, 0 in every off-diagonal cell).

... WHAT DATA MUST BE FILED?

FD.DAT

Final demand is $C + I + X - M + G$. Investment I includes inventory change in a separate column. Government expenditure G is disaggregated into four categories, two federal expenditures and two State/local expenditures. Final demand categories (named in FINALCAT.HDG) are in the columns. Commodities are in the rows. The commodities must be the same as in USE and MAKE, and in the same order.

The columns must be in this order:

1. Personal consumption expenditure (PCE)
2. Gross fixed capital formation (I)
3. Inventory change
4. Exports (X)
5. Imports (M)
6. Federal government defense expenditures
7. Other federal government expenditures
8. State/local education expenditures
9. Other State/local expenditures.

Any tenth column will not be recognized by GEMODEL.PRO.

Points to remember:

All values are at producers' prices including indirect taxes. The net indirect tax row must be zero.

Import values include import duties.

Imports of trade services include the total import duty revenue.

With the exception of the cell in the Trade row, all entries in the imports column are negative values.

Exports of the trade commodity include revenue from export taxes.

Value added rows must be blank. Route final demands for primary factors through special industries as is already the case with the Household, Government, and Rest-of-the-World "industries" in the US Make and Use tables.

There is no place for columns holding total expenditure by federal and State/local governments. GEMODEL.PRO obtains totals by adding the parts.

...WHAT DATA MUST BE FILED?

FD.DAT ... continued

Consumption is defined as consumption by residents. Eliminate negative values in the *Rest-of-the-world* row outside the Imports column. Increase imports of the *Rest-of-the-world* good to re-balance the final demand table.

Government expenditures do not necessarily have to be classified into Defense, Non-Defense, Education, and Other State/local. All that is needed is

2 levels of government
2 final demand columns at each level
all four columns must be the contiguous columns 6 to 9.

In case disaggregated government demand columns are unavailable:

Either: Assume identical expenditure coefficients in all government columns and distribute the total government consumption accordingly.

Or: Move the GGCE column from the FD table to the government column in the USE matrix. Let government output be the new sum of commodity purchases plus value added. Distribute this sum over the 4 government columns and in the government row of FD.DAT. All other government consumption cells in FD.DAT are blank.

In case you file foreign data:

Add the matrix of imports for final demand to the matrix of final demand for domestic products if your input-output data have separate matrices of uses of imports and uses of domestic products. The negative of the row sum over all columns of the imports matrix belongs in the imports column of FD.DAT. Add total revenue from import duties to the imports of the Trade commodity in FD.DAT thereby converting the corresponding cell to a non-negative value.

... WHAT DATA MUST BE FILED?

PCE.DAT

The PCE.DAT file shows personal consumption expenditure by commodity and by national accounts expenditure category. Expenditure categories are in the columns (named in PCECAT.HDG) and commodities are in the rows. Commodities must appear in the same order and with the same names as in USE, MAKE and FD. Sales taxes are included in the value of expenditures.

Consumption is defined as the consumption by residents. Set any consumption by non-residents equal to zero. Adjust the PCE and imports columns in FD.DAT accordingly.

The PCE.DAT file is used to disaggregate personal expenditure by household and by category. You may decide against disaggregation by category. In that case, PCE.DAT would have a single column identical to the PCE column in FD.DAT. The resulting general equilibrium model will be one with a single, composite consumption good. Such a model can be used when there is reason to think that simulation results do not depend on consumption choices.

In case you file foreign data:

Your input-output data may seem to lack a PCE table. Search the data source for disaggregated consumption columns. In Canada, for example, PCE by category is included in several columns of a Final Demand table.

... WHAT DATA MUST BE FILED?

CFT.DAT

The matrix in CFT.DAT shows the commodity composition of gross fixed investment by industry. The industries are in the columns (named in INDUSTRY.HDG). Commodities are in the row (COMMODTY.HDG). A column shows the value of commodities purchased by an industry in the course of its gross fixed investment.[1]

In case you file foreign data:

Your input-output data may seem to lack a capital formation table. Search the data source for disaggregated investment columns. In Canada, for example, final demands for capital goods are available for several industry groupings in columns of a final demand table. Expenditure on construction and on machinery and equipment is available separately for each group. A CFT table may then be completed by assuming similar expenditure patterns for all industries in the group.

[1] See Gerald Silverstein, "New Structures and Equipment by Using Industries, 1977," *Survey of Current Business*, November 1985, pp. 26-35.

... WHAT DATA MUST BE FILED?

TAXES.DAT

The rows of TAXES.DAT contain the following revenues by industry:

Federal payroll taxes	in row 1
State and local payroll taxes	in row 2
Federal profits (or corporate income) taxes	in row 3
State and local profits taxes	in row 4
State/local real property taxes	in row 5

In addition, you can file data that affect the computation of tax rates, namely

Non-corporate consumption allowances by industry	in row 6
Corporate consumption allowances by industry	in row 7

Consumption allowance includes any indirect taxes on the purchase of capital goods.

GEMODEL.PRO expects tax revenues and consumption allowances to be in precisely the order stated above.

The property tax will be treated as an indirect tax on gross output if row 5 is a row of zeros. Otherwise, the property tax will be treated as a tax on capital services and added to the cost of capital.

The cost of capital will also include depreciation if you fill rows 6 and 7. Net saving is computed as gross fixed capital formation plus inventory change less recorded depreciation. Omission of depreciation from the data will cause an overestimate of net saving and of the rate of population growth over a base case, reference growth path.

For any industry, total payroll taxes in rows 1 and 2 must not exceed the total compensation of labour in row $n + 1$ of USE.DAT. The total of capital taxes and depreciation must not exceed the gross value added by capital in row $n + 3$ of USE.DAT.

... WHAT DATA MUST BE FILED?

MARGINS.DAT

The margins table has four columns of indirect commodity tax margins:

Import duty revenue	in column 1
Export tax revenue	in column 2
Federal sales tax revenue	in column 3
State/local sales tax revenue	in column 4

Import duties and export taxes are treated as federal taxes. Export taxes can be in addition to sales taxes imposed on an origin base by any of the two levels of government. The revenue from sales taxes on exports arising from taxation on the origin base belongs in columns 3 and 4.

The sum over all cells in column 1 must equal the duty revenue included in imports of the Trade commodity (in the US tables, row 69 of the imports column in FD.DAT). The sum of export taxes must be included in exports of the Trade commodity.

GEMODEL.PRO uses the last two columns in TAXES.DAT to create matrices of taxes on intermediate use and final demand. The computed final demand tax matrix includes taxes on exports and has no taxes on imports if you specify taxation on the origin base. Computed sales taxes on exports are zero if you specify taxation on a destination base. The sales tax matrices are used to compute a row of sales tax revenue by industry. The row of computed commodity taxes is subtracted from the net indirect tax row in the Use matrix. The residual remaining in the net indirect tax row is treated as a State/local tax on gross output. This residual output tax should not include federal indirect taxes. You should therefore attempt to file *all* federal commodity taxes in MARGINS.DAT.

Estimation of tax margins using inconsistent data from sources such as trade and taxation statistics is not recommended. Consistent data based on the same sources will already have been constructed by an input-output division of a central bureau of statistics. *Use the tax data in the input-output system*.

... WHAT DATA MUST BE FILED?

FAMEX.DAT

FAMEX.DAT is a matrix of household expenditure by National Accounts PCE category and by household. Households (named in HHCAT.HDG) are in the columns. Expenditure categories (named in PCECAT.HDG) are in the rows. The PCE categories must be exactly the same as those in the PCE.DAT file.

The FAMEX.DAT file has three additional rows. If there are *n* PCE categories, the file also has

saving by household	in row *n* + 1
Federal income tax paid by household	in row *n* + 2
State/local income tax paid by household	in row *n* + 3

The data are derived from family expenditure surveys. Households can be grouped by socio-economic characteristics, by percentiles of income before taxes, or by percentiles of expenditures. The calibration routines can fit non-linear personal income tax schedules to tax and income data provided that households are classified in equally large groups (*e.g.* in quintiles or deciles). When households are grouped in classes of differing sizes, as they may be when grouped by socio-economic characteristics and not by income, you may choose to fit linear income tax schedules specific to each household group (see page 2-29).

Column sums are treated as total money incomes. Total expenditures and saving must be positive for every household. Group the households by expenditure plus saving if you think permanent income matters more than current income.

Note: Household expenditure surveys usually exclude from housing expenditure the homeowners' income from equity in their homes. Imputed equity income is, however included in national accounts and input-output estimates of value added by capital in housing activities. For consistency with data in USE, MAKE and FD tables, the housing expenditure in the FAMEX table should include an estimate of imputed income from homeowner equity. Capital gains made in the sale of homes are excluded from all data tables.

... WHAT DATA MUST BE FILED?

FAMEX.DAT ... continued

The household expenditures and saving in FAMEX.DAT are rescaled by GEMODEL.PRO to equal the personal consumption expenditures in FD.DAT and the saving computed as gross investment plus inventory change in FD.DAT *less* capital consumption allowances in TAXES.DAT. This procedure replaces the RAS adjustments that you may have noticed elsewhere in the general equilibrium literature. Thus the household expenditure and saving data need not be perfectly consistent with the corresponding input-output data. However, the last two income tax rows must contain the best estimates of total income tax payments by each household group. Accurate income tax data are required because GEMODEL.PRO receives no other data to compute total income tax revenue and to estimate income tax function parameters.

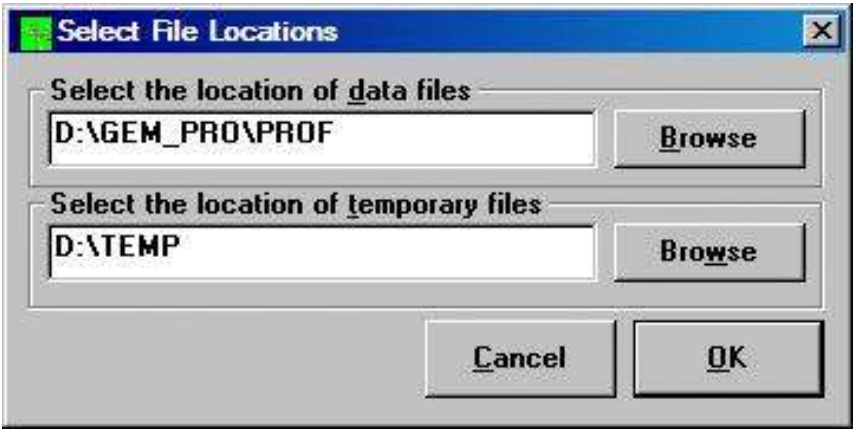


Figure 4: Selection of file locations.

...WHAT DATA MUST BE FILED?

ENDOW.DAT

Factor endowments of households and data used to estimate them are filed in ENDOW.DAT. This file has households in its columns. The rows are:

Net worth	in row 1
Weeks worked during the year by adult members	in row 2
Number of adults in the household	in row 3
Earned income (wages, salaries and self-employment income)	in row 4
Federal transfer payments received	in row 5
State/local transfer payments received	in row 6

Every household must have some net worth. On average, adult household members should work less than 52 weeks per year. The weeks not worked provide an estimate of leisure valued at the average weekly earnings.

As with the data in FAMEX.DAT, some data rows are adjusted and other data rows are inputs to further calculations by GEMODEL.PRO. The first four rows of ENDOW.DAT are adjusted to make them consistent with factor incomes derived from the Use matrix. The data in the last two rows are not transformed but used in further calculations of household shares in transfer payments.

WHAT DATA WERE FILED?

GEMODEL.PRO is supplied with a minimum amount of data necessary to make some practice runs and simulations. Once you have familiarized yourself with the model you will want to complete the data set and to bring it up to date.

The following data matrices are complete:

Matrix	*Source*
USE	*Survey of Current Business*, May 1984, table 1, pp. 52-56.
MAKE	*ibid.*, table 2.
FD	*ibid.*, table 1, page 57.
PCE	*ibid.*, table B, pages 47-49.
CFT	*Survey of Current Business*, Nov. 1985, table 2, pp. 28-34.
MARGINS	Special tabulations by the Bureau of Economic Analysis, U.S. Department of Commerce.

WHAT DATA WERE FILED?

The incomplete tables are:

Matrix	*Source*
FAMEX	Bureau of Labor Statistics, *Consumer Expenditure Survey: Interview Survey, 1982-83*, table 1. The data are not in the 83-category aggregation.
	Income taxes were scaled to 1977 national accounts totals including social security taxes paid by households.
TAXES	
Total taxes on profits	*Survey of Current Business*, July 1982, table 22B.
Federal profits taxes	U.S. Department of the Treasury, Internal Revenue Service, *1977 Statistics of Income, Corporation Income Tax Returns*, publication 16 (12-81), table 2.
State/local profits tax	The difference between the total and the federal tax revenue.
Payroll taxes	*Survey of Current Business*, July 1982, table 6.14.
Depreciation	*ibid.*, tables 6.17B and 6.26B.
Property taxes	Estimated by DIA Inc. See page 4-22.
ENDOW	
Net worth	Proxied by investment income in Bureau of Labor Statistics, *Consumer Expenditure Survey: Interview Survey, 1982-83*, table 1.
Weeks worked	Bureau of the Census, *Current Population Reports, Consumer Income*, Series P-60, No. 132, July 1982, table 5.
Earnings	Bureau of Labor Statistics, *Consumer Expenditure Survey: Interview Survey, 1982-83*, table 1.
Transfers	Estimates based on the BLS survey data and adjusted to 1977 NIPA totals in *Survey of Current Business*, July 1978, table 3.12, page 42.

ADDITIONAL FILES

The GEMODEL.PRO diskette includes also files created during a sample aggregation and calibration:

HH.AGG	Household aggregation parameters
INDUSTRY.AGG	Industry aggregation parameters
PCE.AGG	Personal consumption expenditure category aggregation parameters
INDIRECT.TAX	Commodity tax base specifications
PCETAXF.DAT	Federal commodity tax margins by commodity and by PCE cat.
USETAXF.DAT	Federal commodity tax margins by commodity and by industry
CFTTAXF.DAT	Federal commodity tax margins on fixed capital replacement
FDTAXF.DAT	Federal commodity tax margins by commodity and by final demand
PCETAXS.DAT	State/local commodity tax margins by commodity and PCE cat.
USETAXS.DAT	State/local commodity tax margins by commodity and industry
CFTTAXS.DAT	State/local commodity tax margins on fixed capital replacement
FDTAXS.DAT	State/local commodity tax margins by commodity and final demand
PCECAT.TAX	Federal commodity tax exemptions, PCE
INDUSTRY.TAX	Federal commodity tax exemptions, industries
FINALCAT.TAX	Federal commodity tax exemptions, investment
PCECAT.XAT	State/local commodity tax exemptions, PCE
INDUSTRY.XAT	State/Local commodity tax exemptions, industries
FINALCAT.XAT	State/local commodity tax exemptions, investment
USA77.CFF	Calibration output
USA77.PRO	Calibrated model file for input to simulation experiments
TEST.CAL	Elasticity assumptions made in calibration
NEUTRAL.PRO	Sample simulation experiment
NEUTRAL.OUT	Sample simulation output

THE INDIRECT TAX SYSTEM

Indirect taxes can be commodity taxes and non-commodity taxes. The real property tax is an example of the latter. Commodity taxes include import duties and export taxes that are treated separately. Commodity taxes other than trade taxes are referred to as *indirect tax margins*. Tax margins are distributed over matrices of taxes on intermediate and final commodity uses. The distribution depends on the type of indirect tax imposed by federal and State/local governments. GEMODEL.PRO lets you specify the type of indirect tax system in force. Select **MODEL|BUILD|SPECIFY THE INDIRECT TAX SYSTEM** from the **MAIN MENU** to specify the tax base that yielded the tax margins.

Two dialog boxed appear when you select **MODEL|BUILD|SPECIFY THE INDIRECT TAX SYSTEM**. The first is used to indicate the location of data files and of temporary filest hat will be created (see Figure 4, page 2-13). The second dialog box is the one used to specify the tax system (see the Indirect Tax Margins Specification window in Figure 5.) Use the space bar key to toggle ratio buttons on and off as desired. Choices can vary between levels of government, as illustrated in Figure 4. The tax base specification is general and is modified in particular cases by exemptions.

The exemptions of commodities are indicated by zero tax margins in the MARGINS.DAT matrix. Exemptions of industries and of final demands are indicated by the user. GEMODEL.PRO displays disaggregated demand categories and industries in list boxes where expenditure categories and industries exempted from indirect commodity taxes are selected. Use Click and Ctrl-Click to make your selections.

The example in Figure 5 illustrates the selection of personal consumption expenditures, industries, and government consumption exempted from federal and State/local commodity tax. The exempted items are highlighted in Figure 5. The lists of exemptions do not need to be as identical as in the illustration.

> If there are too many exemptions then there may be no commodity tax base to explain tax margin data. The result is a fatal calibration error.

...THE INDIRECT TAX SYSTEM

Initial, model-equivalent sales tax rates are computed as ratios of the tax margin over taxable commodity use. The computations are made on disaggregated data to avoid aggregation bias.

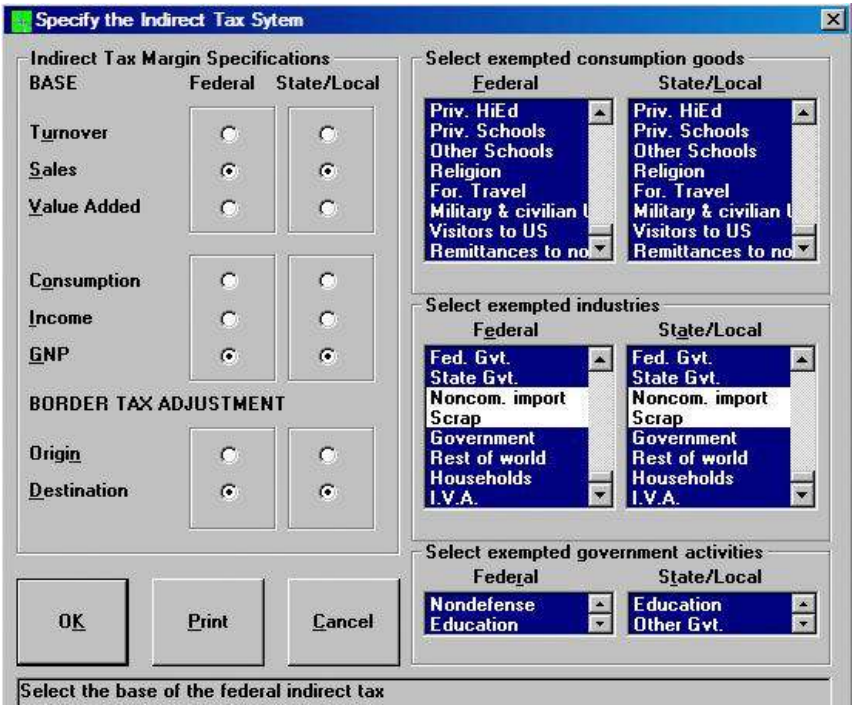


Figure 5: Specifying the indirect tax system.

Taxable use is a row sum over columns in the USE and FD tables. Net exports are excluded under a destination based tax. Other USE and FD categories are excluded from taxable use according to the following scheme:

...THE INDIRECT TAX SYSTEM

Turnover tax:	exempt uses in PCE and Government expenditure; intermediate use by exempted industries; fixed capital consumption by exempt industries; inventory change.
Retail sales tax:	inventory change is always excluded.
Retail sales tax and VAT:	exempt PCE and Government expenditure; fixed capital consumption under an income or a consumption-type tax; net fixed investment under a consumption tax; intermediate inputs to taxable industries.
All:	the use of imported goods under an origin-based tax where exports are included in the base.

EDITING TAX MARGIN TABLES

Skip this section unless you have detailed information about indirect commodity tax margins additional to that filed in MARGINS.DAT.

GEMODEL.PRO creates approximations to tax margin tables that assume a single commodity tax at each level o government. Eight tables of tax margins are created when **SPECIFY THE INDIRECT TAX SYSTEM** is selected from the **MAIN MENU.** These matrices can be edited and even replaced by data. Data are available for some countries (e.g. Netherlands) from their central statistical offices. Select **FILE|OPEN** from the **MAIN MENU** to open tax margin files listed on page 2-17. Editing of the tax margin tables is useful when there is information about commodity taxes that are imposed on a different base than that assumed in the creation of tax margin tables. For example, when the federal commodity tax is described as a value added tax while there is a separate excise tax on gasoline, GEMODEL.PRO treats the excise tax as if it were a value added tax. Excise tax revenue is not distributed over intermediate inputs of gasoline to taxable industries. Such a distribution can be done manually in row 31 of the federal tax margins tables. Edits can change the distribution of tax margins but must not change the total margin on a commodity. See also page 6-12.

AGGREGATION

Aggregation reduces the number of industries, PCE categories, and households on file to numbers within the limits allowed by GEMODEL.PRO. Select **HELP|ABOUT** to see the current limits on disaggregation.

You can choose any aggregation scheme within these limits. Because of *aggregation bias*, simulation results will vary depending on which aggregation scheme was chosen. The chosen aggregation parameters are saved in the data folder in files called INDUSTRY.AGG, PCE.AGG AND HH.AGG .

TEMPORARY FILES

GEMODEL.PRO creates and erases many files while aggregating data and preparing them for calibration.

GEMODEL.PRO asks for the location of data and of temporary files before jumping to the aggregation routine (see Figure 4, page 2-13). The best location for temporary files is separate folder. GEMODEL.PRO will created the specified folder unless it exists already.

DIALOGS

The aggregation program presents two dialog boxes. The first shows the current aggregation scheme and permits selection of industries, consumption goods, or households for aggregation (Figure 6). Thus one can vary the order in which files are aggregated and redo an unsatisfactory aggregation. However, all three aggregations must be made in one and the same session. Even if there was nothing to aggregate, one would still have to run through the aggregation routing to tell GEMODEL.PRO that there was nothing to aggregate.

...AGGREGATION

COMMANDS and PROCEDURE

The current aggregation scheme is shown in the left list box in the dialog illustrated by Figure 6. Aggregates retained in the model are capitalized. The components of an aggregate are shown below it and in lower case letters.

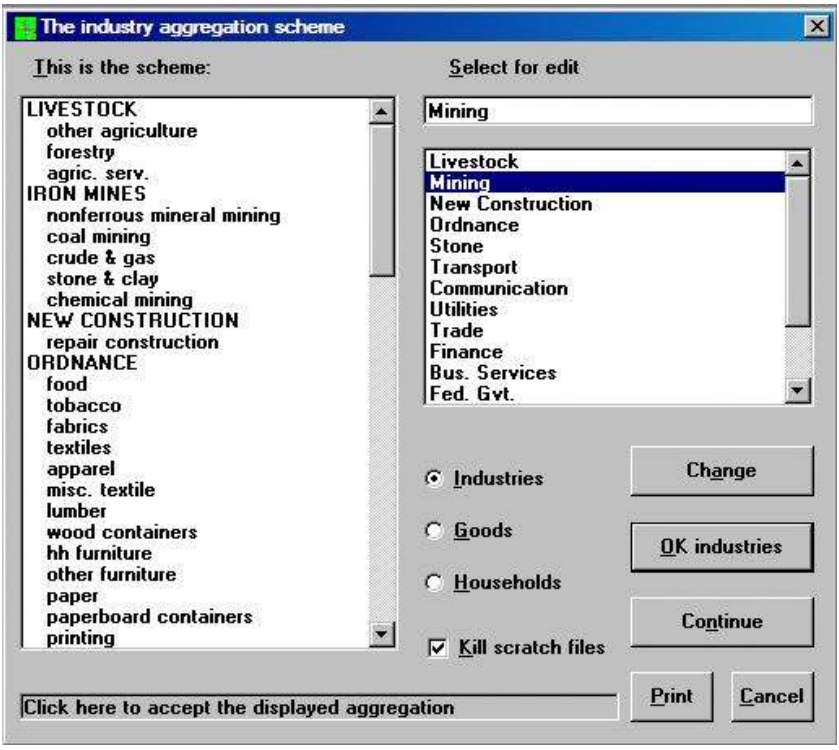


Figure 6: The current aggregation scheme.

Use the list box on the right to select an aggregate that needs re-naming. Type the new name in the text box above the second list. In Figure 6, “Iron mines” was renamed “Mining” after aggregation of all mining to iron mines. Click the OK button when the displayed aggregation is satisfactory. Then click on a radio button o view and work on a different list of expenditures or households and their aggregation.

... AGGREGATION

Click the Change button whenever the aggregation scheme needs to be changed. The second dialog box will then be displayed (Figure 7).

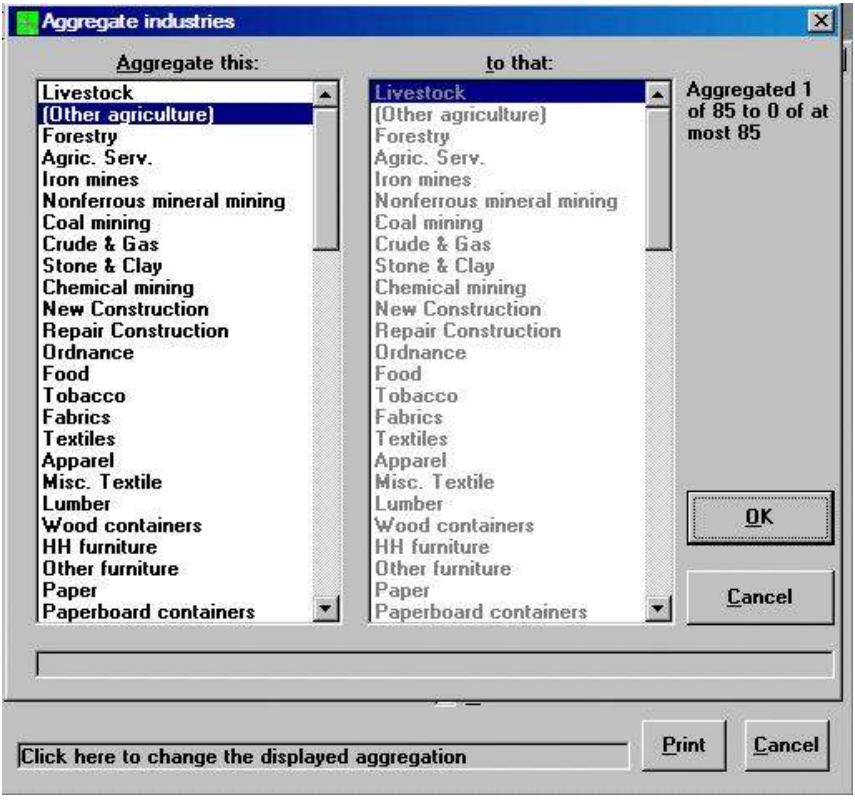


Figure 7: Changing the aggregation scheme.

Figure 7 shows the selection of “Other agriculture” for aggregation to Livestock. “Other agriculture” is then re-displayed in brackets. The brackets indicate that it is no longer available as a component of an aggregate.

... AGGREGATION

The chosen aggregation schemes are retained in *.AGG files in the data folder. These files will be read prior to the next aggregation attempt and the aggregation parameters on file are used to display the default aggregation scheme (Figure 6).

SOME POINTERS

Households: When aggregating deciles to quintiles, aggregate each even-numbered column to the immediately preceding odd-numbered column.

Industries: Never aggregate an industry to the Rest-of-the-World.

Try to retain Rest-of-the-World and Non-Competing Imports as separate "industries." GEMODEL.PRO will close the capital service account in the balance of payments if the ROW is aggregated to another industry.

The *Rest-of-the-World* is the only "industry" allowed to have negative value added.

Inventory Valuation Adjustment can be retained as a separate "industry" if the total represents a positive value added by capital. If not, aggregate it to Finance or some other industry but take care that the value added by capital in the aggregate remains positive. IVA can of course also be deleted completely from the list of industries and from GNP.

The sum of depreciation, corporate income and real property taxes paid by an industry can exceed the gross value added by capital in the industry. Aggregate such an industry to another to prevent negative capital input errors.

PCE Personal consumption uses *negative* amounts of some commodities, *e.g.* of *Scrap* and of the *Rest-of-the-World*. Aggregate consumer goods so that *positive* amounts are consumed of each aggregate.

...AGGREGATION

WHAT HAPPENS WHEN AGGREGATION FORMS ARE COMPLETE?

Rectangular, commodity-by-industry tables are converted to symmetric, industry-by-industry tables. Model-equivalent tax rates and function parameters that can be computed from data on file are obtained during a *precalibration* process. Accounting checks are made. Any errors that are found in the data are displayed on screen. When an error is found, computations are interrupted and no files are saved. Fatal errors that interrupt aggregation and precalibration are:

Negative depreciation in any industry aggregate.

Zero or negative net saving caused either by low fixed capital formation and inventory accumulation in FD.DAT or by excessive capital consumption allowances in TAXES.DAT

Absence of earned income, net worth, leisure or saving in any household.

Zero or negative aggregate demand for a PCE category retained after aggregation.

Negative value added by a factor employed in domestic industry, net of factor taxes.

Negative gross output of any industry other than the Rest-of-the-World.

Final demands in the *Rest-of-the-World* row outside the export and import columns of the FD.DAT file.

Aggregated and calibrated data are saved if no errors are found. The file is saved with the PRECALIB.CFF name. The user can choose a different name in a SAVE FILE dialog box.

The new *.CFF file is for input to a final calibration of free function parameters to elasticity assumptions.

CALIBRATION

Calibration is the solution of model equations for unknown parameters, given data on variable values and parameter assumptions. The values of parameters found in calibration are such that the model's equation system and data meet initial equilibrium conditions. For example, in the production function

$$Q = \phi[\delta L^{-\rho} + (1-\delta)K^{-\rho}]^{-1/\rho}$$

ϕ and δ are found given Q, K, L and σ [$\sigma = 1/(1 + \rho)$], and given that pure profits must be zero in the initial equilibrium of industries that operate under constant returns to scale.

The calibration routines present seven screens on which one enters assumptions by typing on the keyboard. The seven screens and the required keyboard inputs are:

1. Productions functions	Elasticity of substitution of capital for labor (σ).
2. Export demands	Price elasticity of foreign demand for exports.
3. Import demands	Armington elasticity of substitution of imports for domestic products.
4. Personal income tax	Choose between fitting a polynomial tax-liability function of taxable income or exogenous marginal tax rates. In the latter case, enter the assumed federal and State/local tax rates.
5. Household utility	Elasticity of substitution among PCE categories.
6. Savings behaviour	Elasticity of substitution of present for future consumption.
7. Labour supply	Elasticity of substitution of leisure for goods and services.

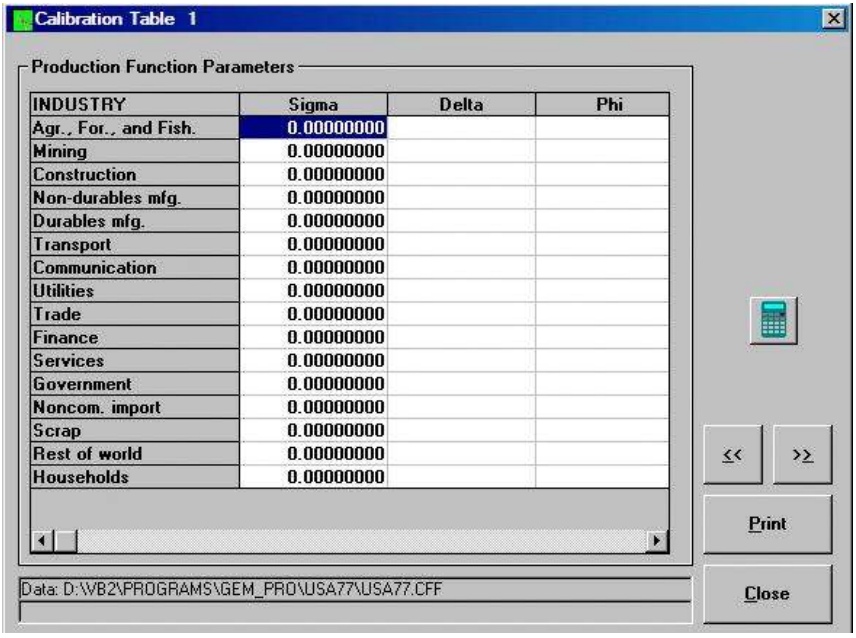


Figure 8: Page 1 before specification of any elasticity of substitution in production.

Select **MODEL|BUILD|CALIBRATE** from the **MAIN MENU**. An OPEN FILE window will appear. Use it to open a *.CFF file in the data folder. Enter assumptions as requested and click the >> button to switch to the next screen. Save an *assumptions file* and a *calibrated data file* when all assumptions have been entered on the seven screen. Do not append name extensions to the names of the assumptions and calibrated data files. GEMODEL.PRO adds the .CAL extension to the name of the assumptions file and the .PRO extension to the name of the calibrated data file.

The illustrations on this and the next page show calibration page 1 before and after elasticities of substitution in production had been entered in the first column.

... CALIBRATION

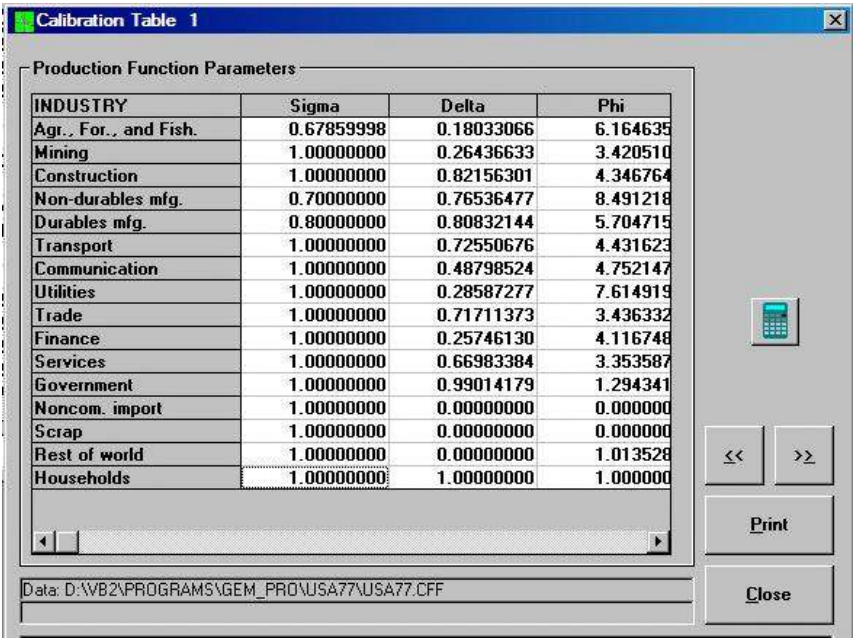


Figure 9: Page 1 after specification of elasticities of substitution.

Do not lose the *.CFF file. It is required for input to simulation. The calibrated data file with the .PRO extension in its name is paired with a file that has the .CFF extension. Both are required during simulations. All aggregations must be repeated to reproduce a lost *.CFF file.

...CALIBRATION

Substitution elasticities must be greater than zero. In consumption they must not equal unity. Some elasticities with respect to price are shown as soon as elasticities of substitution in consumption are entered or edited. Change elasticity of substitution assumptions until suitable price elasticities are obtained. Elasticity of the supply of labour w.r.t. the after-tax wage is shown on page 6. Elasticity of saving w.r.t. to the after-tax rate of return is shown on page 7 of the calibration screens.

Export price elasticities (page 2) are negative but one may enter the assumed values as positive numbers.

The Armington assumption (page 3) does not apply to imports of services supplied by the Rest-of-the-world. Disregard the odd value of the displayed Armington share parameter. It actually is a shift parameter in a constant elasticity function similar to a demand for exports.

Price elasticities of saving (page 7) and labour supply (page 6) are computed iteratively in a sub-model where most prices are exogenous. Labour supply, saving, personal income and income tax payments are endogenous in thissub-model. Marginal tax rates are also endogenous if a polynomial tax function was postulated. GEMODEL.PRO will display an approximate elasticity and a warning that the associated elasticity of substitution is not recommended if more than 10 iterations are needed to solve the sub-model.

On page 4 (see Figure 9) one has a choice of fitting *polynomial income tax functions* or not. If Y is taxable income and T is the income tax liability, then

$$T = a_o + a_1 Y + a_2 Y^2 + a_3 Y^3 + a_4 Y^4 ...$$

The polynomial can go up to the eighth power if there are more than 8 household groups. Do not choose to fit polynomials unless households are classified in equally large groups (*e.g.* income deciles). Fitted marginal tax rates are displayed in the bottom table.

The alternative to polynomials is a linear tax. This may be the only choice if high powers of large incomes cause overflow error messages. Linear function intercepts are displayed on page 6.

Exclusion of some or all savings from the income tax bases is offered so that one can calibrate to an income tax system with savings incentives (*e.g.* deductible pension saving).

...CALIBRATION OF TAX FUNCTIONS

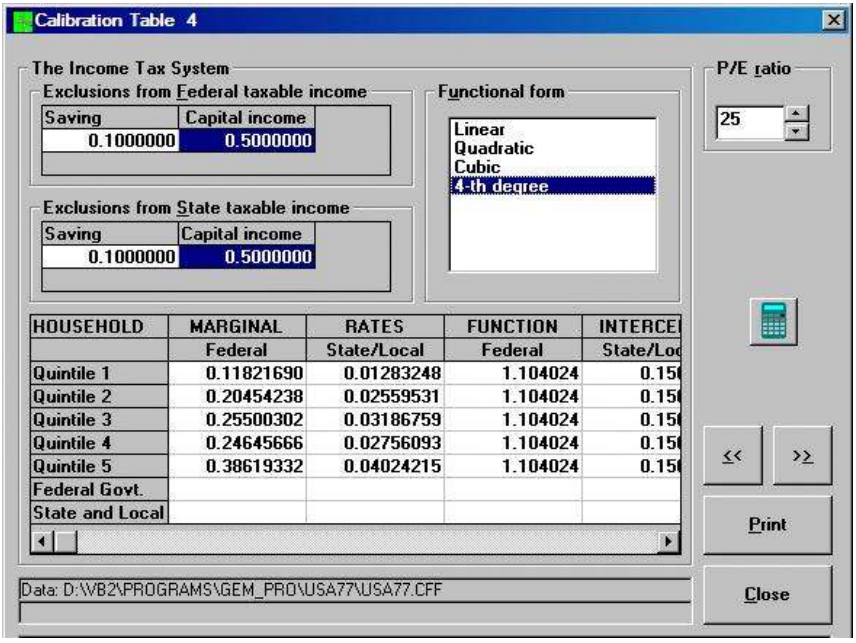


Figure 10: Calibration of income tax functions on page 4.

Exclusion of some or all capital income from the income tax bases is offered to allow calibration to an income tax system with investment incentives (*e.g.* exclusion of imputed returns to equity in owner-occupied homes) and to exclude retained corporate earnings from taxable income of individuals.

A price/earnings ratio is also set on page 4 illustrated above. This ratio is used for valuation of the capital stock in terms of the net value added by capital. The value of the stock is required to calibrate the parameters in household saving behaviour.

SIMULATION

For simulation one
- loads a calibrated file from disk;
- enters function parameter and/or tax changes;
- validates parameter and tax rate input;
- chooses a solution setup;
- solves the model;
- inspects results, compares them to a base case.

OPENING A FILE

Choose **MODEL|SIMULATE** on the **MAIN MENU**. An OPEN FILE window will appear. The file to open is the calibrated data file saved after a successful calibration with the .PRO name extension. Select this file from a list and open it. GEMODEL.PRO will also look for a matching *.CFF file. This file should be on the same folder as the selected .PRO file.

One can also open a file saved from the simulation menu after a successful solution was obtained. The data in such a file have been modified by tax rate and function parameter changes made before solution and by further calculations resulting in the solution. The solution files are also saved in pairs, one with the .PRO name extension, the other with the .CFF name extension, and both with the same main file name chosen when they were saved.

The data in the opened file appear in spreadsheet windows. Figure 11 shows the one where rates of federal indirect tax on personal consumption expenditures are displayed and available for change by the user. Click the >> button to see the next spreadsheet window. Click the << button to the the previous one. Select other windows from the **SHOCKS** menu.

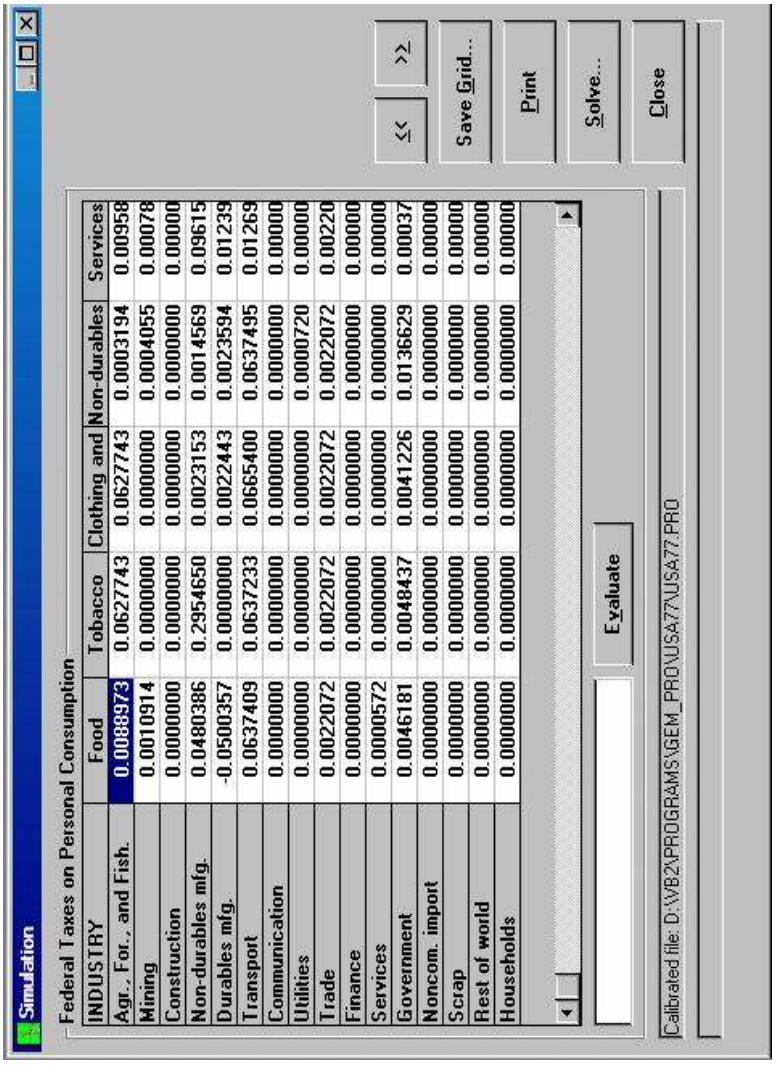


Figure 11: A Simulation screen for setting a shock to the model.

MAKING TAX AND FUNCTION PARAMETER CHANGES

The **SHOCKS MENU** gives access through sub-menus to spreadsheet screens (Figure 11) on which one can change a large number of tax rates, tax revenue levels, production and utility function parameters, export and import demand parameters, foreign capital inflows, and technical coefficients related to the use of industry outputs in production, consumption, investment, and government expenditure. GEMODEL.PRO is the only software that allows easy, interactive access to innumerable tax and parameter changes for extensive sensitivity analyses.

Parameters displayed on screen can be changed either by entering directly new values or by doing elementary arithmetic on them. To enter a new value, move the cursor until the desired spreadsheet cell is highlighted before typing.

DOING ARITHMETIC WITH PARAMETERS

The possible arithmetic operations are addition, subtraction, multiplication, division, and exponentiation. They are all made in the box to the left of the **Evaluate** button.

To add .1 to a highlighted value type *x* +.1 and Click **Evaluate**.
To subtract .1 type *x* −.1 and Click **Evaluate**.
To subtract the highlighted value from .1 type .1−*x* and Click **Evaluate**.
To multiply times 2 type *x**2 and Click **Evaluate**.
To divide by 2 type *x* /2 and Click **Evaluate**.
To divide 2 by the highlighted value, type 2/*x* and Click **Evaluate**.
To square the highlighted value, type *x*^2 and Click **Evaluate**.
To raise 2 to a power equal to the parameter, type 2^*x* and Click **Evaluate**.

...SIMULATION

EXAMPLE: A NEUTRAL PROFITS TAX

Simulate the effects of an increase in federal profits taxes. Open file USA77.PRO. Select **SHOCKS**, then **TAXES & TRANSFERS**, the **FEDERAL**. A further sub-menu appears. Select **FACTORS**. A spreadsheet appears with industries in the rows and with two columns labelled *Labor* and *Capital*.

For an across-the-board, 20 per cent increase in federal profits taxes, change every non-zero tax rate to 0.2. Select **TAXES & TRANSFERS**, then **TAXES & TRANSFERS**, then **STATE AND LOCAL**. Select **FACTORS** and make the State/Local capital tax change setting non-zero capital tax rates to 0.2. If you were after neutrality in the taxation of capital, not just in the taxation of taxable profits, change also the real property taxes on industries. You will then be ready to attempt a solution.

File NEUTRAL.PRO is identical to USA77.PRO except that capital taxes have been changed to 20 per cent in each taxable industry. The same taxes were used as instruments to achieve a revenue-neutral tax change. The simulation results are filed in NEUT_OUT.PRO and can be compared to the base case filed in USA77.PRO. The revenue-neutral federal rate is 14.8%. The revenue-neutral State/local rate is 10.6%. The wage rate is increased relative to the rental of capital. The efficiency gain is $1.46 billion or 0.07% of GNP.

SIMULATION AND CALIBRATION ASSUMPTIONS

Elasticity assumptions appear in simulation menus as items that can be changed. Changing elasticities at this point is not the same as changing them during calibration. Change them here if you want to simulate a sudden change in technology or tastes. Change them during calibration if you want to analyze the sensitivity of model solutions to elasticity assumptions.

DO NOT SIMULATE TOO SOON

Make a habit of first solving without parameter or tax rate changes. Inspect the output. The solution should have been achieved quickly and it should reproduce the data. Look for excessive inaccuracies. Allow for rounding errors in aggregation, matrix multiplications to create symmetric matrices, calibration, and in the solution of simultaneous equations. Errors appear most clearly in prices. Producer prices should all be unity when a calibrated model is solved without any tax or parameter changes.

SOLUTION

Click the **SOLVE** button when all parameter changes are done GEMODEL.PRO then goes through an input validation routine.

INPUT VALIDATION

False solutions can be found if model equations are mis-specified, if parameters are incorrectly calibrated, if policy changes are made inconsistently, or if a data diskette were damaged. Therefore, GEMODEL.PRO makes an input validation before every attempt to solve. Messages appear on screen if any errors are detected. Press an **OK** button to return to the **SIMULATION screen** after an error was detected.

A common type of error is caused by deviation from unity of a sum of parameters that must add up to unity:

Expenditure share parameters (α) in utility functions: When a shift in demand is simulated by reducing the value of an expenditure share parameter in the utility function (α), another such parameter has to be increased to preserve the sum to unity of all αs.

Household and government shares in transfer payments: All tax revenue is disposed of in transfers to households and government. Government expenditure is funded by transfers. Thus a reduction in the transfers to one recipient must be balanced by increases in the transfers to other recipients so that all revenue will be spent.

Commodity use coefficients in personal and government consumption, in investment, and in saving: When a technical change is simulated by increasing the use of *Livestock products* in the supply of *Food*, the use of some other commodity must be decreased to preserve the unity value of the sum of all commodity coefficients in the *Food* category of PCE.

Intermediate input coefficients: When a technical change is simulated by increasing an input-output coefficient, the sum of domestic and imported input coefficients of an industry must not be made to exceed unity. It should remain below unity to allow the use of primary factors.

GEMODEL.PRO proceeds to a **SOLUTION SETUP** if no data and parameter errors are detected.

Three constraints can be added to the equation system during **SOLUTION SETUP**: (1) to hold federal tax revenue at a previously determined level; (2) to hold constant the State/local tax revenue; and (3) to fix all tax revenues.

SOLUTION SETUP

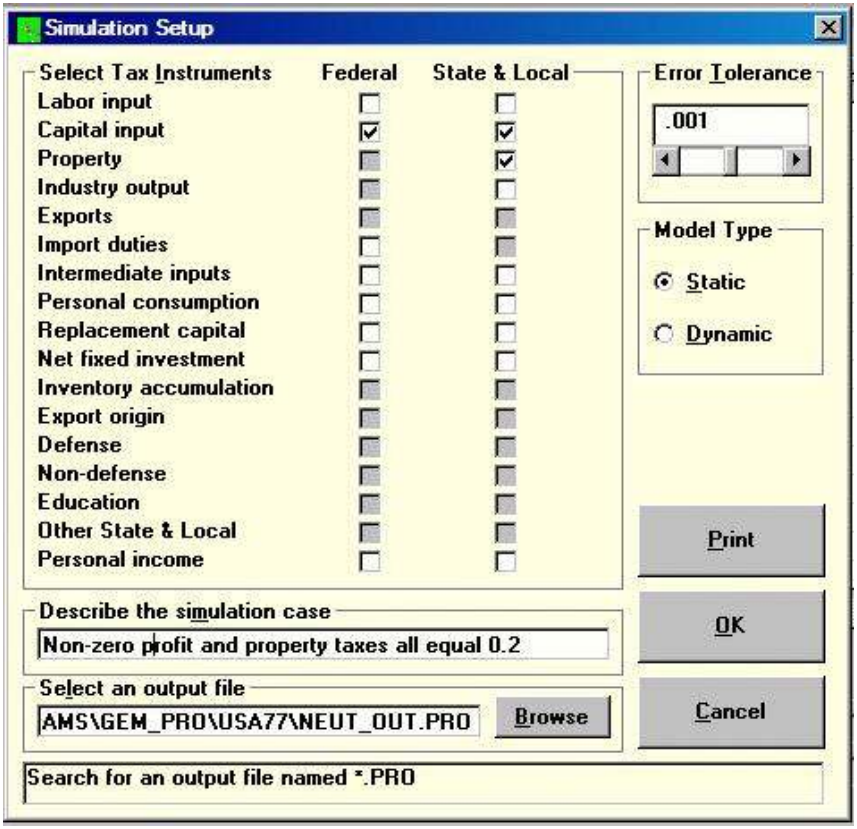


Figure 12: The window to Solution Setup.

Tax instruments are needed to meet the revenue goals set in the constraints. Addition of the constraints requires that one or more tax rates be made endogenous. Federal and State/local tax instruments can be turned **ON** or OFF in **SOLUTION SETUP**. Diverse tax instruments can be combined for simultaneous application. Revenue is unconstrained if **all** instruments are OFF. An instrument is not available if all transactions in the corresponding base are rated at zero. Unavailable instruments have disabled check boxes. Use mouse clicks to insert or remove check marks.

SOLUTION SETUP

Click the **PRINT** button to save a record of your tax instrument settings. Click **OK** when ready to compute the solution.

Simulation results will be saved in a file. The file can be made to include a description of the simulation experiment. The description is also entered at the end of the **SOLUTION SETUP.**

ITERATIVE SOLUTION

Solutions are found iteratively. Iterations stop when excess demands fall below an error tolerance level. The user has to enter his error tolerance level in the **SOLUTION SETUP** form above. The tolerance is proportional. A recommended value is .001, meaning that excess demands will be less than one-tenth of one percent of supplies. Marginal costs of taxes are very sensitive to small changes in variable values. Tolerances smaller than 0.001 should be used whenever such marginal costs are desired.

A count-down to the solution may be displayed during iterations. The equation block that is being revised is also indicated. An error message appears when a solution cannot be found or if the number of iterations is excessive.

A common reason for failure to solve is that a revenue constraint cannot be met with the given tax instruments. The base of the tax that is ON (checked) may be too small or too elastic.

...ITERATIVE SOLUTION

Another reason for failure to find a solution is that elasticity assumptions are unfavorable. Critical elasticities are those relating to foreign trade, saving, and labour supply. See **STABILITY OF THE FOREIGN EXCHANGE MARKET**, and **STABILITY OF ENDOGENOUS MARGINAL TAX RATES.**

Solutions that seem to take too long to be achieved can be speeded up by accepting a larger error tolerance. Inspect the output. Look for industries with notoriously high excess demands. Study their role in the model and the probable effect of excessively large or small elasticities in the production, consumption or trade in the industry's product.

SOLUTION OUTPUT

Simulation results are displayed after a successful, static simulation run. Results can also be viewed by selection of **MODEL|VIEW RESULTS.**

Screen output takes up 13 pages (See Figure 13). The first two screens provide elements to judge the accuracy of the solution by showing excess demands. Click on the >> button to view the next screen. Click on the << button to return to the previous screen. Use scroll bars to view all parts of a large spreadsheet on screen.

Click the **Save Grid** button or select **FILE|SAVE GRID AS** on the **FILE MENU** to save the current spreadsheet as a *.DIF file for interchange with *Excel* and other spreadsheet applications, or as a *.WK1 file readable by older *QuattroPro* or *Excel.*

Click the **CLOSE** button to return to the **SIMULATION MENU**. Repeat the experiment with a small tolerance if its initial level was too large as indicated by the computed size of excess demands.

... SOLUTION OUTPUT

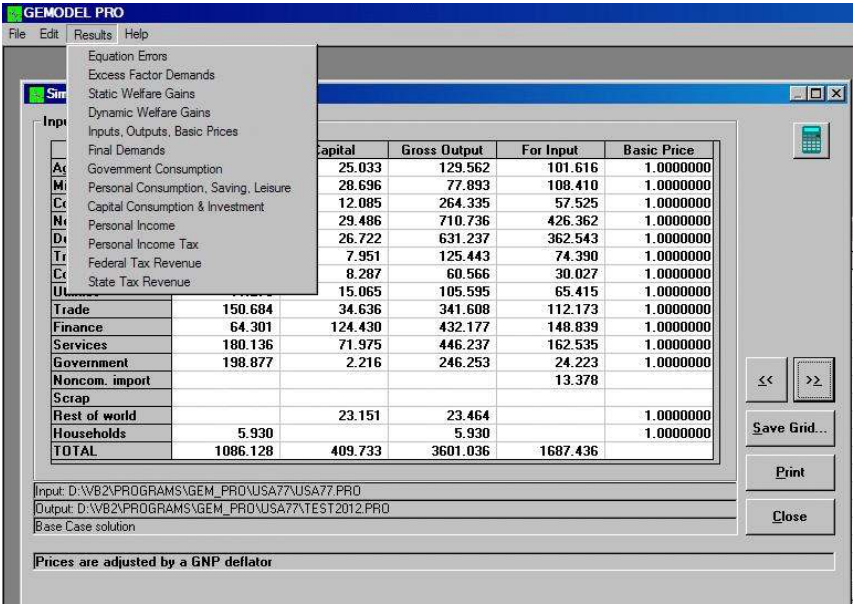


Figure 13: Solution output showing unchanged basic prices in a base case.

Page 1: Look for unusually large excess demands. Errors can result from the fact that the n equations are solved as a smaller system of m equations obtained by numerical substitution of variables. Small errors in the m equations can result in larger errors after substitution into the other the $n-m$ equations. Consider reducing the error tolerance. Error tolerance can be reduced if it is greater than 0.000001 and if the previous solution was found in reasonable time and without too much trouble.

Page 2: The wage rate (*numéraire*) should be very close to unity at the end of a no-policy-change and no-parameter-change experiment.

Page 3: Disregard small Hicksian variations. Welfare change is sensitive to error tolerance and to error in eliminated equations.

... SOLUTION OUTPUT

Page 4: Welfare gains on this page exclude the utility of saving and inventory accumulation. As such they are suitable for computing the present value of welfare changes achieved in dynamically sequenced equilibria. Seepage 3-3 for more details.

Page 5: Basic prices should equal unity in a no-policy-change, no-parameter-change case (see Figure 13). Industry output differs from gross output in the original USE table by the amount of sales taxes on final demand.

Page 6: Saving includes inventory change and the foreign capital inflow.

Page 8: The sum of household savings equals fixed capital formation and inventory change financed by residents. The "consumer price" of leisure is the wage rate *less* the personal income tax at the household's marginal rate. That rate varies from one household group to another and the price of leisure is therefore not printed in the *Price* column.

Page 9: Saving on this page includes the foreign capital inflow. Inventory change is shown separately.
The cost of capital includes factor taxes on capital income, depreciation, and the return on capital including a return on sales tax paid on the replacement cost of fixed capital. Inventory change is included in taxable profits. Depreciation is treated as deductible from taxable profits.

Page 12 Nearly all variables appear in tax revenue equations. Accuracy of the replication of base case revenues after a no-policy-change simulation is therefore another sign that there may be no errors in the calibration and solution routines.

COMPARISON OF SIMULATION RESULTS

Select the **MODEL|COMPARE RESULTS|STATIC** option on the **MAIN MENU** to compute, display, print, or write to disk the differences between two simulation results. The results to compare can be those of static model simulations or the results for a particular period of time in a dynamic sequence of model solutions.

The simulation results must be filed on disk before selecting the **COMPARE** option. The names of the files were determined in the **SOLUTION SETUP** screen (Figure 12).

The **COMPARE** routine asks the names of a Base Case and a Solution file. Type the name of each or click the **Browse** buttons to search for the two files. The files to search are *.PRO files.

The two files to be compared must follow identical aggregation schemes; they must have the same numbers of industries, expenditure categories, and households. USA77.PRO and NEUT_OUT.PRO are two sample files provided with the GEMODEL.PRO software.

Click a radio button to select the output format. The output format can be either (1) changes in levels or (2) percentage changes. No percentage change is calculated when the base case level is zero. The value printed is the variable's level in the alternative solution.

A string of dots indicates that both the base case and the alternative solution values are zero.

The main results are accessed from a **RESULTS** menu. A **MORE** menu gives access to more comparative results such as changes in various coefficients.

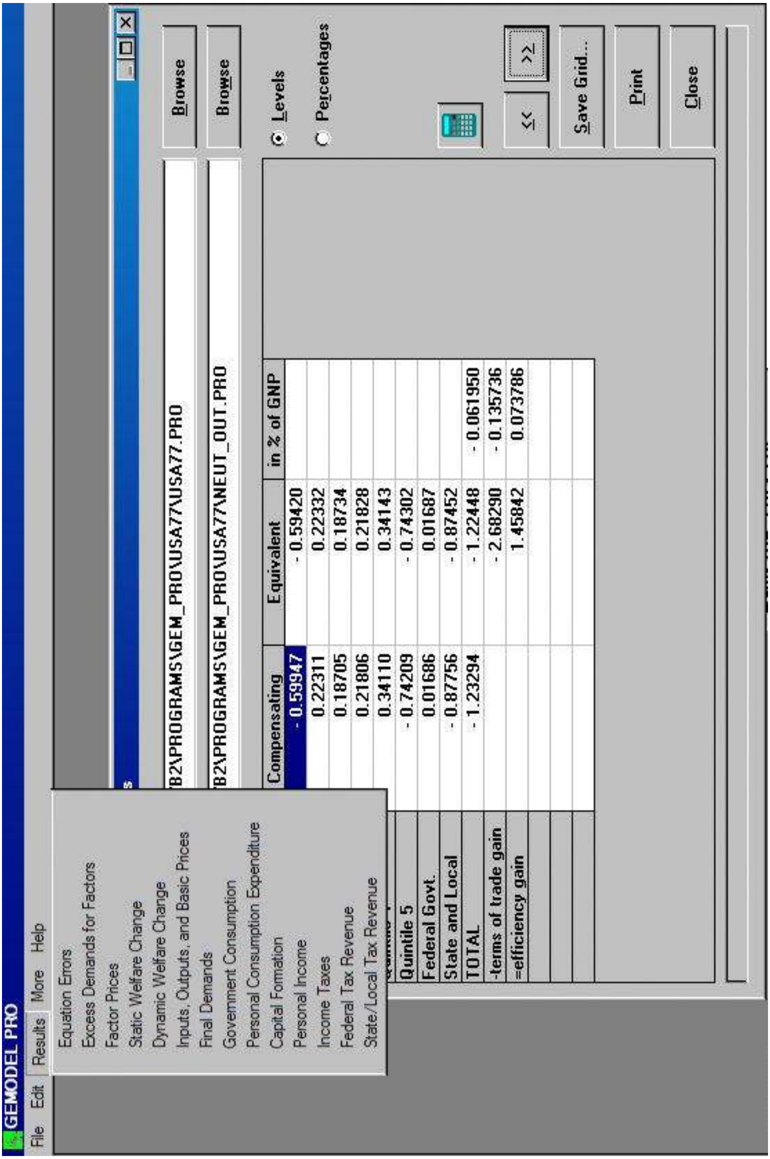


Figure 14: Comparison of static neutral capital taxation simulation results

SEQUENCING

Sequencing of static equilibria over a growth path is available only in the *Professional Version* of GEMODEL.PRO. You can skip this chapter if you own the *Standard Version.*

Dynamic sequencing involves a large number of files. A specially created folder should be available for this purpose.

GEMODEL.PRO writes files for two sequences. The first sequence contains results along a reference growth path in files named BASE_*nnn*.PRO, where *nnn* is a sequential number indicating the time period, usually a year. The other sequence contains a path followed after a policy change made in the initial period. This second sequence is filed in files named SCEN_*nnn*.PRO.

The two sequences must be computed one after the other. First run a no-policy-change simulation. First select **MODEL|SIMULATION** from the **MAIN MENU**. Open a *.PRO file. Click the **Solve** button. Click the **Dynamic** radio button. *Ignore the output file selection* but immediately click **OK** (Figure 12). At the end of this simulation, GEMODEL.PRO will present a **DYNAMIC SIMULATION SETUP** form (Figure 15, page 3-4). Edit the form to set (1) the location of dynamic output files on disk, (2) the number of time periods, (3) the rate of biological growth as a proportion of the rate of growth of the effective labour force, and (4) desired period-by-period adjustment in average personal income tax rates. Enter a number of periods from 1 to 125. Click **OK** when the form is filled correctly. GEMODEL.PRO will then solve and file the results for each time period.

In the first sequence, the growth rate in each period equals the rate of growth of the capital stock. This growth rate is endogenous. Each household's capital is increased by its saving. Likewise, the capital employed in inventory accumulation is increased in proportion to its rental value. You have the opportunity to make policy and parameter changes when GEMODEL.PRO successfully filed the BASE__*nnn files* and returned to the **SIMULATION MENU**.

GEMODEL.PRO allows policy or parameter change when the base case sequence was filed successfully. *There is no other time at which the second sequence can be started.* Closing the SIMULATION screen cancels sequencing.

...SEQUENCING

The rate of growth in the capital stock in the second sequence is endogenous. The rates of growth of labour and of other growing variables are exogenous. The exogenous growth rates are determined in the first, base case sequence.

The variables that grow at the base case growth rate are

- household labour endowments;
- shift factors in export demand equations including exports by the Rest-of-the-world;
- the autonomous inflow of foreign capital;
- the supply of money in a quantity equation.

Moreover,

- imports of capital services from the rest of the world are shifted in proportion to the capital inflow in the previous period.

Application of base case growth rates to these variables assumes that the base case path is a balanced growth path where all domestic factor endowments and foreign economies grow at the same rate. The rate can vary from period to period depending on savings behaviour.

It may be impossible to find the next equilibrium on a growth path. In such a case, there will be an Error message and the solutions will be aborted. Use the **MODEL|VIEW RESULTS** menu option to open the sequenced files that were saved. Inspect the last ones to find reasons for failure to find the next equilibrium on a growth path.

Exit from the **SIMULATION MENU** to another GEMODEL.PRO module menu cancels all dynamic sequencing. If possible do not exit before the reference and policy sequences have been filed.

Calculation of welfare change in the growing economy

Every file in each of the sequences includes a measure of dynamic welfare gains. These gains are measured from the base case and from the initial period. If the sequence of gains made on the reference path is

$$W_{01}, W_{02}, W_{03}, W_{04}, ..., W_{0n}$$

and the sequence of gains after the policy change is

$$W_{11}, W_{12}, W_{13}, W_{14}, ..., W_{1n}$$

then the present value of the policy-induced gains is the present value of

$$W_{11}-W_{01}, W_{12}-W_{02}, W_{13}-W_{03}, W_{14}-W_{04}, ..., W_{1n}-W_{0n}$$

plus a terminal adjustment. The terminal adjustment is the present value of a perpetual annuity of $W_{1n}-W_{0n}$ starting in the n^{th} period.

The discount rate can be supplied by the user. The user can also choose the reference growth rate as a discount rate. If the reference rates of growth are

$$r_1, r_2, r_3, r_4, ..., r_n$$

then the welfare gains made in the m^{th} period are discounted by

$$(1 + r_1)(1 + r_2) ... (1 + r_m)]^{1/m} - 1.$$

The present value computations ar made when **MODEL|COMPARE RESULTS|DYNAMIC** is selected..

GEMODEL.PRO erases all BASE_*nnn* and SCEN_*nnn* files that it finds in a destination folder before writing new sequences to that folder. Therefore, you may want to prepare separate folders, each one to hold results of a different dynamic simulation.

COMPARE DYNAMIC RESULTS

Select the **MODEL|COMPARE RESULTS|DYNAMIC** item on the **MAIN MENU** to cull from sequenced files only the minimum number of results required to compute the welfare gains over time. GEMODEL.PRO will show a screen with several tables and a text box with a **Browse** button to search the files. Click the **OK** button. Results are then shown as in Figure 16, page 3-8.

The measures of welfare change shown in tables are based on the equivalent variation and include a terminal adjustment to include gains beyond the last period in the sequence. Present value calculations are made with two discount rates: the rate of growth and the inverse of the price-earnings ratio that was assumed in calibration.

Aggregate welfare grows by growth of individual welfare and by growth in the number of individuals. Thus, aggregate welfare change and change in the welfare of the initial population are alternative policy evaluation criteria when there is biological growth. Both measures of welfare change are computed.

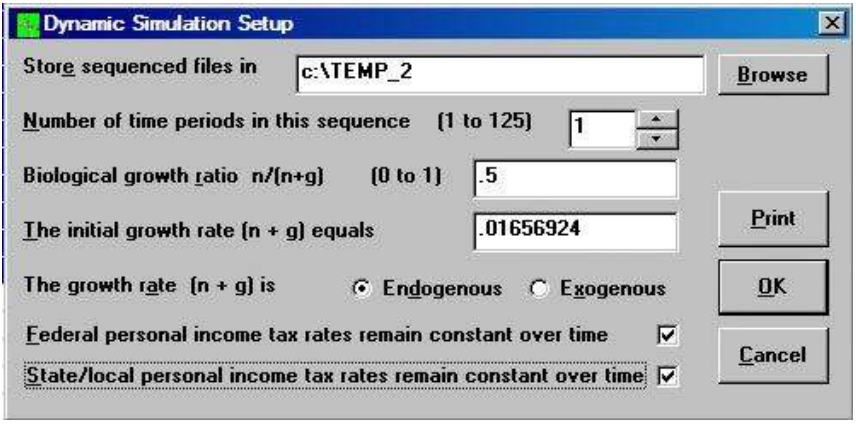


Figure 15: Dynamic simulation setup.

GOVERNMENT GROWTH

Government expenditure on goods, services and transfers grows at the same rate as tax revenue. The growth of tax revenue is affected by your use of tax instruments.

Tax revenue growth depends on exogenous tax rates and on endogenous tax-base growth when tax instruments are OFF. Marginal personal income tax rates may change when a polynomial function of taxable income had been chosen, but the polynomial function does not change.

If one or more tax instruments are ON (checked) before starting on the reference growth path, real tax revenues will grow at the same rate as the capital stock.

If tax instruments remain ON in the revised sequence, real tax revenues will be the same, period for period, as in the reference case. The instruments applied in the reference and in the revised sequence can be different.

PERSONAL INCOME TAX RATES

This section does not apply if you had specified linear income tax functions.

Extrapolation of tax liability with a polynomial function fitted to period 0 data may produce unacceptable results. If there is growth, marginal tax rates implied by the polynomial may rise to confiscatory levels within a few time periods. Undesirable extrapolations are avoided by re-estimating the polynomial coefficients after every solution for a new time period. GEMODEL.PRO re-estimates polynomial coefficients when so requested by the user before the start of dynamic sequencing. The request is made on the **DYNAMIC SIMULATION SETUP** form. The setup form provides the options of holding constant either one or both of the federal and State/local personal income tax rates faced by each household. Use check-marks as shown in Figure 15 to indicate your choice. Click on a check box bar to toggle check-marks on or off.

When constant tax rates are checked, the polynomial coefficients are adjusted with a one period lag. The polynomial coefficients computed after the solution for period t are the coefficients that would have made the average tax rate in period t equal to the average tax rate in period $t-1$. The new coefficients determine personal income tax revenue in period t. Tax rate changes resulting from the use of personal income tax as an instrument to achieve revenue-neutrality are retained after the re-estimation of the polynomial.

GEMODEL.PRO can be asked to recompute the federal tax polynomial coefficients, the State/local tax coefficients, or both, as shown in Figure 15.

PRODUCTIVITY GROWTH

If r is the effective rate of growth of labor, n is the natural rate of increase of the labor endowments, and g is the rate of increase in labor productivity, then r is approximately equal to $n + g$. On the reference growth path, r is also equal to the rate of growth of the capital stock owned by residents.

The ratio n/r can be set anywhere between 0 and 1 during the **DYNAMIC SIMULATION SETUP** (Figure 15). Edit the decimal fraction next to

Biological growth ratio n/(n+g) (0 to 1)

Enter a value between 0 and 1. Zero means that all growth in the effective labor force is assumed to be productivity growth. A 1 means that zero productivity growth is assumed.

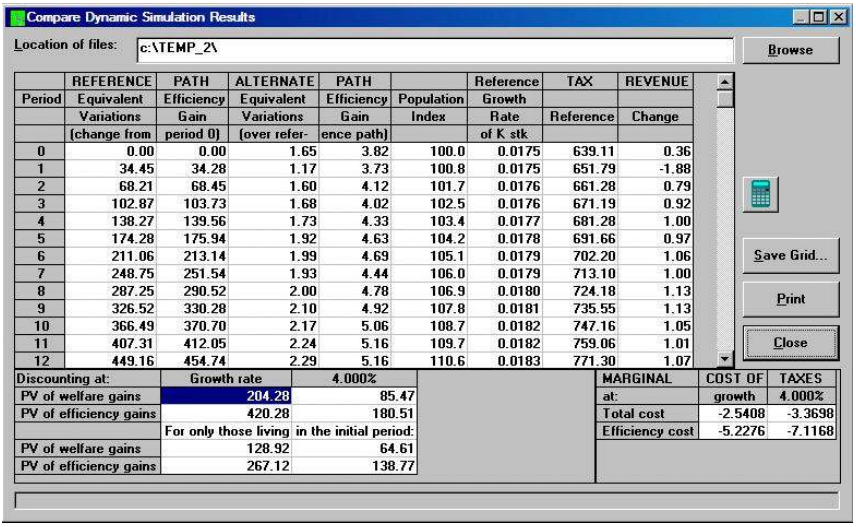
POPULATION GROWTH

Population grows at the same rate in the reference and policy-change sequences. GEMODEL.PRO assumes that population grows at a rate r that is equal to an endogenous reference rate of growth of the capital stock. Alternatively, GEMODEL.PRO can be made to assume an exogenous rate of population growth. Use the **DYNAMIC SIMULATION SETUP** form to set the exogenous rate. Click on a radio button to toggle the exogenous growth option on or off. Enter the growth rate as a decimal value (*e.g.* 0.02 for two per cent per period). The growth rate includes growth in labor productivity in a proportion determined on the same setup form.

STORAGE OF DYNAMIC SIMULATION OUTPUT

ASCII text files are saved for every annual reference and revised case result. The destination of the new files can be any folder, preferrably an empty one. The file destination is specified at the top of the **DYNAMIC SIMULATION SETUP**. Enter the complete path to any suitable folder, *e.g.* C:\TEMP_2. GEMODEL.PRO will create the new folder if it did not exist already.

GEMODEL.PRO erases all BASE_*nnn*.PRO and SCEN_*nnn*.PRO files that it may find at the destination of new dynamic output files. Specification of a new folder is therefore recommended.



Period	REFERENCE Equivalent Variations (change from	PATH Efficiency Gain period 0)	ALTERNATE Equivalent Variations (over refer-	PATH Efficiency Gain ence path)	Population Index	Reference Growth Rate of K stk	TAX Reference	REVENUE Change
0	0.00	0.00	1.65	3.82	100.0	0.0175	639.11	0.36
1	34.45	34.28	1.17	3.73	100.8	0.0175	651.79	-1.88
2	68.21	68.45	1.60	4.12	101.7	0.0176	661.28	0.79
3	102.87	103.73	1.68	4.02	102.5	0.0176	671.19	0.92
4	138.27	139.56	1.73	4.33	103.4	0.0177	681.28	1.00
5	174.28	175.94	1.92	4.63	104.2	0.0178	691.66	0.97
6	211.06	213.14	1.99	4.69	105.1	0.0179	702.20	1.06
7	248.75	251.54	1.93	4.44	106.0	0.0179	713.10	1.00
8	287.25	290.52	2.00	4.78	106.9	0.0180	724.18	1.13
9	326.52	330.28	2.10	4.92	107.8	0.0181	735.55	1.13
10	366.49	370.70	2.17	5.06	108.7	0.0182	747.16	1.05
11	407.31	412.05	2.24	5.16	109.7	0.0182	759.06	1.01
12	449.16	454.74	2.29	5.16	110.6	0.0183	771.30	1.07

Discounting at:	Growth rate	4.000%
PV of welfare gains	204.28	85.47
PV of efficiency gains	420.28	180.51
	For only those living in the initial period:	
PV of welfare gains	128.92	64.61
PV of efficiency gains	267.12	138.77

MARGINAL at:	COST OF growth	TAXES 4.000%
Total cost	-2.5408	-3.3698
Efficiency cost	-5.2276	-7.1168

Figure 16: Comparison of dynamically sequenced simulation results.

Figure 16 shows results of the neutral capital tax example run over 99 years.

BASE CASE SAVING

Fixed capital formation is financed by domestic and foreign saving. Saving is computed using the data on capital formation by industry, depreciation by industry, and the use of commodities in the demand for fixed capital goods.

Let *C* be the commodity by industry matrix of gross investment filed in CFT.DAT. Let **d** be a vector of depreciation or capital cost allowance by industry derived from data in TAXES.DAT as the sum of rows 6 and 7, transposed. Let *C*i be the gross investment by commodity column in FD.DAT.

Let **c** be a vector of gross investment by industry. Then **c** = i*C*. Capital consumption by commodity and industry is then

$$D = C\hat{d}\hat{c}^{-1}$$

where a caret (^) denotes diagonalization. The vector of saving or net fixed capital investment by commodity is then

$$s = (C-D)i$$

BASIS OF VALUATION

The model's US input-output data are at producers' prices. Value added in production includes indirect commodity taxes. Commodity taxes are excluded from value added in GEMODEL.PRO. This other basis of valuation corresponds to Approximate Basic Values recommended in the United Nations System of National Accounts.[2] Basic values are preferred to producers' prices because they provide a more uniform valuation system. By including commodity tax margins, producers' prices vary between types of buyer and depend on the composition of purchases within a commodity group.

Approximate basic values are obtained in pre-calibration by subtraction of estimated commodity taxes from the net indirect tax row in the Use matrix and from gross output. The uses of the *Trade* commodity in final demand are reduced by estimated tax margins to preserve the balance of final demand and supply.

No conversion to approximate basic values is made if columns 3 and 4 of the MARGINS.DAT table are left blank. In that case, valuation remains at producers' prices.

[2] United Nations, Department of Economic and Social Affairs, *A System of National Accounts, Studies in Methods*, Series F, No. 2, Rev. 3, New York, 1968, pp. 40, 48, 61, 67.

BORDER TAX ADJUSTMENTS

Calibration can be done assuming either an origin-based or a destination-based indirect tax system. The base can vary between the federal and the State/local governments. A change of base can be simulated. The base can be changed from the **SIMULATION MENU**.

All exports are zero-rated if the switch to an origin base is made immediately after loading a newly calibrated .PRO file as the initial, indirect taxes on exports (besides explicit, separately treated export levies) are zero. Switching to an origin base would therefore only relieve imports from tax without burdening exports.

Once a solution was obtained, the .PRO file modified by the solution process contains the rates of indirect tax by commodity. These rates are then assumed by GEMODEL.PRO to be the rates of indirect tax on export goods on a switch to the origin base. You need not retain this assumption. The rates can be changed selecting the tax sub-menus of the **SIMULATION MENU**. The solution sought to enable a switch to non-zero taxes on exports can be a no-policy-change, no-parameter change solution.

A switch from origin to destination taxes results in the elimination of exports from the tax base and the inclusion of imports. The rates imposed on imports are the same as those on competing domestic goods in the same intermediate or final use.

Federal import duties and export levies are treated separately and are unaffected by choice of origin or destination bases for other indirect tax margins.

CALCULATOR

A calculator is available whenever a screen shows the calculator icon. The calculator opens with a current spreadsheet value in its text box. Click the **Paste** button to enter a value previously copied to the *Windows Clipboard* with a **Ctrl-C** key stroke or by selecting the **EDIT|COPY** menu item. Click the **COPY** button to pass calculator results back to the *Windows Clipboard* for pasting to a spreadsheet with the **Ctrl-V** key-stroke or the **EDIT|PASTE** menu selection.

The Simulation Dialog box includes a text box and **Evaluate** button to evaluate functions of a value x selected from the spreadsheet.

The following functions are recognized:

LOG common logarithm (base 10)
LN natural logarithm (base *e*)
EXP exponential (e.g. EXP(2) = e^2)
ABS absolute value (e.g. ABS(-3) = 3)

Trigonometric and hyperbolic functions:

SIN	COS	SEC	CSC	TAN	COT
ASIN	ACOS	ASEC	ACSC	ATAN	ACOT
SINH	COSH	SECH	CSCH	TANH	COTH
ASINH	ACOSH	ASECH	ACSCH	ATANH	ACOTH

Operators:

* multiply	+ add
/ divide	- subtract
^ exponentiate	! factorial (0! to 170!)

Constants:

PI = 3.14159... e = 2.71828...
The golden Ratio *Phi* such that 1/*Phi* = *Phi* - 1.

Notation:

1.0E+02 is evaluated as 100.
Implicit multiplication is allowed. For example, (1+2_(3+4) = 21.
Roots can be entered as, for example, 2|9 = 0^(1/2) = 3.
Parentheses {[()]} are recognized.

Variables: *x* is replaced by a selected cell value.

CAPITAL FORMATION

Gross capital formation consists of fixed capital consumption, net investment in fixed capital, and net inventory accumulation. Each investment activity is modeled separately in GEMODEL.PRO.

Capital consumption is modeled as an industry by industry demand for goods in proportion to real capital employed and to industry-specific depreciation rates.

The expenditure on net inventory change equals the after tax return on an initial inventory accumulation fund held by firms.

Net fixed investment equals household saving *plus* a foreign capital inflow.

CONSTANT ELASTICITIES OF SUBSTITUTION

Production, utility, and Armington functions have constant elasticities of substitution. The elasticities must be greater than zero. In utility functions they must also be different from unity. Utility functions are nested. Nesting implies non-constant elasticities of substitution of current consumption goods for either leisure or future consumption.[3]

[3] See Gary W. Yohe, *Exercises and Applications for Microeconomic Analysis*, W. W. Norton, 1979, pp. 186-8.

DATA FILE TYPES

GEMODEL.PRO creates and uses various types of data files. It uses files to describe the indirect commodity tax system, for aggregation, for calibration, solution, and solution comparison. It makes files during computation of indirect tax revenues, aggregation, calibration, after solution, and during output comparison. The various files have specific uses, differ in structure, and are not interchangeable. Files are distinguished by name and by name extension. Names can have eight characters. Name extensions can have three characters.

*.DAT — files hold data used in computation of taxes and aggregation. No user-supplied file names are allowed.

Scratch — files created during tax computation and aggregation are erased before calibration and have no other use.

.CFF — is the result of aggregation. It is used in calibration and simulation and should never be erased.

*.CAL — holds the user's elasticity assumptions made during calibration. It is only used in calibration. Any user supplied name can be in place of the star.

*.PRO — is a calibration result used in simulation. *.PRO files are also saved by the **SIMULATION** module, in which case they contain simulation results. Any user supplied name can be in place of the star.

*.PRO files are paired with *.CFF files. A newly calibrated *.PRO file is paired with PRECALIB.CFF. A *.CFF file saved from the **SIMULATION** module is paired with a new *.CFF file that has the same user-supplied name as the *.PRO file.

Paired *.CFF and *.PRO files are used for input to simulation and to the comparison of results.

BASE_*nnn*.* and SCEN_*nnn*.* files are created in dynamic simulation.

...DATA FILE TYPES

BASE_*nnn*.* files hold results for one period on the reference growth path. GEMODEL.PRO replaces *nnn* with the serial number of the period in the sequence.

SCEN_*nnn*.* files hold the growth path after a policy or parameter change. GEMODEL.PRO replaces the *nnn* with the serial number of the period in the sequence.
The .* denotes .CFF and .PRO.

BASE_*nnn*.* and SCEN_*nnn*.* files can be compared after selection of **MODEL|COMPARE RESULTS|DYNAMIC** from the **MAIN|MENU**.

All files are sequential ASCII text files and carry a date stamp and descriptive text.

DEDUCTIBLE TAXES

GEMODEL.PRO treats State/local income taxes as non-deductible from federal taxes.

The model-equivalent corporate income tax rate is a rate on after-tax profits. Statutory rates are expressed as percentages of before-tax income. If t is the rate of tax on after-tax profit and s is the rate of tax on afer-tax profit, then $t = s/(1-s)$. Denoting federal and State/local taxes with sub-indices 1 and 2,

$$t_1+t_2 = \frac{s_1+s_2-s_1s_2}{1-s_1-s_2-s_1s_2}$$

The relationship between tax rates can be used to manually reduce on screen t_1 when t_2 is increased and assumed deductible.

Personal income taxes are modeled as effective rates on taxable income. If income taxable by the states is the as same income taxable by the federal government, then $t_1 + t_2 = s_1 + s_2 - s_1s_2$, defining t and s as rates on taxable income, s_1 allows for deductibility of State/local tax, and t_1 is an effective rate given s_2.

DEFICIT REDUCTION

In the sample data, federal consumption expenditure plus transfers to the State/local governments and to the first four household quintiles exceed federal tax revenue from all sources. The excess expenditure is balanced by negative federal transfers to households in the 5th quintile. These negative transfers can be reduced to simulate deficit reduction. The change in transfer payments must be balanced by either a change in federal expenditure or in federal tax rates.

To cut expenditure one only needs to change the share of the federal government and of the 5th quintile in total federal transfer payments. The sum of transfer shares must remain equal to unity. That is achieved by adding to the share of the 5th quintile an amount equal to that subtracted from the federal government's share.

Alternatively, suppose a 10 per cent tax increase. Choose federal **TAX REVENUE** from the **SIMULATION** menu. Multiply the revenue target by 1.1 Choose federal **TRANSFER PAYMENTS**. Divide all shares in federal transfer payments by 1.1. The amount of transfers out of increased revenue is thus held constant. Remove the surplus of tax revenue over transfer outlay. Add to the 5th quintile's share an amount that will raise the sum of all transfer shares to unity. Go to choice of tax instruments in **SOLUTION SETUP**. Set some federal tax instruments to ON. The final solution will show a large welfare loss because distorting taxes were used to reduce voluntary deficit finance.

Intergenerational transfers by payment of interest to bondholders are not modelled. Households are assumed to live forever and to expect to pay the taxes required to service the bonds they hold. A negative transfer or voluntary tax substitutes for bond purchases.

DEPRECIATION

GEMODEL.PRO assumes that all fixed capital of an industry depreciates at the average rate for the industry. The rate varies among industries.

Buildings can be made to depreciate slower than machinery and equipment. GEMODEL.PRO can be forced to recognize this difference by changing the weights of assets in the demands for fixed capital goods. Reduce the entries in the New Construction row of CFT.DAT. Continue with aggregation and calibration as usual.

The effect of the data change is *nil* on average depreciation rates by industry, negative on capital consumption of buildings, negative on net investment in machinery and equipment, positive on net saving in the form of buildings, and positive on capital consumption of machinery and equipment.

DIFFERENTIAL INCIDENCE

Turn tax instruments ON (check-marked) to hold tax revenue constant for a differential incidence experiment. GEMODEL.PRO allows a very large number of differential incidence scenarios by combination of different sets of federal and State/local tax instruments.

Tax revenue should not only be held constant but it should also be held to the base case level. The tax revenue screen accessed from the **SHOCKS** menu shows the current, base case and target levels of revenue. The target level should be equal to the base case level unless you want to simulate a change in the distribution of a fixed revenue between the federal and the State/local governments.

Some tax instruments cannot be set to ON. When a tax rate is zero, the corresponding instrument is not available. Enter non-zero tax (or subsidy) rates through the **TAXES** sub-menus to make tax instruments available.

ERROR MESSAGES

Error messages may occasionally appear on screen. Over 80 possible errors, their probable causes and solutions are tabulated at the end of this manual. Common errors are policy-change mistakes caught in solution setup. See the section on **PARAMETER RESTRICTIONS** for constraints on policy and parameter changes.

Division by zero and overflow errors can indicate intolerable policy or parameter changes.

Overflow errors can suggest scaling problems. Rescale the data in all data files converting from, say, millions to billions of dollars.

Errors during and before calibration indicate data inconsistencies. Data inconsistencies are not expected when balanced input-output data are processed. The data can, however, be unbalanced by transcription errors.

Error checking is done by GEMODEL.PRO code and by third-party software. Every effort was made to trap errors and to allow graceful recovery. Your reports of remaining problems will be appreciated.

EXCHANGE RATE

The exchange rate is in dollars per unit of foreign currency. It resembles an index of the prices of domestic goods in relation to prices of imported substitutes but differs from the terms of trade by inclusion of capital flows and factor services in the balance of payments equation.

The model is real. Only the exchange rate adjusts to inflation abroad. Verify this by doubling all foreign currency prices.

Using the USA77.PRO file, a ten per cent increase in all export prices expressed in foreign currency reduces the exchange rate from 1.000 to 0.909 if the exchange rate is left flexible and foreign saving is held constant at 9.5. There is no change in basic prices or any other real variables. There is no welfare change.

FIXED EXCHANGE RATES

The GEMODEL.PRO user has a choice of model closures. The exchange rate can be fixed or flexible. Foreign saving can be endogenous or exogenous. The exchange regime is chosen from the **FOREIGN SAVING** sub-menu. Foreign saving is made endogenous when fixed exchange rates are chosen. Foreign saving is made exogenous when flexible exchange rates are chosen.

Solutions hindered by foreign exchange market instability may be found by switching to fixed exchange rates.

The USA77.PRO file is calibrated to obey Marshall-Lerner conditions. A ten per cent increase in export prices expressed in foreign currency while the exchange rate is fixed improves the trade balance from -9.5 to 16.

GROWTH

Capital and labour grow at the same rate $n + g$ in the neoclassical steady state. The capital/labour ratio is constant and consumption per capita is maximized.

Consumption includes leisure in GEMODEL.PRO. The steady state can then be characterized as one where the ratio of labour to capital *endowment* is constant over time. Labour endowments are made to grow at the rate $n + g$ in the reference growth sequence unless the user specifies a different, exogenous rate. Given unitary income elasticity of demand for leisure derived from the CES specification, labour supply should grow at the same rate as the labour endowment if commodity prices do not change over time. Constancy of relative prices cannot be guaranteed in a model with taxes and foreign trade. Projections with the USA77.PRO file do yield nearly constant commodity prices.

Individual income tax liabilities are computed per capita so that income growth attributable exclusively to population growth will not push any household group into higher tax brackets. Only productivity growth g, price changes, and saving can affect marginal, personal income tax rates.

IMPORT REQUIREMENTS

A ratio of competitive imports to domestic use is calculated for each commodity before aggregations. Commodity use equals intermediate use plus final demand except domestic exports. Given a vector of total use $Ui + e$ and a vector of imports m, the import ratio μ is defined by

$$m = \hat{\mu}(Ui+e)$$

The computation assumes that the import ratio is the same in all uses of a commodity. However, the ratio varies sharply among uses after aggregation of uses and of commodities.

One version of the Armington assumption is that the import ratio is the same in all uses of a commodity aggregate. An alternative is to calibrate separate Armington functions for each cell in an aggregated Use matrix. The first interpretation is inconsistent with disaggregated data. The alternative demands larger computational effort at every iteration. The compromise made in GEMODEL.PRO is to apply the first version of the Armington assumption to final and intermediate demand. The imports for intermediate use are directly affected by price changes and also indirectly by changes in the composition of industrial output, which in turn depends on prices.

With the Armington elasticities in file TEST.CAL, a ten per cent increase in world market prices in TEST.USA results in a 7.3 per cent decrease in imports when the exchange rate is held fixed. Otherwise the exchange rae would fall by 10 per cent.

INVESTMENT

Investment consists of fixed capital formation and of net inventory accumulation.

The cost of inventory accumulation is deducted from business income before distribution of capital income to households. The expenditure on net inventory change is equal to the after-tax return to capital held in an inventory accumulation fund.

Gross fixed capital formation consists of net additions to the capital stock *plus* capital consumption expenditure equal to capital consumption allowances. Capital consumption allowances are made before distribution of capital income by firms to households and government. Depreciation rates are specific to industries. Total capital consumption and its commodity composition are affected by the allocation of capital to industries, which in turn depends on the industrial composition of demand.

Net fixed capital formation is funded by household saving and by foreign capital inflows equal to a current account deficit. The current account includes factor payments in a US model with a special *rest of the world* industry and commodity. Foreign saving is exogenous when the exchange rate is flexible and endogenous. Foreign saving is endogenous when the exchange rate is fixed and exogenous.

Household saving is derived from utility functions and product prices. Households spend their disposable incomes on present and future consumption with static price expectations.

INVESTMENT TAX CREDITS

GEMODEL.PRO computes taxes on value added by capital given deductible capital cost allowances and assuming no investment tax credits. Investment tax credits are like negative sales taxes on investment goods. Such credits can therefore be simulated by reducing sales taxes on investment goods demanded for fixed capital replacement and for net investment (or saving).

LEISURE

Leisure is measured in the same units as labor. The units convention is to measure quantities so that each unit initially fetches a price equal to unity. The price of leisure is the foregone wage after deduction of income tax. The tax rate is the marginal, combined federal and State/local tax rate.

Labor is homogeneous and fetches a single wage rate in all its uses. Income inequality is a result of unequal endowments with homogeneous labor. Being endowed with more labor, high income workers can demand more leisure than low income workers.

GEMODEL.PRO measures work and leisure in weeks rounding fractional weeks up to whole weeks. Thus if one worked 50 weeks in a year, the ratio of leisure to work is 1/25 for that year. The ratio would be much higher if fractional weeks were counted.

If 42 hours are worked each week then 52 weeks of work are only 13 whole weeks because 42 hours is 1/4 of the 168 hours in a week. Divide the weeks worked data in ENDOW.DAT by 4 and GEMODEL.PRO will compute a ratio of leisure to work of 79/25.

MARGINAL COST OF TAXES

The marginal cost of taxes is the decrease in the aggregate equivalent variation per dollar increase in tax revenue. The cost is that of all taxes in the model and not only the one that was changed. GEMODEL.PRO computes two measures of the cost: a *national cost* that includes terms of trade gains in the measure of welfare change, and an *efficiency cost* that excludes international redistributions of welfare by changes in the terms of trade.

Precision of the computed marginal cost depends on error tolerance and on the size of the tax rate change. The tax rate change should be small. Error tolerance should be small enough to detect a meaningful change in tax revenue. The marginal cost is not computed when tax revenue changed by less than the error tolerance. Marginal costs are also not computed in sequenced solutions for the second and later periods.

There is no change in revenue unless tax instruments are OFF. Alternatively, some tax instruments can be left ON if the new revenue target differs from the most recently achieved revenue level.

If ΔW is the change in welfare and ΔT is the change in tax revenue, the computed marginal cost of taxes if $MC = -\Delta W/\Delta T$. The marginal cost is positive if an increase in revenue cause a decline in welfare. That is the reason for the minus sign in the formula.

A marginal cost is printed whenever there is a significant change in revenue. Ignore the printed cost when the simulation was not designed for it.

Case 1: An increase in capital endowments results in increased welfare and tax revenue. A negative marginal cost of taxes is printed. Ignore it.

Case 2: A revenue-neutral federal tax reform results in increased welfare and in increased State/local tax revenue. A negative cost of State/local taxes is printed. Ignore it; all it shows is that State/local government shares in gains from federal tax reform.

Case 3: A federal tax rate is increased. State/local tax revenue is held constant by a property tax increase. A correct marginal cost of federal taxes is printed. The size of the cost depends on the State/local reaction. A lower cost of federal taxes might be found if State/local government revenue had been held constant by adjusting the State/local personal income tax rates.

MULTIPLE EQUILIBRIA

Multiple equilibria may exist if factor endowments are unevenly distributed among households, if a household prefers the goods that are intensive in the use of the factor with which the household is most richly endowed, and if elasticities of substitution in consumption average out to less than unity. Some of the multiple equilibria are unstable. If such multiple equilibria exist, then it may be impossible to find any one of them.

NUMÉRAIRE

The wage rate is the *numéraire*. Any deviations of the wage rate from unity are due entirely to deflation of money prices by a GNP deflator.

NUMERIC INPUT

Input only 15 significant figures. Enter tax rates as decimals. To enter 6 per cent, type 0.06.

OTHER USES OF INPUT-OUTPUT ANALYSIS ROUTINES

The GEMODEL.PRO code contains routines for matrix aggregation and for conversion of data from commodity by industry space into industry by industry space. These routines can be used to convert data classified by commodity to data classified by industry, using your industry aggregation scheme. Columns 5 to 14 of the MARGINS.DAT file are available for this purpose. Any commodity data stored in these columns will be converted to data by industry and saved on disk in the same folder as the PRECALIB.CFF file. The new file will be called SCRATCH.SQR. The columns in this file correspond to columns 5 to 14 in MARGINS.DAT. The rows correspond to the industries retained in your model.

Example:

To convert price elasticities of foreign demands for US commodity exports to elasticities of demand for industry products, follow these steps:

1. Copy the exports vector from FD.DAT to column 5 of MARGINS.DAT
2. Type export price elasticities into column 7 of MARGINS.DAT
3. Store in column 6 the product of column 5 by column 7. Highlight the Col. 7 heading and press ?. Highlight the Col. 5 heading and press *. Highlight the Col. 6 heading and press =.
4. Delete column 7 by pressing Ctrl-Z at the end of column 6. Save the MARGINS.DAT file.
5. Aggregate as usual.
6. Open SCRATCH.SQR in *Notepad* or *Wordpad*. Look at two numbers following each industry name. The first is the exports by the industry. The second is the exports multiplied by a price elasticity of demand for industry output. Obtain the elasticity as the ratio.
7. Use the new elasticity of demand by industry in calibration.

See also the section on value added taxes on page 4-32.

PARAMETER RESTRICTIONS

Some parameters may not assume certain values. Other parameters must add up to unity or less.

Elasticities of substitution must be greater than zero. In consumption they must also be different from unity. The calibration module rejects illegal values.

Share parameters must add up to unity. The sums are made over the rows in a simulation screen column. The affected parameters are:

transfer payment shares

commodity composition coefficients
- in personal consumption expenditure
- in net saving
- in fixed capital replacement by industry
- in inventory change
- in government expenditure

expenditure shares in utility functions

The sum of domestic and imported intermediate input coefficients must be less than unity for every industry that creates value added.

Income tax rates cannot be confiscatory. Import duty rates may not exceed unity.

GEMODEL.PRO checks for these conditions prior to every attempt to solve. Appropriate messages are displayed on screen and the solution is aborted whenever a parameter restriction is violated.

PRECISION

GEMODEL.PRO works with double-precision. Do not make keyboard data input of more than 15 significant figures.

The precision of simulation results can be increased by reduction of the tolerance level but do not set the tolerance so low that rounding errors keep the algorithm from recognizing a solution. The lowest admissible tolerance is 0.000001.

The solution algorithm eliminates variables by numerical substitution. The solutions for eliminated variables are functions of retained variables and their errors. Thus some variables are more error prone than other variables.

The precision of simulation results depends also on the initial guesses. Different guesses lead to different results unless the error tolerance is very small.

Numerous initial guesses are made by GEMODEL.PRO. The user is relieved of the tedious task of setting them.

The above facts make it virtually impossible to replicate simulation results unless the initial data, guesses, and tolerance are also replicated.

PRICE LEVEL

GEMODEL.PRO is a real model. Only relative prices matter. Recognition of relative price changes is facilitated by holding constant an index of nominal prices. The price level is determined by a quantity equation. Nominal GNP is not changed by a static simulation experiment.

In dynamic sequencing the quantity equation allows growth in the money supply at a rate equal to the rate of growth. Seignorage is neglected and excluded from federal government revenue.

PROPERTY TAXES

Estimates of property taxes paid by each industrial sector can be hard to obtain. The sample data filed in line 5 of TAXES.DAT are estimates obtained from the National Income and Product Accounts and from the benchmark Input-Output tables. The estimate assumes that property taxes paid by business are a constant fraction of indirect non-commodity taxes. Non-commodity taxes equal indirect taxes *minus* commodity tax margins. Property taxes on housing distort the ratio. The distortion is avoided by subtraction of taxes on housing from both the numerator and the denominator. The detailed computations for 1977 US data are outlined in ten steps below:

1. Convert tax margins by commodity to tax margins by industry (see page 4-19 on conversion of a vector's dimensions).
2. Find 1977 indirect taxes on housing in the *Survey of Current Business*, July 1978, table 1.20.
3. Find total, State/local property taxes in the same *Survey*, table 3.4
4. Find non-commodity taxes by industry. Subtract margins found in step 1 from the indirect business taxes in the USE table.
5. Deduct housing taxes found in step 2 from non-commodity taxes on the Real Estate industry in the USE table.
6. Divide the property tax total from step 3 by the total of non-commodity taxes on all sectors.
7. Multiply non-commodity taxes by the ratio found in step 6.
8. Add housing taxes found in step 2 back to property taxes on the Real Estate industry found in step 7.
9. Enter property taxes found in step 9 on line 5 of TAXES.DAT
10. Restore the indirect tax row of USE.DAT back to its original values.

All computations were done at the 85-industry level. Computations were done on screen in USE.DAT rows below the 88th. Tax margins by industry were copied from a SCRATCH.SQR file created by GEMODEL.PRO aggregation routines when column 5 of MARGINS.DAT contained the sum of columns 3 and 4.

REST-OF-THE-WORLD

GEMODEL.PRO uses the special industry named *Rest-of-the-world* to model two-way flows of international factor services. The industry's output is foreign source income of US residents net of payments to non-residents. Changes in this net output change the supply of factor services to domestic industries.

The output is a CES function of the capital and labor employed. The function breaks down when capital and labor inputs have different signs. In that case, the GEMODEL.PRO calibration procedure sets labor input to zero and makes capital input equal to total value added. The sign of the CES function is the same as that of total value added in the ROW sector.

When modeling an economy other than the US you may want to name the ROW sector in a language other than English. Because of the exceptional treatment of the ROW sector, GEMODEL.PRO must be able to recognize it. The following names will be recognized:

REST OF WORLD
ROW
R.O.W.
AUSLAND
RESTO DEL MUNDO
RESTE DU MONDE

RETAINED EARNINGS

GEMODEL.PRO assumes that no earnings are retained by business. All business income is deemed to be distributed to households. The distribution is proportional to capital endowments as all households are assumed to hold identical portfolios. Income taxes, however, do not treat retained earnings as taxable personal income. The difference between the treatment of retained earnings in the accounting for income and taxes can be recognized in calibration by exclusion from taxable income of a fraction of capital income.

SCRAP

Scrap includes used and second-hand goods. The scrap commodity is produced by a special industry. There are no inputs to the industry. The scrap commodity is supplied by real world industries, as is shown in MAKE.DAT.

Scrap can be excluded from the list of industries. It was retained in the sample files supplied with GEMODEL.PRO as an illustration of the model's flexibility and its ability to handle diverse industries and commodities.

SOLUTION ALGORITHM

GEMODEL.PRO is solved by an unpublished proprietary variant of the Gauss-Seidel algorithm.

Various blocks of equations are solved separately. Some blocks are recursive. Other blocks are solved by back-substitution from a smaller number of equations after numerical elimination. Other blocks are solved by Gauss-Seidel. Equations for variables that are exogenous to the various blocks are solved by Gauss-Seidel.

Matrix inversions for solution of blocks of linear equations are done by LU decompositions and with double precision.

No non-linear equations are ever linearized. Non-linear forms are retained in all operations.

STABILITY OF ENDOGENOUS INCOME TAX RATES

This section does not apply unless you choose to calibrate polynomial income tax functions.

Measure marginal personal income tax rates on the vertical and saving on the horizontal axis of a graph. If saving is deductible from taxable income then both saving and marginal tax rate functions are downward sloping. The iterative solution for saving and the tax rate is stable if the marginal tax rate curve cuts the savings curve from below. Elasticities of saving with respect to the marginal tax rate and of the marginal tax rate with respect to saving must both be low. Large income tax deductions per dollar of saving can be a cause of non-convergence.

Labor supply is determined at the same time as saving and marginal tax rates. On a tax rate and labor plane, labor supply should cut the tax function from below when labor is measured on the horizontal axis. Either labor supply is inelastic or the tax function should not be too progressive.

STABILITY OF THE FOREIGN EXCHANGE MARKET

The Marshall-Lerner stability condition is that the elasticities of export and import demand must sum to more than unity in absolute value. Verify that this is the case in every newly calibrated model. Select **SIMULATION** from the **MAIN MENU**. Select **TRADE** and then **EXPORT DEMANDS** from the **SHOCKS** menu. Increase all foreign product prices by ten per cent. Select **MODEL CLOSURE**. Click a radio button to select Fixed Exchange Rates. Select **SOLVE**. *Leave all tax instruments OFF (un-checked).* The solution should show an improved trade balance because under fixed exchange rates an increase of foreign prices is equivalent to a devaluation. With data and assumptions such as those in the USA77.PRO file, the trade balance improves from -9.5 billion to +16 billion dollars.

SUB-NATIONAL MODELS

GEMODEL.PRO can be used to simulate the economy of a State or Province provided there are adequate input-output and other data. Simulation of a sub-national economy raises three issues regarding the "exchange rate," the utility of federal expenditure in the State, and out-of-State transfers of federal revenue collected in the State.

Federal transfers out can be modeled as proportional to value added in the government industry or as proportional to government expenditure in the State. In the first case, disaggregate the government industry. Record separately value added in the State by State/local government and by the federal government. Record federal transfers out as a use of non-competing imports by the federal government industry. If transfers are viewed as proportional to federal expenditure, record them as a use of non-competing imports in federal government consumption.

The utility of federal expenditure in the State is printed separately in simulation output tables. All or part of it can be disregarded in case it is not thought useful to residents of the State.

An exchange rate is required to close the State's economy to the rest of the nation as a whole and to the rest of the world. The exchange rate can be held fixed if capital flows are allowed to be endogenous.

TAX INSTRUMENTS

Tax instruments are policy tools available to make tax revenue reach a predetermined value. This value is either the initial revenue or a new value entered after selecting **TAX & TRANSFERS** from the SHOCKS menu.

Tax instruments are available whenever at least one of the corresponding tax (or subsidy) rates is different from zero. Initial rates are determined in calibration and define the initially available instruments. Additional instruments can be provided by setting tax rates to non-zero values.

The choice of tax instruments is made during **SIMULATION SETUP** after choosing the **SOLVE** option. Different sets of federal and State/local instruments can be chosen. Click on a check box to toggle instruments ON or OFF. Press the **OK** button when all tax instruments are set to the desired state.

Those instruments that are ON are used to reach the target revenue level. All taxes in the set of instruments are changed in the same proportion. If revenue had to be increased by 10 per cent, the taxes that are ON are increased by 10 percent and the subsidies that are ON are reduced by 10 per cent.

Tax instruments that are OFF are left undisturbed by deviations of revenue from the target level. Non-zero tax instruments that are OFF do, however, raise revenue.

TAX POLICY AND PARAMETER CHANGES

Function parameters and tax rates are selected from the **SHOCKS** menu in the **SIMULATION** module. New values can be typed in and entered where an old value is highlighted in reverse video. Use cursor (arrow) keys and scroll-bars to select a parameter or tax rate on screen. Press the Esc key to exit and to return to a menu.

Arithmetic can be performed on highlighted elements and on entire rows and columns. Consult the **CALCULATOR** section.

Certain parameters and tax rates are subject to restrictions. See the section on **PARAMETER RESTRICTIONS**.

TAX RATES

All tax rates are *ad-valorem*. Most are expressed as rates on net-of-tax values. If τ is the rate on tax-paid value, the GEMODEL.PRO rate is

$$t = \frac{\tau}{1-\tau}$$

There are two exceptions. Import duties are expressed as rates on duty-paid value. Personal income tax rates are expressed as rates on taxable income.

Marginal personal income tax rates are exogenous when calibration was made assuming linear tax schedules. Marginal tax rates are endogenous functions of taxable income when polynomial functions are chosen. In that case, polynomial coefficients are exogenous.

See also the section on **DEDUCTIBLE TAXES** (page 4-8).

TECHNOLOGY ASSUMPTIONS

GEMODEL.PRO makes the industry-technology assumption when constructing industry-by-industry tables from commodity-by-industry data. Commodity technology can be assumed and GEMODEL.PRO can be made to use commodity-by-commodity tables under either technology assumption. To implement the alternatives, create the appropriate USE, FD, PCE, CFT, MAKE and MARGINS tables. Let

V the industry-by-commodity Make matrix
$\hat{\mathbf{x}}$ a vector of gross output by industry
$\hat{\mathbf{q}}$ a vector of commodity outputs
$\hat{\mathbf{e}}$ a vector of final commodity demand
U a commodity-by-industry Use matrix
W a factor-by-industry matrix of value added including indirect tax;

then $B = U(\hat{x})^{-1}$ is a technology matrix
$D = V(\hat{q})^{-1}$ is an industry market shares matrix
$C = V'(\hat{x})^{-1}$ is a commodity-mix matrix

Now to convert any matrix A such as USE, FD, PCE, CFT or MARGINS to their new dimensions, perform one of the following multiplications:

Technology	*Dimensions*	
	industry by industry	*commodity by commodity*
industry	DA	AD
commodity	$C^{-1}A$	AC^{-1}

Primary inputs are:

Technology	*Dimensions*	
	industry by industry	*commodity by commodity*
industry	W	$[W(\hat{x})^{-1}] D (I-BD)^{-1} \hat{e}$
commodity	W	$[W(\hat{x})^{-1}] C^{-1} (I-BC^{-1})^{-1} \hat{e}$

Apply the converted USE, FD, PCE, CFT and MARGINS tables to build your model after filing a dummy MAKE matrix that is a square identity matrix.

DIA Agency, Inc., supplies an *IO&SAM* software package that can be used to make menu-driven conversions of input-output tables. *IO&SAM* processes tables of more than 1,000 columns with menu selections for creation of industry-by-industry or commodity-by-commodity tables under industry- or commodity-technology assumptions.

TERMS OF TRADE GAINS

A terms of trade gain equals the balance of payments evaluated at old prices and new quantities. It can be interpreted as the foreign aid that would have to be received to get the equivalent of the new equilibrium situation without a terms of trade change.

Let X and M be exports and imports of n goods and services including factor services, and let B be the current trade balance.. The gain is

$$W = \frac{Bp_s^0}{p_s^1} + \sum_1^n \pi^0 e^0 M_i^1 - p^0 X_i^1$$

where p^0 are initial prices including indirect taxes found in calibration, π^0 are initial import prices expressed in foreign currency, and e^0 is the initial exchange rate. The summation measures the trade balance calculated at import and export prices of the initial period. The first term measures the actual trade balance deflated by an index of prices of capital goods. or a source of the formula, see United Nations, *System of National Accounts, 1993*, pages 404-5. As noted in the source, there is no general agreement on the choice of deflator for the first term on the right-hand side.

TOLERANCE

GEMODEL.PRO is solved iteratively. Iterations stop when errors in the equations retained in the model are smaller than a stated error tolerance level. The error tolerance is proportional. The default value of 0.001 means that a demand will differ from the supply by less than one-tenth of one per cent of the supply. A tolerance of less than 0.000001 is not accepted. The size of the error tolerance is set during the **SIMULATION SETUP**.

TRADE

Trade includes wholesale and retail trade. The trade commodity and the trade industry must be identified for proper allocation of indirect taxes when computing tax margin matrices and when computing initial tax rates. GEMODEL.PRO identifies the trade by its name. You may want to name it in a language other than English when processing foreign data. Admissible names are

TRADE
HANDEL
COMERCIO
COMMERCE

TRANSFER PAYMENTS

All tax revenue is disposed of by transfer payments. Governments are included among the recipients of transfers.

Federal transfers to households are a residual affected by errors in data or by differences between family expenditure survey and national accounts data.

Residual transfers to households can be negative. An interpretation of negative transfers is that households pay more to government for purchase of bonds than they receive in bond interest and other transfer payments. See the section on **DEFICIT REDUCTION**.

VALUE ADDED TAX

A VAT can be stipulated when the indirect tax base is specified before aggregation and it can be a policy choice in simulation. The **SHOCKS** menu provides access to all taxes that would be eliminated under a counter-factual VAT.

When the actual tax system is not a VAT but a VAT is specified before aggregation, GEMODEL.PRO computes indirect tax collection matrices that represent revenue from tax margins under a multi-rate VAT without behavioral adjustment and without change in total revenue from indirect tax margins. Such matrices can be used in their own right but should not be used in aggregation and calibration.

WELFARE CHANGE

Welfare changes are measured in Hicksian compensating and equivalent variations. Two alternative measures of each are printed in simulation output files and screens. The first, static measures include the value of saving. Dynamic, one-period welfare changes exclude the value of saving so that there will be no double counting when computing the present value of welfare changes over several periods. The static and dynamic measures differ in sign when there are large changes in saving. All welfare changes are changes from the initial level found in calibration.

YEARS' PURCHASE

The years' purchase is a price/earnings ratio applied to convert capital income to a capital stock. The default value is 25 for a 4 per cent yield. The user can set different values in calibration and/or simulation.

VARIABLES AND PARAMETERS

Symbol	*description*	*maximum No. in Standard ver.*		*note*
		Vars.	Parms.	
α_1	expenditure parameter in first utility nest		34	
α_2	expenditure parameter in second utility nest		32	
α_3	expenditure parameter in third utility nest		1024	
β_1	elasticity of substitution in first nest		34	
β_2	elasticity of substitution in second nest		32	
β_3	elasticity of substitution in third nest		32	
γ	years' purchase or price-earnings ratio of capital		1	
δ	labor share parameter in CES production function		32	
Δ_k	fraction of capital income excluded from taxable income		2	
Δ_s	fraction of savings excluded from taxable income		2	
ζ	Armington share of imports		32	(**)
η	price elasticity of foreign export demand		32	
θ	federal and State/local destination tax flag		2	
ε	Armington elasticity of import demand		32	
λ	tax rate adjustment flag		2	(v)
ξ	value added per unit of gross output		32	
π	world market price in foreign currency		32	
ρ	substitution parameter in CES production function		32	
σ	elasticity of substitution of capital for labor		32	
τ	tax function parameter, federal & State/local		18	(*)
φ	ratio of imports to use	32		
ϱ	purchaser prices of goods in final demand	70		
ϕ	scaling factor in CES production function		32	
χ	scalar in the foreign demand for exports		32	(*)
Ω	real foreign capital inflow		1	(v)(*)
A	industry by industry domestic input coefficients		1024	
B	final demand coefficients by industry		2100	
c	real capital cost allowance by industry		32	
D	capital consumption coefficients (part of B)			
d	depreciation rate by industry		32	
E	personal consumption coefficients (part of B)			
e	exchange rate (domestic currency per unit)	1		(v)
e^*	domestic final demands by category	70		
e_{ij}	real household consumption (part of e^*)			
f	annual, future consumption by household	32		
g	real government expenditure (part of e^*)			
G	government expenditure coefficients (part of B)			
GNP	gross national product at current prices	1		(*)

...VARIABLES AND PARAMETERS

h	current leisure by household		32	
H	government receipts from taxes and transfers	2		
k	inventory demand coefficients (part of B)			
K	household endowment with capital		32	(*)
K	capital service input by industry	32		
K_0	inventory accumulation fund		1	(*)
L	household endowment with labor		32	(*)
L	labor input by industry	32		
M	industry by industry imported input coefficients		1024	
N	population index		1	(*)
p	basic prices by industry	32		
p^*	consumption deflator specific to households	32		
p_s	net fixed capital formation deflator	incl. in ϱ		
q	gross output by industry	32		
r	rental price of capital paid by industry	1		
R	government tax revenue from all sources	2		(v)(*)
r^*	net, after tax rental of capital	32		
S	aggregate saving by households (part of e^*)			
s	net saving by household	2		
T	income tax paid by household & government	64		
t_{ij}	rates of federal and State/local input taxes		2048	
t_k	rate of federal or State/local corporate tax		64	
t_l	rate of federal or State/local labor tax		64	
t^m	rate of federal import duty		32	
t_p	rate of State/local property tax		32	
t_q	rate of State/local output tax by industry		32	
t_x	rate of federal export tax		32	
t^y	marginal personal income tax rates	64		
U	utility of household or government consumption	34		
u_{ij}	shares in transfer payments		66	
v	value added by industry	32		
w	wage rate paid by industry	1		
w^*	net, after tax wage received by households	32		
x	real export by industry	32		
Y	market income of households	32		
y	taxable income of households, federal & State	64		
Y^d	disposable income of households	32		
Z	real net inventory change (part of e^*)			

Notes: (v) can be made endogenous or exogenous.
(*) grows or is modified along the reference growth path.
(**) only the parameter for the *Rest of the world* is modified by growth.

EQUATIONS

Value added

Value added at factor cost is net of factor taxes and depreciation. The ratio of value added to gross output is constant. If **q** is a vector of gross output by industry and **v** is a vector of value added, then

$$v_i = \phi_i\left[\delta_i L_i^{-\rho_i} + (1-\delta_i)K_i^{-\rho_i}\right]^{\frac{1}{\rho_i}}; \qquad \sigma_i = \frac{1}{1+\rho_i}$$

$$= \phi_i L_i^{\delta_i} K_i^{1-\delta_i} \qquad when\ \rho_i = 0$$

L is labour input.
K is net capital input.
δ is a share parameter.
σ is the elasticity of substitution.

Marginal condition in production

$$\frac{L_i}{K_i} = \left[\left(\frac{\delta_i}{1-\delta_i}\right)\frac{r p_s (1+t_{ki}^f+t_{ki}^s+t_{pi}^s) + d_i \varrho_i}{w(1+t_{li}^f+t_{li}^s)}\right]^{\sigma_i}$$

w is the wage rate.
r is the real rental price of real capital services.
p_s is the net fixed capital formation deflator.
d is a vector of depreciation rates by industry.
ϱ_i is the market price of a composite capital good used by the i^{th} industry.
t^f, t^s are federal and State/local tax rates.
t_k, t_l, t_p are rates of tax on capital, labor, and property.

EQUATIONS

Intermediate use

Given a matrix *U* of intermediate input flows, a gross output vector **q**, and a vector of import ratios φ defined on the next page, domestic and imported inputs are

$$\mathbf{a} = A\mathbf{q} = (I-\phi)U\hat{i}$$
$$\mathbf{m} = M\mathbf{q} = \phi U\hat{i}$$

Gross output prices at basic values

The vector of basic prices **p** is given by

$$p'\left[I - A^{*} - \hat{t}_{q}^{s}\right] = z$$

I is an identity matrix of appropriate dimensions. A^{*} is a matrix of domestic input coefficients including commodity tax margins. An element in the i^{th} row and j^{th} column is $a^{*}_{j} = a_{ij}(1+t^{f}_{ij}+t^{s}_{ij})$. $\mathbf{t}^{s}_{\mathbf{q}}$ is a vector of State/local output taxes. The right-hand side vector **z** is the per-unit cost of primary inputs:

$$z_i = \frac{w(1+t_{li}^{f}+t_{li}^{s})L_i + [rp_s(1+t_{ki}^{f}+t_{ki}^{s}+t_{pi}^{s}) + d_i\varrho_i]K_i}{q_i} +$$
$$+ e\sum_{j=1}^{n} m_{ji}(1+\theta^{f}t_{ji}^{f}+\theta^{s}t_{ji}^{s})\frac{\pi_j}{1-t_j^{m}}$$

e is the exchange rate.

π is an import price expressed in foreign currency.

t^{m} is an import duty rate expressed as a ratio to duty-paid value.

θ is a (0,1) flag indicating whether indirect commodity tax margins are origin- or destination-based.

n is the number of industries.

EQUATIONS

Export demand

$$X_i = \chi_i \left[\frac{p_i(1+t_{xi}^f+(1-\theta^f)t_i^f+(1-\theta^s)t_i^s)}{e\pi_i} \right]^{\eta_i}$$

[•] is the price of a domestic export relative to a world market price.
χ is a scaling parameter.
t_x^f is a federal export tax.
η is a price elasticity of foreign demand.

Import demand

The vector of total import demand for final and intermediate use is

$$m = \hat{\varphi}\, e^* + Mq$$

$$\varphi_i = \left(1 + \left[\frac{\zeta_i}{1-\zeta_i} \cdot \frac{p_i(1-t_i^m)}{e\pi_i} \right]^{-e_i} \right)^{-1}$$

φ is a share of imports in total domestic use of goods.
ζ is an Armington share parameter.
ε is the Armington elasticity of substitution of imports for domestic products.
e^* is a final demand vector consisting of personal consumption expenditure, gross fixed capital formation, net inventory change, and gross government consumption expenditure.

Foreign balance $\sum_1^n X_i p_i(1+t_{ix}^f) - e\sum_1^n m_i\pi_i = -\Omega p_s$

where Ω is the real foreign capital inflow. The net investment deflator p_s is an element of ϱ defined at the top of the next page.

EQUATIONS

Market prices of goods in domestic final demand

A vector of prices of composite goods in domestic final demand is a weighted average of domestic and import prices including commodity tax margins:

$$\varrho_j = \sum_{i=1}^{n} b_{ij}\left[(1-\varphi_i)(1+t_{ij}^{f}+t_{ij}^{s})p_i+\varphi_i\frac{e\pi_i}{1-t_i^{m}}(1+\theta^{f}t_{ij}^{f}+\theta^{s}t_{ij}^{s})\right]$$

B is a matrix of coefficients of commodity demand by final demand category. The final demand columns include PCE, CFT, inventory change, and GGCE.

Utility of household consumption

$$U_i = \left[\alpha_{1i}^{1/\beta_{1i}}\left[\alpha_{2i}^{1/\beta_{2i}}\left(\sum_{j=1}^{n}\alpha_{3ij}^{1/\beta_{3i}}e_{ij}^{(\beta_{3i}-1)/\beta_{3i}}\right)^{\beta_{3i}/(\beta_{3i}-1)} + (1-\alpha_{2i})^{1/\beta_{2i}}h_i^{(\beta_{2i}-1)/\beta_{2i}}\right]^{\beta_{2i}/(\beta_{2i}-1)} + (1-\alpha_{1i})^{1/\beta_{1i}}f_i^{(\beta_{1i}-1)/\beta_{1i}}\right]^{\beta_{1i}/(\beta_{1i}-1)}$$

i denotes the household.
1, 2, 3 indexes the nesting level.
e is current consumption of goods.
f is future consumption of goods per period.
h is current leisure.
α is an expenditure share parameter.
β is an elasticity of substitution.

Utility of government consumption

$$U_j = \left[\alpha_{1j}^{1/\beta_j}g_{1j}^{(\beta_j-1)/\beta_j} + (1-\alpha_{1j})^{1/\beta_j}g_{2j}^{(\beta_j-1)/\beta_j}\right]^{\beta_j/(\beta_j-1)}$$

g is real expenditure on one of two government consumption goods
j indexes federal or State/local government.
α is an expenditure share parameter.
β is an elasticity of substitution.

EQUATIONS

Future consumption

$$f_i = \left(\frac{r}{\gamma}\right)\left(\frac{p_s s_i}{p_i^*}\right)$$

r is the rental price of capital.
γ is the years' purchase or price/earnings ratio of capital.
r/γ is a rate of return to capital
$p_s s_i$ is the i^{th} household's saving at market prices
$p^\dagger$ is a consumer price index specific to the i^{th} household.

Personal income

$$Y_i = r p_s \bar{K}_i + w(\bar{L}_i - h_i)$$

$\bar{K}$ is household endowment with real capital.

$\bar{L}$ is household endowment with labor.

Taxable income

$$y_{ij} = Y_i - \Delta_{1j} s_i p_s - \Delta_{2j} r p_s \bar{K}_i$$

i indexes households.
j indexes governments.
Δ is a decimal proportion of income excluded from income taxable by the jth government.

Household tax liability

$$T_{ij} = \sum_{k=0}^{n} \tau_{kj} \left(\frac{y_{ij}}{N}\right)^k$$

n equals 1 when a linear tax is specified or is as much as 8 when a polynomial tax is chosen.
τ is a polynomial tax function coefficient.
N is an index of population that grows at a rate equal to the rate of biological population growth starting from a base of 1.

EQUATIONS

Marginal personal income tax rate

$$t_{ij}^{y} = \sum_{k=1}^{n} k\tau_{kj}\left(\frac{y_{ij}}{N}\right)^{k-1}$$

Disposable household income

$$Y_i^d = Y_i - \sum_{j=1}^{2}\left(T_{ij}+u_{ij}H_j\right)$$

u is a household's share in transfer payments.
H is total government receipts from taxes and transfers.

Net wage earned by a household

$$w_i^* = w\left(1-\sum_{j=1}^{2} t_{ij}^{y}\right)$$

Net rental of capital earned by a household

$$r_i^* = r\left(1-\sum_{j=1}^{2}(1-\Delta_{2j})t_{ij}^{y}\right)$$

Household saving at market values

$$p_s s_i = Y_i^d\left(1 - \frac{\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}-1}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right)}{1+\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}-1}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right)+\left(\frac{p_i^*}{w_i^*}\right)^{\beta_{2i}-1}\left(\frac{\alpha_{2i}}{1-\alpha_{2i}}\right)}\right)$$

Total real saving

$$S = \sum_{i=1}^{m} s_i$$

m is the number of households.

EQUATIONS

Demand for leisure

$$h_i = \frac{\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}-1}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right) Y_i^d}{1+\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}-1}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right)+\left(\frac{p_i^*}{w_i^*}\right)^{\beta_{2i}-1}\left(\frac{\alpha_{2i}}{1-\alpha_{2i}}\right)\left(\frac{p_i^*}{w_i^*}\right)^{\beta_{2i}-1}\left(\frac{\alpha_{2i}}{1-\alpha_{2i}}\right)} \div w_i^*$$

Price index of goods in current household consumption

$$p_i^* = \left(\sum_{j=1}^{n} \alpha_{3ij} \varrho_j^{1-\beta_{3i}}\right)^{\frac{1}{1-\beta_{3i}}}$$

Household demand for goods

$$e_{ij} = \frac{\alpha_{3ij}\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}-1}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right) Y_i^d}{1+\left(\frac{\gamma}{r_i^*}\right)^{\beta_{1i}}\left(\frac{1-\alpha_{1i}}{\alpha_{1i}}\right)+\left(\frac{p_i^*}{w_i^*}\right)^{\beta_{2i}-1}\left(\frac{\alpha_{2i}}{1-\alpha_{2i}}\right)\left(\frac{p_i^{*\beta_{3i}-1}}{\varrho_j^{\beta_{3i}}}\right)}$$

Capital consumption by industry $c = \hat{K}d$

$\hat{K}$ is a diagonal matrix of real capital employment by industry.
d is a vector of capital cost allowance rates by industry.

Expenditure on net inventory change

$$Z = \frac{rp_s\bar{K}_0}{\varrho_z}$$

$\bar{K}_0$ is the capital stock reserved to fund inventory change.
ϱ_z is the deflator of inventory change at market prices.

EQUATIONS

Government receipts

$$H_1 = R_1 + \frac{u_{21}R_2}{1-u_{21}u_{12}}$$

$$H_2 = R_2 + u_{12}H_1$$

R is tax revenue

u_{ij} is government *j's* share in transfers made by government *i*.

Government demand for goods

$$g_{ij} = \frac{u_{jj}H_j\alpha_{ij}}{\varrho_{ij}^{\beta_j}\left(\sum_{i=1}^{2}\alpha_{ij}\varrho_{ij}^{1-\beta_j}\right)}$$

i, j index goods and government, respectively.

Internal balance

$$[I-A]q = (I-\hat{\varphi})(Ee+Gg+\hat{S}k+\hat{Z}z+Dc)$$

I is an identity matrix with as many columns as the number of industries.

A is a matrix of domestic intermediate input coefficients.

q is a vector of gross output by industry.

φ is the ratio of imports to domestic final demand.

E is a matrix of personal consumption expenditure coefficients.

e is a vector of household expenditure.

G is a matrix of government expenditure coefficients.

g is a vector of government demands.

Ṡ is a diagonal matrix where every element on the diagonal is equal to aggregate real saving S.

k is a vector of net fixed capital formation coefficients.

Ż is a diagonal matrix where every element on the diagonal is equal to total, real net inventory change.

D is a matrix of coefficients in gross fixed capital formation.

c is a vector of real capital cost allowance by industry.

The last term in brackets on the right-hand side equals **e***.

EQUATIONS

Federal tax revenue

Omitting sub- and superscripts denoting federal taxes and origin/destination base flags

$$R = w\sum_{n=1}^{n} L_i t_{li} + rp_s \sum_{i=1}^{n} K_i t_{ki} + \sum_{i=1}^{n} X_i p_i t_{xi} + e\sum_{i=1}^{n} m_i \frac{\pi_i t_i^m}{(1-t_i^m)} +$$
$$+(1-\theta)\sum_{i=1}^{n} X_i p_i t_i + \sum_{i=1}^{n}\sum_{j=1}^{m} e_j^* b_{ij}[(1-\varphi_i)p_i + \varphi_i \frac{e\pi_i}{(1-t_i^m)}\theta]t_{ij} +$$
$$+\sum_{i=1}^{n}\sum_{i=1}^{n} q_i[a_{ij}p_i + m_{ij}\frac{e\pi_i}{1-t_i^m}\theta]t_{ij} + \sum_{i=1}^{k} T_i$$

n is the number of industries.
m is the number of domestic final demands.
k is the number of households.
$\mathbf{e}^*$ is the vector of domestic final demands for household consumption, government consumption, capital consumption, net investment and net inventory accumulation.
m is a vector of total imports for all uses.
A is a matrix of intermediate use of domestic products.
M is a matrix of imports for intermediate use.

State/local tax revenue

$$R = w\sum_{i=1}^{n} L_i t_{li} + rp_s \sum_{i=1}^{n} K_i(t_{ki}+t_{pi}) + \sum_{i=1}^{n} p_i q_i t_{qi} + \sum_{i=1}^{n} X_i p_i t_i(1-\theta) +$$
$$+\sum_{i=1}^{n}\sum_{j=1}^{m} e_j^* b_{ij}[(1-\varphi_i)p_i + \varphi_i \frac{e\pi_i}{1-t_i^m}\theta]t_{ij} + \sum_{i=1}^{n}\sum_{i=1}^{n} q_j[a_{ij}p_i + m_{ij}\frac{e\pi_i}{1-t_i^m}\theta]t_{ij} +$$
$$+\sum_{i=1}^{k} T_i$$

Tax rate adjustment

$$t_i^{n+1} = t_i^n \left[1 + \lambda_i \left(\frac{\bar{R}}{R^n} - 1\right)\right]^{Sign(t_i)}$$

EQUATIONS

n is the iteration number, t_i is a tax rate in the instrument set, R^n is tax revenue at the n-th iteration and λ_i is (0,1) flag equal to 1 when the instrument is ON.

Labour market equilibrium

$$\sum_{j=1}^{k} \bar{L}_j = \sum_{i=1}^{n} L_i + \sum_{j=1}^{k} h_j$$

The first summation on the right-hand side includes employment of labour in the *rest of the world*.

Capital market equilibrium

$$\sum_{j=0}^{k} \bar{K}_j = \sum_{i=1}^{n} K_i$$

The RH side includes employment of capital in the *rest-of-the-world*. The LH sum is over all households and the inventory accumulation fund.

Quantity equation

$$w\sum_{i=1}^{n} L_i + \sum_{i=1}^{n} (rp_s + d_i \varrho_i) K_i + \sum_{j=1}^{2} R_j - \sum_{j=1}^{2} \sum_{k=1}^{m} T_{jk} = \overline{GNP}$$

n is the number of industries including the *rest-of-the-world*.
m is the number of households.
income tax paid by households is deducted to avoid double counting of factor income.

Reference growth rate

The capital stock is $\gamma \Sigma K$ and the additions to it are $S + Z + \Omega$. The rate of growth r is given by

$$\gamma K^{t+1} = \gamma K^t + S^t + Z^t + \Omega^t$$

$$r = \frac{K^{t+1} - K^t}{K^t} = \frac{S^t + Z^t + \Omega^t}{\gamma K^t}$$

Growth of household endowments with capital expressed in capital service units for any i-th household and for the inventory accumulation fund

$$\bar{K}_i^{t+1} = \bar{K}_i^t + \frac{S_i}{\gamma}$$

$$\bar{K}_0^{t+1} = \bar{K}_0^t + \frac{Z}{\gamma}$$

EQUATIONS

Growth of effective labour endowments by biological and productivity growth

$$\bar{L}_i^{t+1} = (1+r)\bar{L}_i^t$$

Biological population growth

$$N^{t+1} = (1+\theta r)N^t$$

where θ is the fraction of total growth that is biological.

Growth of nominal GNP

$$\overline{GNP}^{t+1} = (1+r)\overline{GNP}^t$$

Growth of the foreign capital inflow

$$\Omega^{t+1} = (1+r)\Omega^t$$

Growth of foreign demand for domestic exports

$$\chi_i^{t+1} = (1+r)\chi_i^t$$

Growth in imports of the *Rest-of-the-world* goods

The domestic demand for this import is not an Armington function but

$$m_{row} = \zeta_{row}\left(\frac{p_{row}(1-t_{row}^m)}{e\pi_{row}}\right)^{\varepsilon_{row}}$$

A capital import in year *t* equal to Ω^t creates a domestic liability to pay an annuity equal to the corresponding capital service or Ω^t/γ. This annuity is included in imports from the *rest-of-the-world* in period *t+1*. Thus

$$m_{row}^{t+1} = m_{row}^t + \frac{\Omega^t}{\gamma}$$

$$\zeta_{row}^{t+1} = \left(\frac{e^t\pi_{row}}{p_{row}^t(1-t_{row}^m)}\right)^{\varepsilon_{row}}\left(m_{row}^t + \frac{\Omega^t}{\gamma}\right)$$

TAX MARGIN ESTIMATES

Ratio of imports to use
The ratio μ is defined by $\mathbf{m} = \hat{\mu}\mathbf{U}\mathbf{i} + \mathbf{e}^*$

m is a vector of imports.
U is a matrix of intermediate use.
$\mathbf{e}^*$ is a vector of final demands for personal consumption, gross fixed capital investment, net inventory change, and gross government consumption.
intermediate import requirements are $\mathbf{M} = \hat{\mu}\mathbf{U}$

Capital consumption $\mathbf{c}' = \mathbf{i}\mathbf{C}$

$$\mathbf{D} = \mathbf{C}\hat{\mathbf{d}}(\hat{\mathbf{c}})^{-1}$$

i is a unit vector of appropriate length.
C is a commodity by industry matrix of gross fixed capital formation filed in CFT.DAT.
c is total gross fixed investment by industry.
d is capital cost allowance by industry.
D is a matrix of capital consumption by commodity and by industry.

Net saving $\mathbf{s} = (\mathbf{C} - \mathbf{D})\mathbf{i}$

s is a vector of net investment by commodity.

Indirect commodity tax margins
Define a partitioned matrix of final demand E as

$$\mathbf{E} = |\mathbf{Use} \vdots \mathbf{PCE} \vdots \mathbf{D} \vdots \mathbf{s} \vdots \mathbf{z} \vdots \mathbf{x} \vdots \mathbf{G}|$$

The tax base is $\mathbf{B} = \hat{\tau}\mathbf{E}\hat{\rho}$

ρ_i equals 1 if the corresponding column of E is in the tax base and is equal to zero otherwise.
τ_i equals $(1 - \mu_i(1-\theta))$, $\theta = 1$ under destination taxes and 0 otherwise.

...TAX MARGIN ESTIMATES

Given a vector **r** of tax margins by commodity, the vector of tax rates **t** is given by

$$r = \hat{t}\hat{t}E\hat{\rho}i$$
$$R = \hat{t}\hat{t}E\hat{\rho}$$

R is the matrix of indirect commodity tax margin revenue by commodity and use. Partitions of the matrix are filed on disk and can be edited by the user.

AGGREGATION

Let Π be a matrix of aggregation parameters. An element π_{ij} equals 1 if column *i* is to be aggregated to column *j* and is zero otherwise. Let the industry shares in commodity markets be

$$B = \Pi'(V\hat{q}^{-1})$$

V is an industry by commodity matrix of output filed in MAKE.DAT.
q is a vector of gross output by commodity.

The aggregated data are then

$U^* = BU\Pi$	intermediate use, industry by industry
$M^* = BM\Pi$	imports in intermediate use, industry by industry
$A^* = U^* - M^*$	intermediate use of domestic products, industry by industry
$E^* = BE\Pi$	personal consumption expenditure, industry by category
$D^* = BD\Pi$	capital consumption, industry by industry
$G^* = BG$	government consumption, industry by category
$\mathbf{x}^* = Bx$	exports by industry
$\mathbf{m}^* = Bm$	imports by industry
$\mathbf{s}^* = Bs$	net fixed capital formation by industry
$\mathbf{z}^* = Bz$	net inventory change by industry
$R^{f*} = BR^f\Pi$	federal, industry by category revenue from commodity tax margins
$R^{s*} = BR^s\Pi$	State/local industry×category revenue from commodity tax margins

CHANGING THE EQUATION SYSTEM

GEMODEL.PRO has a predetermined equation system. There are no code changes one can make to change the system but the model is flexible enough to allow simulation with different models. The following is only a partial list of possibilities:

Choose a functional form

Production functions can be CES, Cobb-Douglas, and linear without primary factor input.

Personal income tax liability can be a linear or a polynomial function of taxable income. Average and marginal tax rates are endogenous in the latter case and depend on income levels.

Delete an entire block of equations

Aggregate inventory change with fixed capital formation in FD.DAT to eliminate all equations related to inventory accumulation.

Aggregate the *Rest-of-the-world* "industry" to some other industry to eliminate the foreign factor service account. Delete the industry from the data altogether to model GDP instead of GNP.

Change assumptions about depreciation rates

Edit rows in CFT.DAT to change the rates at which various types of capital are assumed to depreciate. Reduce the weight of the longer-lived capital.

Choose a model closure

Substitute fixed for flexible exchange rates and turn the foreign capital inflow from exogenous to endogenous.

Turn tax instruments ON to make tax revenue exogenous while including some or all tax rates in the list of endogenous variables.

Change technology assumptions

File commodity by commodity or industry by industry tables created under industry or commodity technology assumptions.

SAMPLE OUTPUTS

Your GEMODEL.PRO diskette includes four sample output files for a 1977 U.S. model named USA77.CFF, USA77.CAL, and USA77.PRO.

USA77.CFF is the result of a 16-industry aggregation. USA77.CAL is a file of elasticity assumptions. USA77.PRO is a file of calibrated model parameters and tax rates for use as base case input to simulations.

Elasticities of substitution of capital for labour in USA77.CAL follow the assumptions made by L. Ballard, Don Fullerton, John Shoven and John Whalley[4]. Price elasticities of export demand were derived from elasticities in a study by Robert E. Baldwin.[5] Utility function parameters were chosen to yield labour supply elasticities and savings elasticities as near to 0.2 and 0.4 as possible. The former is a value assumed by Ballard, Fullerton, Shoven, and Whalley. The latter is Boskin's estimate.[6]

The 16-industry aggregation scheme

The paucity of payroll tax data filed in TAXES.DAT constrains the choice of industry aggregations. The aggregates correspond to those for which payroll tax data were readily available. The Scrap industry was retained only to illustrate GEMODEL.PRO's ability to cope with such a peculiar industrial account.

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4. *General Equilibrium Analysis of U.S. Tax Policies*, Chicago: University of Chicago Press, 1985.

5. *U.S. Tariff Policy: Formation and Effects*, study prepared for the Bureau of International Labour Affairs, U.S. Department of Labour, June 1976.

6. Michael J. Boskin, "Taxation, Saving, and the Rate of Interest," *Journal of Political Economy*, 86(2) Part 2, April 1978, S3-S28.

..SAMPLE OUTPUTS

Agriculture	Livestock
	Other agriculture
	Forestry
	Agricultural services
Mining	Iron mines
	Nonferrous mineral mining
	Coal mining
	Crude oil & natural gas extraction
	Stone & Clay
	Chemical mining
Construction	New Construction
	Repair Construction
Mfg. of durables	Ordnance
	Lumber
	Wood containers
	Household furniture
	Other furniture
	Glass
	Stone
	Primary iron
	Nonferrous metal
	Metal containers
	Heating
	Screw machinery
	Other metal
	Engines
	Farm machinery
	Construction machinery
	Materials handling equipment
	Metalworking
	Special machinery
	General machinery
	Miscellaneous machinery
	Office machinery
	Service machinery

...SAMPLE OUTPUTS

Mfg. of durables	Electrical apparatus
	Household appliances
	Lighting
	Radio, TV equipment
	Electronic components
	Miscellaneous electrical machinery
	Motor vehicles
	Aircraft
	Other transport equipment
	Scientific equipment
	Optical equipment
	Miscellaneous Manufacturing
Mfg. of non-durables	Food
	Tobacco
	Fabrics
	Textiles
	Apparel
	Miscellaneous Textile
	Paper
	Paperboard containers
	Printing
	Chemicals
	Plastics
	Drugs
	Paints
	Petroleum Refining
	Rubber
	Leather
	Footwear
Transport and warehousing	
Communications	Communication
	Broadcasting
Utilities	
Trade	

...SAMPLE OUTPUTS

Finance, insurance, and real estate	
	Finance
	Real Estate
	Inventory valuation adjustment
Services	Hotels
	Business Services
	Eating places
	Auto repair
	Amusements
	Health & Education
Government	Federal Government enterprises
	State Government enterprises
	Government
Noncom. import	
Scrap	
Rest of world	
Households	

Aggregation of personal consumption categories

Food	Food
	Purchased Meals
	Cafeterias
	Farm food
Tobacco	
Clothing	Shoes
	Women's Cloth
	Men's Clothing
	Uniforms
	Jewelry
	Other Clothing
	Cleaning
Non-durables	Toilet articles
	Semidurables
	Household supplies
	Stationery
	Drugs

...SAMPLE OUTPUTS

Services	Barbershops
	Domestics
	Other Household services
	Other Personal Business
	Tires
	Auto Repair
Housing	Owner-occupied Housing
	Rented Housing
	Farm Housing
	Other Housing
Durables	Furniture
	Appliances
	China, glass
	Other durable
	Ophthalmic and orthopaedic appliances
Utilities	Electricity
	Gas
	Water
	Fuel
	Telephone
Health, education and religion	
	Physicians
	Dentists
	Other medical
	Private Hospital
	Private Higher Education
	Private Schools
	Other private education and research
	Religion
Finance and insurance	Brokerage
	Bank service charges
	Imputed bank services
	Life Insurance, expense of handling
	Health Insurance
	Legal Service
	Funerals
	Auto Insurance less claims

...SAMPLE OUTPUTS

Automobile	New Autos
	Used Autos
	Other Motor Vehicles
	Gasoline and Oil
	Tolls
Transportation	Bus
	Taxicab
	Railway, commutation
	Railway, intercity
	Intercity Bus
	Airline
	Other intercity
Other PCE	Books, maps
	Magazines and newspapers
	Toys
	Wheel goods, sports equipment
	Radio & TV equipment
	Radio Repairs
	Flowers
Recreational services	Movies
	Theater
	Sports, spectator
	Clubs and fraternal organizations
	Amusements
	Parimutuel net receipts
	Other Recreation
	Foreign Travel
	Military & civilian US personnel abroad
	Visitors to US
	Remittances to non-residents

...SAMPLE OUTPUTS

Household aggregation

The five quintiles in the data were retained without any further aggregation.

The assumed indirect tax system

The indirect tax base assumed is a retail sales tax on GNP and destination, both at the federal and the State/local levels. Assumed exemptions are concentrated in government, services, and agriculture. The GEMODEL.PRO disk includes the results of **TAX MARGIN ESTIMATES** in files USETAXF.DAT, PCETAXF.DAT, CFTTAXF. DAT, FDTAXF.DAT, USETAXS.DAT, PCETAXS.DAT, CFTTAXS.DAT, and FDTAXS.DAT.

Sample simulation

File NEUTRAL.PRO is identical to USA77.PRO with the exception of the following tax rates: federal tax on capital inputs, State/local tax on capital inputs by industry, and State/local property tax by industry. The same tax rates were set for all taxable sectors. File NEUT_OUT.PRO contains the solution with application of the following instruments used to hold constant both the federal and the State/local tax receipts: federal corporate income tax, State/local corporate income tax, State/local property tax.

... SAMPLE OUTPUTS

A MODEL OF CANADA, 1980

The *Professional Version* of GEMODEL.PRO includes files for a 1980 model of Canada. The files are in sub-folder CANADA80.

The public *Statistics Canada* data for the model are

the revised input-output table for 1980
the revised national income and expenditure accounts for 1980
the 1980 *Survey of Consumer Finances* tape
the 1978 *Family Expenditure Survey* tape
the *Corporation Income Tax Statistics*
and the *Labour Statistics*

Besides public data, the model's data include also capital cost allowance by input-output industry and commodity indirect tax margins retrieved from the unrevised input-output tables for 1980. The remainder of this section explains how the data were arranged and applied to create GEMODEL.PRO data files. National accounts data are referenced by *CANSIM* D-numbers.

Sectoring

Most input-output data are at the medium level of aggregation. At this medium level, the revised tables had 50 industries, 92 commodities, and 8 categories of value added. The final demand table had 40 personal consumption and 72 investment columns. The number of industries in the unrevised data was only 43.

The number of industries was changed from 50 to 55 by aggregation of two industries and by addition of six industries. *Wholesale Trade* and *Retail Trade* were aggregated into a *Trade* industry. The new, special industries are *Households, Federal Government, Provincial and Local Government, Non-competing and Unallocated Imports and Exports, Rest of the World*, and *Subsidies*.

... SAMPLE OUTPUTS

The number of commodities was reduced by one and then increased to 100. The reduction is by aggregation of the trade commodities. The increase is by disaggregation of *Royalties on Government Natural Resources* from *Financial Services*, by disaggregation of *Government Goods and Services* from *Miscellaneous Personal Services*, by addition of *Household Services, Federal Government Services, Provincial and Local Government Services, Rest of the World*, and *Subsidies*, and by transfer of *Non-competing Imports* and *Unallocated Imports and Exports* from value added to commodities.

Households are grouped by income deciles. The model was aggregated to 30 industries including special ones, 23 consumer goods, and 10 household groups.

Make and Use matrices

The input-output tables used were unbalanced by suppression of confidential data and by rounding. The larger imbalances were corrected using information from Canadian tables for other years or at other levels of aggregation. Remaining discrepancies were eliminated by the RAS method implemented in *IO&SAM for Windows* by DIAAgency, Inc.

Value added

Subsidies are removed from the value added matrix. The row of subsidies in the input-output *Use* table is changed in sign, transposed to a column, and transferred to a new column in the *Make* matrix. Total industry output is thus increased by the amount of subsidies.

... SAMPLE OUTPUTS

The sum of **net indirect taxes** was preserved by making special government industries purchase a special commodity *Subsidies.* The value of subsidy payments by federal, provincial, and local governments was given in the national accounts (D11387, D11420 and D11472). Subsidy payments are offset by negative indirect taxes on the special industries. Thus the total value added at market prices is not changed.

Indirect taxes on final demand are deleted from the indirect tax row and added to the *Trade* row. The total of indirect taxes on final demands is added to the indirect tax on the *Trade* industry recorded in the *Use* matrix and to *Trade* commodity output in the *Make* matrix.

Value added by **primary factors** employed in final demand is transferred to value added in special industries and recorded in the expanded *Use* matrix.

Supplementary Labour Income is added to *Wages and Salaries* by industry.

Unincorporated business income imputed to the *Owner-Occupied Housing* industry is transferred to *Other Operating Surplus* of the same industry. Unincorporated business income in other industries is distributed over labour and capital income. Two-thirds of unincorporated business income is added to wages and salaries plus supplementary labour income, the remaining third is added to other operating surplus.

The accounting for value added by **Government Royalties on Natural Resources** is changed to treat royalty income as government revenue. National accounts figures are used to allocate royalties to federal (D11303) and provincial governments (D11308). The operating surplus of the royalties sector is transferred to operating surplus of the special government industries. Industry and commodity outputs are re-balanced by recording the inputs to the royalties sector as intermediate inputs of government services.

There is no accounting of foreign investment income. The **Rest of the World** sector does not employ capital. Total value added equals GDP.

... SAMPLE OUTPUTS

Final demand

Government Revenue from Sale of Goods and Services in *Final Demand* table columns is changed in sign, transposed, and recorded in new *Make* table rows as a commodity supply by special industries. This increase in final demand is balanced by a reduction in government consumption of government services supplied as special commodities. Total value added and final demand are unchanged.

Taxes

Firm-level data for federal and provincial **corporate income taxes** are adapted to establishment level data at the input-output aggregation. The distinction between firms and establishments was ignored in most cases. For some industries -- especially in mining and services -- aggregated firm level data were distributed over input-output industries in proportion to operating surplus.

Labour taxes are employer contributions to provincial workmen's compensation boards and employer and employee contributions to federal unemployment insurance and pension plans. Contributions to the provincial *Quebec Pension Plan* are lumped with those to the federal *Canada Pension Plan.*

Property taxes were estimated by the method outlined on page 4-22.

The data in the **Capital Cost Allowance** row are estimates produced by the Input-Output Division of Statistics Canada before the revision of the input-output system. The old estimates were for 43 industries. Estimates for industries introduced with the revision were made proportional to operating surplus.

...SAMPLE OUTPUTS

Margins
A column of **Import duties** was supplied by Statistics Canada at the 92-commodity level and for revised data.

Export taxes and other **indirect tax margins** were obtained from Statistics Canada before the input-output system revision. Federal taxes include an old *Manufacturer's Sales Tax* that has since been replaced by a federal *Goods and Services Tax*. Federal commodity tax margins add up to total federal indirect tax revenue. Provincial tax margins exclude most retail sales tax revenue.

Two *Margins* tables were prepared in sequence and the **Tax Margin Estimates** module of GEMODEL.PRO was run twice to implement two different assumptions about the structure of the indirect tax system. In the first round, federal tax margins were assumed to consist exclusively of the federal *Manufacturer's Sales Tax*. This tax could be specified as a destination-based retail sales tax with exemption of all non-manufacturing industries. Provincial margins were specified as a turnover tax without exemptions because they exclude all retail sales taxes other than those on telephone services and electricity supply. The resulting files were copied to a temporary folder before starting a second round of **Tax Margin Estimates**. In the second round, the *Manufacturers' Sales Tax* was removed from the federal tax column in the *Margins* table and replaced with a column of federal excise taxes and excise duties. Both federal and provincial margins were then specified as destination-based turnover taxes without exemptions. The federal tax margin matrices resulting from the second round of **Tax Margin Estimates** were then added to the corresponding results of the first round. The sums are estimates of federal tax margin matrices that reflect the difference in operation of the federal *Manufacturers' Sales Tax* and the other federal indirect taxes.

Exclusion of provincial sales tax (PST) from the **MARGINS.DAT** file means that GEMODEL.PRO lumps the PST with other indirect, provincial and local output taxes.

... SAMPLE OUTPUTS

The result of the two rounds of tax margin estimates is filed in USETAXF.DAT, PCETAXF.DAT, CFTTAXF.DAT, FDTAXF.DAT, USETAXS.DAT, PCETAXS.DAT, CFTTAXS.DAT, and FDTAXS.DAT in sub-folder CANADA80, and summarized in the table below.

Estimated commodity tax margins, Canada 1980
(in millions of dollars)

	Federal	Provin-cial	Total
Intermediate use	2483.5	2212.5	4,696.00
Personal consumption expenditure	4016.2	2460.7	6,476.90
Depreciation of fixed capital	211.8		211.80
Net fixed capital formation	557.7		557.70
Government expenditures	34.1	146.2	180.30
TOTAL	7303.2	4819.4	12,122.60

Excludes trade taxes.

Tax Margin Estimates should not be run again if these results are to be conserved.

... SAMPLE OUTPUTS

PCE and CFT

The *Personal Consumption Expenditure* and *Capital Flow* tables are extracts from the *Final Demand* table in the input-output system. Personal consumption expenditure includes the outlay by churches, universities, trade unions, and other non-profit organizations.

The fixed capital formation columns in the input-output *Final Demand* table are disaggregated by type of asset and by industry. For each industry, the machinery and equipment column was added to the construction column. The industry aggregation is not the same as that in the *Use* and *Make* tables. Absence of some capital formation data does not present a problem, provided that the model's industry aggregation corresponds to that employed in the *Final Demand* table. Government investment was disaggregated between federal investment and provincial and local investment in proportion to national accounts figures. Federal investment is from *CANSIM* series D11169. Provincial and local investment is in series D11189, D11206, and D11207, and includes hospital investment.

Famex

Consumption expenditures, savings, and total, federal and provincial income tax payments were tabulated using the 1978 survey tape. Households were grouped in income deciles. Total consumption by decile was increased to equal the national accounts level (D11972) without changing the distribution among deciles. Consumption by expenditure category and by decile was adjusted by the RAS method. The control totals by decile were the ones just described. The control totals by expenditure category are those in the national accounts (D11973 to D12020).

Undistributed corporate profits (D12099) were distributed among deciles in proportion to net worth by decile (on which see below). The result was added to personal **saving** and adjusted so that the sum equals the national accounts sum of personal and corporate saving (D11559 + D12099).

Income taxes paid by decile were adjusted so that the sum equals the sum of national accounts figures for federal (D11238) and provincial (D11243) collections. The total per decile was then distributed between federal and provincial governments in proportion to their shares in the total.

Endowments

Net worth, **weeks worked**, **number of adults**, and **earnings** by income decile were obtained from the 1980 *Survey of Consumer Finances* tape. Transfers were computed as a residual in a first run of the GEMODEL.PRO Aggregation routines. A provisional residual was obtained as net federal transfer payments to households in a first solution output file. The computed residual was disaggregated into federal and provincial and local transfers using national accounts figures (D11347, D11370 + D11380). Provincial and local transfers to non-profit organizations (D11377, D11378, D11379, D11383) were distributed among deciles in proportion to their recorded expenditure on educational and cultural services. Other provincial and local transfers were distributed among deciles in proportion to the calculated residual. Federal transfers were then replaced with a residual computed in a final round of aggregations and calibrations.

Calibration

Elasticities of **capital/labour substitution** in production follow the pattern in the US model of Ballard, Fullerton, Shoven, and Whalley. **Price elasticities of export demand** are equal to U.S. import demand elasticities in the May 1987 version of Clopper Almon's Maryland model. The model's elasticities were converted to GEMODEL.PRO elasticities using the procedure described on page 4-19. Armington elasticities were chosen to approximate U.S. export elasticities in the Maryland model. Elasticities of substitution for **leisure** and **savings** were chosen to yield elasticities of labour supply and of savings of approximately 0.2 and 0.4, respectively.

...SAMPLE OUTPUTS

Personal income tax payments are calibrated as quadratic functions of taxable income. Taxable income excludes some capital income and savings. The excluded capital income is imputed net rent (D12092) and undistributed corporate profits (D12099). The exclusion factor is a ratio to total capital income estimated as net domestic income (D11001) plus investment income received from abroad (D12191) *less* the sum of wages and salaries (D11002), two-thirds of unincorporated business and farm income (D11005 *plus* D11006), and investment income paid to non-residents (D12198).

The ratio of saving excluded from the tax base is the ratio of sheltered saving to total private saving. The latter is aggregate saving (D11508) *less* government saving (D11512). Sheltered saving is taken to be equal to undistributed corporate profits. Other forms of tax-deferred saving such as pension saving are disregarded in the estimates.

Model behavior

The resulting model is one were a 10 per cent devaluation improves the trade balance by 24.7 per cent. Depending on the domestic policy change, terms of trade gains are about one-tenth of efficiency gains or less. The rate of growth over the first twenty years is 3.2 per cent per year, assuming that population grows at the same rate as the capital stock.

A twenty per cent cut in federal corporate income tax rates was simulated as part of a revenue-neutral tax change. Tax revenues were held constant by allowing federal and provincial income tax rates to adjust to the federal corporate tax rate change. One-half of growth was assumed to be biological growth. Marginal personal income tax rates were readjusted from year to year to maintain the growth in average tax rates. There is nearly no change in saving and in the capital stock employed in the twentieth year. Tax incidence is shifted from non-residents to residents. A welfare loss (discounting at either 4% or at n+g) of 14 to 18 billion dollars results mostly from terms-of-trade changes. The attempt to hold average tax rates constant results in regressive marginal tax rate changes. A smaller welfare loss of 7.6 to 9.3 billion dollars results when marginal tax rates are made to increase in the same proportion for all households or when the year-to-year maintenance of average rates is abandoned. Only half the smaller welfare loss is shifted to non-residents.

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
Alphas of *household name* add up to *n.n*	Solve	Difference from 1	Repeat share parameter change
Armington share of *Industry Name*		illegal value greater than 1	Repeat share parameter change
Armington elasticity of *Industry Name*. Coefficients add up to *n.n*		illegal negative value	Repeat parameter change
Beta *household name*		Illegal elasticity, non-positive or 1	Repeat elasticity change
Can't find polynomial tax function parameters. Bad tax data.	Calibration	Regression error	Choose linear tax
Can't find file *.TAX, a file containing tax exemptions.	Aggregation		Repeat Tax Margin Estimates
Can't find file *.XAT, a file containing tax exemptions.			
Cannot find *filename*.CFF	Calibration Simulation	Cannot find precalibration output matched to *.PRO file that had been opened.	Files could have been moved to different folders. Copy them to same folder.
Cannot find a trade commodity	Tax Margin Estimates	Wrong name given to trade commodity in the COMMODTY.HDG file, or no trade commodity in the data.	Find data for a trade commodity. Name the commodity in a way recognized by GEMODEL.
Cannot find a trade industry	Aggregation	Wrong name given to trade industry in the INDUSTRY.HDG file, or no trade industry in the data.	Find data for a trade industry. Name the industry in a way recognized by GEMODEL.
Column name is aggregated to *other name* but *other name* is aggregated to *yet another name*	Aggregation	Chained or nested aggregation	An aggregate can only be aggregated to itself. Revise your aggregation scheme. If you aggregate A to B, you must aggregate B to B and nothing else.

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
Commodity composition of *PCE category name*. Coefficients add up to *n.n*	Solve	Sum of coefficients different from 1	Return to SIMULATION menu
Commodity composition of saving. Coefficients add up to *n.n*			
Commodity composition of capital replacement by *industry name*. Coefficients add up to *n.n*			Repeat parameter change
Commodity composition of inventory change. Coefficients add up to *n.n*			Attempt to solve again
Commodity composition of government demands. Coefficients add up to *n.n*			
Complete the tax system specs	Tax Margin Estimates	Forgot to choose tax bases	Fill the tax base form
Consumption of *PCE category name = n.n*	Aggregation	Illegal negative value	Change the aggregation scheme. Study the *rest-of-the-world* row in PCE.-DAT
Delta *industry name*	Solve		Repeat CES share parameter change
Depreciation rate *industry name*			Repeat parameter change
Disk drive *d:* is full	Sequencing		Choose alternative location for sequenced files.
Division by zero	Spreadsheet		
Excessive iterations. Increase the tolerance.	Solution	Solution is not reached within reasonable number of iterations	Try to solve again but with more error tolerance. There may be no solution if this error recurs. Otherwise solve yet again but with smaller tolerance.
Export scalar *industry name*	Solve	Illegal negative value	Repeat parameter change
File is too large	Spreadsheet	The file was edited with other software and its size increased beyond GEMODEL limits	Use same other software to edit file and reduce its size to acceptable limits
File not found	Compare dynamic	Unexpected loss of sequenced files	Files may be in different folders. Copy all to the same folder.

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
File.SQR and *FileXAT.SQR* have inconsistent dimensions	Aggregation	Error when editing Tax output. Changed dimensions of *S.DAT files	Repeat Tax Estimates.
File.SQR and *FileTAX.SQR* have inconsistent dimensions		Error when editing Tax output. Changed dimensions of *F.DAT files	Then aggregate again.
Hawkins-Simons conditions *industry name*	Solve	input coefficient greater than 1	Repeat coefficient change
household name does not save	Aggregation		Correct FAMEX.DAT file
household name does not work		non-positive weeks worked	Correct ENDOW.DAT file
household name does not earn		non-positive labour income	
Household name faces a marginal tax rate of *n.nn*	Solution	Combined, federal and State/local tax rate exceeds 1	Abandon polynomial tax function when personal income is expected to vary by much.
Household name is destitute		Non-positive disposable income	Review labour supply elasticity, income tax rates, transfer payment shares.
household name has no leisure	Aggregation		Correct ENDOW.DAT file
Household name demands negative *PCE category name*	Aggregation	Negative values in PCE.DAT file, in columns aggregated to *PCE category name*	Change the aggregation scheme
in ENDOW file: zero earned income	Aggregation	lack of or incorrect endowment data	Correct ENDOW.DAT file
in Endow file: zero net worth			
Incompatible PCE and FAMEX categories	Aggregation	Wrong number of PCE categories in one of the two files	Correct data files
Inconsistent matrix dimensions in MAKE.DAT and CFT.SCR	Aggregation	User changed data files between Tax Margins Computation and Aggregation	Do another Tax Margins Computation, then aggregate.
Inconsistent matrix dimensions in MAKE.DAT and FD.SCR			
Inconsistent matrix dimensions in MAKE.DAT and IMPORTS.SCR			.

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
industry name capital input is negative	Aggregation	Loss making industry has negative value added by capital. Capital cost allowance plus capital taxes exceed VA by capital.	Change the aggregation of industries to ensure that value added by capital is positive.
industry name gross output inconsistent with final demand	Aggregation	Cannot reconcile data in FAMEX.DAT and/or CFT.DAT with those in FD.DAT	Correct data files to balance commodity demands with supplies
industry name labour input is negative	Aggregation	Error in USE.DAT	Correct USE.DAT file
It is not possible to continue processing unless all aggregations are done and confirmed.	Aggregation	Omitted to aggregate industries, or PCE categories, or households	Aggregate each or quit aggregation altogether
Labour supply *household name*	Solve	Illegal negative value	Repeat parameter change
Labour endowment *household name*		Negative or zero value	
Leisure demand *household name*		Illegal share parameter, negative or greater than 1	
n.n = GNE <> GNP = *m.m*	Aggregation	Undetermined accounting error	Balance the data in a social accounting matrix. Apply the SAM approach to data collection
Negative labour input to the Rest of the World	Aggregation	L and K have different signs in a sector not recognized as the ROW	Name the ROW in a way recognized by GEMODEL.
Negative labour input to *industry name*	Solution	Imports exceed domestic demand	Review elasticities in export/import trade
Negative depreciation in *industry name*	Tax Margin Estimates, Aggregation	Error in TAXES.DAT Negative values in CFT.DAT	Correct capital cost allowance data and CFT.DAT
Negative imports of *industry name n.n*	Aggregation	Illegal positive value in imports column of FD.DAT	Correct data file FD. DAT
Not enough tax instruments in use to reach the desired revenue	Solution	Attempting large revenue change on a narrow base	Add instruments. Attempt to solve again
Omega *household name*	Solve	Illegal elasticity, non-positive or 1	Repeat parameter change
Phi *industry name*		illegal non-positive value	
Saving *household name*		Illegal share, negative or greater than 1	
Sigma *industry name*		Illegal non-positive value	

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
Subbeta *household name*		Illegal value, non-positive or 1.	Repeat elasticity change
The exchange rate = *n.nn*	Solution	Exchange rate out of reasonable bounds	Review elasticity assumptions in export/import trade
The price of the savings good is *n.n.*	Aggregation	Zero or negative savings or excessive indirect subsidy to saving	Correct FD.DAT investment column, negative tax margins
There are only *nnnnnn* bytes free on drive *drive*	Tax Margin Estimates	Not enough room for temporary files in the chosen location	Choose new temporary file location. Remove obsolete files
There is no net saving	Aggregation	Excessive depreciation in TAXES.DAT. Total CCA exceeds gross fixed capital formation	Correct data. Toss out depression year data.
Too disaggregated. Eliminate *n* columns.	Aggregation	Exceeds the limit for number of aggregates in *Academic* or *Professional* version	Revise the aggregation scheme to reduce the number of aggregates
Total saving by residents in file FAMEX.AGG is *n.n*		Illegal non-positive value	Correct the data for fixed capital formation in FD.DAT and CFT.DAT, and depreciation in TAXES.DAT
Transfer payments by federal government unbalance its budget	Calibration	Sum of transfer shares is different from 1	Balance the data in a social accounting matrix.
Transfer payments by State/local government unbalance its budget			Apply the SAM approach to data collection
Transfers paid by federal government. Shares add up to *n.n*	Solve	Difference from 1	Repeat parameter change
Transfers paid by State/local government. Shares add up to *n.n*			
Unexpected final demand in Rest-of-world row of FD	Tax Margin Estimates Aggregation	Negative PCE, investment, and/or GGCE	Edit files FD.DAT and PCE.DAT. Redefine consumption as consumption of residents. Re-balance imports.
Unexpected revenue on a zero base in State/local (row,col) *(n,m)*	Aggregation	Error when editing output of Tax Margin Estimates. Federal tax cuts too far into State tax base	Redo tax margin computation.

ERROR MESSAGE	LOCATION	PROBABLE CAUSE	REMEDY
Unexpected revenue on a zero base in federal (row,col) *(n,m)*	Aggregation	Error when editing output of Tax Margin Estimates. State tax cuts too far into federal tax base	Edit output files again.
Unstable elasticity combination	Calibration	Too many iterations to solve partial model with elasticity implied in last parameter assumption	Change the parameter assumption
Use has *n* rows while FD has *m*	Tax Margin Estimates Aggregation	Either USE.DAT or FD.DAT had been changed by copying a file from a different model	Inspect both files. Recover files belonging to the same model and data set.
World price *product name*	Solve	Illegal non-positive value	Repeat parameter change
Wrong file! *FileNNN.CFF* and *FILEXXX.CAL* have different numbers of consumer goods	Calibration	Must be using old assumptions file with new aggregation output.	Make a new *.CAL.
Wrong file! *FileNNN.CFF* and *FILEXXX.CAL* have different numbers of industries			
Wrong file! *FileNNN.CFF* and *FILEXXX.CAL* have different numbers of households		Or copied incompatible files across folders.	Keep files for different models in separate folders.
Zero tax base in commodity row *n*	Tax Margin Estimates	Excessive tax exemptions	Remove tax exemption of activities that use the commodity in row *n*
Zero capital endowment	Solve	Zero or negative aggregate capital endowment of all households	Repeat parameter change

SUBJECT INDEX

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